THE BLACK WOMAN'S TOOLKIT: STORIES OF PERSISTENCE IN UNDERGRADUATE MATHEMATICS COURSES

by

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ABSTRACT

OLANREWAJU TITILOPE ORIOWO. The Black Woman's Toolkit: Stories of Persistence in Undergraduate Mathematics Classrooms.
(Under the direction of DR. ALLISON MCCULLOCH)

Black women are underrepresented in secondary math education, but their presence is critical for young black girls who dream of STEM careers. Some researchers believe that the number of Black women pursuing secondary math licensure can be increased through improved recruitment strategies, while others focus on causes of leakage in the education pipeline. This study focuses on what can be learned from the Black women who persisted so that this can inform strategies to support retention. To that end, this study sought to discover types of capital that Black women, who are preservice Mathematics teachers (PSMTs), relied on to persist towards the completion of their teacher preparation programs.

Framed using Critical Race Feminism and Black Feminism, this study employed Counternarrative Inquiry to discover the capital that the five PSMTs credited for their ability to stay the course. The PSMTs attended universities that were either public or private, Predominantly White Institutions (PWIs) or Historically Black Colleges and Universities (HBCU). Through thematic inductive analysis of narrative interviews, six capitals were revealed to have been instrumental in the PSMTs' persistence: expectation capital, mathematical capital, fortifying capital, actuation capital, equanimity capital, and confounding capital. The findings indicate that, while PSMTs might use the same capital, they use it in a variety of ways and for different purposes.

A key implication of the findings from this study is that, if undergraduate math educators can mitigate or eliminate the conditions within the math classroom that triggers the use of many of the capitals in this study, Black women who are PSMTs may be able to divert their energies to

developing robust mathematical identities. A second implication was that if the faculty and staff of teacher preparation programs demonstrate the qualities of caring and commitment to their success, Black women who are PSMTs might look to them as a source of fortification for their persistence. The community of mathematics educators can act now to support the retention of the Black female PSMTs who are currently in teacher preparation programs. The impact of the actions they take is amplified when there is intentionality, vigilance, and a genuine desire for the successful program completion of Black female PSMTs.

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> *As we learn to bear the intimacy of scrutiny and to flourish within it, as we learn to use the products of that scrutiny for power within our living, those fears which rule our lives and form our silences begin to lose their control over us* (Audre Lorde, Sister Outsider)

I first want to express profound gratitude to the members of my committee. Your academic insights and scholarship let me know that your scrutiny of my work could only yield a refined academic and professional product. You each extended invitations to participate or to collaborate in research, boosting my development as a researcher and educator. Dr. McCulloch, thank you for agreeing to be my chair. It is because of your work that I understand the significance and the magnitude of the role. You graced me with the benefit of your experience and skill as a researcher and as an educator. You provided detailed feedback, the depths of which reveal your investment in my growth and your interests in my thoughts. You also took on the task of helping to manage my stress and temper my anxiety. I was not the only student in your orbit, neither was I the only commitment in your life and yet you gave, and you gave. You encouraged me to present my work, even in its most fledgling state, and your hand of guidance never left me.

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> *When Black women in this country come together to examine our sources of strength and support, and to recognize our common social, cultural, emotional, and political interests, it is a development which can only contribute to the power of the Black community as a whole*
> (Audre Lorde, Sister outsider)

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DEDICATION

I dedicate this work to the multipliers of ìrètí (hope), the divisors of ìbùkún (Blessing), the daughters of Africa, and the sisters of the world who inhabit (or expect to inhabit) the mathematics classrooms in this country and around the world. Our Black girls are waiting for you.

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LIST OF ABBREVIATIONS

HBCU	Historically Black colleges and Universities
PWI	Predominantly White Institution
PSMT	Preservice Mathematics Teachers

CHAPTER 1: INTRODUCTION

What is a toolkit? For anyone who has engaged in any Do-It-Yourself (DIY) activities, a toolkit is a must: it contains tools and resources that will be used to complete the DIY project. The toolkit for a first-time DIYer is certainly not as diverse as that owned by someone with more experience, which means the toolkit grows with time and experience. Additionally, with experience, a person learns to use the tools within the toolkit in new ways and in unexpected contexts. The most important thing about a toolkit is that it must be possessed. One must first own a toolkit in order to use and grow the collection of tools therein. I define the Black Woman's toolkit, as the collection of skills, resources, and abilities that a Black woman uses to accomplish something of value to her, whether the *something* is academic, social, or personal. The definition of resource is "a source of supply, support, or aid, especially one that can be readily drawn upon when needed" (Dictionary, n.d.). I use the term *resource* to include the people and community from which Black women draw help and support.

Historically, Black women have not been perceived as possessing the tools to accomplish what the dominant society holds in high regard, in the manner that the dominant society believes it ought to be accomplished (Collins et al., 2020; Gholson, 2016; Joseph et al., 2017). Nowhere is this more evident in the various lenses and perspectives in which researchers have addressed the STEM participation of Black women, particularly in mathematics, a subject upon which STEM aspirations are built. In this study, I focus on the tools that Black women have found useful in their quest to become licensed secondary mathematics educators. In this context the tools are often referred to as capital, which I define as the accumulation of useful assets and advantages dedicated to the attainment of something valuable (e.g., education degree) or the fulfillment of a dream or a goal (e.g., becoming a teacher). According to Dumangane (2017), most research

about capital falls into three categories: economic, social, and cultural. Economic capital refers to financial resources and assets; social capital is used to describe social networks; and cultural capital tends to embody a set of skills, knowledge, and cultural practices and values (Dumangane, 2017; Go, 2013; Wallace, 2017). I use *capital* to embrace all three categories.

As of 2021, women account for about 27% of the US STEM workforce even though they are about 50% of the US population (Martinez & Christnacht, 2021). The disproportionate numbers of women seeking and completing STEM degrees impacts the US economy in that it "negatively impacts the number of qualified workers in high demand STEM fields" (Alexander & Hermann, 2015, p. 308). The STEM fields, however, are broad, and experiences are complex across the specific disciplines, races and genders, thus it would be imprudent to suggest that all women, notably Black women, experience all aspects of STEM degrees in similar ways. Indeed, studies regarding minoritized women's participation in undergraduate STEM majors note differences in the uptake of natural sciences as opposed to physical sciences, computer science compared to engineering and mathematics (Tao & Gloria, 2018). While these studies have found some commonalities to the experiences of Black women in these programs (imposterism, low self-confidence, low self-efficacy, etc.), there is a niche in STEM that is usually not included in these discussions: secondary mathematics education. Students seeking to be secondary mathematics teachers in traditional undergraduate preparation programs are typically included in the amalgam of education majors, which overlooks the truth that they straddle the STEM and education world. In most institutions this includes completing the equivalent of a B.A. or a B.S. in mathematics. As mathematics ability is fundamental to any STEM aspirations, it is important to attend to how Black girls and women experience mathematics, especially those who want to teach historically marginalized students who have dreams of STEM futures. Further, I contend

that the presence and experience of Black women in the niche of secondary mathematics education extends beyond generating workers to meet the economic demand for STEM.

From 2008 to as recently as 2020, Black women steadily accounted for about 8% of the STEM bachelor's degrees obtained by women in US post-secondary institutions (NCES, 2021). The most recent American Community Survey shows that, although Black women are making great strides in undergraduate degree attainment, very few were in the field of education and fewer still in mathematics and statistics. Black women accounted for 6.24% of all bachelor's degrees in 2020 (NCES, 2022) which is about two thirds of the undergraduate degrees awarded to Black college graduates. However, only 3.24% of the degrees awarded to Black women were in the field of education and 0.4% in the field of mathematics and science (NCES, 2022). Since data that drills down to the specific licensure areas for the education degrees is unavailable, we can assume that secondary mathematics education was not a popular choice, implying that the actual percentage of secondary mathematics education degrees might be closer to the proportion of mathematics and statistics degrees. To put this in perspective, 15% of students enrolled in US public elementary and secondary schools are Black or African American (NCES, 2022), 7.5% of public-school teachers are assigned to secondary mathematics, and 6.7% of teachers are Black. If we were to assume the proportion of secondary mathematics teachers applies to distributions by race, then we can expect about 0.5% of secondary mathematics teachers to be Black. At this rate, a fraction of a percentage of these students can hope to have a Black, female, mathematics teacher.

Black female mathematics educators serve as role models for Black girls with STEM aspirations and as cultural brokers who facilitate the bridging of the ethnic identity and mathematics identity of Black students (Sparks & Pole, 2019; Townsend et al., 2010). However,

the present supply of Black female mathematics educators cannot support the demand in US public secondary schools. If Black female preservice secondary mathematics teachers (PSMTs) are the best indicator of future supply, then research is required to examine the talent pipeline from undergraduate teacher preparation programs to the classroom.

There is a growing body of work that considers the experiences and barriers Black women and girls encounter that contributes to their absence or low numbers in STEM and other mathematics-related disciplines. Research has described that Black women often experience a series of barriers and obstacles that contribute to hostile learning environments and damage to self-efficacy (Ellington & Frederick, 2018; Joseph et al., 2019; Tao & Gloria, 2018). Sparks (2018) noted that the main reason for the low numbers of Black students in STEM majors is higher rates of attrition due to stereotype threat, microaggressions, and imposter syndrome. Within the context of education, the systemic and systematic effect of those three contributors to attrition is due to the first tenet of Critical Race Theory, which is the ordinariness (and intercentricity) of racism in institutions of higher education (Delgado & Stefancic, 2017; Yosso, 2005). For Black female STEM students, attention to intersectionality is paramount when research reveals that women of Color in STEM are more likely to face stereotype threat by virtue of a "double bind" (McGee & Martin, 2011) due to race and gender membership. Justin-Johnson (2004) also found that African American females, owing to their multiple intersections, are more likely to experience microaggressions, to feel unwelcome, unsupported and excluded, and find difficulty bonding with faculty and their peers.

There are crucial research findings that are not as popularly disseminated, findings from studies showing that Black girls are interested in STEM careers (Leonard et al., 2020), studies that describe Black women who persist through the obstacles to thrive in STEM (Minnett et al.,

2019), and studies that reveal how some institutions confounded the low STEM persistence experienced by others (Sparks, 2018). Sparks (2018) noted that, where most universities see high attrition and low persistence in African American students, Historically Black Colleges and Universities (HBCUs) have been able generate significant STEM bachelor's degrees, especially in Black women, potentially because of their emphasis on nurturing their "psychological and intellectual development" (Sparks, 2018, p.244). Indeed, studies show that women flourish when exposed to rigorous curriculum, when given multiple opportunities to learn, when inducted into the structure and culture of STEM, and when their intersections (race, gender, and socioeconomic status) are attended to (Sparks, 2018).

Despite the suggestion that Black women do not have the background knowledge for (King & Pringle, 2020) or an interest in STEM majors (King & Pringle, 2018), research has shown in fact that many Black students are positively disposed to STEM (Mickelson, 2001; Sparks, 2018) and that "African American females are the most positive of all subgroups about STEM" (Sparks, 2018, p. 243). Leonard et al. (2020) found that African American girls have more positive attitudes towards mathematics than their White and Latina counterparts, challenging the societal belief that women are neither good at nor confident in mathematics. Young et al.'s (2020) study regarding the AP exam participation of Black girls revealed that "Black girls are more likely to pass rigorous AP calculus exams yet participate less frequently" (p. 216). By seeking to understand the Black women that do persist, perhaps we might learn how to better forge a link between STEM aspirations and STEM matriculation for Black girls.

Sparks (2018) and other critical researchers (e.g., Collins, 2004; Leggon, 2006; Ong et al., 2011), stress the need for more research that "focuses on the specific needs of African American females in STEM majors" (p. 244), in order to combat the assault of deficit-oriented

studies that positions Black women as deficient when compared to the White, male norms that dominate STEM. I am proposing a study that extends and focuses this call to action to understanding *how* the Black female preservice math teachers, the ones who will embody the vision of STEM possibilities for Black girls, persisted through the obstacles they may have encountered, as noted by a wealth of researchers, to become licensed secondary mathematics educators. I choose to present future Black female mathematics educators in a positive light, using an asset-based orientation to create a space for their counter-stories.

Current retention patterns of Black female teachers place in jeopardy the already low representation of Black women in mathematics education (Allen-Handy & Farinde-Wu, 2017). If we are to mitigate the attrition rates, we must first seek to understand how Black female preservice mathematics teachers experience mathematics courses at the undergraduate level, as this is a critical gatekeeper to STEM matriculation. However, Black female educators do not exist in a vacuum; rather, they are the product of their experiences as students in a K -12 setting, who continue to become students in mathematics teacher preparation programs, who then return to the classroom as mathematics teachers. I propose that those who persisted in this valiant return did so using resources and skills (capital) that they acquired along their K-16 journey. Where most studies focus on one main station in this educational journey, in this study, I seek to understand not only the types of capital that fed their persistence, but to also explore any changes in their use of the tools in their growing toolkits. By listening to stories Black women tell of how they persisted through mathematics courses, beginning with their earliest memories as a mathematics learner, I hope to follow the development of the capital that they relied on at each stage in the educational journey (primary, secondary, and tertiary). The purpose of this study, therefore, is to listen to the experiences of Black, female, preservice mathematics teachers to

understand the capital to which they ascribe their ability to persist through undergraduate mathematics courses so as to attain secondary mathematics education licensure. To reach those ends, I propose to use Counter-Narrative Inquiry (Mertens, 2020) to address the research questions guiding this study, which are:

1) When sharing stories of persistence in undergraduate mathematics courses, what types of capital do Black women who are preservice mathematics teachers believe was instrumental in that persistence?
2) With respect to capital, what are the similarities and differences among Black women's stories of persistence in undergraduate mathematics?

Significance of Study

The findings from this study could offer insight to mathematics educators at various levels as to how to create an environment that nurtures the types of capital that Black girls and women trust to help in their persistence, how to infuse opportunities for these capital to be developed during preparation programs, and how to instill a desire for Black women who become secondary mathematics teachers to do the same once they are responsible for their own students. Ultimately, this study has the potential to realize an increase in the number of Black women in the STEM pipeline.

To understand why there are not more Black women seeking to become licensed secondary mathematics teachers, we should first explore the experience of the women who not only made the choice but are persisting towards matriculation. Unlike other studies, the study that I propose will attend to the capital that persisting Black female preservice Mathematics Teachers (PSMTs) used, not only to make it *to* their current teacher preparation program, but also to make it *through* the program to reach the ultimate destination of a classroom of their own.

Methodological Approach

Theoretical Framework

To carry out this investigation, I employ Critical Race Feminism and Black Feminism framework to examine stories told by the participants. Collins (2015) emphasized the necessity for the experiences of Black women to be centralized in analysis. Critical Race Feminism, stemming from Critical Race Theory, attends specifically to the multiplicative impact of race and gender (Few, 2007), while Black Feminism highlights "Black women's interpretations of our social worlds" (Collins, 2015, p. 2349). Together, Critical Race Feminism and Black Feminism represents a paradigm shift from Black women as *objects* of knowledge to *agents* of knowledge.

Research Design

In alignment with Black feminism, the research design for this study is Counternarrative Inquiry, a subset of Narrative research or Narrative inquiry. My decision to use counternarrative inquiry is based on its necessary preservation of the voice of the participant. In seeking stories that refute the dominant, deficit narrative that precedes Black girls and women into mathematics classroom, it is important to restore power by privileging the voices of the unheard. Toliver (2022) stated that stories "carry a piece of the storyteller into the larger world" (p. xxxii) and urges the story listener (researcher) to listen with mind, body, spirit, and heart, be to feel and to wonder, and to consider relationship between the narrator, the listener, and the story. Counternarrative inquiry will allow me to demonstrate the value placed on the stories told by the participants, positioning them as holders of knowledge.

Sampling and Participant Selection

There were five participants for this study, purposefully selected from an assortment of universities, including Historically Black Colleges and Universities (HBCUs), Predominantly

White Institutions (PWIs), and public and private universities. This was to ensure that a wide and varied set of experiences are represented in the study. Accordingly, participants for this study met the following criteria:

1. 18-years or older,
2. Female,
3. Black or African American,
4. Attends a four-year university or college (HBCU, PWI, public or private)
5. At least a rising senior in a licensure-seeking secondary mathematics teacher preparation program. Recent graduates (within two years of graduation) were also welcome to participate.

Using purposeful sampling, I reached out to mathematics and mathematics education faculty in various universities, seeking recommendations for candidates that meet the above criteria or faculty who would have access to such candidates. I hoped to have a sample that included equal numbers of students from HBCUs and PWIs (4 from each type of institution), but I realized that was as much about the availability of time for extensive recruiting and the willingness of the candidates in desired institutions to participate.

Data Collection

I conducted three narrative interviews with each of my participants via a teleconferencing platform. Each interview lasted between 60 - 90 mins, meaning that I spent about three to four and a half hours in conversation with each participant in this study. The interviews followed the McAdams (2008) Life Story Interview format which prompted participants to share their stories in episodes. The episodes in this study were aligned to the stages in a typical education progression, from elementary, to middle school, to high school, followed by tertiary education

pursuits. The beauty of a narrative interview is that the interviewer falls into the background, using few questions and prompts, allowing the narrator to be centered as the knowledge-maker.

Data Analysis Procedure

My first step was to read through each interview a couple of times to remain as intimately connected to the data as possible (Tracy, 2013; Wolcott, 1994). To generate a chronological representation of each participant's stories, I first coded the interviews to mark the time periods in which each story took place. Where the participant mentioned a specific grade (e.g., 1st grade), I coded the statement as such. I then used thematic inductive analysis, guided by Black Feminist theory and Critical Race Feminism, to iteratively explore themes within and between and among the participants' interviews. Ideally, each participant would have the opportunity to review the chronological narrative to ensure that the knowledge that they shared was preserved in my treatment of the data. Other measures of reliability were incorporated, since time elapsed between interviews and data analysis eliminated member checking as a measure of reliability and trustworthiness. This is explained in Chapter 3.

Assumptions and Limitations

A potential limitation in my study is my use of "Black" as a descriptor. Similar to Young et al. (2020), I use "Black" to describe "multiple ethnic groups including but not limited to African American, African, Jamaican, and Haitian students" (p. 207); it is possible that experiences can be further nuanced due to ethnic origin, but for the purposes of this study, I operated under the assumption that the common physical racial characteristics sufficiently explain how the women in this study experience mathematics classrooms across the different contexts. Another limitation is the level of detail or the depth of reflection the participants are

willing to offer during the interviews. Some stories might require more time and trust than the interviews permit.

Roadmap

Following the positionality statement, Chapter 2 presents a review of the literature that begins by establishing why Black women who are mathematics educators are important to Black female students, landing on the concern with their low numbers in K-12 classrooms. I continue by tracing the learning experiences of Black women as they journey from K-12 until they reach teacher preparation programs as undergraduates. Within the K-12 experiences, I focus on thoughts and ideologies that taint the learning landscape, continue with discussion about the problem of Black achievement being compared and subordinated to White performance, the ways in which Black girls receive the message that they do not belong in Mathematics spaces, ending with the reasons some Black girls do not have the mathematics background required for STEM pursuits. As undergraduates in STEM, I first consider undergraduate degree attainment of Black women could have been impacted by the K-12 experiences, noting how mathematics remains a gatekeeper for Black women in STEM programs. Lastly, I attend to obstacles that Black women face as preservice teachers; I highlight the re-emergence of barriers previously faced during K-12 (e.g., identity development) and indicate new foes such as preparation programs that do not center the racialized experiences of Black women. I conclude chapter two by addressing research attempts and commentary on capital, and by exploring the various approaches and theories that guided studies that are similar to mine. Chapter three offers a more detailed description of the research design, showing how I incorporated fundamental aspects of the theoretical framework into data collection and analysis. I also provide the specific details about the analysis of the interview data that I collected, and the care to secure the confidentiality

of the participants and to protect the integrity of the knowledge that was shared with me in these intimate interactions.

In the latter half of this dissertation, I present the narratives of each of the five Black female preservice mathematics teachers (PSMTs), organizing the narratives by the capitals gleaned in the data analysis process, in chapter four. Due to the wealth of unique information detailed in each narrative, it is in chapter five that I present cross-case analysis of the PSMT narratives. This allows the reader to withdraw from the individual narratives and consider the similarities and differences that offered insight to the key implications in this study. Lastly, in chapter six, I present a summary of findings from chapter four and chapter five to foreground the discussion on the study implications, followed by the recognition of limitations to the study, and considerations for future research that either mitigates the limitations or that seeks to extend or enhance the study in future iterations.

Positionality Statement

I AM

I am Renegade, sweet, beautiful traitor

I am Mother Salmon challenging currents with single-minded purpose

I am Multiplier of ìrètí (hope) and Divisor of ìbùkún (Blessing)

I am Daughter of Africa and Sister of the World

I am Seeker of all that is true, in all of truth's dynamic glory

I am Spiral of Knowing, ever equilibrating

I am More than I was and Less than I will be

I am all that I am and part of who We are

An original poem by Olanrewaju T. Oriowo

I am a Black, Nigerian, cisgender woman who was born in Nigeria and raised in three countries across three continents. I was fortunate to have been educated in private institutions (except for the sixth grade, which was when I lived in England) due to my father's employment as a faculty member at various universities. Once I left Nigeria, I was plunged into situations where I was always one of the few or the only Black girl in the class, or in my entire grade. My first active experience of racism and the deficit perspective of academic ability was in England, where I attended a public school as a sixth-grade student. Without being assessed, I was placed in the lowest class for mathematics. The teacher did not understand why I was quiet in class; she did not know that within a few days of attending the school, certain students told me that, since I did not use deodorant, that I must stink. My mother eventually had a word with my teacher who raised the issue in class. Since the initial plan was that my family would return to Nigeria after a year in England, my parents made sure that I took the entrance examination for the private secondary school that was affiliated with the university where my father was employed in Nigeria. I took the exam in my headmaster's office (he proctored the assessment). He scanned my responses when I was done and then sent me back to my classroom. I was moved to the highest math section the very next day. To top it all off, I was one of four girls who surpassed the cutoff of the national assessment that assured us a scholarship to the top grammar school in the region. My academic prowess continued when my family moved to Kuwait, where I attended the most prestigious British private school in the country. This would not have been possible without the support of both my parents who are strong academics in the field of medicine. I remained in the top 10% of my grade until I graduated, continuing to a degree in Electrical Engineering, three graduate degrees, and my present participation in a doctoral program.

I did not explore my identity as a Black woman until I came to the United States as an international student in a public university. I was not immediately embraced by the Black community, particularly Black women; I eventually came to understand that African women were often fetishized by African American men which raised the hackles of my African American female peers. I also quickly understood that not all scholarships are treated equally, and that when a Black student says they are on scholarship, the immediate assumption is that it is not a merit-based scholarship. I did my best to be distanced from any suggestion that I was a scholarship recipient, which I was not.

My decision to become an educator was confirmed after teaching at a private school, but my passion for supporting the success of Black students in urban schools was imprinted during my student teaching. My students helped me understand the oceans of difference in our experiences, but I could also see how much creativity and genius there was, just begging to be revealed to the world. I have an unwavering belief in the mathematics ability of Black students, especially Black girls with STEM and mathematics-related career aspirations or even those that are just trying to make it through the required undergraduate mathematics courses.

I acknowledge my personal connection to this study as it partially reflects my experiences as an engineering student and explains my use of the theoretical framework. As a Black woman who felt she had to constantly justify her presence in STEM, I recognize that many of the stories shared in this study could awaken dormant feelings. I also recognize that the collection of experiences of each participant yields a unique tale that may bear some resemblance to my experiences, however they are no less unique. The use of narrative inquiry is, itself, a bias-preventing measure. The narration is the data and, as such, must be preserved. My perspective must not superimpose the voice of the narrator. It was crucial, then, that I capture my thoughts

before and after each narrative interview in a journal, creating a space for me to wrestle with whatever emotions are brought up before attending to the participants' stories. I also leveraged measures for reliability that are appropriate for narrative research. More detail is provided in chapter 3.

CHAPTER 2: LITERATURE REVIEW

This review of literature is divided into three main sections, the first of which addresses the importance of Black teachers to Black students. Within this section, I share what critical researchers have learned about the unique contribution Black teachers bring to academic spaces, characteristics that positively affect the academic and social outcomes of Black students, the added value of same-sex mentorship on STEM aspirations and participation for Black girls, and the incongruous relationship between the importance and the representation of Black female teachers in K-12 mathematics classrooms. In the second section, I contextualize the experiences that, according to research, typifies the learning landscape for Black girls who will eventually become secondary mathematics teachers; this is to lay the groundwork for why I believe that Black women who persist to become secondary mathematics teachers would have accumulated resources and skills to support this persistence. This section charts the factors that influence these experiences from elementary school to undergraduate institutions. In the final section, I consider the theoretical frameworks and methodological choices leveraged by researchers and scholars with similar foci so as to justify the approach to be used in my study.

Most discussions of STEM majors leave out a niche that exists in an overlap: Secondary mathematics educators straddle the worlds of STEM and education. The path to licensure for secondary mathematics teachers requires significant investment in mathematics courses, sufficient to prepare students for the advanced mathematics courses that are highly desired for college preparation. This path must also run through the pedagogical preparation provided by departments of education, sometimes as partnerships with departments of mathematics and statistics. Essentially, studies about STEM majors do not usually include secondary mathematics educators, whose stories are left to be told by education researchers.

There is a growing body of research that makes it clear that there are significant differences in how female students of color experience STEM programs (e.g. Cohen & Nee, 2000; Easton-Brooks, 2019; Gholson, 2016; Ireland et al., 2018), and, slowly, critical mathematics researchers are exposing these differences as it relates to Black, female mathematics teachers (Benson et al., 2020; Campoli & Conrad-Popova, 2017; Farinde-Wu et al., 2020). What these few studies have revealed is that, although Black women are proportionally represented in the acquisition of undergraduate degrees, scant few are opting for careers in education, much less mathematics education (NCES, 2022). What follows is an exploration of the importance of Black teachers to Black students in K-12, then Black female mathematics teachers to Black girls, so as to illuminate the incongruence between their importance to the STEM hopes for Black girls and their presence in mathematics classrooms.

Why Do Black Teachers Matter to K-12 Mathematics Education?

One cannot grasp the significance of this study without first understanding why Black teachers matter to Black students, why Black female mathematics teachers matter to Black female students with STEM aspirations, and why attending to future Black female mathematics educators is meaningful. Black teachers, in general, are important for the outcomes of Black students because students respond favorably to teachers with whom they share the same race, ethnicity, and even sex (Benson et al., 2020). Moreover, with studies revealing a disconnect between the STEM interest of Black girls and the realization of STEM hopes in undergraduate programs for Black girls, the same-sex impact of teachers, particularly mathematics teachers, must be addressed. Our understanding of Black female secondary mathematics teachers is nested within research that focuses on STEM education and mathematics teacher preparation. To further this understanding, I explore what literature has identified as important traits and contributions of

Black teachers to the outcomes of Black students, and the impact of their presence (or absence) on the experiences of Black girls with STEM aspirations.

Why Black Teachers Matter to Black Students?

A scan of literature reveals certain qualities and student outcomes that are uniquely related to the presence of Black teachers in U.S. K-12 classrooms. These include their impact on the graduation rates of Black students, their influence in the preparation of all students for participation in a global economy, their function as cultural brokers, and their ability to enhance a connection of Black students to the larger Black community. Specifically, I consider the significance of cultural congruence between teachers and students, with a deeper dive into the importance of Black female STEM role models for Black girls, ending with a quick consideration of the current status of Black, female mathematics educators.

Impact Of Teachers with the Same Racial/Ethnic Background

Papageorge et al. (2018) found that Black students who are randomly assigned to Black teachers in primary school are 13% more likely to graduate HS and 19% more likely to enroll in college, noting that teacher race is "an observable characteristic that has potentially large impacts on student outcomes" (p. 3). Indeed, research has shown that the presence of Black teachers, even in White classrooms, benefits all students as it helps students challenge negative stereotypes and prepares them to engage in a global and multiracial economy (Campoli & Conrad-Popova, 2017).

Aside from the delivery of academic content to students, Black teachers are academic culture brokers for Black students, especially those with little exposure to highly educated people (Papageorge et al., 2018). Other researchers noted that Black teachers impact the outcomes of Black students by assuming multiple roles, including role models, advocates, mentors (Farinde-

Wu, 2018; Milner, 2012), and othermothers (Dixson & Dingus, 2008) or otherfathers (Brown, 2012). For example, a participant in Milner's (2012) narrative study showed how she adopted multiple roles, including that of social worker and surrogate parent, with her students. She considered these relationships to be vital to the success of teachers and to the outcomes of the students.

One of the most profound contributions of Black teachers is the ability to ground their teaching in the relationships that students have with the larger Black community, thereby infusing pride in their students' racial and cultural identity (Papageorge et al., 2018); this pride that is also believed to help Black students forge a solidarity and affiliation with the Black community, thus giving them a political and social reason to value their education attainment (Papageorge et al., 2018). The grounding is accomplished through the use of culturally relevant teaching practices (Brown et al., 2019).

Why Black Girls Need Black, Female Teachers

Townsend et al. (2010) found that there is a strong correlation between the "academic achievement and ethnic identity among African American youth, such that having a sense of connection and pride in ethnic group membership is related to positive self-perceptions concerning academic ability" (p. 275). Researchers further suggest that exposure to Black women in STEM careers allows Black girls to consider similar career possibilities for themselves (King & Pringle, 2018; Sparks & Pole, 2019). It is important, therefore, for Black girls to see more role models in highly technical fields such as engineering, computer science, and mathematics, according to Sparks and Pole (2019). The presence of these role models not only give Black girls something to which they can aspire (Fellus, 2019), but also as a resource for increased self-assurance towards the required educational attainment (Townsend et al., 2010).

Where Did All the Black Teachers Go?

Prior to desegregation, Black teachers were the primary means for the academic enrichment for Black students in the US, making it more remarkable to see such low, stagnant numbers in recent years. While desegregation was a major coup for the Civil Rights Movement, the unintended consequence was the near extinction of Black teachers from the teaching landscape. Where some researchers refer to a mass exodus of Black teachers (Farinde-Wu et al., 2020), this overlooks the fact that Black teachers were rendered obsolete either by being forced out of jobs, were placed in racially hostile work environments so that they would leave on their own or found themselves disqualified from teaching due to new teacher certification requirements (Benson et al., 2020). Although some researchers such as Grundy (2017) intimated that there were other contributors to this exodus (e.g. more career opportunities for Black women post-desegregation), many researchers believe that the constructed invisibility of Black teachers in US classrooms can be attributed to racial hiring processes practiced by K-12 school districts, who are considered gatekeepers to employment (Farinde-Wu et al., 2020).

The most widespread fact about K-12 education is that the overwhelming majority of teachers are White women (Farinde-Wu, 2020; Hancock, 2011; Papageorge et al., 2018). Table 1 shows that, from 1987 to 2018, the number (and proportion) of female teachers has increased in parallel to the number of teachers in the US public school system. In this same timeframe, the number of Black teachers has also increased, but the proportion has been steadily dropping. As of 2017-18, 76.5% of public, primary and secondary school teachers were women (NCES, 2022) and roughly 5% were Black women (Carver-Thomas & Darling-Hammond, 2017; Farinde-Wu et al., 2020). The representation of Black women in public school classrooms is almost proportional to their presence in the US population.

Table 1

Distribution of US public school teachers

	1987-88	1990-91	1999-2000	2003-04	2007-08	2011-12	2015-16	2017-18
Total teachers	2,323,204	2,559,488	3,002,258	3,250,624	3,404,519	3,385,171	3,348,826	3,545,286
Total female teachers	1638267	1840035	2248320	2438092	2583598	2583545	2572605	2711776
% female teachers	70.5	71.9	74.9	75.0	75.9	76.3	76.8	76.5
Total Black teachers	190797	211640	227505	257484	239464	231074	224373	238548
% Black teachers	8.2	8.3	7.6	7.9	7.0	6.8	6.7	6.7

Note. The percentage of female teachers was calculated by dividing the total number of female teachers by the total number of teachers. A similar calculation was carried out to determine the percentage of Black teachers.

Table 2 takes another look at bachelor's degree attainment, except, this time, with a focus on between group and within group comparisons of degrees in education and in mathematics and statistics. When compared to all women in education, the representation of Black women is comparable to the distribution of bachelor's degrees obtained by Black women (as a proportion of all bachelor's degrees), although we must not ignore the fact that there has been a consistent decline in the last few years. Similarly, a proportion of between 4.5 and 5% for Black women's mathematics and statistics degrees is also not startling. What is particularly interesting, however, is that, as of 2019-20, 3.64% of the degrees earned by Black women were in education and 0.4% was in mathematics and statistics. If education and mathematics and statistics are not popular choices among Black women seeking undergraduate degrees, we can infer that the intersection of those two disciplines would reveal even more dismal numbers. This also means that the pool of Black female secondary mathematics teachers is small, to begin with.

Table 2

Black women with bachelor's degrees in education and mathematics & statistics

	2016-17	2017-18	2018-19	2019-20
Bachelors in education				
% of black women /all women in education	6.91%	6.91%	6.79%	6.63%
% Black women/Black women with bachelor's	3.80%	3.74%	3.71%	3.64%
Bachelors in math and stats				
% of black women /all women in math and stats	4.92%	4.73%	4.47%	4.49%
% Black women/Black women with bachelor's	0.39%	0.41%	0.39%	0.40%

Note. The data for this table was consolidated from Table 318.45: Number and percentage distribution of science, technology, engineering, and mathematics (STEM) degrees/certificates conferred by postsecondary institutions, by race/ethnicity, level of degree/certificate, and sex of student, for years 2016 – 2020.

Data trends show that the number of Black women in STEM careers, particularly those in secondary mathematics education, remains stagnant (this will be discussed in more detail in a later section), suggesting a bleak future for Black girls. However, looking at these numbers from a positive perspective, one could say that the participation of Black women remains steady. While there are many studies seeking to understand what is causing the "leaks" in the licensure pipeline focuses on the challenges faced in teacher preparation (e.g., Farinde-Wu et al., 2020), I contend that there is far more to be gleaned from the experiences of the Black women who, in spite of the challenges, stayed the course towards licensure. These are the women holding the numbers steady and, perhaps the ones who will inspire the next cadre of Black, female mathematics educators. It is from these women that we may learn important lessons on what we

can do to help these numbers grow. Their experiences could hold the key to what is needed for substantive change to mathematics teacher preparation.

The Educational Pipeline for Black, Female, Future Math Teachers

A journey through the mathematics education experiences of Black female mathematics teachers is crucial in establishing potential ways in which they assembled a toolkit of capital that aided their persistence to licensure. One of the commonplaces of a narrative research design (more detail provided in chapter 3) is *temporality*, the understanding that events or phenomena are situated in time with connections to what happened in the past, and with consequences that are carried into the present and the future (Connelly & Clandinin, 2006). The persistence of Black women who are future secondary mathematics teachers did not begin the moment they chose a college major. Indeed, these women cycled through three periods of being in classrooms: the first as K-12 students, the second as undergraduate students seeking licensure, and the third when they accomplished their goal and returned to the classroom as educators. Available research informs that, during K-12, Black girls are educated in a landscape that is tainted with deficit narratives that could impact how Black girls see themselves in relation to mathematics. Studies will also show that what Black girls experienced in K-12 continues to shape their expectations at the university level, particularly during teacher preparation.

How Black Girls Experience K-12

As several researchers will note, attention to the racialized and gendered experiences of Black girls in mathematics classrooms is nascent, making it challenging to find the ideal assortment for deep coverage. To that end, I have included some of the common factors identified in research as having profound implications on the mathematics learning landscape for

Black girls. I limit these factors to a tainted learning landscape, exclusion of Black girls from the mathematics community, and issues of inequitable access and college preparation.

A Tainted Learning Landscape

The learning landscape is permeated with myths and dominant narratives that precede Black girls to classrooms. First, the myth of neutrality of mathematics has been challenged and refuted by critical researchers, yet it lingers in mathematics learning spaces and in society. Second, deficit views of Black learning invade the learning environment, feeding the, third, discourse about achievement gaps.

The most popular belief held by many researchers and educators is that mathematics instruction is neutral, objective, or decontextualized (Aikenhead, 2017; Joseph, 2021; Joseph et al., 2019; Leonard et al., 2010). Reaching back to the historical underpinnings of modern mathematics instruction, Aikenhead (2017) shares that the Platonist belief regarding mathematics is that it is discovered, suggesting that it is fundamental and unquestionable; such a stance renders invisible the cultural mathematical ways of knowing held by indigenous, and by extension, historically marginalized communities. Aikenhead (2017), however, takes the position that, since every major culture has a unique mathematics knowledge system, "mathematics is culturally *pluralist* but not relativist" (p. 88). This means that mathematics is a summative term that represents the collection of various cultural mathematics knowledge systems rather than a single, dominant system (Aikenhead, 2017).

However, according to Boaler (2002), cultural reproductions are regularly performed in mathematics classrooms: the essence of cultural reproductions is that those in power inevitably institute a hegemony that reflects aspects of their culture. These cultural reproductions take on many forms or ideological principles, including meritocracy and color-blindness (Rubel, 2017).

The principle of meritocracy, specifically within the US, simultaneously implies that success is the result of hard work and that the lack thereof is due to laziness or inability. The principle of colorblindness, by teachers, manifests as claims that race does not play a role in their treatment of perspectives about their students; this indicates an unwillingness to acknowledge the growing racial and cultural diversity in US classrooms (Kisker et al., 2012; Rubel, 2017). Both of these ideologies function as "tools of whiteness" (Rubel, 2017, p. 68) in that they fail to acknowledge historical and systematic barriers to, and exclusion from, equitable opportunities (Kisker et al., 2012; Rubel, 2017).

The Myth of Neutrality

Cultural reproduction, as mentioned above, leads to (or is a mitigating factor) perpetuating the myth that mathematics is culturally neutral. Typical expressions of this myth include the persuasive, socially accepted stance that mathematics ability is naturally occurring, mostly in males, and individually experienced (Darragh, 2014), or the belief that mathematics holds a prestigious position in society that excludes Black females in a gendered and racialized manner (Gholson & Martin, 2019). For the Black girl in a mathematics classroom, the various expressions of the myth of neutrality could lead to feeling as though she does not belong and cause her to question the possibility for success in a career that requires substantial mathematics acumen. Belief in this myth leads one to believe that learning must be experienced individually, which is an accepted norm within White, middle-class society (Darragh, 2014). The exercise of this belief contributes to feelings of isolation for Black girls who, according to Joseph et al. (2019), prefer to learn in collaborative environments. Lastly, this myth could lead to mathematics instruction that strips away power and ownership of mathematics from Black girls, further placing STEM hopes out of reach (Darragh, 2014).

Deficit Views of Black Learning that Invade the Learning Environment

The acceptance of the myth of neutrality in mathematics supports pre-existing deficit views of Black students and their ability to learn. Gholson and Martin (2019) maintain that the extant research surrounding Black girls and mathematics is replete with lowered beliefs about their knowledge, their competencies inside and outside of classroom contexts. King and Pringle (2018) posit that many teachers adopt these stereotyped views of Black girls before these students have even entered the classroom. One such narrative about Black girls is that their critical mathematics skills are subordinated to that of their White counterparts, a narrative that is injurious to their self-efficacy and could lower the expectations that their teachers have of them (Gholson & Martin, 2019). A second view is that Black girls do not belong in mathematics spaces, a view that is enacted in hostile mathematics classrooms. The final view is Black girls do not have the mathematics background to pursue STEM at the undergraduate level.

Black Achievement is Subordinated to White Performance

Reports about the performance of Black students in standardized assessments showcase comparisons to the performance of their White counterparts, setting White students as the academic norm (Young et al., 2018). However, assessments have been shown to play a role in the propagation of dominant narratives of Black students, including Black girls. Nortvedt and Buchholtz (2018) believe that

> students, teachers, policy-makers and even researchers may have naive and strong beliefs about the objectivity and validity of assessments, including the belief that a single test or observation can tell the truth about the achievements of students, teachers, or educational systems (p. 555)

These strong beliefs have been found to inform the instructional choices made by teachers of Black girls, suggesting that there might be a strong relationship between equity and how students are assessed (Nortvedt & Buchholtz, 2018). Davis and Martin (2018) asserted that instructional practices, such as teaching to the test, are founded on institutionalized racial beliefs about the mathematical ability of African American students, contributing to the poor college preparation received by Black girls, especially those dreaming of STEM careers.

Young et al. (2017b) criticized researchers who are so narrowly focused on the racial achievement gap, particularly between white and non-white students, to the exclusion of insight that could be gained from looking within the races. Gap-gazing studies about the presence of achievement gaps still dominate conversation about Black girls and their academic performance (Young et al., 2017b). The problem with these types of studies is that it undermines or renders invisible findings that Black girls "value the knowledge and skill sets gained as a result of their participation" (King & Pringle, 2018, p. 560) in STEM learning experiences or that Black girls are more likely to pass more rigorous Advanced placement Calculus examinations (Young et al., 2020). Deficit narratives are, therefore, more likely to find their way into the identities of Black girls, thereby reproducing itself in the decisions these students make regarding their education and future careers. When girls accept messages that they don't belong in mathematics, they are at risk of continuing this disidentification forever (Pringle et al., 2012).

Black Girls Do Not Belong in Mathematics Learning Spaces

Mathematics education has long been a source of emotional pain and mathematics classrooms an unwelcome space for Black learners (Gholson & Martin, 2019) and the unseen nature of this pain could cause teachers to believe that "they are not part of an oppressive system within mathematics education" (p. 402). In subtle, sometimes unintended ways, Black girls

receive messages that they are unwelcome or do not belong in mathematics spaces. Black girls, as some studies show, find mathematics classrooms unwelcoming and sometimes hostile, which impacts their development of a mathematics identity and their ability to merge this identity with their ethnic identity. Black girls have had to adapt different survival methods, often becoming caricatures of their true selves, in order to protect themselves from the discomfort and isolation that they feel.

Dehumanization of Black Girls

Perhaps Freire (1970/2000) said it best that dehumanization is "*not* a given destiny but the result of an unjust order that engenders violence in the oppressors, which in turn dehumanizes the oppressed" (p. 44). For Joseph et al. (2019), the humanity of Black girls is yet to be realized in the United States. Aside from the subjugation that is rooted in the historical devaluation through slavery, Black women and girls continue to be positioned as lacking in intelligence (Joseph et al., 2019), as disruptive in classrooms (Chambers et al., 2016; Joseph et al., 2019), and as possessing a limited range of emotions (Gholson & Martin, 2019; Townsend et al., 2010).

Chambers et al. (2016) remarked that teachers, school staff and administrators are overly focused on the behavior of Black girls rather than on their academic growth. Black girls are portrayed in the media as "loud, crude, callous, argumentative" (Townsend et al., 2010), the antithesis of White, middle-class expectations. Black girls are also viewed as hypersexual and savage beings, which was used to justify the "enslavement and incessant sexual violation" (Townsend et al., 2010) visited on enslaved Black women, and which continues to shape "the performance of Black Girlhood" (Gholson & Martin, 2019, p. 401). These contribute to Black girls, according to Joseph et al. (2019), being more likely to be suspended than their white

counterparts. These suspensions not only deprive Black girls of valuable instructional contact, but also impact their self-concept thereby dealing a decisive blow to their ethnic pride and academic identity (Joseph et al., 2019; Townsend et al., 2010).

Gholson and Martin (2019) refer to a “Blackgirl face”, an affected “emotionlessness and indifference is often perceived by others as academic disidentification or apathy” (p. 399). A feminized version of the Black male’s cool pose, Blackgirl face is a shield to counter the social vulnerabilities created by intersectional forms of racialized, gendered, and class-based oppression" (Gholson & Martin, 2019, p. 391). Gholson and Martin’s study was intended to investigate the political and the everyday mathematics interactions between teachers and students. Their phenomenological study focused on a young, Black, middle school girl as she tries to survive in the hostile mathematics environment (Gholson & Martin, 2019). Several interviews and observations later, Gholson and Martin (2019) noted the times when the student retreated behind her protective Blackgirl face performance, and the ways that she adjusted this performance when in the mathematics classroom, when working with her peers, and when talking to her teacher. Most notable was the way that the student’s “body constricted[ed] in the presence of a mathematical authority figure” (Gholson & Martin, 2019, p. 400).

Hindered Development of Positive Mathematics Identity

The development of a strong mathematics identity that does not conflict with ethnic pride is critical for Black girls with a STEM trajectory as it helps students fight against prevalent deficit narratives (Gholson & Martin, 2019). Townsend et al. (2010) posit that “ethnic identity may help facilitate self-assured functioning” (p. 275) and Joseph et al. (2017) also highlights the importance of a positive mathematics identity for Black girls, regardless of where they are in the P-20 educational journey, as it anchors the other sources of persistence from which they draw.

Darragh's (2014) position is that mathematical identity development requires repeated performances of actions that forge a learners' identification with other mathematics learners. Students recognize actions such as being invited to solve problems on the board, being able to help classmates with problems, and doing mathematics that involves more than "just learn[ing] proper rules" (p. 97) as part of being good at math. Yet these actions are not to be found in classrooms where teachers have low expectations, classrooms in which many Black girls find themselves, thus limiting their opportunities to develop a positive mathematical identity (Yow, 2011).

Fellus (2019) points to the existence of historical and sociocultural scripted roles that tend to both direct and replicate what a learner believes about his or her mathematical ability. These scripted roles, performed within the learning environment, influence the sociocultural selfhoods available to Black girls. When a culturally relevant and empowering environment is unavailable, teachers and students fall back to the default menus and performance of gendered identity (Fellus, 2019). For Black girls, the implication is that they are doomed to the performance of gendered and racialized identities, one that does not include strong and positive mathematical identities.

Black Girls Do Not Have the Mathematics Background for STEM

With mathematics as the cornerstone for STEM preparation, inequitable access to high quality mathematics instruction and to rigorous mathematics courses become obstacles for Black girls with STEM aspirations (Beekman & Ober, 2015; Berry, 2008; Chambers et al., 2016). The systematic exclusion that has led to low achievement and participation of Black girls in mathematics, and the pattern of behavior where teachers' decisions to place Black girls in advanced math courses are based on cognitive and non-cognitive behaviors (Joseph et al., 2019).

While access to education is, for the most part, guaranteed, "access to rigorous mathematics coursework is racially stratified" (Chambers et al., 2016, p. 304). Access to advanced mathematics courses is controlled by gatekeepers who (teachers, counselors, administrators) who, when it comes to Black girls, base their decisions on behavior. Behavior is used as a proxy for assessed academic ability (Berry, 2008; Chambers et al., 2016), and the behavior expectations, as mentioned in earlier sections, are based on a standard that deems Black girls out of favor. This places Black girls firmly out of consideration for the rigorous mathematics courses needed for adequate college preparation for STEM pursuits (Anderson, 2020; Leyva & Zander, 2020), positioning them as lacking the mathematical rigor that colleges and universities demand. This also significantly threatens Black girls' successful completion of the math courses.

The research paints a clear picture of the K-12 environment in which future Black female preservice mathematics teachers are prepared for the next stage of their educational journey. These potential future mathematics educators are subjected to hostile and dehumanizing mathematics learning spaces where their mathematics ability is viewed as below standard, where their ethnic and cultural ways of learning and relating to others are viewed as disruptive, and where they are deprived of access to rigorous coursework as well as opportunities to develop a strong mathematical identity. The decision to continue their education journey in a STEM trajectory is not lightly made, and possibly belies a series of resources to which they were anchored. These resources have not been addressed in the studies referenced thus far.

How Black Women Experience Undergraduate STEM Programs

For Black girls who dream of STEM careers, undergraduate degree selection is a concrete step towards the realization of those dreams, therefore it is necessary that we view institutes of

higher education as an important site for preparation. In this section, I focus on the trends in undergraduate degree attainment in STEM and education as they reflect the impact of the K-12 education experiences of Black women. I also focus on the shadows cast by these experiences: mathematics remains a gatekeeper, the continued challenge of identity development, and the cultural misalignment of teacher preparation programs and Black women. Though these challenges are not necessarily new to Black women who are future secondary mathematics teachers, they can be a resurrected foe to be conquered anew.

Effect of Experiences on STEM Undergraduate Degree Attainment

Black women have consistently accounted for about two thirds of Black undergraduate degree attainment (6.24%); by extrapolation, Black men only account for about one third of Black undergraduate degrees. While this appears as cause for greater concern, the focus on Black women over Black men in this study, is in response to the disappearance of Black women from education where they were once significant players in the education of Black students (Clark at al., 2013). However, of the undergraduate degrees earned by Black women, only 0.4% were in mathematics and statistics. The consistently low mathematics and statistics degrees conferred to Black women could point to their decision to avoid a repeat of their mathematics learning past or the blow to their self-efficacy in mathematics. Table 3 shows a consistent and proportionate level of undergraduate degree attainment by Black women, but this does not extend to mathematics which is a key component of STEM degrees. Although research has shown that Black girls do enjoy mathematics and science (e.g., Collins et al., 2020; Leonard et al., 2020; Young et al., 2020), this enjoyment has not translated to more women joining the ranks of mathematicians.

Table 3

Distribution of bachelor's degrees conferred to Black men and women

Bachelor's degrees to Black women and men	2016-17	2017-18	2018-19	2019-20
Total Degrees Conferred	1,956,114	1,980,665	2,013,086	2,038,431
Total Degrees Conferred to Black Men + Women	196,338	195,014	196,654	197,444
Total Degrees Conferred to Black Women	125,770	124,687	125,853	127,120
% Black (Men + Women)	10.04%	9.85%	9.77%	9.69%
% Black Women	6.43%	6.30%	6.25%	6.24%

Note. The percentage of Black women with bachelor's degrees was calculated by dividing the total number of bachelor's degrees conferred to Black women by the total number of bachelor's degrees conferred. A similar calculation was carried out for the percentage of bachelor's degrees conferred to Black students.

Participation Trends of Black Women in STEM majors

A report assembled by the National Center for Education Statistics (NCES) (2014) shows that, of the 48% of students with declared STEM majors at the beginning of their undergraduate education, 65% of African American students left the field, mostly in favor of non-STEM pursuits and almost half were female. Among the students who persisted, 81% had taken courses beyond the college requirements, specifically calculus and advanced mathematics (NCES, 2014).

The high rate of Black women leaving the STEM field as undergraduates could account for what we see in Table 4 and Table 5. Table 4 shows trends in science and engineering occupations in the US, organized by race and ethnicity. Where Hispanic and Asian participation has more than doubled since 1993, Black representation has seen a, roughly, 33% increase.

Table 4

Distribution of workers in Science & Engineering occupations, by race and ethnicity: Selected years, 1993–2015

Race and ethnicity	1993	1995	1997	1999	2003	2006	2008	2010	2013	2015
American Indian or Alaska Native	0.2	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.2	0.2
Asian	9.1	9.6	10.4	11.0	14.2	16.1	16.9	18.5	17.4	20.6
Black	3.6	3.4	3.4	3.4	4.3	3.9	3.9	4.6	4.8	4.8
Hispanic	2.9	2.8	3.1	3.4	4.4	4.6	4.9	5.2	6.1	6.0
Native Hawaiian or Other Pacific Islander	NA	NA	NA	NA	0.3	0.5	0.4	0.2	0.2	0.2
White	84.1	83.9	82.9	81.8	75.2	73.2	71.8	69.9	69.9	66.6
Multiracial	NA	NA	NA	NA	1.4	1.4	1.7	1.4	1.5	1.6

Table 5

Percentage distribution of Black women with STEM degrees and certificates: 2008-2020

Year	Certificate	Associates	Bachelors	Masters	Doctoral
2008-09	19.79	18.12	9.94	5.85	3.89
2009-10	20.40	18.18	9.50	6.23	3.56
2010-11	21.42	17.02	9.20	6.20	3.80
2011-12	18.70	16.31	9.26	6.59	3.80
2012-13	17.43	15.93	8.93	6.74	3.98
2013-14	18.83	15.12	8.56	6.13	3.73
2014-15	17.81	15.26	8.36	5.65	3.24
2015-16	17.46	13.39	8.17	5.14	3.70
2016-17	17.06	12.69	8.17	5.04	3.55
2017-18	16.64	11.89	8.00	5.13	3.60
2018-19	16.20	11.97	8.08	5.82	3.33
2019-20	16.60	11.99	8.13	5.79	3.33

Note. The percentages shown reflect the proportions of Black women compared to all women with STEM degrees and certificates.

Table 5 shows the distribution of Black women with STEM certificates or degrees from post-secondary institutions. The overall trend is that as degree status increases, the participation of Black women decreases, ending with Black women accounting for less than 4% women with STEM doctoral degrees. It is possible that feelings of underpreparedness and lack of access to rigorous mathematics (Beekman & Ober, 2015) is a carryover from secondary education that continues to erode the participation and persistence of Black girls in all levels of STEM degrees.

Mathematics as a Continued Gatekeeper for STEM

According to Ellis et al. (2016), mathematics is a common bottleneck for students who wish to pursue a career in any of the STEM disciplines, including secondary mathematics education. Using the decision to continue to Calculus II as a proxy for persistence, the researchers found that a popular reason for a lack of persistence was the feeling that their grasp of Calculus I was not strong enough to ensure successful completion of Calculus II (Ellis et al., 2016). There were more women who subscribed to this reason (low self-efficacy) and this finding is echoed by other researchers (Alexander & Hermann, 2016; Marra et al., 2009). Marra et al. (2009) noted also that a perceived lack of inclusion was also experienced particularly by Black women. This isolation is similar to that experienced by Black girls who are able to gain entry into advanced mathematics courses in high school (King & Pringle, 2018), making it difficult to be a part of a community or establish a support system to help them persist in classrooms that are often hostile.

Black Teachers in Teacher Preparation Programs

The number of Black preservice teachers in traditional teacher preparation programs continue to hover in stagnation (Farinde-Wu et al., 2020). Studies attribute this to experiencing microaggressions in classrooms, trouble navigating white supremacist spaces, racial battle

fatigue (Benson et al., 2020), and racialized standardized testing (Petchauer, 2016). White supremacist spaces are described, in research, as spaces where the values, experiences, and behaviors of White people are elevated as superior, the ideal, or the norm (Rubel, 2017). There are three main issues revealed in relevant studies: 1) troubled attainment of teacher licensure, 2) identity formation and development, and 3) preparation programs that do not center the racialized experiences of preservice teachers of Color.

Trouble with Licensure and Certification

Petchauer (2016) problematized the teacher certification process, specifically the standardized basic skills assessments (such as Praxis) that were originally intended to identify teachers who might be "less than competent as classroom teachers because they do not possess a common knowledge base as defined by the test" (p. 171). Rather, these assessments have become tools for racial stratification (Petchauer, 2016). Standardized assessments, such as the Praxis, are narrowly defined and culturally biased, largely privileging test takers who are members of the dominant society, and the publicity surrounding licensing exams raises African American passage rates as problematic when compared to White candidates, while remaining silent about the pass rates of other racial groups, setting White rates as the standard for African American candidates (Petchauer, 2016). The most compelling influence on the self-efficacy of African American teacher candidates regarding their performance on the praxis was previous mastery or failure experiences with other classes or standardized tests, followed by the vicarious experiences of other African American students, family members, or friends (Petchauer, 2016).

The trouble with standardized licensure examinations is familiar to the challenges with achievement noted in the K-12 experiences of Black women. It resonates with the deficit research that compares the performance of Black students to White counterparts, maintaining the

performance of White students as the standard (Yow, 2011). It also is reminiscent of the damaged self-efficacy in mathematics that resulted from lowered expectations and oppressive teaching practices (Gholson & Martin, 2019; King & Pringle, 2018).

Identity Formation and Development

At the K-12 level, researchers noted that a strong, positive mathematics identity is necessary for Black girls aiming for STEM futures (Joseph et al., 2017). The identity formation and development for Black women who are preservice secondary mathematics teachers remains critical and takes on added significance as Black women try to feel a sense of belonging to the mathematics community and to the teaching profession. A powerful threat to this identity formation is stereotype threat. This threat is a resurrected foe for Black girls who, during their K-12 life, were entrenched in learning environments saturated with negative stereotypes about their mathematics ability.

Sparks (2018) conducted a study that sought the experiences of Black female preservice students with STEM majors, positing that there were two types of identity at work in their identity formation process: *core* identity and *role* identity. Core identity involves the recognition of one's position as an "underrepresented minority pursuing a degree in a STEM field" (Sparks, 2018, p. 245), whereas role identity is determined by the interactions students have with the STEM environment. This role identity is a critical piece of how preservice teachers navigate transition from preservice teacher to professional educator, each time identifying and becoming part of a new community and learning to see oneself and the world anew (Sparks, 2018). The researcher found that the core identity of the participants was impacted by feelings of inadequacy and lack of preparation, causing them to prefer isolation and invisibility, especially resisting attention "because of their presence as Black or female students" (Sparks, 2018, p. 249). The role

identity of the participants was hindered, based on Sparks' (2018) finding, by the fact that most of the participants had little to no exposure to Black female mathematicians or scientists in high school. These are lingering effects of the poor mathematics instruction Black girls received in secondary school and the absence of Black women as secondary mathematics instructors.

Stereotype Threat and Management

Stereotype threat, the fear of confirming the deficit views represented in racialized and gendered stereotypes, has been found to impact the learning experiences of Black girls in K-12 classrooms, but is also present in their experiences in teacher preparation programs (Plachowski, 2019; Sparks, 2018). Taylor and Walton (2011) describe stereotype threat as a "disruptive apprehension about the possibility that one might inadvertently confirm a negative stereotype" (p. 1055), and this phenomenon could be amplified in those who are the targets of the stereotype. For example, girls are more susceptible to stereotype threat when the academic material is associated with negative stereotypes about women (Taylor & Walton, 2011). By extension, Black girls, who are aware of the lowered expectations around their math performance, are prone to experiencing stereotype threat.

Future Black female secondary mathematics teachers are not exempt from stereotype threat; indeed, it is one of the causes of battle fatigue while in preparation programs and in the field (Plachowski, 2019). The teachers who persist are often caught between the struggle between awareness of stereotype threat and overcoming it through stereotype management but eventually find success. One of the ways that Black students resist stereotype threat is through stereotype management, which is the ability to "overcome the external stereotypes, as well as feelings of stereotype threat" (Sparks, 2018) through the use of "strategies to minimize the psychological damage" (McGee, 2015, p. 616). For example, two high achieving Black students

in McGee's (2015) study let their self-efficacy shape the narrative about their math ability and achievement. Another student in that same study opted to leave the program at the elite STEM institution he was in to relieve the burden of being perceived as gaining access to the prestigious university through affirmative action (McGee, 2015). Sparks (2018) noted that Black women in STEM have found success in the face of stereotype threat by creating strong peer relationships, maintaining ties with "original peer and familial groups" (p. 257), and by resolving to persist against all obstacles.

Preparation Programs Do Not Center Racialized Experiences

As mentioned in an earlier section, preparation towards licensure is not sufficient to support retention in the field (Farinde-Wu et al., 2020; Plachowski, 2019). Since most teachers in teacher preparation programs are White and female, cultural reproduction is almost inevitable (Plachowski, 2019). According to Farinde-Wu et al., (2020), teacher preparation programs are designed to meet White, middle class norms since white teachers are the majority of the teaching force. These programs can sometimes be seen to reflect a White supremacist culture (Benson et al., 2020).

Also mentioned in an earlier section is that Black teachers are more likely to employ culturally relevant practices when teaching Black students. However, when teacher preparation programs do not center the racialized K-12 experiences of preservice teachers of Color, it hinders the development of culturally relevant tools and skills and adds to the lack of connection or validation of ethnic identities (Plachowski, 2019). Just as asset-based pedagogies yield better outcomes in Black girls learning mathematics (Jett, 2013; Joseph, 2021), Black female preservice mathematics teachers could also benefit from such practices in preparation programs. Since Black women who have come through the U.S. K-12 education systems are already

sensitized to the racialized environments and have built up a means to navigate them, a quest for social justice becomes their driving force as a result (Benson et al., 2020). This quest should be nurtured, according to Plachowski (2019), yet many preparation programs have not taken advantage of this predisposition.

Several experiences highlighted in studies about Black girls in K-12 mathematics classrooms re-emerge in undergraduate experiences with renewed or extended impact. Mathematics remains a gatekeeper, this time as a barrier to progress in STEM majors. The poor mathematics instruction that eroded the self-efficacy of Black girls continues to obstruct the persistence of those who were also denied access to rigorous mathematics courses in high school, prompting switches to majors that are less mathematically demanding. Black women who are preservice mathematics teachers still must abide the negative stereotypes about their mathematics ability, this time deciding to either succumb to it or to manage it. Lastly, Black female preservice teachers are yet to feel that their cultural ways of knowing and learning are valued in teacher preparation programs; these programs are better aligned to the cultural norms of White, middle-class women who are the majority in teacher preparation.

What Capital has been Identified in Research?

Much of the research that has been shared, thus far, describes what might have contributed to the low numbers of Black female PSMTs. These studies focus on Black female PSMTs from a deficit perspective. What we are yet to consider are their experiences from an asset perspective, with specific attention to the Black women who persisted in STEM courses and majors, and the capitals that they relied on in that endeavor. One of the earliest studies addressing capital is the work of Pierre Bourdieu, who suggested that there are three types of capital (cultural, social, and economic) which are accumulated and possessed by members of the

dominant group in society (Bourdieu & Passeron, 1977). Bourdieu further suggested that these capitals are either acquired through formal schooling or learned through family, and that they are necessary for upward mobility within the society (Bourdieu & Passeron, 1977). According to Yosso (2005), this view of cultural capital firmly places members of historically marginalized populations outside the realm of who possesses the capital for social mobility. Although not much, there is growing attention to capitals that marginalized students have used to support their academic persistence. In what follows, I present Franklin's (2002) commentary on the value of the cultural capital of African Americans to public education, followed by Yosso's (2005) Community Cultural Wealth which counter's Bourdieu's narrow definition of cultural capital. I then conclude with Joseph et al.'s (2017) outline of what persistence capitals for Black girls in mathematics could entail.

African American Cultural Capital and the Power of the Collective

Franklin's (2002) objection to Bourdieu and social theorists of his ilk, is to the use of cultural capital to mean "the forms of educational credentials possessed by members of upper and middle classes, which become economic resources for individual economic advancement" (p. 177). The first objection is that this view implies that those without education credentials are also without cultural capital, and the second objection is to the idea that these capitals are to benefit the individual, not the collective (Frankin, 2002). According to Franklin (2002), social scientists and economists acknowledge that social capital is a vital component of economic development and to the success of enterprises. This acknowledgement was due, in no small part, to studies illustrating that the development of key African American institutions (educational, philanthropic, and economic) hinged on "both social and collective forms of cultural capital" (Franklin, 2002, p. 177). In additional to the financial, physical, and human capital that were

thought to be the key to business functionality under capitalism, African American enterprises leveraged the social capital of local communities and the collective efforts African American networks because they knew that the enterprises and institutions would benefit the African American community, as a whole (Franklin, 2002). One of the most important institutions was that of primary, secondary, and higher education. Franklin (2002) emphasizes that the power of the cultural capital of African Americans is evident in what they were willing and able to accomplish for the education of Black students, despite "attempts to suppress social and economic circumstances in this country" (p. 180). Indeed, the public education that is intended to benefit all children in the United States, is possible because of the cultural capital of African Americans (Anderson, 1988; Franklin, 2002).

Yosso and Community Cultural Wealth

Yosso (2005) critiqued Bourdieu's cultural capital, claiming that it centered "White middle class culture as the standard" (p. 76), and proposed six capitals that resulted from a research focus on the "experiences of People of Color in critical historical context" (p. 77). Departing from Bourdieu's capitals, Yosso (2005) defined capitals as cultural wealth that marginalized communities use to "survive and resist macro and micro-forms of oppression" (p. 77). The six capitals that Yosso (2005) identified are aspirational capital, linguistic capital, familial capital, social capital, navigational capital, and resistant capital. These capitals are defined from the perspective of historically marginalized students in educational institutions, the site for formal learning, with attention to the wealth that they bring from their own cultures and use to persist towards their academic goals. For example, linguistic capital is defined as "the intellectual and social skills attained through communication experiences in more than language" (Yosso, 2005, p. 78). Yosso (2005) explains that this capital draws attention to how multilingual

students parlay their linguistic and communication skills to interact with content (and people) in myriad ways. While Yosso's (2005) study is instrumental in beginning the articulation of a decentralized cultural capital, ascribing these capitals to an amalgam of marginalized people obscures the uniqueness of their experiences, especially that of Black women. It is these experiences and capitals that the proposed study seeks to illuminate.

Critical Constructs for Capitals that Support Mathematics Persistence

Although inspired by Yosso's (2005) capital, we are still faced with scant research about the capitals used by Black women to persist in STEM courses. To fill the void, we lean on the work of Joseph et al. (2017) to build an impression of what these capitals could be. Joseph et al. (2017) conducted an overview of literature from which we can glean critical constructs for capitals that Black girls have used to support their persistence as they navigate the educational pipeline in mathematics education. While the researchers do not specifically mention capital, they do outline important skills and resources that support persistence in math learning, which is aligned to this study's articulation of capital. The researchers identified three categories or themes for these skills and resources: structural disruptions, community influences, and resilience strategies.

Structural disruptions are defined as "interruptions in the basic ways the education system operates" (p. 209). One type of disruption is the availability of culturally responsive faculty and staff. For example, the researchers note that, although Black math teachers are rare, "a rise in equity-focused mathematics teachers in general can influence persistence" (p. 210). This implies that exposure to mathematics teachers who embrace equitable teaching practices can support the achievement and persistence of Black girls. Community influences are defined as "dynamic interactive relationship forces that support students as they persist" (p. 212) through the

education pipeline. These relationships can be with families, peers, and faculty or staff, as long as they feature positive interactions and engagement (Joseph et al., 2017). For example, mentorship from faculty with whom Black girls share racial or gender congruence, has been shown to strengthen the identities of Black girls, and impact their mathematics self-concept (Allen & Joseph, 2018; Joseph et al., 2017). Lastly, resilience strategies are described as Black girls taking an "active role in the ways they respond to and interact with their environments, particularly in mathematics spaces" (p. 214). These are strategies that Black girls use to sustain their academic trajectory in spaces that were not designed with their success in mind (Joseph et al., 2017). For example, when Black girls resist the low expectations communicated, verbally or tacitly, by teachers or classmates, they can overcome obstacles to their progress (Joseph et al., 2017).

There is a dearth of studies that attend to the unique niche where Black women pursuing secondary mathematics licenses are situated, fewer still are studies that articulate the capital that these Black PSMTs utilize to realize their goals of becoming secondary mathematics teachers. However, what the studies mentioned above offer is a starting point for this study. They begin the process of giving form to a presently nebulous concept, which is the capital that Black female PSMTs use to support their persistence through undergraduate mathematics courses.

Approaches of Other Researchers in Framing Similar Studies

In order to increase the number of Black students, particularly Black girls, who can realize their STEM aspirations, there needs to be a surge in the number of Black teachers and STEM professionals to which they are exposed with regularity, but especially in a classroom setting. Research can support this mission by attending to the social, emotional, and political factors that contribute to the present low numbers of Black women in secondary mathematics

education. Studies with deficit orientations in this regard are plentiful but there is a growing number of asset-based studies regarding how Black girls and women experience K-16 education. To that end, it is prudent to consider the methods and theoretical frameworks other critical researchers have employed in asset-based explorations.

Common Methods Used in Asset-Based Studies

Asset-based studies direct attention to the strengths of the research participants, doing so using (mostly) qualitative. Some qualitative methods of note include qualitative case study, ethnography, and counternarrative/counter-storytelling. Though not as common, quantitative methods have been used for asset-based research, sometimes in mixed-methods approaches or as strictly quantitative.

Qualitative Case Study

Case study research, according to Mertens (2020), is an approach that facilitates thorough investigations into complex phenomena. This type of study focuses on a single unit, or case, which is defined within a bounded system which could be a person, a group, or even an institution (Merriam & Tisdell, 2016). Ellington and Frederick (2010) use the case study design to detail how participants saw their role in their own persistence and to identify the personal characteristics to which this persistence is attributed. The researchers also sought to examine the extent to which the participants acknowledge the influence of family, school, and community on their persistence. For their study, the unit of analysis was Black undergraduate mathematics majors who had or intended to take courses beyond calculus. One interesting finding from this study was that the large Black community helped students build a social consciousness/identity that motivated their persistence (Ellington & Frederick, 2010).

Leyva et al. (2021) used this same design to explore the ideological and institutional ideologies that influence how marginalized students experienced oppression in calculus and precalculus, striving to identify the instruction strategies that mediated this oppression. The unit of analysis in this study was women enrolled in calculus or precalculus courses within a single institution of higher education. What they concluded was that instruction practices that marginalize students do not have to be explicitly racialized or gendered in order for them to be perceived as such (Leyva et al., 2021). The researchers also noted that instructors' behaviors and comments are sociohistorically situated, and that calculus and precalculus are replete with instructional events that promote whiteness and patriarchy (Leyva et al., 2021).

Auto-Ethnography

Ethnography, in its many forms, is focused on human society and culture and uses thick description and interpretation to try to understand the cultural meaning of a phenomenon (Merriam & Tisdell, 2014). Auto-ethnography combines auto-biographical and ethnographic methods to understand group culture through the study of an individual (Haynes et al., 2016). Haynes et al., (2016) use Collaborative Auto-Ethnography (CAE), a unique subset of auto-ethnography, to analyze how prior experiences in U.S. classrooms influenced the persistence of three, Black, female doctoral students. The uniqueness of CAE is that it allows a multi-subjective study of a social phenomenon without compromising the self-reflexion and cultural interpretation within the individual auto-ethnographies (Haynes et al., 2016).

Counternarratives/Counter-storytelling

Counternarrative or counter-storytelling is a subset of narrative inquiry that foregrounds the voices of historically marginalized populations to challenge dominant, deficit narratives (Mertens, 2020). Counter-storytelling is versatile in that it can be used on its own or embedded

within an overarching methodology, as is the case with Berry's (2008) study focused on the success of African American boys in mathematics. Berry (2008) uses counter-storytelling within a phenomenological methodology to capture experiential knowledge that runs counter to dominant literature about African American boys.

Leyva (2021) uses counternarrative research to explore the experiences of Black women and their resilience so as to confront the racialized-gendered spaces of mathematics education. This method allowed Leyva (2021) to identify two educational practices that could affect structural disruptions: classroom instruction that emphasizes peer collaboration along the lines of race and gender, and the creation of affinity spaces for Black girls and women to defy the perception of their presence as exceptional in mathematics spaces.

Quantitative designs

Quantitative designs, specifically correlational or causal comparative studies, are useful when studying variables that are non-manipulable, variables such as sex, race/ethnicity, and socioeconomic status (Mertens, 2020); these types of studies seek to answer questions regarding relationships between variables without necessarily determining causation. For example, Chambers et al. (2016) sought to examine the relationship between the mathematics self-efficacy of Black women students, and enrollment in postsecondary institutions (specifically four-year institutions). Since students who start their postsecondary education in a four-year institution are more likely to complete their bachelor's degree, this variable is a proxy for improved educational attainment (Chambers et al., 2016). What the researchers learned was that higher mathematics self-efficacy is positively related to enrollment in four-year institutions.

Common Theories Used to Guide Asset-Based Studies

Although not an exhaustive list, three of the more popular frameworks or theories in asset-based studies include Critical Race Theory (CRT), Critical Race Feminism (CRF), and Black Feminism.

Critical Race Theory

Critical Race Theory (CRT) is a body of legal writing by people "ideologically committed to the struggle against racism, particularly as institutionalized in and by law" (Bell, 1995, p. 898). Critical Race Theorists have used this theory in efforts to empower the disenfranchised, to include traditionally excluded views (Bell, 1995), and, especially in education, to refute "dominant ideology and White privilege while validating and centering the experiences of People of Color" (Yosso, 2005, p. 74). Delgado & Stefancic (2017) explain that CRT is guided by four basic tenets: the first tenet is the ordinariness of racism makes it difficult to confront and eradicate. While institutional rules that are intended to thwart discrimination and discriminatory practices truly only capture blatant instances of racism, much goes unnoticed due to its subtle presence. The second tenet is interest convergence which implies that because large segments of the dominant society benefit from racism, the incentive to eradicate it is motivated by converging interests of the oppressed and the oppressor rather than a mutual belief in the need for the liberation of the oppressed. The third tenet is that racism is a social construct rather than a biologically determined. This is evident when "dominant society racializes different minority groups at different times" (Delgado & Stefancic, 2017, p. 10) which shows that race and racialization is fluid, not fixed, and flows with the whims of the dominant society. The final tenet is that members of marginalized communities can use counternarratives to "communicate to their white counterparts what they are unlikely to know" (Delgado & Stefancic, 2017, p. 11). The

implication is that counternarratives are communicated through the uniqueness of the lived experiences of the marginalized.

Researchers (e.g. Yosso, 2005; Milner, 2012) have applied CRT in various ways: Yosso (2005) expanded the idea of cultural wealth using CRT as a lens to center the experiences of People of Color, capturing assets and resources encapsulated in the rich histories and lives of People and Communities of Color. Stinson (2008) used CRT as a component in his theoretical framework, to address two research questions, one concerning the ways in which participants defined success and the contributing sociocultural factors, and the second surrounding the sociocultural and sociohistorical factors that defined their identities as mathematics learners. From CRT, Stinson (2008) embraced two tenets, the tenet that racism is permanent and "normal", and the tenet regarding the use of counter-stories to share untold stories. Milner (2012) also rooted his narrative study in CRT, citing that CRT allows the centralization of race and racism through counternarratives.

Critical Race Feminism

Clark & Saleh (2019) describe CRF as "a feminist intervention within critical race theory" (p. 162). While CRF espouses tenets similar to CRT, CRF places added emphases on the intersectional impact of gender, particularly for women of color. First, CRF calls for the antiessentialization of the experiences of women of color, indicating that their experiences are unique due to their existence at the nexus of racism and sexism (Clark & Saleh, 2019). Secondly, CRF inspires the "challenging of social injustices and eliminating persistent inequalities experienced by women of color" (Clark & Saleh, 2019, p. 162), suggesting that action is required to thwart the persistent inequalities visited upon women of color. Lastly, CRF employs

counternarratives as a tool of resistance, and to "illuminate the voices women of color and the impact of their multiplicative identities on their experiences" (Clark & Saleh, 2019, p. 162).

King & Pringle (2018) used Critical Race Feminism (CRF) "as a lens to expose racial and gender essentialism" (p. 541), which stresses the intersection of race and gender, rather than placing one as primary and the other as secondary. Race and gender are physically observable traits in Black women that simultaneously influence how they are perceived, received, and treated (King & Pringle, 2018). The study was to address the access and engagement of black girls, the ways in which the girls translated this learning to their formal education settings, and their perceptions of race, gender and class in their STEM learning experiences. King and Pringle found that, contrary to commonly held beliefs, black girls valued the knowledge acquired through the program and were motivated to seek opportunities for further engagement during the regular academic year.

Young et al. (2020) also used CRF in tandem with Critical Quantitative Inquiry to examine how Black girls performed on advanced placement (AP) exams. This study was to challenge the "common" mediators of success and to be the foundation of efforts to improve the performance of Black girls. Young et al. (2020) determined that Critical Race Feminism was the ideal marriage of race-based and feminist epistemologies, ensuring that the needs and voice of Black girls would not fall through the cracks.

Black Feminism

Black Feminism has origins that reach further back than the Combahee River Collective (1977) where a collective of Black feminists and lesbians shared their thoughts about the genesis of Black feminism from years of the combined influence of racial and sexual identity in the lives of Black women. The Combahee River Collective (1977) articulated four important precepts that

are central to Black Feminism, the first of which is that the struggles of Black women are rooted in "membership in two oppressed racial and sexual castes" (p.2). Black women activists, such as Dr. Angela Davis asserted that even the Black female body is a visual opposition to the White male rule of the U.S. political system, which is the cause for their unique experiences and struggles within said system (Combahee River Collective, 1977).

A second precept of Black feminism is the need to dismantle the interlocking racial, sexual, economic, and patriarchal systems of oppression (Combahee River Collective, 1977; Few, 2007). Black feminism illuminates how the racial and sexual oppression of Black women also limits their options within a capitalist labor force, accounting for their marginalized place within the U.S class system (Combahee River Collective, 1977).

A third precept is the rejection of "malignant images of Black womanhood" (Few, 2007, p. 455). Historically, the Black female body was violated by White men "as a weapon of political repression" (Combahee River Collective, 1977, p. 4). The legacy of the violation lingers with the sexual objectification of Black girls and women that floods multimedia and social media platforms (Townsend et al., 2010). Black Feminism necessitates a "healthy love for ourselves, our sisters, and our community which allows us to continue our struggle and our work" (Combahee River Collective, 1977, p. 4). The work of Black feminists is reinforced by the collective embrace of the beauty and humanity of the Black female body.

The final precept is that "the personal is political" (Combahee River Collective, 1977, p. 5). The work of Black feminism is to actively produce knowledge because "no one before has ever examined the multilayered texture of Black women's lives" (Combahee River Collective, 1977, p. 5). Black feminists realized the need for activism through knowledge creation, an undertaking that drew criticism and vitriol from both Black and White communities (Combahee

River Collective, 1977; Few, 2007)). The social cost of being an intellectual Black woman thinker was greater than that for educated, middle- and upper-class White women, therefore the work of Black feminism is political activism undertaken in the face of social and political backlash (Combahee River Collective, 1977).

Noted scholars (e.g. Collins, 2015; Leonard et al., 2020) have used Black feminism to convey critical insights about the experiences of Black women. Leonard et al. (2020) felt that Black Feminism was well suited for the validation of Black women's knowledge and experiences. The researchers were drawn to the core themes (work, family, sexual politics, and political activism) "within the U.S. context of racial and gender oppression" (Leonard et al., 2020, p. 15). By focusing on the narratives of five generations of Black women from the same family, the researchers sought to examine how racialized and gendered mathematics education was reproduced through neutral education policies and practices, and to expose their "literacy, identity, resilience, and educational opportunity" (Leonard et al., 2020, p. 17). When Patricia Hill Collins wrote Black Feminist Thought, she did so with the purpose of revealing the truth about the power relations that influenced the ways in which African American women were represented in the media (Collins, 2015). She felt it necessary that Black women's experiences be centralized in analysis to "highlight black women's interpretations of our social worlds" (Collins, 2015, p. 2349), demanding a shift in paradigm from Black women as objects of knowledge to agents of knowledge. Key to Black Feminism is the idea that real social change will be the result of changed individual consciousness and the "social transformation of political and economic institutions" (Lemert, 2004, p. 413).

In a multitude of ways, asset-based studies about black girls and women position Black women as possessing knowledge, wisdom, resources, and strategies that support persistence, and

success in spaces that were not designed with them in mind. Without downplaying the real systemic obstacles and barriers that they face, these studies give rise to findings that counter the dominant narratives that are pervasive in academia, findings that are often invisible in mathematics education research.

Conclusion

For Black girls who hope for a career in STEM, exposure to Black women as STEM role models provides an opportunity to embrace an academic identity that does not stand in conflict with ethnic pride. Yet the continually low representation in STEM careers and majors means that many Black girls might miss out on this identity development. As mathematics is the cornerstone for STEM aspirations, the presence of Black women in secondary mathematics classrooms could turn the tides. The low numbers of Black women in mathematics teacher preparation programs, however, is a challenge that has not been surmounted. Having established the conditions in which, and through which, Black female mathematics teachers found their way into K-12 classrooms in the U.S., this study places priority on the preparation experiences of these future teachers. Plachowski (2019) asserted that research intended to address the teacher diversity gap either places emphasis on preparing white teachers to teach diverse student populations or focusing on how few people of Color are choosing to become teachers. Instead, according to Plachowski (2019), the research on the teacher diversity gap should consider how preservice teachers of Color persist to licensure acquisition while building the capacity to remain in the profession. Teacher preparation programs are, therefore, an important site for exploration, beginning with the state of the supply pool for Black teachers, and common experiences for Black teachers working their way through the teacher preparation pipeline.

As one researcher noted, properly prepared teachers need not only persist to licensure, but must build an arsenal to sustain them once they are in the field, in their own classrooms. Where some studies have highlighted the battleground, and others have made mention of the effort exerted by the teachers who persisted in spite of the obstacles, a gap remains in available literature, one that seeks the insight of the Black female preservice mathematics teachers who persisted and the specific capital that they drew upon to make this persistence possible. This could yield the knowledge to inform how teacher preparation programs better support Black women who are future secondary mathematics teachers to persistence and retention once in the field.

CHAPTER 3: METHODOLOGY

Black women who become secondary mathematics educators begin their journey as mathematics learners in the US K-12 education system. Research studies show that Black girls encounter various systemic and sociopolitical barriers that could hinder their progress to high school graduation and to post-secondary pursuits, yet many persist, some even opting for STEM majors and secondary mathematics education. However, Black women are still underrepresented in STEM majors and careers, and studies show that this is not due to a lack of interest or ability (Leonard et al., 2020; Sparks, 2018). This study focuses on the niche of Black women on the secondary mathematics teaching track: by understanding the experiences of those who have persisted, we might learn how to provide better support.

As such, the purpose of this study is to explore the experiences of Black women who are preservice mathematics teachers (PSMTs) to understand the capital to which they ascribe their ability to persist through undergraduate mathematics courses en route to secondary mathematics teaching licensure. Accordingly, the guiding research questions are:

1) When sharing stories of persistence in undergraduate mathematics courses, what types of capital do Black women who are preservice mathematics teachers believe was instrumental in that persistence?
2) With respect to capital, what are the similarities and differences among Black women's stories of persistence in undergraduate mathematics?

Theoretical Framework

This study was guided by Critical Race Feminism with a Black Feminist lens. Critical Race Feminism (CRF) originated within Critical Race Theory but was extended to capture the

multiplicative identities of women of color (King & Pringle, 2018; Young et al., 2020). Black Feminism was included as a lens to center the study on the experiences of Black women.

As noted in the review of literature, CRF is an extension of Critical Race Theory (CRT) that focuses on the lives of people facing discrimination along the lines of race, class, and gender against the backdrop of White patriarchy (Clark & Saleh, 2019). According to Few (2007), CRF is a theory that "recognizes the multiple locations that women inhabit" (p. 456), a perspective that Critical Race feminists believe is excluded in CRT's essentialization of all minorities. CRF stresses the intersection of race and gender, rather prioritizing one over the other (King & Pringle, 2018).

Black feminism, as defined by the Combahee River Collective (1977) is "the logical political movement to combat the manifold and simultaneous oppressions that all women of color face" (p. 2) which notes that the adversarial relationship between Black women and the US political system as due to their existence at the intersection of racism, sexism, and classism. Recall, from Chapter 2, that Black Feminism is set apart by its core themes: addressing the power relations of racism, sexism, classism, and heterosexism; exercising the voice of Black women in opposition to the oppression that sought to silence or dehumanize them; social justice through knowledge creation, as resistance to oppression; and understanding the complexity of the intersecting systems of power in all aspects of the lives of Black women (Collins, 2015; Combahee River Collective, 1977).

The foundation of Black Feminism is the "shared belief that Black women are inherently valuable, that our liberation is a necessity not as an adjunct to somebody else's may because of our need as human person for autonomy" (Combahee River Collective, 1977, p.4). In recounting the origins of the Black Feminist movement, the Combahee River Collective (1977) declared that

the primary impetus behind their work was “to be recognized as human, levelly human” (p. 4). A simple enough statement that belies a troubled past, the recognition of Black women’s humanity has proven elusive for Black women in the United States and other countries (like Brazil) that bear the legacy of slavery and its lasting repercussions. Freire (1970/2000) stated that dehumanization is “*not* a given destiny but the result of an unjust order that engenders violence in the oppressors, which in turn dehumanizes the oppressed” (p. 44). To Freire (1970/2000), just as the dehumanization of one dehumanizes the other, the humanization of one humanizes the other. To secure the humanization of all, there needs to be a collaboration between the oppressed and the oppressor.

CRF and Black Feminism share components that are significant to the framing of this study; these components are intersectionality, sociocultural context, and activism. The experiences of Black girls are intersectional in that their experiences are because of their race and gender (and often social class and ethnic origin). Crenshaw’s (1991) use of the term *intersectionality* was to explain the phenomenon whereby “race, class, gender, sexuality, ethnicity, nation, ability, and age operate not as unitary, mutually exclusive entities, but as reciprocally constructing phenomena that in turn shape complex social inequalities" (Collins, 2015, p. 2). This is similar, in spirit, to Collins’ Matrix of Domination where the main idea is that individuals could be impacted by the consequences of any combinations of these social constructs simultaneously in an overlapping, as opposed to additive, manner. For example, being Black and a girl exclude Black girls from where mathematical ability is perceived to lie, which is within White males. Leyva (2016) states that intersectionality, a perspective of Black Feminist, is the lens through which marginalized individuals speak of their oppression and their counternarrative resistance.

Both lenses also allow attention to the sociohistorical context of the stories. Few (2007) used CRF and Black Feminism to introduce Black consciousness into family studies because they "provide sociohistorical lenses to the experiences of Black women and their families in the United States" (p. 453). Few (2007) believed that the attention to the sociohistorical context surrounding the informant's story adds emphasis to the informant's perspective while retaining the uniqueness of the informant's experience. The experience of Black women in teacher preparation programs are situated within social institutions, White, patriarchal spaces that undervalue and negate the beliefs of women who aspire to STEM careers (Sparks, 2018), and that uphold dehumanizing, anti-Black institutional behaviors and practices (Leyva, et al., 2021).

Lastly, both CRF and Black Feminism inherently propel action or praxis. Few (2007) states that Critical race feminists are often interested in research that aims to be transformative, "fostering some kind of political, social, or economic transformation that benefits the people they study" (p. 457). Black Feminism is also a political movement to inspire change in the lives of Black women and their families (Combahee River Collective, 1977). As a guiding framework, I use CRF and Black Feminism to justify the selection of research design and as a lens to understand the stories shared by the PSMTs in this study. This is further detailed within appropriate sections.

Research Design

In alignment with the theoretical framework, the research design for this study is Counternarrative Inquiry (Mertens, 2020). Counternarrative Inquiry is a subset of Narrative research or Narrative inquiry, which is characterized as "an approach to the study of human lives conceived as a way of honoring lived experience as a source of important knowledge and understanding" (Clandinin & Rosiek, 2007, p. 42). This lived experience is communicated

through stories or narratives, told by the narrator (the participant) to the listener (the researcher), where the focus is solely on the narrator's specific story (Mertens, 2020). Stories themselves are data, crucial sources of knowledge, where insights into lived experiences are useful both to the narrator and to social science scholarship at large (Clandinin & Rosiek, 2007; Willig, 2017).

Clandinin and Rosiek (2007) believe that narrative inquiry is the ideal methodological approach as it embodies choices that are situated and executed in time and reflects consequences of these choices in the lived experience of an individual or a community. Within the latter statement, we find three characteristics that are commonplace to all branches of narrative inquiry: temporality, sociality, and place.

Temporality is the acknowledgment that all experiences are influenced by the past and are carried into the future (Clandinin & Rosiek, 2007; Connelly & Clandinin, 2006); stories are not told as a moment in time but as the experience of phenomena through time, past, present, and future (McAdams, 2008). In the interview protocol, the participants were prompted to share stories during specific periods of their lives, both before and during their preparation experience. This allowed access to the genesis and evolution of capitals within the participants' narratives.

Sociality is concerned, simultaneously, with the personal and social conditions that surround a tale (Clandinin & Rosiek, 2007). The interview protocol invites the participants to be expansive in their narration to encourage detailed descriptions of social conditions (e.g. socioeconomic status, group membership, and gender).

Lastly, *Place* refers to the necessary centrality of location for the narrative inquirer, the physical space or sequence of places in which the story unfolds (Clandinin & Rosiek, 2007; Connelly & Clandinin, 2006). It is vital that narrative inquirers understand that all events take place somewhere, and that the "somewhere" could significantly impact the story that is being

told (Connelly & Clandinin, 2006). The participants in this study attended public and private universities that were either Predominantly White Institutions (PWI) or Historically Black College and Universities (HBCUs). With prompting, they were encouraged to elaborate on the impact of these places in their preparation experiences.

These traits of narrative inquiry allow insight to the sociocultural contexts and the impact of the intersecting systems of oppression in the lives of the storytellers, which is an important tenet of both CRF and Black Feminism.

Counternarrative Inquiry

Counternarrative Inquiry, as it is currently understood, is a branch of narrative research that, according to Mertens (2020), is "designed to bring the voices of marginalized communities, such as people of color, into visibility as a means to challenge a derogatory dominant narrative" (p. 307). One of the earliest uses of narrative research was in women's studies: Vaz (1997) used oral narrative research to highlight the struggles of Africana women against colonialism and patriarchy. While not many, there have been other researchers who have employed counternarrative inquiry to similar ends. Milner (2012) used counternarrative inquiry to challenge negative perceptions of Black teachers that can be found in research. Leonard et al. (2020) applied the counternarrative research design to a study framed using Black Feminism within a sociohistorical context. With *Brown v. Board of Education* as a crucial historical marker, the researchers used the accounts of five generations of Black females from one family to describe how the changes in society surrounding the ruling impacted their mathematics educational attainment, their daily lives, and their career trajectories (Leonard et al., 2020).

Counternarrative inquiry aligns with CRF and Black feminism in that it allows attention to a common tenet of both lenses, which is the use of counternarratives as a tool of resistance and

for illumination. By listening to the stories of the individual Black women in this study, I invited each of the women to speak to their lived experiences, sharing what is not known or understood by the dominant society (Combahee River Collective, 1977; Few, 2007). Counternarrative inquiry also allows an alignment to Black feminism, specifically, as we honor Black women as intellectual knowledge creators through their storytelling (Combahee River Collective, 1977).

I used CRF and Black Feminism to frame the counternarratives shared by participants regarding the capitals they drew on to persist through undergraduate mathematics courses en route to secondary mathematics education licensure. I felt it necessary to preserve of the voices of the Black women in this study. In seeking stories that refute the dominant, deficit narrative that precedes Black girls and women into mathematics classroom, it was important to restore power by privileging the voices of the unheard. Toliver (2022) stated that stories "carry a piece of the storyteller into the larger world" (p. xxxii) and urges the story listener (researcher) to listen with mind, body, spirit, and heart, be to feel and to wonder, and to consider relationship between the narrator, the listener, and the story. Counternarrative inquiry allowed me to demonstrate the value placed on the stories told by the Black women, placing them in the position of the holder of the knowledge.

Participant Selection

There were five preservice math teachers (PSMTs) in this study, purposefully selected from an assortment of universities, including Historically Black Colleges and Universities (HBCUs), Predominantly White Institutions (PWIs), and public and private universities. This was to ensure that a wide and varied set of experiences were represented in the study. The PSMTs for this study met the following criteria:

1. 18-years or older,

2. Female,
3. Black or African American,
4. Attends a four-year university or college (HBCU, PWI, public or private)
5. At least a rising senior in a licensure-seeking secondary mathematics teacher preparation program. Recent graduates (within two years of graduation) were also welcome to participate.

Using purposeful sampling, I first sought the assistance of people within my personal and professional network to identify potential study participants. I then reached out to mathematics and mathematics education faculty instructors in various universities, seeking recommendations for candidates that met the above criteria or faculty who had access to such candidates. I also sent research announcements to key universities with significant populations of Black students. Lastly, I posted the research announcement on social media platforms, including Instagram and X (formerly Twitter).

When I reached out to faculty members, I gave them the option to either send my information to eligible students, or to provide their emails to me so that I may reach out to the students myself. When I received student referrals, I sent them an introductory email explaining the study, confirming their willingness to participate, and then gave them instructions on the steps to schedule the three interviews. I recruited five Black women who were eager to share their stories with me: Brandy, Scarlet, Gabi, Yvonne, and Nyla. Table 6 contains general demographic information about the PSMTs in the study, but more details about the PSMTs will be provided within their narratives in chapter 4. To the best of my ability, the PSMTs, their institutions, and any people that they referenced are blinded in their narratives. Each PSMT was

assigned a pseudonym either of their own selection or of my own creation (with their permission).

Table 6: *Brief demographic description of the PSMTs*.

Pseudonym	Status at time of interview	Institution		
		Public or Private	HBCU or PWI	Region
Brandy	Recent Graduate	Public	PWI	Southeast
Scarlet	Senior	Private	PWI	Northeast
Gabi	Recent Graduate	Public	PWI	Southeast
Yvonne	Rising Senior	Public	HBCU	Southeast
Nyla	Rising Senior	Public	PWI	Southeast

Data Collection

The data for this study was collected using narrative interviews. I conducted three narrative interviews with each PSMT, using the McAdams (2008) Life Story Interview model (described in detail below). The narrative interviews were conducted via Zoom, a teleconferencing platform, as this was the most convenient way to be able to interview participants who live in different states across the country. Each interview lasted between 60 - 90 mins, meaning that I spent about three to four hours in conversation with each PSMT in this study.

Life Story Interview

The specific interview style in this study is the McAdams (2008) Life Story Interview. I chose to adopt this interview style as it encouraged the participants to share episodic stories about their experiences (in the case of this study, the episodes will be elementary, secondary, and undergraduate education). McAdams (2008) shares six principles in operation when using this

interview style, three of which include 1) self is both the storyteller and the subject of the story, 2) stories are reflections of the cultural context in which they are told and 3) stories are a way to integrate people, ideas, and events that ordinarily appear disconnected. The first principle aligns with the both CRF and Black Feminism precepts regarding the power and knowledge expressed through the unique voice of the marginalized (Few, 2007) in that it allows the storyteller to be the center of the story. The storyteller is the source of knowledge about their unique experience and their perspective is in the spotlight. The second principle also aligned with the theoretical framework in that the impact of the interlocking oppressive systems (racism, sexism, classism, etc.) will be reflected within the narratives as Black women navigate social institutions that were designed with a perspective that excludes their ways of learning and knowing (Combahee River Collective, 1977; Clark & Saleh, 2019; Leonard et al., 2020). By attending to the sociohistorical through the interview protocol, I was able to invite the PSMTs to speak about their experiences which were situated within a physical place (type of institution) and time. The alignment with the third principle was where the capital of the PSMTs were truly illuminated, as the PSMTs told stories where the players and the setting constituted points of interaction. The nudging in the interview protocols served to foster reflection in aid of the integration of people, ideas, and events. More importantly, they invited details regarding the specific oppressive systems that shaped the experiences of the individual PSMTs, supporting the common goal of antiessentialism held by both CRF and Black Feminism (Clark & Saleh, 2019; Few, 2007).

Each narrative interview was directed by interview protocols to maintain consistency and to allow the PSMTs to share critical insights in their stories. The first interview focused on stories of mathematical experiences prior to the PSMT starting an undergraduate teacher preparation program at a four-year university. The second interview, then, featured stories about

how the PSMTs experienced undergraduate mathematics courses, whether these mathematics courses were within or outside of the college of education. I should note that some of the PSMTs took undergraduate mathematics courses at a community college before transferring to a four-year institution. In one case, this was after graduating from high school, and in a couple of other cases, it was as a dual enrollment course in high school. The flow of the conversation is what determined whether this was revealed in the first interview or the second interview, so I was careful to take notes as I listened. The final interview primarily encouraged reflection on the first two interviews, as well as the opportunity to discuss potential efforts to be transformative in the lives of their future students. What follows is a brief overview of the three interview protocols.

Interview Protocols

I used three interview protocols to guide the conversations with the PSMTs. The aims of each interview were mentioned previously. While each interview protocol had prompts, they were used only if the PSMTs' stories did not organically flow into the things I was hoping to learn about. Let me reiterate that the prompts were intended to also bring out the sociocultural and sociohistorical contexts that frame the experiences of Black women within systems of oppression, specifically institutions of formal education. These contexts were to help demonstrate alignment to the complex intersections of racism, sexism, and classism, a critical precept in both CRF and Black Feminism. The complete protocol is available in Appendix A but what follows are the main prompts for the three interviews:

Interview 1

> Warm up Prompt: Tell me about your earliest memories about learning mathematics or using mathematics? It can be in any environment, not just school.

Prompt 1: (Elementary math experiences) As you look back on your experiences learning mathematics around your elementary years, whether inside or outside of school, what are some moments that stand out? What happened in those moments? Who were the important players when you replay the scenes in your head?

Prompt 2: (Middle school math experiences) I'm curious to hear about what learning and using mathematics was like for you around your Middle school years, inside and outside of school. Can you tell me some stories about that time in your life? What were some typical experiences? What were some unusual experiences?

Prompt 3: (High school math experiences) I would love to hear some more stories about your mathematics experiences during your high school years. Can you tell me some stories about what it was like being a mathematics learner around the time that you were in high school? It can include experiences outside of school.

Interview 2

Warm up Prompt: How have you been since our first discussion? Did you replay any parts of our conversation? Which ones? Did these thoughts lead you to other interesting thoughts? Do you care to share?

Prompt 1: Tell me about your experiences as a mathematics learner in/during your undergraduate mathematics course (this can include your math methods courses). What was it? How did you feel going in? What did you expect from that course? What formed the basis for your expectations?

Prompt 2: Did you take any mathematics courses once you had completed the required math courses for your major?

Concluding Prompt: Looking back on our conversations, what are some tips or pearls of wisdom that you would offer future mathematics learners like yourself? As a future mathematics educator, what would you do differently for the Black girls you either teach or have the opportunity to influence?

Interview 3

Warm up Prompt: It's been (# days) since we started this conversation. How are you feeling? Did you talk to someone about our conversations?

- Have you jotted down any thoughts since we last met? Do you care to share them?
- I listened to our conversation a couple of times and there was something you mentioned that struck me as possibly important, so I wanted to ask you about…
- Do you have any questions for me?
- How would you define your identity as a mathematician? How about as an educator?
- What does community mean to you or look like? How has that changed, if at all, through your journey?

A side note about the third interview protocol: there were originally just the first three follow-up questions. The last two were added after the final interview with the first PSMT, Brandy, because it came up in conversation and appeared to be important for her. I included them in the subsequent interviews to see if it became significant across the PSMTs. The third interview protocol and nudges were an opportunity for the PSMTs to showcase their activism, their desire to bring transformation to the students they will, one day, teach. This activism is a critical tenet of both CRF and Black Feminism, where action is required to disrupt the social

injustices and persistent inequalities experienced by Black women (Clark & Saleh, 2019; Combahee River Collective, 1977).

An important aspect of the interview protocols was that they were unstructured enough to allow the stories to unfold as they would in a regular conversation, yet with gentle nudges to elicit information that would help address the research questions guiding this study. I structured the prompts to make sure I was able to capture a chronological recounting of the PSMTs' experiences, but I did not sacrifice the story for order. The reality of any narrative interview is that stories are usually not told in a straight line. Telling one part of the story would spark a connected memory about a different time. As much as possible, I followed the stories of PSMTs and noted important details about time as they became available. I then used follow up questions to lead back to any prompts that had not been addressed in the process.

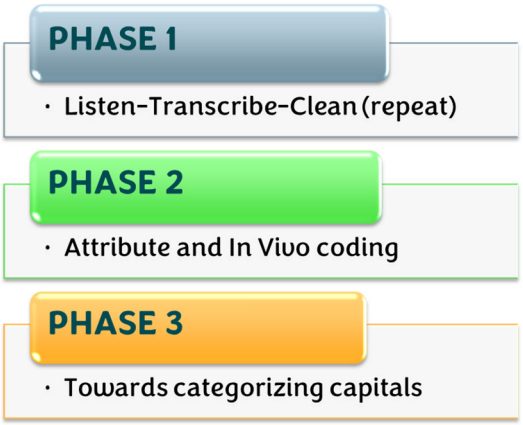
The risk with any storytelling interaction is that the narrator can recall moments and the associated emotions, whether good or bad. I anticipated that some of the stories the PSMTs would share could be painful or uncomfortable to share and made sure to inform them that they were in control of the interaction. I noted in the consent form that the PSMTs could ask to pause or terminate the interview when they needed. At the start of each interview, I reminded the PSMTs that they could share as much or as little as they were comfortable sharing, and that they could ask me to pause or stop the interview, if needed. I also made sure to be in an enclosed space at the time of the interviews, to assure the PSMTs of the confidentiality of our interaction and their stories. I was honored by the trust that the PSMTs placed in me with the stories that they shared and did my best to honor their words in my analysis.

Data Analysis

The three main phases of the data analysis process are represented in Figure 1. The primary activities in each phase are represented in the diagram but what follows offers greater detail about the activities therein. Regarding order, the first pass of each phase was done by PSMT: I performed a phase of analysis on all three interviews with one PSMT before repeating that phase for another PSMT. I wanted to remain immersed in the specific speech patterns, colloquialisms, and storytelling style of each PSMT to ensure a truer representation of the interaction. Inevitably, I would return to the transcripts of a previous PSMT when prompted by new insights.

Figure 1

Main Phases of the Data Analysis Process



Phase 1: Listen-Transcribe-Clean (repeat)

The primary activity in this phase was the listen-transcribe-clean cycle. This phase was necessary to support the preservation and integrity of the stories shared by the PSMTs. Black Feminism and CRF place value on the counternarratives of the PSMTs as sources of knowledge and tools of resistance, so the careful listening to the spoken and unspoken, and attention to the

accuracy of the transcription support these precepts. The analysis of the interviews began with watching the video recordings to make note of any significant non-verbal cues. I did this because the videos would then be deleted (as articulated in the IRB application), leaving just the audio files. I listened to the audio files a couple of times so that I could be as intimately connected to the data as possible (Tracy, 2013; Wolcott, 1994). By listening, first as an active participant in the narrative interaction with the PSMTs, and secondly to secure the accuracy of the transcription, I became a cocreator of knowledge with the PSMTs, which is specifically noted within Black Feminism (Combahee River Collective, 1977). I then uploaded the audio files to Otter.ai, the platform that I used for the initial transcription and subsequent cleaning of the interview transcripts.

The transcribe-clean processes were accomplished simultaneously within the Otter.ai platform. While listening to the audio files, I verified the identity of the speaker to make sure that statements were attributed to the correct person. In addition, I corrected any inaccuracies resulting from muffled speech, poor audio quality, and unexpected noise in the background. Although Otter.ai was the main platform for the transcription, I retained the zoom-generated transcript as a back-up. This proved particularly useful in situations when verifying speakers and timestamps.

It was during the final cleaning process that I inserted descriptions of any non-verbal cues or extended pauses within the transcripts. I also enacted the blinding process so that the cleaned transcripts would be anonymized. I replaced the names of people, places, and programs with pseudonyms to protect the identities of the PSMTs, as indicated in the IRB application. After verifying the accuracy of the transcription and making necessary corrections, I disposed of the audio files, retaining only the transcribed interviews as the data that was to be analyzed. I then

uploaded the blinded, transcribed documents to a Computer-Aided Qualitative Data Analysis Software (e.g., Atlas.ti) for coding.

Phase 2: Attribute and In Vivo Coding

Attribute coding was a necessary step to draw out the three important characteristics of any narrative - *temporality*, *sociality*, and *place* (see chapter 3 for details). To generate a chronological representation of each participant's stories, I began with attribute coding to mark the time periods or moments in time in which each story took place. For example, when a PSMT was telling a story about something that happened when she was in the first grade, I coded that story as *1st grade*. A temporal code could also be an era (e.g. during COVID) or the PSMTs status when taking a math course (e.g. second semester of freshman year). To capture the sociality of the stories, I looked for statements that described various aspects of social conditions (e.g. socioeconomic status); for instance, Yvonne described her school as a Title I school, and Scarlet mentioned that she had to enter the school lottery to be able to attend a private school. Lastly, to capture *place*, I coded information regarding physical locations where stories took place (city, state, home, school, etc.); for example, PSMTs named the locations of their universities, or Gabi described when her family moved from one city to another. Recalling that the interview protocols featured prompts and nudges that would draw out the sociocultural, sociohistorical, and socioeconomic aspects of the PSMTs' narratives, the attribute coding marked these aspects to contextualize the chronology of the narratives. This helps to give clarity to the oppressive systems that shaped the PSMTs, which is aligned to multiple tenets that are common to CRF and Black Feminism (e.g. racism, sexism, classism, patriarchy, etc.).

Once satisfied with the attribute coding, I read the PSMTs responses with specific attention to statements about persisting and highlighted statements as units of analysis

(quotations) within Atlas.ti. I targeted stories or statements around temporal codes (e.g. 1st grade, middle school, sophomore) where the PSMT was talking about a math course or learning math. The quotations ranged from sentences within a PSMT's response to several exchanges between me and the PSMT; what mattered was that the quotation captured some mention of persistence in a math course. I paid special attention to stories about difficulty, waiting for the PSMT to mention how they found their way to success or something they did to mitigate a situation related to their math course. At first, I coded each quotation as *potential capital*, not to imply that this was a capital, rather to indicate that the statement could lead to the discovery of a capital. I did a second pass over the interview before using *in vivo* coding to give more definition to the actions, perspectives, and feelings being communicated by the PSMT (Saldaña, 2016). The in vivo coding also helped preserve the words and unique expressions of the PSMTs, a necessary action to align with the theoretical framework (CRF and Black feminism). If the words spoken by the PSMTs are indeed valuable knowledge, then it mattered that I protect the integrity of what they communicated both verbally and tacitly. At the end of the iterations in this phase, I generated 21 in vivo codes shown in Table 7.

Table 7

List of codes generated from Phase 2 of the analysis process.

Codes related to persistence		
Balance with Passion	Creativity	Make Math Connections
Be Better than Bad teachers	Defying Expectations	Love/Interest in Math
Be Resourceful	Do it on my own	Prove Myself Worthy/Capable
Better future for Black Students	Faith/Spirituality	Recognize my Brilliance
Comfortable with Discomfort	Future Career	Self-Confidence/Self-Efficacy
Community of Peers	Help from Family	Study Skills Strategy
Congruency with Teacher	Knowledge is my weapon	Understanding the System

A critical next step within this phase was the development of a codebook to ensure a strong foundation for thematic analysis. I needed to make sure that each of the codes in Table 7 carried the same meaning within and across the PSMTs' interviews. I started the process by attending to codes that appeared similar to avoid redundancy. For example, *defy expectations* and *prove myself worthy* were codes that needed to be distinguished from one another. I created a table with three columns: the first column contained the name of the code, in the second column the description of the code, and in the third column, one or two sample statements that I labeled with the code. I shared the table with my research advisor and my research mentor, who tried to arrive at the same conclusion, given the description I provided. In this case, I did decide to remove the *prove myself worthy* code because I did not feel that there were any statements that provided a clear distinction, at least in the interviews presented in this study. We repeated this process until I had definitions that were more precise. I applied this process to the remaining codes.

For the final refinement, I selected large segments from the interviews of two different PSMTs and tasked my two collaborators with coding them using the codebook. I met with my collaborators individually to discuss code agreements and conflicts. In each meeting, where coding conflicts existed, we determined whether it was because of the code definition or because the quotation size needed to be adjusted to include more context or exclude extraneous ideas. I refined the code definitions, after each meeting, until I arrived at the codebook which is available in Appendix B. I then used the final codebook to revisit and refine my coding in the PSMT interviews.

Phase 3: Towards Categorizing Capitals

It was in this phase that I used thematic inductive analysis iteratively to explore themes within and between the PSMTs' interviews. Tracy (2013) regards the iterative approach as "a reflexive process in which the researcher visits and revisits the data, connects them to emerging insights, and progressively refines his/her focus and understandings" (p. 184). This reflexive process was necessary due to the richness of the data that the narrative interviews generated. I started by grouping codes that shared a similar ethos, and in a second column, I described the ethos that unified them. This resulted in six groups with corresponding unifying descriptions or themes (see Table 8).

Table 8

Code groups and unifying description.

Group	Codes	Description/Theme
1	Better math experience for my future students Focus on Future Career Better future for Black Students	The ability to focus on a future desire or goal
2	Opportunities to infuse creativity or other learning modalities Make Math Connections Love/Interest in Math	A fortitude that stems from the thrill of engaging with mathematics in various ways
3	Help from Family Community of Supportive Peers Others Recognize my Brilliance Supportive/Encouraging/Helpful faculty/staff Racial/Gender Congruency with Teacher	Support that the participants receive from a variety of sources
4	Balance pain from negative math experiences with personal passion Understanding the intricacies of the system Empowered by Anonymity a.k.a. Opportunity for remote learning	Participants take steps to alter circumstances in their favor
5	Faith/Spirituality Become Self-Sufficient Comfortable with Discomfort	In moments when isolation or discomfort is felt strongest, participants draw strength from within.
6	Defying Expectations Knowledge is my weapon against microaggression	Participants resist, challenge, negative ideas, spoken or perceived.

From here, I embarked on the journey of naming the themes, knowing that these names would become my capitals. For each code group, I generated a list of words that came to mind based on the descriptions, the codes within the group, and sample quotations from the interviews. I pored over the dictionary definitions of each word, finally selecting the word whose definition aligned with the ethos of the group. The final list of capitals with descriptions and definitions is

shown in Table 9, but a full list of the capitals, definitions and associated codes are in Appendix C.

Table 9

Capitals, Descriptions, and Definitions.

Capital	Description	*Definition
Expectation (I have hope for the future)	The ability to focus on a future desire or goal	"a prospect of future good or profit" or "the act or state of looking forward or anticipating"
Mathematical (I love engaging with mathematics)	A fortitude that stems from the thrill of engaging with mathematics in various ways	"of, relating to, or of the nature of mathematics"
Fortifying (I am surrounded by support)	Support that the participants receive from a variety of sources	"to furnish with a means of resisting force or standing strain or wear"
Actuation (I can take action)	Participants take steps to alter circumstances in their favor	"the state or condition of being impelled or moved to action"
Equanimity (I have help from within)	In moments when isolation or discomfort is felt strongest, participants draw strength from within.	"mental or emotional stability or composure, especially under tension or strain; calmness"
Confounding (I can resist)	Participants resist, challenge, negative ideas, spoken or perceived.	"perplexing or bewildering", or "throwing someone or something into confusion or disorder"

Note: All definitions were obtained from Dictionary.com. The phrases in parentheses were the ethos that I used as placeholders until I decided on a name that captured what the PSMTs shared.

Once the capitals had been named, I drafted narratives for each PSMT, organizing each narrative by the capitals. I began each narrative with the life and experiences of the PSMT,

starting with their earliest memories of learning mathematics, and ending before they began attending university. From that point, each narrative was written according to this order of capitals: expectational capital, mathematical capital, fortifying capital, actuation capital, equanimity capital, and confounding capital, as it applies to the narrative. Each of these narratives are presented in Chapter 4.

Risks and Benefits

This study shed light on the persistence, and challenges that Black women experienced, yet was often invisible to mathematics teacher educators. Rather than seeking innovative recruitment strategies to increase the representation of Black women in secondary mathematics education programs, I contend that improving retention is a more powerful strategy that will impact the proportions of Black women who attain degrees and secondary mathematics education licensure. I anticipated that this study would reveal suggestions for changes to secondary mathematics teacher preparation programs and to the dispositions of mathematics teacher educators that would support a welcoming and inclusive learning environment in which Black women can thrive.

The benefit to the participants was the opportunity to reflect on their experiences and maybe gain personal insights that they had not considered before. This reflection came at the risk of awakening and reliving painful past experiences; for that reason, the consent forms expressly indicated that participation was voluntary, and that the participant was free to end the interview at any point during the interview. This was also communicated at the beginning of each of the three interviews conducted with each participant.

Strategies for Quality

For dependability or reliability, I invited the assistance of other researchers (my research advisor and research mentor) to assure the reliability of the coding process used to identify the capitals mentioned in the narratives (Cho & Trent, 2014). The descriptions of the codes were an iterative endeavor that ended once we were able to code with satisfactory interrater reliability.

Owing to my chosen research design, Cho and Trent (2014) suggested the use of catalytic validity as the measure of quality for my study. Catalytic validity, a lesser-known type of validity, is said to be a particularly useful measure of quality for empowering, transformational, and social justice research as it checks the extent to which participants are invited to demonstrate critical consciousness, potentially with plans to be agents of change (Lather, 1986). This type of validity was evident in prompts within the interview protocols (See Appendix A) that encouraged reflective statements where the PSMTs acknowledged the need for their future students to assemble and access capitals from their own toolkits, and where they spoke their intention to be a part of that process as a mathematics educator. I included prompts and nudges in the interview protocols to encourage such reflection, only to be used if the reflection does not organically occur. Statements that suggested an agentic response to experiences were also coded during the analysis process. This quality strategy aligns with Black Feminism and CRF in the recognition that Black Feminism is a political stance that moves critically conscious women to transformative action (Combahee River Collective; Few, 2007).

CHAPTER 4: PSMT NARRATIVES

In this chapter, I will present the individual narratives that were the fruit of the analysis described in Chapter 3. What follows are the individual narratives, presented in the following order: Brandy, Scarlet, Gabi, Yvonne, and Nyla. Each narrative was written following the same order of capitals: expectation capital, mathematical capital, fortifying capital, actuation capital, equanimity capital, and confounding capital, as it applies.

Brandy's Story

Brandy's earliest memory as a mathematics learner centers around a TV show where a group of students would fight monsters using math. What captivated Brandy, however, was the one Black girl in the group. Brandy thought "I was just … so excited to see …, that girl looks like me and she's doing math. I think that was the first time where I was like, oh, math is kind of cool". This early interest in mathematics was further reinforced by summers participating in a STEM enrichment program facilitated by her father, who is also a mathematics teacher. This pre-college program was an opportunity for underrepresented middle and high school students to engage with STEM through various activities during the summer, and on Saturdays during the regular school term. Brandy remembers going to work with her father, or her father bringing home various robots that Brandy and her younger sister would play with. Looking back, Brandy realized that she and her sister did not have a typical upbringing. She explained that

> I feel like a lot of kids get…, especially young girls, we get like dolls and …these toys we've gendered into…being feminine, but like, we had just as many robots and…STEM related sort of video games…I didn't realize that other kids didn't have that kind of experience because that was just so normal for us to be… constantly exposed to… STEM activities…I think [that] really made me like math and science.

Brandy's desire to become a teacher was influenced by her first-grade teacher who encouraged hands-on interaction with science and other STEM -related content. By the third grade, Brandy was identified as gifted and talented in mathematics, and her prowess was recognized through the awards that she won. Having decided to become a mathematics teacher, Brandy applied to, and was accepted into, the same university from which both her parents received their undergraduate degrees.

In Brandy's story, we will see the following capitals in action: Expectation Capital, Mathematical Capital, Fortifying Capital, Actuation Capital, Equanimity Capital, and Confounding Capital. Her early awareness of race, racism, and the importance of representation penetrates her experiences that lead to the use of all but one capital, Mathematical capital; in this area, Brandy reinforces her love of the subject with strategies to address new complexities in the content.

Expectation Capital

Until middle school, Brandy remembers her classes and peers being fairly diverse and her teachers, although mostly White, were supportive. Things changed when Brandy tested into advanced math classes, finding herself in a space where she was one of two Black students, she being the only Black girl. She remembers feeling isolated. She also recalls a growing awareness of race and racism around that time. She explained, "And, you know, I think, that was the moment when I really thought about … race and how … people perceive me in the world". She recalls her first time truly struggling in math. As the only sophomore in her AP Calculus class, Brandy remembers how excited her teacher was when he announced to her Precalculus class that she would be taking his AP Calculus course the next semester. The announcement was particularly remarkable as the teacher later mentioned that he had never taught AP Calculus

before. This fact became evident once the semester began. Brandy commented on the teacher's frequent lateness and how often it appeared as though the teacher would use the first twenty minutes of class time to decide how to teach the content. By the middle of the semester, the class average was a C/D. Many students, including Brandy, became anxious. Concerned over her anxiety and frustration, Brandy's father requested a meeting with her teacher, but the outcome took her by surprise. Brandy's father told the teacher that Brandy hoped to be a math teacher, which was why this class was so important to her. In response, the teacher first blamed Brandy's young age for her poor performance, continuing that she does have math talent which would be wasted by being a teacher but that "teaching is best for women. Because of the short hours they can get home and take care of things in the house". Brandy was livid at the sexist statements made by her teacher. She felt that "students don't deserve this…. they shouldn't have a teacher that's gonna say sexist things in a classroom environment". Determined, Brandy told herself, "well, I'm going to be a teacher anyway. And I'm going to be better than you are. I will make sure that kids get a better teacher". This was the first instance of expectation capital in Brandy's story.

Once Brandy became an undergraduate student, Expectation capital was a strong motivator in moments of difficulty. Sometimes the difficulty was from realizing that there were some content gaps in her math learning, other times it was from feeling isolated in large classrooms filled with unfamiliar faces. In addition, the weight of being one of the only Black people in predominantly White spaces was pronounced when conversations in education classes centered around students of color. Brandy shared, "I felt really alone in that…I also hate feeling like I'm the one who has to say something because I'm the only black student in the room. Like it shouldn't be my burden to take on". When the burden became too much to bear, Brandy sought

out her advisor, having decided to change her major. As it became clear to her that there was nothing that interested her more than math education, she decided to tough it out. Brandy had to regularly remind herself that “I really had to keep that motivation of like ‘by doing this, you're going to help students’”. Being a teacher is important to Brandy, not only because her father is a teacher, but because teaching is one way to help students.

There is another reason why Brandy chose to continue the push to become an educator: Brandy frequently reflected on the fact that she had very few Black math teachers of any gender throughout her journey.

> And so I really wanted to… make sure that maybe more students would get to have a black math teacher by having me …, and maybe being able to encourage other students who maybe want to be teachers, other black students to … continue. I think that was the thing that kept me going throughout that time. Just … because I just know that representation is so important

When we recall how Brandy was captivated by seeing a Black girl doing math on a television show, it lets us know that representation, or the absence thereof, was something that young Brandy had been thinking about, even if she did not have the words to articulate it. In addition to wanting to be a good teacher who helps students, Brandy believed that it was important for Black students to see Black math teachers, and this kept her pressing towards licensure. With expectation capital, Brandy was determined to be one of those Black teachers.

Mathematical Capital

Brandy’s earliest and fondest math learning experiences were outside of the formal education spaces. She frequently accompanied her father, a mathematics teacher, to work, and participated in the pre-college STEM program for underrepresented students that he facilitated

on weekends and during the summer. Unlike many of her classmates, by the time she was in middle school, math had become a subject that Brandy cherished. Brandy recalled that, “I just really had a love and interest for math. So… it didn't really matter to me about…when am I going to use this because… [it is] exciting in and of itself”. Throughout her journey as a math learner, Brandy looked for ways to engage with mathematics in a multitude of ways. She fondly recalls one of her middle school teachers who often related mathematical content to his own experiences at work or in travel. By using examples like the St. Louis arch as a real-life parabola when teaching about quadratic functions, Brandy felt that the teacher “really emphasized to me the importance of applying and like showing students the application side and not just talking about math, in … an abstract context”. Perhaps because Brandy’s introduction to mathematics was through its applications in her father’s summer camps, her teacher’s ability to connect abstract math concepts with concrete math applications resonated with Brandy. It reminded her to draw on physical applications of math, whenever possible, to enhance her understanding of the abstract.

Brandy is also a talented writer, and she soon discovered that she was able to convey this other passion to her mathematics studies. Brandy glowed,

> I actually really liked proofs a lot. I think because… it's like combining, like, writing with math… I really like to write. For me. It was like, easy to like, logic my way through a proof … kind of read it out, figure it out

After having struggled through some math courses earlier in her undergraduate pursuits, Brandy was refreshed to be able to leverage her strong writing skills within a mathematical context.

Through the various uses of mathematical capital, we see that Brandy’s experience as a mathematics learner is enriched by forging connections between pure mathematics and its

applications, as well as by drawing on other skills to find new ways to communicate, and understand, mathematically.

Fortifying Capital

Although Brandy encountered loneliness and isolation in her mathematics and education courses, she mentions several sources of support, or Fortification capital. First and foremost, Brandy has strong family support. Since her father is also a mathematician and educator, he was her first stop when she needed help with math content. Brandy shares that

> most of the time I asked my dad at home because he taught geometry. I think a bit of algebra too. So… a lot of times I would … go home and ask him questions, and he would have … old textbooks and stuff that I could use and look through

Brandy also looked to her family for help beyond mathematics. As a student attending a PWI at the height of the George Floyd protests, racial tensions and discussions were fore fronted in her classroom experiences, particularly in her education courses. She explained that "I would usually call them on the phone sometimes when stuff like that happened [and] be like, 'this is crazy' and they're like 'Yeah'..., because they also had a lot of those same experiences when they were students". Since her parents are alumni at her university, Brandy felt that they would be able to understand and give context to her experiences.

Brandy also found support outside of her family; she discovered that her peers could also be helpful. Brandy first learned the benefits of having supportive peers when she started high school. Unlike her middle school years where she was at a more diverse school, her high school had a predominantly Black student population. Brandy said that "...once I got to high school, I would ask my peers [for help] a lot more because like I said, it was mostly black". Even though

Brandy was the youngest in her math classes, which were filled with upperclassmen, she felt a sense of comfort and belonging. She stated that she had

> seniors asking me like, 'hey, like, do you understand what's going on here? I don't know what's going on'. So it made me feel like I can also ask other people, I didn't feel as though … I have to prove myself or anything like that…at least for those first two classes [in high school], I definitely felt like I connected [with] community and…it was easier for me to ask for help or not know something.

By being surrounded by students who looked like she did, Brandy was able to let go of the imposter syndrome that had begun to develop. She also felt safe to "not know" and to seek help: she no longer felt the need to prove to her teacher or her peers that she deserved to be in these advanced math courses.

When Brandy was in Calculus II, as an undergrad, she was happy to find a supportive peer in her class. Early in the course, Brandy realized that there were some content gaps in her knowledge which initially made things difficult. She found this to be tough

> because I had to… go back and …relearn all these things. One of my best friends who I've known since sixth grade and we were lucky enough to get there [to the same university] all throughout middle and high school for the most part. I was like asking him like 'hey, so like what is this ? …or like, can you help me?' so we would study together.

The added benefit of this peer support was that Brandy had known this student since middle school. She knew that this student would understand where she was coming from and could relate to what she was feeling. She knew that, together with this familiar face, she could strive to review missing math content.

There were other occasions where peer support was key for Brandy. One such occasion was in a math class where she was assigned to a partner, notably a White male. Brandy fondly remembered that she

> didn't like [feel] judged…it was interesting. Oftentimes, I've had like, White men in my classes value my opinion, more so than White women in classes. So I've actually had really great experiences with working with White men in my classes, which I think is really interesting… So yeah, … we really worked well together

Brandy noticed that, when taking STEM classes for non-STEM majors, she was frequently questioned and challenged by the White women she was placed with, even though she had greater comfort and ability with the mathematics content. Having her contributions valued by a peer that was so different from her greatly improved her learning experience because she felt like her intelligence was validated.

Brandy also found strength and support in faculty and staff at the university. When Brandy was about to take a Calculus II test, she was visibly nervous. She remembered that,

> one time right before a test, I was … super stressed out and … anxious and she could …tell and she said 'you're gonna do well… I believe in you' and … even after I took my test… like the next class period, she was like' how do you think it went?' And that was just really sweet and made me feel really encouraged.

Where Brandy would usually turn to her family, she was delighted to find words of encouragement coming from staff members at the university. Brandy could feel her circle of support expanding. Brandy's experiences with fortifying capital are a strong counter to the loneliness and isolation that is commonly felt by Black girls in STEM spaces.

Actuation Capital

Brandy did not shy away from taking action in an attempt to sustain her persistence in her math courses and with the licensure program. She used her knowledge of university systems to locate assistance and to make curricular selections that were to her benefit. As a calculus III student, Brandy took advantage of the university tutoring services, giving her tutorial support through the course. Brandy elaborated that she "met with him every week for the rest of the semester. So that helped a lot too. Because he really … made sure [I understood], he was like ' draw this out, so that way you can see it". By working with her tutor, Brandy had someone committed to ensuring her understanding of the concepts and who also showed her visual strategies to ameliorate problem solving.

During course selection, Brandy became more proactive in deciding which differential equations section to enroll in. She used a university tool that allowed students to see the student reviews and average student performance for various professors, followed up with her father, an alumnus of the university, before making her picks. Brandy shared that she

> looked up … all the differential equations professors…one of the professors…was a professor [my father] had and he was awful. [My father] told me 'do not take this professor…I don't care…If he's the only professor that teaches the class like you need to take something else'...And so I found a professor that had really great reviews… So I was like 'Okay, I'm gonna take this'. It was … a night class. But he was like, the sweetest old man.

Rather than just selecting the course based on desired time frame, Brandy chose instead to seek out instructors who had favorable reviews from previous. The fact this professor taught the class at night did not detract from the good experience Brandy went on to have as his student.

Brandy learned, courtesy of the pandemic, that she actually thrived in virtual classes. She credited this to the fact that she

> wasn't looking around to see… how many Black people are in the room or…what the diversity looks like because most people have their cameras off…I think it made me okay with asking questions… I didn't have to worry about [being] judged. I wasn't worried about… asking a dumb question or …being seen as…that dumb, Black girl that shouldn't be here…So I really loved my virtual math classes… I did really well in that class.

The anonymity that online classes afforded allowed Brandy to give more focus to the math. Brandy went on to select online classes whenever possible. Lastly, due to the painful experiences that made her almost abandon the math education path, Brandy decided to balance her courses with something that brought her joy. "[I] decided to add a minor in English to…help balance out some of those math and science classes". By adding the minor in English, Brandy's courses would be a combination of courses that afforded more creativity, which she felt was lacking in the mathematics instruction she had been receiving. In the few examples shared, Brandy demonstrates the ability to take decisive action to alter her circumstances either by using her knowledge of university systems and the support services they provide and by altering her curriculum of study to include courses that offered the creativity that she craved.

Equanimity Capital

In addition to being a Black woman, Brandy's faith is a significant part of her identity. Even as Brandy was applying to graduate programs, she emphasized the importance of her faith by stating that "there's always…this… intersectionality of … also, being a Christian, and … having that religious identity, and what that looks like for me". Brandy was excited when she "joined an on-campus ministry called Black campus ministry and so specifically for black

students" because not only could she engage in her faith practices, she felt that the Black campus ministry gave her a space to speak openly about the racial climate in the wake of the George Floyd protests. Brandy explained that

> [the ministry leader] would make time …talk about …the… of racism we were experiencing on campus and … challenges of being one of … 200 Black students on campus. So it just was really helpful to have … all those little spaces that were really helpful for me to debrief in.

The exercise of her Christian faith also brought her into a space where she could contextualize her experiences in the context of her faith and her Blackness, both critical parts of Brandy's identity.

Confounding Capital

Early experiences with race and racism made Brandy delight in confounding naysayers. Brandy's excellent academic achievement was recognized with access to advanced courses and also in the receipt of awards. Brandy recalls that, in middle school, she received the award for most improved student, which was unusual in that this award typically goes to low performing students who made astonishing growth. Brandy's parents, who were in the crowd, later made Brandy aware of the comments they heard from other parents in the crowd: apparently, many were shocked that a Black girl had earned the highest score in math. According to Brandy,

> there were some undertones of … racism, like 'oh, wow…that black girl got…the highest math score out of all these kids'…that…really stuck out to me… I mean…it's sad, but like, at the same time, I kind of… enjoyed defying expectations… or proving people wrong.

The incident almost dampened Brandy and her family's excitement that Brandy had accomplished a rarity. Brandy did not let that happen. She decided to revel in the knowledge that she had disproved the negative thoughts and expectations surrounding her race and her academic ability.

Around the same time, Brandy realized a growing needed to prove that she was worthy to receive help from her instructors, tracing the genesis of that feeling to engineering classes taught by

> this older white man who was very racist…even though he wasn't my math teacher, I think I translated…the experiences that I was having in there and... him making me feel like I was different or didn't deserve the kind of help that my white peers got…it made me …take that kind of mindset into math and say 'Okay, I need to … prove that I'm supposed to be here and like that I can actually do this.

This often caused frustrated evenings of homework, working harder to make sure that she was even more prepared for the next day's lessons. The heightened awareness of the negative expectations about Black girls and their mathematical ability contributed to some of the anxiety Brandy experienced in her undergraduate math courses but she took time to reflect: she reflected on the fact that she is a legacy student at a PWI, earning a degree at no personal cost as she was a recipient of met-based scholarships, learning in buildings named after people "did not believe that black people belonged anywhere and white spaces". When she put all that in perspective, there

> was …a sense of pride for me in some way. …Even when I would have those interactions in classes where I felt like people weren't listening to me or people weren't valuing me…I

> think that was a helpful reminder to be like ‘you know, you, you've already defied the expectations. just being here is enough.

Confounding capital not only helped Brandy to stand firm against negative racial stereotypes, both spoken and implied, it also gave her the perspective and the resolve to press on towards the goal. Her persistence then becomes testament to her defying adverse expectations.

Brandy’s story of persistence highlights an acute awareness of racial and gendered stereotypes that infiltrate mathematics learning spaces, and a resolve to be a part of the solution. Compelled, through expectation capital, to become one of the Black, female mathematics teachers that future Black students will encounter, Brandy leans into mathematical capital to indulge her love for mathematics and actuation capital to effect changes to painful or uncomfortable learning experiences. Brandy is reassured that she is encompassed by support from within (equanimity capital) and without (fortifying capital) and, when all is said and done, she reminds herself that she has already confounded racist attitudes.

Scarlet’s Story

Scarlet’s earliest memory of learning mathematics was watching her father sitting at the kitchen table. Scarlet explained that her father was

> an extreme budgeter and penny pincher... I would remember sitting down and watching him at the kitchen table…writing out how much he had to put aside for the rent and how much he had to do for this and that… he was a calculator; he would just do it himself.

When she began formal education in the public school system, Scarlet’s academic vigor quickly landed her in advanced courses from as early as elementary school. When Scarlet started middle school, her mother, who was a public-school teacher at the time, made it clear that she had a specific vision for her. Scarlet revealed that her mother “decided she wanted to send me to a

private school, so that I could get the foundations that I needed so that I could transfer back into public school, and then get the scholarship to go to university". Scarlet's mother knew that Scarlet would need a competitive advantage to get into a good university, and this advantage was not available in the public school system at the time. For the first time in her life, at this private school, Scarlet felt hesitant in her mathematics class.

> I had never doubted how intelligent I was when I was in [City] public schools, but when I got to private school, and they were doing algebra, I started to feel stupid because I didn't understand what they were teaching,

Scarlet remembered. The first time Scarlet had to attend summer school was in the sixth grade at this private middle school. Attending summer school did not make things much better for Scarlet as she still did not understand what was being taught. She thought this might have been because "they were trying to teach … in a different way…it just didn't make sense to me". Starting middle school at this private school began to erode Scarlet's confidence in her math ability.

Scarlet's time at the private school offered another new experience: it was the first time she personally experienced racism. Scarlet's public-school classes were filled predominantly with Black students, but at this private school, Scarlet's minority status was profound. She experienced many instances of racial aggression and microaggressions. In one case, when Scarlet came to school in box braids, a student asked how her hair could have grown overnight and subsequently pulled out one of her braid extensions. A particularly painful experience was when Scarlet was getting dressed at the back of the gym, hiding because she had become self-conscious about her appearance, she overheard two Jewish girls talking about her, saying things like "she's so stupid…and that stupid nigger this and that stupid nigger that". When Scarlet made her presence known, the girls apologized, to which she responded, "you're not sorry because you

are sorry, you're sorry because you got caught". Although Scarlet had never been able to put words to racism, this moment became the definition of racism in her mind. This was also the moment that Scarlet began to internalize painful experiences. Scarlet suffered more racist indignities when she attended summer school and summer camps, usually with the same students at her private school. Scarlet's parents enrolled her in summer school each year because her teachers said that she was falling behind in math. Looking back, Scarlet said that

> if they had explained it in this way, I would have gotten it, but I think there was probably an expectation that I would have been at a certain level …it was just like 'this is how you do it'...not even this is why this is how you do.

Scarlet realized that she needed more explanation on why certain things were the way they were, but her teachers did not teach that way. Scarlet did not feel as though she could talk to her teachers, and, since she was the only Black girl in her classes until she got to the ninth grade, she also felt isolated from her peers.

During her time at the private school, Scarlet was also diagnosed with a chronic disease that would lead to further medical complications. Scarlet was often sick, missing significant instructional time. While her performance in other classes did not suffer as much, Scarlet's math performance, and her math self-efficacy, plummeted. Scarlet recalled that she "did well in all my other classes… but when it came to math, ... I just gave up". Scarlet remained at this private school until the end of her sophomore year, returning to the public school system as a high school junior. This transition had a different effect on Scarlet. "I remember feeling bored because a lot of the things that I had done in private school were so beyond what they were doing in the public school", Scarlet shared. Even though Scarlet was now ahead of her peers in math, her medical condition continued to take its toll on her academic life. Upon graduating from high

school, Scarlet took an extended hiatus from academic pursuits due to her ongoing medical difficulties, the severity of which caused her to almost give up on her future. Scarlet worked full time while continuing to receive medical treatment until a woman from her community urged Scarlet's mother to convince her to get a medical coding certificate at the nearby community college. Scarlet enrolled in that program, completed it, and decided to become a medical assistant, mainly because she "was afraid of what that was going to mean in terms of math if I want to be a nurse, and I was like if I'm a medical assistant, I'll have to do the least amount of math". In time, Scarlet rekindled a relationship with math, which encouraged her to transfer from the community college to one of the top private universities in the state. Although she initially enrolled in the biomedical engineering program, Scarlet changed her major to secondary mathematics education.

In Scarlet's story, we will see five capitals at play: expectation capital, mathematical capital, fortifying capital, equanimity capital, and confounding capital. Her expression of each capital is interwoven with her earlier experiences as a learner in both public and private K-12 institutions.

Expectation Capital

Scarlet's expectation capital is expressed first as a wish to give her future students a better math learning experience, and next as a desire to create a better future for Black students like her. Until her mother enrolled her at a private school, at the start of middle school, Scarlet had been in advanced classes with students who looked like she did and who, like her, did not really struggle with new math content. At the K-12 private school, however, Scarlet found that the differences between herself and her classmates were more than skin deep. She found that her peers were learning content that surpassed what she would have been learning at the public

school. She also found that she was not able to learn math content because of the style of delivery used by her teachers. She hated the fact that the teachers would present content "without explanations…or why it would be useful". Perhaps it was because her first exposure to math was watching her father use it within various contexts, but Scarlet knew that she needed something more than what her teachers were willing or able to provide.

Scarlet did as much as she could on her own, but she knew that she, and probably other students, needed something that wasn't commonly offered, especially in a public-school setting. For this reason, Scarlet wanted to become a teacher so that she could "teach them the why, instead of the how, so that they can make it applicable to anything". To that end, she hoped to "design a curriculum that teaches kids, not the formulas, but how to understand the problem, to use the tools that you have to figure out the answer". Scarlet was compelled by a desire to ensure that other students, especially students who learn the way she does, will have access to a mathematics classroom where the teacher is intentional about delivering instruction holistically. Her ultimate goal is to create a "STEM academy that uses … music and art…to teach so [students] have practical applications". According to Scarlet, art and music are "things that the kids like to do, but the school system has taken out of the school to cut costs". In the school she hopes to create, Scarlet would leverage the experiences that students enjoy into their mathematical learning.

Scarlet has a more intimate reason for persisting towards secondary mathematics education: she wants Black girls like her to have a better future. Enrolling at the private middle school coincided with the onset of Scarlet's medical trouble. Scarlet went from being the class clown in advanced courses at urban schools, to being the isolated Black girl struggling to fit in with her mostly White peers in a private school setting. Coupled with the simultaneous onset of a

chronic medical condition and adolescence, Scarlet was overwhelmed with all that life was sending her way. During her freshman year of high school, Scarlet eventually had a couple of Black girls in her class, and she did her best to fit in. Alas, Scarlet's status as a loner continued. Scarlet expounded that the girls would make her

> feel different because they would always be talking about like this boy or that boy…they would give my phone number out when they didn't want to talk to somebody…they would pick on me … and they would make fun of my clothes.

Scarlet endured more humiliating experiences in the hope of finally being accepted by someone, even painful romantic relationships. Scarlet shared that

> a lot of stuff happened to me, which unfortunately is what happens to a lot of black girls and in urban settings, so my motivation was you know, I don't want to see a black girl go through what I've gone through, and I want them to believe in themselves.

Beyond the teaching of mathematics, beyond the creation of a curriculum and academy that would incorporate music and art into mathematics instruction, Scarlet wanted to make sure that Black girls would have a better future and a better sense of self. Scarlet told the story of a young Black girl at the community center, a girl whose mother was a drug addict. Scarlet would have the girl run errands to earn some money, money which would inevitably be claimed by the girl's mother to pay bills. Scarlet was sure that this girl was probably enduring other ills that Black girls in urban communities experience (e.g. forced adultification and sexual abuse); While she did not go into detail, Scarlet explained that she knew, firsthand, about these experiences. Scarlet wanted to "make the world a better place than I found it and to try to help as many young girls not have to experience what I did to get to where I am now". This mantra defined Scarlet's expectation capital.

Mathematical Capital

Scarlet's mathematical capital appears first as an appreciation for the connectivity between mathematics and other STEM subjects, how math appears in daily life, and how math can be enhanced by the infusion of creativity into mathematics activities. Scarlet's introduction to mathematics is couched in a warm story about watching her father at the kitchen table. She remembered him tackling the budget and even investing in stocks and bonds for Scarlet and her siblings. This early math experience nurtured Scarlet's curiosity for the application of mathematics across STEM subjects and more.

Overwhelmed by the chronic health condition she was diagnosed with when she was in middle school, Scarlet's mathematics enthusiasm and her general zest for life suffered. She graduated from high school and made her first attempt at going to university but, because she was "in an abusive relationship… I was missing class, and I also failed that semester because of that relationship…and then I just dropped out altogether". Her medical condition did not improve and, after about eight years of hospital visits for treatment, Scarlet said that she "literally was just waiting to die". About ten years after graduating from high school, a woman from the community recommended that Scarlet enroll in classes at the local community college. Scarlet grudgingly started and completed a medical coding degree. Scarlet said that she "did really well in it… there wasn't any math involved". Scarlet's math self-efficacy suffered the most because of her chronic illness, causing her to avoid math as much as possible. Scarlet went on to complete another program that certified her to do administrative work in the medical field. With all her medical struggles, Scarlet decided that she wanted to be a nurse, a decision that concurred with her life-saving organ transplant. Before she could realize her enrollment in a nursing program, Scarlet's new organ failed but she "was still determined to do what I have to do". Within the first

two semesters of the program, Scarlet's faltering math self-efficacy resurfaced in her remedial math class. "What did you expect? You don't remember any of this. You don't even really know what you're doing", Scarlet chastised herself. The intervention of her teacher led to a successful finish followed by more successes, prompting Scarlet to change her major to biomedical engineering. This will be explained later in the section.

By the time Scarlet transferred to a university, it was becoming clear to her that "even though biomedical engineering was cool, like I really liked the math of it". In her biomedical design class, Scarlet's attention was on "how you use differential equations to figure out how you can like to work from the time domain to the frequency domain and things like that so that you can make the devices work". With each math class she took, Scarlet grew more enamored of the interconnectedness of the various strands of mathematics. She concluded that "if you can understand what the math is doing, you can use it in anything". Scarlet's belief was solidified when she "had to take a statistics class, and then I saw in statistics and probability how calculus is used in both". Around this time, Scarlet had started working full time at a community center that her mother founded. When she started working with children who would come to her for math help, it became clear to Scarlet that what she really wanted to do was to teach mathematics to children. She found that studying math education gave her broader access to seeing all the ways that math permeated other subjects and industries. As the math classes she took grew in sophistication, so did Scarlet's resolve to "try to find a mathematical or scientific way of understanding why this process...has to happen that way". Scarlet declared that "math to me is a cornerstone of everything, and if you can understand that you can understand anything". As long as Scarlet was able to find the math in a situation, she was able to persist through math and STEM courses.

In addition to seeing math connectivity across content, Scarlet also found that she learned better when she was able to engage with math using different learning modalities and when she could infuse some artistic creativity and expression into math activities. By the time Scarlet joined the math education program, she experienced a resurgence in her math enjoyment which helped her to persist. “I found that I've had a lot of opportunities to take my artistic skills and use them in doing my assignments”, Scarlet effused. She described how using “things like Illustrator and Photoshop allows me to think mathematically about how I'm going to create something”. Scarlet gave an example of an assignment in a math methods class, where students were to watch a teacher’s recorded teaching segment and provide a summary of the teacher’s math instruction. Rather than simply writing the summary, Scarlet “took the video and overlaid it with commentary about what the teacher was doing, because that allows me to do the assignment but also to be creative about it”. Being able to express herself artistically in the process of engaging with mathematical content and activity keeps Scarlet immersed in her learning and in her progress towards licensure.

Scarlet’s mathematical capital began as happy memories with her father which awakened an appreciation for the connectivity of mathematics across other academic content. Scarlet took pleasure in discovering new ways to engage with mathematics, adding a creative flair to math activities when the opportunity presented itself. This enjoyment was instrumental in bringing Scarlet back to higher education, specifically into the secondary mathematics education program, and helping her persist through her math courses.

Fortifying Capital

Fortifying capital does not play a strong role in Scarlet’s story but there are a couple of instances where she did activate this capital by relying on an encouraging professor. Starting

when she attended the private middle school, Scarlet did not get very involved with her teachers; her negative experience with the teachers at the private school she attended trained her to give them a wide berth. By the time she went to community college, Scarlet was accustomed to figuring things out on her own. However, a couple of professors were able to pierce Scarlet's protective shield. Scarlet told the story of her linear algebra professor who "recognized that I was different but put it in a positive light". She liked his class because he "was simple in what he was explaining. Like, he wasn't like, using convoluted terms". When Scarlet had to retake an engineering course that she failed, she happily took it with the professor who taught her linear algebra and passed. Scarlet had a similar experience with a professor when she transferred to the private university; this professor taught her geometry for teachers course. Scarlet already valued the fact that this professor taught using simpler language, similar to the way that she thinks and speaks. On that merit alone, Scarlet happily signed up to take his problem-solving class, but what really set him apart was that he recognized that "people have different ways of learning and different ways of solving problems, and like he recognizes that and celebrates it". In the rare occasions that Scarlet encountered faculty who appreciated her uniqueness, Scarlet not only experienced success in their courses, but she also looked for other opportunities to thrive under their tutelage. These professors accepted and nurtured her uniqueness, thereby supporting her persistence and her identity as a mathematician in her progress toward licensure.

Equanimity Capital

Scarlet's equanimity capital was revealed both as a decision to be self-sufficient and in her spirituality. Scarlet's self-sufficiency was first witnessed when she transferred from the public school system to a private school, at the beginning of her sixth-grade year. To ensure that Scarlet would have every advantage to access a top private university, Scarlet's mother decided

that the private middle school was the best choice. Scarlet's mother also made sure that she participated in every summer camp that Scarlet's classmates attended. Although all these decisions were for her benefit, Scarlet's social and emotional well-being suffered.

Recall that Scarlet immediately became an outcast at the private school because she was Black, because she did not come from wealth. As she had attended an urban public elementary school, Scarlet discovered that the students at this private school (who were mostly White) had already learned math content to which she was just being introduced. Scarlet found it difficult to grasp math content as it was delivered by her teachers, but she did not feel comfortable asking the teachers or her classmates for help. Scarlet was alone. "I really didn't even talk to my mom and my father about what was happening…I just, I didn't really know what to do", Scarlet confessed. She did not tell her parents that she was being bullied by her classmates, or that her classmates hurled racial slurs at her. She endured the bullying during the school year, and it continued when she went to summer camp with the same girls. It was also at this time that Scarlet was diagnosed with a chronic disease that caused multiple sick days or visits to the hospital. 11-year-old Scarlet made a tough decision, "I just,... I gotta go to school… I just gotta figure this out on my own… I didn't know who to go to for help".

From then on, Scarlet often took matters into her own hands. Because her parents were at work, Scarlet became responsible for getting to and from her medical appointments. This meant "walking myself to the train station…at five o'clock in the morning when it's dark outside and walking myself home from school, but it's dark outside, by myself", Scarlet explained. While she accepted that her parents might have been busy, Scarlet noted that "a lot of times in urban communities, that's what happens…kids are asked to be adults before they're actually adults". With premature adulthood foisted upon her, Scarlet continued to take care of matters on her own.

She had little guidance from her family when the time came to apply to college or to pay for the SATs.

> I pretty much had to go figure out how to pay for my SATs and go take my SATs. I pretty much had to figure out how to do my FAFSA without providing my parents information. I had to figure out the admissions process,

Scarlet detailed, although she did receive some direction from her guidance counselor. Although Scarlet had an older sister, she did not reach out to her for help. She felt that her sister's advice would not be helpful since her sister had made, and was still making, poor life decisions.

As mentioned earlier, after her long hiatus, Scarlet finally enrolled in a community college and, eventually, to a private university. When she took calculus I at the community college, Scarlet felt that her teacher left much to be desired. Scarlet said that she "I taught myself and then …I just was like,'Well, this is kind of cool'....and I started to get better grades". Encouraged by this triumph, Scarlet was able to continue to get better grades as she progressed from community college to the university, succeeding in calculus II, calculus III, and even differential equations. In most of her math classes, Scarlet did not have any assignments or projects that required a partner, so she was quite content to work alone. When she started taking math education courses, Scarlet saw the return of some of the biases that marred her middle school and early high school experiences at the private school. In her geometry for teachers course, Scarlet was paired with a White man who, having already obtained a graduate degree, was now pursuing a teaching license. When the professor announced the pairing, Scarlet "saw on his face that he was like, 'Oh, I have to work with her?'". Subsequently, the student would not respond to Scarlet's requests to meet so that they could work on their assignments. After repeatedly approaching the professor about the situation, to no avail, Scarlet just had to present

what she had prepared. Their presentation lacked cohesion, and the content confused their audience. Scarlet, again, decided that “if I don't have to work with people, I won't…I'm just like ‘fuck it!’. I'm gonna do what I'm here to do”. Whether she was abandoned by a partner or whether she needed more than her professor could give, Scarlet relied on herself to persist through her math classes.

Lastly, Scarlet had one more manifestation of equanimity capital which was a deeply held spiritual belief. Although she does not ascribe to any particular religion, Scarlet recognized an important commonality in a number of religions that she holds dear. Scarlet shared that “if you sit down and you read the holy books, you see that it says that greatness is inside of you…and that's the Torah, the Koran... the one for Buddhism...they all say the same thing…greatness is inside of you”. Not only did Scarlet remind herself of this belief during the times when she felt looked down upon or undervalued because she had a different way of thinking mathematically, she shared this with the students she worked with at the community center. This was an important anchor to Scarlet’s ability to be self-sufficient. Scarlet’s equanimity capital allowed her to navigate isolation and bias in her math classes. She knew that she possessed, within her, everything that she needed to make it through.

Confounding Capital

Scarlet’s confounding capital took one form: defying expectations. Scarlet suffered repeated blows to her self-esteem when she started middle school at the private school, both academically and socially. Coupled with the chronic illness that was a blight on her attendance record, Scarlet was a shadow of her former self. Her peers made fun of her looks, and her teachers did not think she was academically strong. She lost faith in her mathematics ability and, when she did resume her education, Scarlet did her best to avoid math classes or any major with

a significant math requirement. Even in her work at the community center, Scarlet often dealt with people who underestimated her and her leadership, thinking that she "was just going to be a pushover…was going to be easy…was naive". When Scarlet returned to community college and rediscovered her brilliance, she began rebuilding her crumbled self, physically and emotionally. Scarlet began to practice "self-care and self-love, like you know, like I said, I like my wigs. I like my nails…I get my nails done every two weeks, I get my lashes done every two weeks". Although Scarlet's appearance did not conform to common, biased impressions of a mathematician or an intelligent individual, she happily welcomed this false perception. Scarlet explained that there were several times when her classmates underestimated her because of her colloquial manner of speaking. "I can understand what's being said to me in mathematician speak, and I can articulate it in mathematician speak, but my preferred way of speaking is every day", Scarlet revealed. She continued with a story that occurred in her secondary methods class. The class has been asked to present the solution to a problem where they had to determine how many handshakes would occur if, given that there were 20 people in the room, each person had to shake everyone's hands. When Scarlet presented her solution and how she got it, one frustrated classmate accused her of having used a formula. He could not believe that Scarlet had succeeded where he had failed. Scarlet was pleased because her classmates "didn't expect what had happened, they didn't see it coming". Scarlet further elucidated that she is undaunted when people deem her unworthy or lacking when they see her, stating that

> I'm adamant about keeping my style. I have a gazillion tattoos. I like my nails to be long. That's what I want…I want you to walk in a room and assume one thing…and when I open my mouth, and I speak, it's something completely different.

The glee of confounding those who underestimated her kept Scarlet reaching for greater success, thus enabling her persistence.

In Scarlet's story, we see how she uses expectation capital to plan for a better future and mathematics experience for her future students; she uses mathematical capital to immerse herself in learning and thinking about mathematics by seeking interconnectivity while infusing artistic creativity. Scarlet also finds nurturing support in math faculty who recognized and lauded her unique way of reasoning mathematically. Lastly, Scarlet's equanimity capital compelled her to reach within for the help when none could be found in her peers and teachers, and her confounding capital confirmed to the naysayers that she was, indeed, a mathematical force with which to be reckoned.

Gabi's Story

Gabi's earliest memory as a mathematics learner was in a formal setting as a kindergartener. She recalled the vibrant, colorful classroom and the reading corner. Gabi also remembers that she already had a good handle on the basics of math (counting and multiplying) because "my parents taught me a lot". Although Gabi's father never graduated from college, he had been a math major and was a capable mathematician. Gabi remembered sitting at the dining table with her two older sisters, doing math drills under the tutelage of her father. Gabi and her sisters were all mathematically gifted, but they also excelled at other subjects. "I was really good at everything…everything was really easy for me", Gabi explained, but being smart drew negative attention from her peers. This led to the bullying that overwhelmed many of her memories of elementary school. Gabi's identity as a mathematician was defined by how little she had to do to get excellent grades, and by how much she enjoyed doing math or solving math-related puzzles.

When, halfway through her fifth-grade year, Gabi's parents got divorced, Gabi, her mother, and her two sisters moved to a different city to live with her grandmother. Moving to a new school is never easy, especially when you have just started middle school. At her old school, Gabi was one of three Black girls in her classes. At her new school, there was a larger Black and Hispanic presence and yet, according to Gabi, "I don't know why, but it made things worse". Where she used to get picked on for being smart, she was now getting picked on for being different from the other Black students. Gabi explained that she stood out because "I'm smart. I don't get in fights. I don't yell and I don't cuss." which are stereotypical "Black" behaviors. Gabi further shared that "I wasn't accepted by the black community, I was accepted by the white community, which is why they called me an Oreo, because I was more white than I was as black". Her focus on high academic achievement meant that she did not exhibit the stereotypical "Black" traits; Gabi found herself alienated from the people that looked like her.

By the time Gabi went to high school, things had changed. Gabi's academic prowess (demonstrated by getting high grades) earned her a place at an early college. Her new classmates were also academically focused, which Gabi found to be a great point of connection. Gabi's academic life improved significantly because her classmates accepted her as a fellow academic giant. The added benefit of her enrollment at this early college was that, by the time she graduated, Gabi had also earned an associate's degree.

In Gabi's story of her mathematics experiences, we see her use five capitals: expectation capital, mathematical capital, fortifying capital, actuation capital, and equanimity capital. Gabi is the only participant who was an in-service teacher at the time of the interviews, having graduated just a few months earlier. In her story, we catch a glimpse of how her use of capital flows into her activities as a licensed teacher.

Expectation Capital

For as long as she could remember, Gabi had wanted to be a teacher. We saw this desire evolve as Gabi's expectation capital became an integral part of reshaping her academic expectations. Gabi's persistence is initially fueled by her love for teaching; it then takes on a new form as negative encounters with teachers prompt her to prepare to be a better teacher to her future students, ending with the ultimate hope for Black students to have a better relationship with mathematics.

Gabi has several family members who are teachers, specifically her great grandmother, her aunt, and other distant family members. While this was not the reason that she decided to pursue a degree in mathematics education, Gabi proclaims that "I just wanted to teach! Not because they were [teachers], just because!". This focus on her future career as a teacher helped Gabi remain on course to licensure, even when she experienced some academic setbacks during her first year at university. Having completed Calculus I and II while at the early college high school, Gabi's first math course at university was Calculus III. She quickly realized that the habits that led to success at the early college high school were not enough to experience the same success at university. "[in] early college, I studied [just]enough to where I understood what I was doing…when I came to university, I did practice work and I thought it was fine… it was a hard adjustment". At the early college, doing practice problems was enough for Gabi to understand the math content, but practice problems alone were not enough to get by at university. Gabi was no longer getting the high grades that once came so easily, high grades that had become her defining characteristic in elementary and middle school. Gabi knew she had to adjust her expectations in order to keep going. She humbled herself by accepting that she may never get the top grades that she used to. Rather than being focused on getting high grades, Gabi explained

that she “wasn't geared on like, making like A's, I was more expecting them to teach me…how to teach math”. Gabi reminded herself that her larger purpose in the program was to be able to teach math to students, not just to get high grades for personal gratification. This adjusted focus helped her retain her math self-concept. By shifting her focus from obtaining high grades to learning how to teach math to her future students, Gabi was able to continue her journey towards licensure with an attitude that drove her persistence.

Gabi’s expectation capital became enhanced as she reflected on some of her experiences when she moved to a new city, and new school, in the middle of her fifth-grade year. Gabi had become accustomed to the bullying from some of her peers because of her outstanding academic performance. While all this bullying was taking place, Gabi recalled that there was no teacher support for her. In one story, Gabi talked about a Black boy who frequently made fun of her or tormented her. In one particular interaction, his offensive comments began towards the end of math class and continued as the class transitioned to the social studies class. Upon entering her social studies class in tears, Gabi noticed that the teacher “didn’t say anything about it…she didn’t point it out, she didn't help me. She just kept going with the class”. In fact, her math teacher had also made no effort to intervene. Gabi did not want other students to feel unseen by their teachers. Once at the university, Gabi’s goal of becoming an educator was sharpened by the need to “meet my students' needs before I even teach them mathematics”. This mindset was reinforced by the education courses she took at the university, when she learned about Maslow’s hierarchy of need. As Gabi continued with her university math courses, her commitment to be a better support to her students gave her the added prodding she needed to keep going through the increasing difficulty of university math courses.

Once Gabi transitioned to student teaching, the final pieces to her expectation capital were defined. She wanted her students to feel encouraged, and to not be dissuaded by setbacks like what she had experienced in calculus III. She wants her students to see their "self-worth in a math classroom… math is for mistakes and not for you being perfect". Gabi wants to create a classroom environment that is forgiving of mistakes and that encourages students to see themselves as mathematicians. When Gabi thought back to how she felt when she was alienated by her Black peers because she was academically talented, she knew that she also wanted impress on her future Black students that "I want them to see … math is not just for like, what they think math is for, like a white male…it's also for them… and I hope they recognize that". Gabi wants her future Black students to realize that it is okay for them, as Black people, to do math and to do it well.

Gabi's mission to become an educator grew from an earnest desire to teach, becoming a higher purpose of helping all students find the mathematics classroom to be a safe place for them to learn, to be seen, and to make mistakes. Most importantly, she wants her Black students to see that there is no conflict between being Black and being a mathematician.

Mathematical Capital

Gabi's interest in math began when she would watch her older sisters as they sat at the dining table, working on math problems with their father. As the baby of the family, Gabi's father was less strict and more encouraging with her, so her introduction to mathematics was pleasant, fostering a positive relationship. As a result, the expressions of Gabi's mathematical capital are derived mainly from a love and interest in mathematics.

Gabi shared about how she used to love getting headaches in her math class because "I saw that math was a puzzle, and I love puzzles. So getting a headache meant that I was learning.

And I would leave class with a headache, but I was happy about it". Where others would be deterred by the intense experience in the math class, Gabi relished the challenge math offered and felt a sense of satisfaction at the manifestation of the effort she put in. Even though the transition from high school to university caused some academic setbacks, Gabi did not let that diminish her love for math. There was a point, during that first year at university, where Gabi had even begun to question her identity as a mathematician. In the past, Gabi felt that her high grades made her a mathematician. When she started getting lower grades in her university math courses, Gabi questioned whether she was indeed a mathematician. She was enrolled in a math programming class and discovered, to her delight, she enjoyed being able to use computer programming to solve a variety of math problems. Gabi realized that "[she] loved playing with numbers, and sequences and matrices and algebra, and calculus, I love all of it". Gabi's identity as a mathematician was restored when it became clear to her that, while she wanted to learn so that she could teach others, she enjoyed mathematics for what it was. When the time came for Gabi to take statistics, something she dreaded, she was surprised that she performed much better than she expected.

Through the ups and downs of advanced mathematics courses, Gabi's mathematical capital restored her identity as a mathematician and transformed her experience in math courses that used to cause her to tremble. Mathematics was something that brought her personal pleasure and contentment.

Fortifying Capital

Gabi's earlier experiences of being bullied when she was in elementary school caused her to shy away from interactions with certain people, causing her to opt for isolation. When her parents' divorce prompted the move to a new city and new school, things seemed to become

worse as she felt that her teachers would not help her. While working toward secondary mathematics licensure, however, Gabi learned that peers, faculty and staff, and family were sources of fortifying capital.

Gabi's discomfort around her peers, when she moved to middle school, was more painful because the worst of the bullying came from other Black students. Gabi felt that her alienation from the Black community at that time was because she was smart, and because she did not epitomize the negative stereotypes about Black girls. Things changed when she got to high school as Gabi gained admission to an early college program, spending her days with like-minded peers who enjoyed academic pursuits. Her math classes encouraged group interaction where Gabi and her classmates would "work [on problems] together... compete to see who finished faster, that kind of stuff. It was fun!…if we didn't get it, our peers would explain it to us…and if you're not passing, we're going to help you". Outside of the classroom, Gabi participated in a multitude of extracurricular activities where she eventually made friends with girls who were "weird" like her. Having herself been considered weird, she found a kinship with girls who were "silly, interested in different topics that other people aren't interested in…yeah, just anyone different". This was the genesis of Gabi's fortifying capital.

When Gabi left home for university, she, at first, felt lonely since she was away from her family and her friends. She was one of two Black girls in her program, and she was one of the only freshmen in her math classes since she had completed Calculus I and II at early college. Things started looking up for Gabi in her geometry class because she "was in a math class with two other girls who were also educators…so that helped". Progressing from university mathematics courses to mathematics education courses, Gabi declared that "those were places where I felt like, 'Great! I'm in a community' and though they don't look like me, they're still in

my community and [we'll] work together on stuff and figure it out together". Similar to when Gabi started at the early college, Gabi found it easier and better to learn with people who, like her, were committed to being educators.

Gabi's family was always a source of support even though she was far from home. When she had academic setbacks, her family still encouraged her and urged her to keep trying. When she began to question whether she was suited to being a math educator, Gabi had frank discussions with her aunt and grandmother who were also educators. "They didn't tell me to stop, even though my grandma was just like financially, it's not the best career goal, but if that's what you want to do then go for it. They still supported me either way". Knowing that her family would be there for her, regardless of what decision she made, helped Gabi focus on doing whatever she decided was right for her.

During her student teaching assignment, Gabi noticed that she had been assigned to the only other Black math teacher in the school, who also happened to be a woman. Gabi was also amazed at how "black or brown students understand me, they respect me, partly because I'm black, partly because I respect them too". Upon further reflection, Gabi remembered that she had been taught some undergraduate math courses (at the early college) by a couple of Black female math teachers. "I guess I saw them doing [math] and I was like, I can do that. I can do this because you can do it. And if they weren't Black, I still had that mentality, but they were Black so I talked to them more", Gabi explains. Seeing a Black woman teaching math helped her see herself as mathematically capable, and Gabi also felt more comfortable talking to them. This is especially significant when we recall that Gabi had stopped seeing teachers as someone who would help when her middle school math teacher and social studies teacher failed to intervene when she was being bullied.

Once she had finished her university math requirements, the majority of Gabi's courses were held within the college of education. Here, Gabi was surrounded by helpful and encouraging faculty and staff. Gabi recalled that, during that rough first year at the university, she would "go to her room and cry a lot…and she would hear me out and everything…that really helped". Gabi also fondly remembers the education program coordinator as "so understanding and so open about everything…She listens to me …she's done so much for me like even as a black student, even as a woman, she makes sure like I was mostly supported even with our differences". The community that Gabi felt she had found with her fellow preservice educators extended to the staff and faculty at the college of education.

Far from the alienation of her early years, Gabi's fortifying capital became multifaceted. She learned that she could find friendship and academic companionship with peers in her college of education community; she learned that she could be the Black math teacher that other Black students could identify with, just as she had identified with her Black, female math teachers; and she learned that the faculty and staff at the college of education were a helpful part of her educator community.

Actuation Capital

Gabi's actuation capital is evidenced in her ability to turn to a personal passion in order to balance or mitigate the pain caused by a present predicament. The persistent trauma due to being bullied by her peers taught Gabi to seek solace in order to continue towards her goals.

We first saw this capital in action when Gabi was in middle school. Gabi's passion for art was so great that she is convinced that, had she not wanted to be a teacher or a mathematician, she would have been an artist. Art has a vital role in Gabi's life. She shares that the bullying she experienced in middle school made her feel isolated. She did not want to bother her mother who

was coping with the divorce, or her older sisters were themselves being bullied at their schools. The overflow of the pain led to periods of self-harm but, according to Gabi, art "helps me calm down, or, like, get my thoughts out". When she did not feel that she could tell people, even her mother, about the bullying, she turned to art to give her a safe outlet.

Gabi continued to stay connected to artistic pursuits, whether through participation in the art club when she was at the early college, or painting in her dorm room at the university. During the most trying times of her first year at university, especially when she was in Calculus III, Gabi turned to painting. In one of her pieces, Gabi drew a tree that was "growing from the heart…It's like growth or like... feeling …whole", reminding her that trying moments were opportunities for growth. She also has several paintings with stylized apples, a popular symbol of the teaching profession. Through her painting, Gabi maintained her focus on becoming a teacher.

As a student teacher and, later, a licensed teacher, Gabi continued to paint during her personal time, but also with her students. When she noticed that her students were becoming worn out and distracted, Gabi shared that she "still make[s] them do math, but understanding like [sometimes] you need a day". Gabi brought in paint supplies and let her students share in the artistic catharsis.

Gabi took action to overturn painful academic experiences by immersing herself in her personal passion for painting. She now actively models the use of this capital with her students.

Equanimity Capital

The Equanimity capital in Gabi's story was demonstrated on the occasions when Gabi chose to fend for herself rather than reaching out to other people for help. It was also visible in action in her exercise of her Christianity and, lastly, in her resolve to find a way to be comfortable in uncomfortable situations.

Gabi's use of equanimity capital began as a result of her parents' divorce. When her parents got divorced halfway through Gabi's fifth grade year, Gabi, her mother, and her sisters, moved in with their maternal grandmother for financial reasons. At her new school, Gabi was being bullied by her peers, so she did not yet have friends to take away the sting of that bullying. Gabi, who would usually confide in her mother about everything, decided to start keeping things to herself. Gabi disclosed

> I [didn't] want to add more stress to my mom, so I did not talk about it as much. I mean...a little bit … but I kept most of it away from her. As much as I could… I'm good at holding stuff in.

With their mother still grappling with the impact of the divorce, Gabi and her sisters did their best to help and to not be a burden. To Gabi, this meant not adding any more things for her mother to worry about, so she did her best to take care of her struggles on her own. Gabi did not tell her mother about the bullying until she was filling out the application for the early college program but, by then, choosing to be self-sufficient had become a habit. She talked about how she limited her interactions with her teachers ever since two teachers failed to intervene when they saw her being bullied. In her advanced math class, while in middle school, Gabi revealed, "I didn't talk to those teachers. I worked it out the best I could myself and we had like feedback at the end". Gabi continued this habit until her second year at university, when she made a friend in her geometry class. "I'm pretty sure I worked on my own. I made one friend in that class, I think, but COVID hit". Gabi's self-sufficiency was not a preference but, rather, a necessity for persistence.

Gabi's equanimity capital took another form, which was the exercise of her Christian faith. Gabi is a devout Christian and being a part of a Christian community was important for her

spiritual well-being. Her faith was even more significant because she believed that it was God who told her to teach as a profession. “I went to church a lot, and heard God be like, "teach!", Gabi expounded. When the difficulty of her early math classes made her question her ability to become a math teacher, Gabi remembered that moment and wondered

> did God really say that? But I was like, if he didn't say that, he'll push me in another direction. If he did say it, well, let's go!... I'm here and it's still working out…I'm not going to question it because something wrong happens.

Gabi’s faith in God was such that she trusted that He would nudge her to change her direction if needed. As no such nudge occurred, Gabi continued her journey to licensure.

Finally, Gabi demonstrated her equanimity capital in her resolve to weather discomfort. Her negative experiences with her Black peers in middle school made her a little concerned when she was about to receive her student teaching assignment. Gabi shared

> even if I moved to a black school, I still might feel alienated…I've experienced [being] called an Oreo just because I'm different, and so I feel like either way I'm going to have to deal with some form of feeling like I'm different, and I know that I am.

Gabi has come to accept that there will always be people who treat her badly because she is different. She accepted that she was different, and, in this acceptance, she found comfort in situations that, ordinarily, would be unbearable. As a side note, when Gabi earned her license and was placed at her first teaching assignment at a middle school, she was surprised to find that her Black and Brown students accepted her and respected her. She marveled that she had finally been offered the acceptance that had been denied her when she had been a middle school student.

In Gabi’s story, we saw how the bullying from peers, and the passivity of her middle school teachers birthed the use of expectation, actuation, and equanimity capital in a protective

manner. We also saw, in Gabi's use of fortifying capital, the unraveling of the alienation that marked the period of bullying so that Gabi saw herself as someone who was surrounded by people wanting to help. Lastly, Gabi's mathematical capital made math more precious to her because she realized that math was more than something she needed for her career; it was a personal source of pleasure.

Yvonne's Story

The common thread in Yvonne's early memories of math is the friendly competition with her peers. Yvonne remembers when, in kindergarten, "we were learning how to say our numbers … in the thousands and then ten thousands… and we took that as a competition", and then by the second or third grade, her teacher would split the class into teams. She and her peers would compete for prizes by answering math questions. Yvonne admitted that she "fell in love with it then because I was good at it and I was able to grasp the content really quickly", and thus began her relationship with mathematics.

From kindergarten until her senior year in high school, Yvonne attended schools that were predominantly Black and Hispanic. Although these schools were classified as Title I schools, Yvonne formed helping and trusting relationships with her peers and her teachers in this environment. Even if there was friendly competition, Yvonne and her peers would help a struggling peer, especially with math since, according to Yvonne, "all of my peers were relatively good at math". Yvonne also lived in the same neighborhood as many of her peers and so, she would invite them over for dinner, promising that "we can do the homework together and it's really like I'm about to play school". Her favorite thing to do was pretend to be a teacher, so much so that, during the summers, her aunts would send her cousins over to her house because they knew that Yvonne would make sure they got their summer work done. Her cousins dreaded

this but, Yvonne gushed, “that was just always exciting for me to do”. From an early age, Yvonne knew that she wanted to be a teacher.

Yvonne is the middle child, sandwiched between two brothers. Yvonne was proud to share that she was not a first-generation college student as both her parents were college graduates, having both attended predominantly White universities. The love of STEM is shared among her family members, although Yvonne and her father are math lovers while her mother and brothers favor the sciences. When the time came for Yvonne to decide where to go to university, her K-12 experiences at predominantly Black and Hispanic schools, coupled with the ringing endorsement from her older brother led to the decision to attend a Historically Black College or University (HBCU). Yvonne’s older brother regaled her with stories about the HBCU he attended, telling her about how he had a teacher that would call him to make sure he came to class. Yvonne had always loved the family-like feel of her K-12 life and she wanted the same at her university. Yvonne said that she

> knew I wanted to be comfortable where I was going to spend the majority of my life for the next four years, and then knew that the support I just wanted that support that I knew everyone else was talking about that you get from [HBCUs]... that family aspect.

For this reason, Yvonne chose to attend a university that was in a different state from her home state, but she was excited for the journey.

In Yvonne’s story, we see how five capitals demonstrated: expectation capital, mathematical capital, fortifying capital, actuation capital, and equanimity capital. Although there was some conflict between Yvonne’s expectation of an HBCU and the reality, she was still able to rely on her capital to support her persistence through her undergraduate math courses.

Expectation Capital

Yvonne's expectation capital was revealed two ways, the first as a focus on her future career as a secondary math educator, and secondly as a desire to secure better math learning experiences for her future students. Yvonne had known that she wanted to be a teacher since she was in elementary school, but this idea solidified specifically when she was in the fifth grade. She explained that she had a teacher, Ms. F, who "really focused on mathematics. So I feel like that's also what kind of drove me to love math so much". Like many other students in the U.S, the fifth grade is where Yvonne's teachers were content specialists. Yvonne loved how Ms. F took "the time to teach us skills outside of just the curriculum that she was told to teach us…[it] was very rewarding", and she credited Ms. F's contribution for her own decision to "stick with math". Yvonne described how Ms. F used a school fundraiser as an opportunity to extend students' learning by making them responsible for various aspects of the fundraising endeavor, from making sales, to offering coupons and calculating costs and revenue. When Ms. F had to undergo a surgical procedure that required significant recovery time, Yvonne and her classmates were assigned a new teacher. But Yvonne would continue to email Ms. F. Yvonne cringed at the

> old emails that I would send her…reading it is so cringy because I'm a fifth-grade student bothering her at this time. And she was just like, 'when you go to middle school, I know you're gonna take all the math honors courses and everything.

Ms. F made herself available to young Yvonne and continued to encourage her while she herself was in recovery. Yvonne was profoundly inspired to be a math teacher just like Ms. F.

Yvonne would go on to have more exemplary teachers when she got to middle school and high school and one characteristic that these teachers shared was that they were all supportive. Yvonne stated that she and her peers "had a lot of support within teachers and even

teachers that were not really your teacher, but in the same grade, that you can go to and ask for help". Her teachers were supportive and made room for students to ask questions so that they would not hesitate to ask for help. When Yvonne got to university, she was disappointed to find that her math professors did not share this characteristic. In her numerical methods class, Yvonne had to restrain herself from challenging her teacher about his teaching methods. Yvonne described one instance where her classmate, a bright physics major, asked the professor to explain the steps he had taken in an example. The professor "asked her a really basic question and she answered it, of course…he literally started jumping up and down clapping his hands… he's like, 'Oh my gosh...at least she knows something'...that offended me". Yvonne felt that students deserved to have teachers who did not ridicule them for having questions, but that made the classroom environment safe for them to inquire. Yvonne held back from giving this professor a piece of her mind because "he controls my grades and…I just did not want to get on his bad side" as it could hinder her progress. She did, however, remain adamant that "you should not be a professor…. [if] you don't create a safe space for your students". Yvonne was going to be a better teacher than this professor had been to her.

Yvonne's first experience with geometry was in her sophomore year at high school, and admittedly was not a fan. "Me and geometry are just not good friends", Yvonne expressed. Having told her teacher that she hoped to be a math teacher, her teacher asked about the math courses Yvonne hoped to teach. "I would love to teach calculus and algebra", Yvonne replied, only to be informed that most first year teachers are likely to be assigned to teach geometry. Undaunted, Yvonne knew that she would need to work harder for better understanding of geometry. During her sophomore year at university, Yvonne was, once again, in a geometry class. Although she still was not a fan of geometry and continued to struggle with the content,

Yvonne appreciated that the course "seemed like a refresher of geometry", giving her another chance to strengthen her geometry. Later, when Yvonne was enrolled in a class designed to prepare students to take the Praxis math content exam, Yvonne placed greater emphasis on geometry practice problems, not only because it would be on the licensure exam, but also because geometry would probably be her first teaching assignment.

Yvonne's excitement to be a teacher encouraged her to continue to reckon with a subject that was her least favorite, motivating her to give geometry added attention so that her success with her licensure exams would be assured. Additionally, her distasteful experience with the numerical methods professor reminded her that she was going to be a teacher that creates a better learning environment for her future students, just as her K-12 teachers had done for her.

Mathematical Capital

Yvonne demonstrates her mathematical capital in her expression of love for the subject as well as her ability to detect and leverage the connection between various aspects of mathematics. Yvonne's love for mathematics began in elementary school, a love initially fueled by the discovery that she could grasp mathematical concepts with little difficulty. As Yvonne engaged with more complex mathematical content, her love for math became more defined. Yvonne is captivated by the dynamic nature of math, and the sheer variety of options when trying to solve a problem. Yvonne is tenacious when a problem proves to be complex, proclaiming that

> the challenge of that alone is what I love about it…it might take you a day or two days or three days, and then you finally get to the end to find a solution…that alone just draws me into it.

Just as she enjoyed the friendly competition with her peers, Yvonne relished the journey towards a solution to a math problem. Because of the thrill of the challenge, Yvonne enrolled in AP

calculus in high school, even though she had met the math requirements to graduate. She explained that “we didn't have to take calculus…you could have chose[n] to stop your math journey at calculus, but I wanted to try AP and get the college credit if I could”. Yvonne tried and succeeded at acquiring the AP credit for calculus.

As a university student, Yvonne’s love and interest in math overshadowed the complexity because she was always won over by learning more facets of mathematics. When Yvonne took discrete math, she gushed that she “loved it...it was something I've never seen before, so that was also really cool. But the math content was just interesting. I really enjoyed that!”. Yvonne was briefly stymied when she took a proofs class because she could not reconcile having to use sentences to explain math. Yvonne repeatedly wondered “why are we writing sentences and words and everything with math? Why am I proving this?”. Once the alien nature of the writing was overcome, Yvonne found that she, in fact, enjoyed the various approaches to writing proofs. By the end of the course, Yvonne claimed that “I love writing proofs now…so that was a really good course”.

Yvonne’s ability to make math connections was fostered in high school. Being in the habit of saving all her notes from year to year, she would frequently dig through them when she encountered something familiar. This was the earliest use of leveraging content from past classes as a bridge to understanding the present. When she was a junior in high school, Yvonne would ask her teacher for help when she was stuck on a problem or a concept. Her teacher would guide her with a reminder about when Yvonne likely learned the concept, followed by “do you recall this from geometry or algebra?”. The guidance her teacher provided gave Yvonne a better roadmap for correlating the various parts of mathematics. Yvonne became more intentional

about noticing patterns as she learned new content. She felt that this habit prepared her for calculus at university.

Yvonne described a time in her calculus class when she had been wrestling with a problem in her homework. When she was beginning to be strained from the exertion, she took a break. During that break, she remembered how her high school teacher taught her to refer to prior content to gain insight into her current problem. Yvonne then

> started to pull stuff from past classes……started to make connections from that math course or past math knowledge to new things. So I started using other courses as well, just the connection between things that we're learning throughout our years.

Yvonne was able to stitch together related content which helped her overcome the homework problem that had her stymied. Yvonne maintained this habit in future math courses.

Yvonne's mathematical capital began as a love for math, for the challenge it offered, its complexity, and its nuances. Yvonne added a new expression to her mathematical capital when she, inspired by her high school teacher, reached back to content learned in previous math courses to create new understanding. With this, Yvonne progressed through increasingly sophisticated undergraduate math courses.

Fortifying Capital

We see Yvonne's fortifying capital take four forms. The first form was an appreciation of the support received from a community of peers in her classroom; The second was the help she receives from her family members; the third form was the comfort and ease of communication she experienced with teachers with whom she shared racial and gender congruence and, lastly, the support and encouragement from faculty and staff at her institutions of education.

One of the reasons Yvonne decided to attend an HBCU was because her entire K-12 journey had been in schools with a predominantly Black and Hispanic student demographic. Yvonne's classes were filled with students of color, and this created a cohesive school environment. Yvonne mentioned that, in her middle school math classes, "if you weren't grasping something, [there] was someone next to you that will assist you". This communal spirit made it easier for students to ask each other for help without fear of ridicule. Yvonne also explained this bond was made stronger by the years of familiarity the students had with each other. Because "a lot of people I went to elementary school with…went to the same summer camp, we went to the same middle [and] high school…we just always had that bond", Yvonne shared, and this bond continues today as she is still in contact with many of these students.

Once Yvonne got to university, she began to notice the students who were in a STEM education program because they ended up in the same classes. When Yvonne specifically mentioned the impact of having a fellow secondary math education student in her classes, she said

"me and her have been in the same courses since freshman year which I love because we see that we're both on the same track with everything. So I'm a lot more comfortable asking for help because, these students, I've seen since I've gotten to [University]".

This closeness was invaluable especially when Yvonne and this other student were taking numerical methods with a professor that would chide her friend whenever she asked a question. Yvonne was frustrated that this professor was making the class environment uncomfortable but, because of this peer support, Yvonne and her friend worked together to be able to have a successful finish. They could talk about their experience with this professor, finding solace in their shared suffering.

The second form that Yvonne's fortifying capital took was help from family. Yvonne, as a middle schooler, had heard so many scary stories about what being in high school would be like. At one point, she even thought it would look like the school in the movie Lean on me in which a teacher was sent into a low performing urban school rampant with drug and narcotic activity. While she knew that the content would be more difficult, she was afraid of what she did not know. Yvonne decided to "[try] to become as prepared as possible. I asked my older brother questions, my mom, my dad...just trying to prepare for that". Her family was able to allay most of her fears.

In the time between high school and her first year at university, Yvonne sought the help of family instead of her peers. Yvonne had been placed in honors math classes in middle school, but she did not make it into honors classes in high school because of an adaptive, standardized test for the selection process. Yvonne claimed that, historically, she did not perform well on standardized tests, thus losing her place in honors classes. Although Yvonne knew that her peers would always help her if she needed it, she struggled with her identity as a high achiever when she was no longer in honors classes in high school. Yvonne was conflicted about reaching out to her peers, even though she knew they would help. She realized that she was used to being the person that people sought out for help, and not the other way around. Yvonne said that she "kind of frowned upon asking for help, especially from peers. Because, though…we weren't in competition…we had honors classes and regular classes. …so it's like, well, if I'm not in honors anymore, then what does that make me?". This hesitation to ask for help continued when she started university, where Yvonne "struggled silently or asked my parents when I got home". Since her parents and her older brother were STEM focused, she knew she could at least ask her father for help with math or mother or brother for help with science. Yvonne eventually

rekindled her communal relationship with her peers in math classes, but during this time she relied on her family.

The third form of Yvonne's fortifying capital is racial and gender congruence. Although Yvonne's elementary, middle, and high school had high populations of students of color, the teacher demographic did not mirror this. Yvonne remembered that she had her first Black teacher, who was also a woman, when she was in the first grade. She said that she "really felt that connection with her…because I was able to see myself in her…she was my first African American teacher and she was another woman at that, so that was another thing that drew me into her". Yvonne also remembered that this teacher would speak wisdom and encouragement to all her students, which placed her firmly in Yvonne's heart. Yvonne's eighth grade math teacher was also a Black woman who, in addition to building their math foundation, taught her students key lessons. For example, due to the accent that people of her culture have, Yvonne's teacher made sure that her students embraced their unique accent "but let us learn how to code switch…to [know]how to present yourself outside of your home" so that they could feel comfortable in any environment.

Yvonne explained that "as a child, …we gravitate to adults that look like us. They represent us… being a woman alone already had the upper hand in my life because I'm like, 'Okay, like you're basically mom!'", revealing that female teachers, especially, Black female teachers inhabited the place of "mother" in her mind. She further clarified that seeing a Black female teacher strengthened her own resolve to be the representation that these women were for her. Yvonne shared that these women were her role models and that "I'm comfortable to ask any question, whether it's about math or outside of math". The ease Yvonne felt around female

teachers, particularly Black female teachers, helped her overcome her hesitation in asking for help.

Yvonne decided to go to a HBCU because she assumed that the teacher demographic would look more like that of the student population. She was surprised to find that this was not the case, especially in the math department. “I kind of assumed a lot of my professors would be people of color, which they are not right now”, Yvonne revealed. Although she admitted that her math teachers, for the most part, were helpful, Yvonne yearned for the family environment that she believed was characteristic of Black teachers and women teachers. When Yvonne was struggling with Calculus III at the university, she reached out to her high school math teachers, with whom she maintained contact. All Yvonne’s high school math teachers were women and about half were Black women. Her high school calculus teacher, who was White, was especially helpful in supporting Yvonne through Calculus III.

Finally, Yvonne learned that faculty and staff at the university could be helpful resources. As mentioned previously, Yvonne assumed that since her current teachers, who were not Black as she expected to be the case at an HBCU, that they would not be as helpful as her Black teachers in high school had been. She discovered differently when she took a math programming class. Yvonne did not enjoy computer science when she was in high school, so she was not pleased when she had to take a math programming class at university. “I just don't like it… why are we doing this as math majors?”, Yvonne said, as she described her struggles with this course. On the verge of failing, Yvonne remembered a student telling her that “the math department, they love to take care of you…[if] they know you're a math major, they're like, ‘Okay, we're gonna make sure we get this grade up’”. Yvonne approached her math teacher, who allowed her to retake some tests and to do test corrections, so that she could make it through that

programming class. Yvonne could now attest to the support of at least one teacher in the math department.

Yvonne's fortifying capital began with the support from like-minded peers from elementary school to middle school. Although this expression of fortifying capital faltered briefly between high school and her first year at university, it resurfaced by her sophomore year. She was able to rely on her family during the times when she did not feel comfortable asking her peers for help. While Yvonne was more comfortable with teachers with whom she shared gender congruence, and most comfortable when the teachers were Black and female, she still learned that the faculty and staff at her university could also be a part of her success team.

Actuation Capital

Although not heavily featured in her story, Yvonne does leverage actuation capital to support her persistence in an undergraduate math course. When Yvonne was accepted at her university, she also applied to be a part of a program for students with STEM majors. The reason she applied for this program was that it not only made her eligible for certain scholarships, but it also provided mentorship. An added benefit of the program was that scholars were able to move on campus "a little earlier to… bond with each other and learn about the campus so that when classes start, everything seems a little bit smoother". This made Yvonne feel less apprehensive once her classes started. Yvonne discovered the true value of the program much later in her program.

Recalling earlier, that Yvonne had been at risk of failing her math programming class. She remembered that "within the sky tech program, we have a lot of tutors…so I knew that 'Okay, I need to get some tutoring right now!'". Yvonne needed this course for her program, but she also did not want to lose her scholarship; so much depended on a successful outcome in this

course. Although she still has much to learn about coding, Yvonne was able to pass this class and continue towards math teaching licensure. Yvonne's membership in this university STEM program gave her access to resources like the tutoring and mentoring program, while also easing her transition to university by helping her bond with students who shared a common major. Yvonne's actuation capital is demonstrated in understanding the intricacies of university systems and using them to her advantage.

Equanimity Capital

Yvonne's equanimity capital is revealed in her choosing to be self-sufficient when she was not getting what she needed, and in her decision to find a way to tolerate discomfort. Yvonne was required to take two successive courses to prepare students for the teacher licensure exams. Each course was facilitated by two instructors, one responsible for math content, and the other for math pedagogy. Yvonne found herself at odds with the math content instructor's decision to just do a series of practice problems. She expressed that "I feel like…if the professor would have taken all of the practice tests and look[ed] and see, percentagewise, what area we need to focus on a little bit more, that would have even been better". Yvonne felt that she and her classmates would have benefitted from a more intentional approach to deciding focal content in this preparation. In the second course in the series, Yvonne felt that the instructor's approach, which echoed that of the content instructor in the first course, would hinder her preparation. The urgency was amplified because she was required to pass her content exams before she could begin student teaching. Yvonne did not want anything to stand in her way. When the facilitator suggested that students could strengthen their individual weak areas by tutoring other students, Yvonne grudgingly acquiesced to be a tutor so she could work with students who needed help in geometry. She applied to be a tutor, paid and unpaid, but she rarely was assigned a student who

needed help with geometry. Finally, Yvonne decided that she would have to take control of her own preparation. She "just took that time to practice on content…I've just been using outside sources. I ordered some practice books from Amazon to make sure that I'm at least helping myself". Yvonne applied the approach that she felt should have been enacted in these two preparatory classes. While she could see the value in tutoring others, she knew that she would not be able to get the focused attention that she needed unless she took matters into her own hands. Yvonne felt much better about that decision.

The final expression of equanimity capital was seen when Yvonne learned how to be comfortable in situations that were uncomfortable. Even though Yvonne spent the majority of her education journey in institutions with predominantly Black and Hispanic student demographics, she had frequent reminders that the country looked very different from what she saw in her classes. While all the schools she attended were classified as Title I schools, it was not until high school that there was a greater presence of White students. Yvonne commented that there were

> a lot more White kids there, which is fine. But our valedictorian, my senior year, was an African American female and then the years prior, they were Hispanics, which I love because you know, people of color, you know, we got it.

Knowing that this academic representation was not common in other spaces, Yvonne was proud when the students from historically marginalized populations showed their academic excellence. The prevalence of students of color at her schools did not shield Yvonne from negative racial stereotypes from one of her teachers. Yvonne had enrolled in an AP English course which she dropped because of an offensive interaction with her teacher. When many students in the class had performed poorly on one test, the teacher said that "if your parents read to you when you

were a child, then maybe you will be doing better in my class". Yvonne was particularly affronted because she "felt like it was kind of like a jab, like black people can't read or something… that's how I took it…I felt like that was kind of her putting her race on a pedestal compared to everyone else". Yvonne appreciated all the support her parents gave her educationally and could not abide anyone discrediting their efforts. In retrospect, Yvonne said that "now that I'm older, I don't really put that on her as a person. I just feel …she's just ignorant when it comes to, you know, racial knowledge". Although furious, Yvonne chose to view her teacher as ignorant rather than intentionally racist.

Yvonne hoped that the university environment would be more like the family-like space that her middle school and elementary school provided. What she discovered was that there would always be someone who reminded her of the world in which she would soon be employed. She spoke of one White male student in her proofs class that would disrespectfully challenge the professor, "questioning the professor on facts…[it] got a little bit annoying, because … just basically disrupting the class with your own opinions about things". Yvonne remembered seeing similar behavior in White students in her middle school and high school classes. She was more surprised that these students had the gall to be openly condescending when they were the minority in her school. Yvonne realized that "they just …view the world like that they were a majority in that space". It seemed that, even in spaces where they were few, White people might still see themselves as superior to other races. Yvonne's contemplation led to the epiphany that she needed to become comfortable with discomfort. "I learned to … try to find a way to be comfortable in discomfort, if that makes sense", Yvonne declared. She expanded that she was aware that she will have White colleagues who may also see themselves as superior to her, "So I kind of have to be okay with being in that type of setting …but being

comfortable with discomfort doesn't equate tolerating disrespect…those two are two different things". Remembering the teacher who claimed that her parents had to read to her growing up, Yvonne made a clear distinction between accepting the discomfort in a situation and accepting disrespect. Yvonne resolved that, in time, she would "have a better understanding of how to be fully comfortable in those settings, but also not allow that setting to mentally destroy me". Yvonne would keep exercising her equanimity capital not only to make it through her preparation program, but also to protect herself once she becomes a licensed teacher.

Yvonne used equanimity capital to take control of a learning situation that was not meeting her needs, which could compromise her performance on one portion of the licensure exams. Yvonne also learned that her comfort was not guaranteed once she was teaching in the real world and committed to finding ways to be comfortable in these tense situations.

Yvonne's story shows the five capitals that she used to help her make it through undergraduate math courses so that she can continue towards her goal of becoming a secondary mathematics teacher. Her expectation capital sharpened her focus on the career that she had wanted ever since she was in elementary school and helped her commit to being academically and professionally prepared to inhabit the role of teacher. In hardship, Yvonne's mathematical capital, demonstrated by a love of math and a desire for a connected understanding of mathematical concepts, reinvigorated her efforts when presented with new or difficult content. Her fortifying and actuation capital revealed just how much support and resources Yvonne could tap into and, lastly, Yvonne's equanimity gave her the fortitude to withstand uncomfortable situations without losing her sense of self and self-respect.

Nyla's Story

Nyla's earliest memory of learning mathematics in a formal setting was in kindergarten. From kindergarten until second grade, Nyla received separate math lessons from her peers because her teachers kept finding that "the material wasn't challenging [her]". Nyla also remembers being aware of the different ways in which her teachers responded to her accelerated pace of learning. Where her first-grade teacher once called Nyla's mother to complain that Nyla was leading the class, her second-grade teacher would give Nyla math content from the third grade. The second grade was also when students were grouped by ability and so Nyla also began meeting with the AIG coordinator from that point on. Nyla offered a little more context to this experience, sharing that "I grew up in a very white area, and so I was the only black kid in my class… not just black girl, black kid". In fact, until middle school, Nyla was the only Black student at her school.

Middle school brought another change to Nyla's academic life: there were no more classes to accommodate her advanced learning. Nyla became bored, and then talkative. Her frustrated sixth grade teacher called home to report that Nyla was disruptive, because even placing Nyla next to the quiet students would not stop her from talking. Nyla admitted that "since I wasn't being challenged, I was very bored so overall my interest in school went way down". Things became interesting again when she began taking algebra in the eighth grade, but this enjoyment was dampened because Nyla's teacher, an early career teacher, was having difficulty trying to meet the varied academic needs of Nyla and her peers. Needless to say, there was another phone call home.

By the time Nyla got to high school, she once again had access to advanced classes, with math teachers who presented material in ways that were engaging. She has fond memories of

precalculus and AP Calculus, the content as well as the instructors. Nyla further indicated that, had her high school math experience not been as great as it was, “I don't think that I would have wanted to pursue mathematics, or I definitely wouldn't want to teach math”. Nyla credits the positive experiences with her high school math teachers had on her choice of college major and future career.

Going to college was something Nyla had resolved to do since she was in the third grade. Both of Nyla’s grandmothers were college graduates, and her parents were also academics. “Going to college…that was in the cards”, Nyla discloses. Nyla knew, by her junior year of high school, that she would study math or something with a substantial mathematics requirement. Her decision to pursue mathematics education specifically, was courtesy of her homeroom teacher. Nyla had signed up for a horticulture class as a “filler” because she had completed most of the credits she needed to graduate. The homeroom teacher, who had been Nyla’s homeroom teacher all through high school, asked Nyla if she would like to be her teaching assistant instead. Nyla agreed, enjoying the experience so much that she decided to give teaching a try.

In Nyla’s story, we see expectation capital, mathematical capital, fortifying capital, equanimity capital, and confounding capital in action. Nyla’s story spans two universities and features some of the challenges of being a gifted mathematician from an early age.

Expectation Capital

Nyla’s expectation capital took two forms: a focus on her future career as an educator, and a desire to give her future Black students a better math experience. Nyla became interested in the teaching profession after her homeroom teacher, who taught math, presented her with the opportunity to be her teaching assistant. Although Nyla had never struggled with mathematics content, she has never been a fan of geometry. “To be real, I didn't enjoy that. I don't like

geometry to this day", Nyla reveals. Nyla's first struggle with a mathematics class was for a different reason. Nyla was taking a math education class where the teacher required the students to put themselves "in the shoes of a struggling high school math student". Having never struggled or needed to ask for help in any math class, Nyla had no personal frame of reference. "I really struggled and had to work really hard at doing that", Nyla explains. Amid this struggle, "that was the first time that I realized that, you know, if I'm gonna be a teacher, I have to do that, don't I?". Nyla realized that understanding how a struggling student might think is a necessary skill for an educator who will craft lessons for students with varied abilities. This new insight into her future career altered Nyla's perception of the struggles she was experiencing.

When clinical experiences (e.g. classroom observations) became more frequent for Nyla, she experienced another facet of expectation capital. Unlike the schools she attended, where she was either the only Black student or one of a handful of Black students at the school, Nyla's clinical assignments were mostly schools with high minority populations. Nyla remarks "I got to work with a lot of young Black women in the classes that I'm in. And it's more than the Black woman I would have interacted with when I was in high school". Nyla was pained when she recalled the joy in the faces of the Black girls in the classes to which she was assigned, and their dismay when her assignment was over, stating that "this made me sad...I could tell that they were really happy that I was there, and that it was somebody like them". By their reaction, Nyla could see how much it meant to those Black girls to have seen someone who looked like them in their classroom. This is a constant reminder for Nyla that, beyond math, there is a greater reason for her to continue on this road to licensure.

Nyla's expectation capital is rooted in the need to prepare herself to be a good mathematics educator by accumulating the tools for her future trade. This capital is further

anchored in the significance of her presence as a Black female mathematics educator for many Black girls who, like her, have never had a Black math teacher.

Mathematical Capital

Nyla's mathematical capital manifests as a love for the subject. In her story, we see how her fascination with math predated her formal learning of mathematical content, and how she loves to share what she knows with others.

Before formally learning decimals in the third grade, Nyla (upon reflection) realized that she had been introduced to the concept through an unlikely avenue - Pokémon. Nyla recounted that she "started being introduced to the difference between, adding and multiplying decimals and how that looked and worked" when she began to notice how using two weapons that each caused 50% of damage did not lead to 100% damage. Nyla also laughs that her friends still get tired of her when they play video games together because she "starts getting too much into math". While she had fun playing video games, she was always drawn to the math behind it. In a formal academic sense, Nyla enjoyed learning challenging math concepts. Nyla's disciplinary issues during middle school were due to her boredom in class. Because she quickly surpassed the learning goals outlined by the curriculum, some of Nyla's teachers were unprepared to improvise instruction to accommodate her accelerated learning. Nyla's interest in math and schooling was also being eroded as a result of this boredom. By the time she got to high school, Nyla was able to take advanced math classes which she enjoyed tremendously with a noticeable reduction in disciplinary phone calls to her mother.

One of her favorite undergraduate courses was differential equations. "Everybody hates DiffEQ and I'm like, 'Listen, I'm a DiffEQ defender, Okay?'. I love differential equations", Nyla proclaims. She appreciated the flexibility to use a variety of methods to approach each problem

and happily tutored other students who struggled with the material. While she did not truly struggle with math content as an undergraduate student, Nyla explains that boredom was the more pressing issue. When boredom tries to sneak in, Nyla's motivation comes from feeling like math is a game, stating that "I just really enjoy the game. So, I mean, this isn't hard for me now. It's pretty fun". By immersing herself in the game of math, Nyla kept boredom and disengagement at bay, assuring her persistence.

Fortifying Capital

In Nyla's story, we saw fortifying capital take on three forms: being surrounded by supportive peers, tapping into the encouragement from faculty and staff, and being elevated by the unsolicited recognition of her brilliance.

Historically, Nyla had mixed feelings about her peers. Having grown up in an area where Black people were scarce, Nyla had become accustomed to being the only, or one of the only, Black students in the entire school. There was some degree of camaraderie since she had attended the same school with the same group of people since kindergarten but, on occasion, Nyla was reminded that she was different from everyone else. "I have a lot of respect for my peers…but it was also like, at times, they would throw the fact that I was different in my face, whether that was intentional or unintentional", Nyla began, following up with the example of an exchange she had with a White peer. In middle school, Nyla and one other Black girl from her class were captains of the basketball team and were also on the track team. That year, both Nyla and the other Black girl had broken county records in track and field and a White peer decided that "well, it's because you guys are black!". Nyla allowed some grace that the student had not meant it maliciously, but she was also aware of the negative stereotypes about girls not being good at math or that "Black people aren't necessarily as academically inclined as other people".

As a result, Nyla's relationship with her peers was predominantly one of convenience. Things changed in high school. According to Nyla "it was in high school when I found my friends who liked a lot of the same things that I did, and so more acceptance there". Even though she was still one of a handful of Black students at the school, Nyla felt that she at least had a few people who allowed her to be her entire self. Nyla shared that the university offered a similar opportunity to meet people who made her feel accepted, particularly within a mathematics context. She especially remembered her calculus IV class which Nyla described as "a class where we were all pretty, pretty tight…especially since we had those study sessions, like a lot of us, we got to know each other through that". Nyla and her peers became an informal study group, developing an intimate bond unlike anything she had ever experienced. Nyla, who used to be content studying alone, began to enjoy learning and studying with her peers.

Although Nyla had found a peer community, she still tended to stay quiet in her math courses, perhaps because of the various calls home to her mother about Nyla constantly talking in class. This is why Nyla was surprised on two occasions when her classmates pointed out, with admiration, her strong mathematical skills. The first occurrence was in her modern algebra class when her peers pointed out that Nyla "always [knew] what's going on in that class". Even though Nyla did know what was going on in the course, she was astounded that she had been noticed. The second occurrence was more astonishing. Nyla's study group had met to prepare for their upcoming math test and, the following day, Nyla overheard a conversation between two White boys, one who had been present at the session and one who had not. Nyla was still a little wary of White peers because of her middle school experiences, so she did not expect to hear this White student say that she "was great! She basically tutored me for two hours…she really helped me a lot". The greater surprise for Nyla was that this student said this without knowing that she

was nearby. Nyla was elated to be a part of a community and to have her prowess recognized by other people.

Lastly, Nyla added faculty and staff to the list of people who supported her. Nyla begins by explaining that "at no point during my entire school career [did] I have a Black math teacher or a Black teacher. So, that's like a big thing". This sheds some light on the numerous times that Nyla's mother received phone calls from teachers who were frustrated by Nyla's accelerated learning, overlooking the boredom that she was experiencing. Nyla also told a story about one of her high school teachers, a religious man, who told one of her classmates (who was biracial) that "her parents were going to hell because interracial relationships were a sin". For the most part, Nyla kept to herself until certain teachers and staff showed her that they cared about her. In her Junior year, Nyla experienced some mental trauma that led to her being hospitalized for over a week. Nyla's guidance counselor not only connected Nyla and her mother to resources, but she also remained vigilant over Nyla to ensure a painless return to classes. Nyla was thankful for the atypical closeness that she had with her guidance counselor. Nyla's high school also had an unusual system where students had the same homeroom teacher for their entire high school stay. It was this homeroom teacher (who also taught math) who invited Nyla to be her teaching assistant, awakening Nyla's desire to be a teacher. Nyla claimed that "it definitely helped because …she had known me for four years" because she made the offer to Nyla when she discovered that Nyla had signed up for a horticulture class just to kill time. After making the offer (which Nyla accepted), the homeroom teacher and the guidance counselor worked together to make the teaching assistantship possible. There was also a married couple, both math teachers, who taught Nyla AP Calculus and AP Statistics. In Nyla's estimation, both teachers were authentic, committed to student success, and excited about math. Their commitment to student

success was demonstrated when these teachers offered out-of-school preparation for the AP exams, during which they provided food and snacks which they paid for out-of-pocket. The investment from these faculty and staff members encouraged Nyla to be less hesitant with the teachers she met at university.

Although forming connections with teachers at university was a little more difficult, Nyla was happy to have met one of her teachers, Dr. L, who she got to know better due to a research opportunity. She also appreciated how another teacher, Dr. B would always catch her in the middle of a corny joke like “this is one of the platonic solids…and then I would be like, they're platonic solids because they're all friends”. For a girl who used to get in trouble for showing her comical side in class, Nyla felt embraced in this class because the teacher allowed her to be herself. Both these teachers supported Nyla’s continued engagement in her math courses by allowing her to express who she was and by giving her opportunities to deepen her learning through research.

Although Nyla did not struggle mathematically, her fortifying capital altered her learning experiences by allowing her to feel welcomed and accepted in a space where she usually felt like she needed to hide a part of herself. She felt safe studying with peers, and she felt seen by peers, faculty, and staff.

Actuation Capital

Actuation capital manifested in two forms in Nyla’s story. The first form involved an understanding of the intricacies of the school system, both K-12 and higher education. The second manifestation was the discovery that the anonymity of asynchronous learning was beneficial.

Nyla was actively involved in myriad organizations in high school, on top of which she was on the track team and basketball team while maintaining straight A's. By her junior year, Nyla revealed that she "was just suffering mentally… I was getting super depressed, super burned out. It advanced to a point where I was like, 'I need help!'". Together, Nyla and her mother approached the guidance counselor who provided them with resources and directed them to a therapy organization that partnered with Nyla's school. Nyla was hospitalized for over a week, and, upon her return, she availed herself of these therapy services. The blessing of this school's partnership with the therapy organization, Nyla shared, was that the organization would "have therapists come to the schools and students could receive therapy at a school so it eliminated that barrier of like, 'well, my parents don't have a car'…. I took advantage of that[therapy] about once a week". These weekly therapy sessions helped Nyla explore and understand some of the sources and triggers that led to her depression and burn out. Paramount among those was "I think it was just [the] intense pressure that I put on myself…not meeting your own standards can feel really bad and I think I was starting to not reach my own standards". Nyla learned, through therapy, that she had begun to set impossible standards for herself, constantly pushing herself to do more, to do better. These impossible standards bled into her enjoyment of math, her math identity, and her self-esteem.

When Nyla went to the first university she attended, "one of the things that we went ahead and set up when I went in, was therapy appointments with the students' psychological services". Because she knew that institutions do have services and resources that can help students, including psychological and counseling services, Nyla made sure that she remained plugged in to these services in order to persist with her licensure prep program. Nyla further informed that, once she began her field experiences, the availability of resources for students was

“something that I've asked about when I've gone to clinicals or other schools now”. Realizing how much of a difference it made in her life, Nyla is primed to be aware of the resources provided by school systems to help students like herself.

The second manifestation of Nyla’s actuation capital was the discovery that the anonymity from asynchronous classes was both empowering and freeing. Forced into remote learning by the COVID pandemic, Nyla was concerned that asynchronous classes, especially math, could hurt her academic performance. What she discovered was that asynchronous had some significant benefits. The first benefit, according to Nyla, was that “it was just nice to be able to really map things out for myself, and really just have the space”. Recalling that Nyla’s early math experiences put her ahead of the instructional pacing of her teachers, being able to control her own pace was exciting. Additionally, asynchronous classes released Nyla from the pressure of being the only Black girl in most of her math classes. Having grown up in a small town with very few Black people, Nyla explained that she expected to “be a mouthpiece for your race…in a lot of ways the only sort of understanding [White people] are going to have of black people comes from you, and there's a lot of pressure that comes on”. One way that the pressure manifested was that Nyla was careful when asking questions in class so that she would not be seen as challenging the teacher. Because it took so much energy to frame her questions so that they were not received as a challenge, Nyla often chose to remain silent in class. Nyla found that the asynchronous classes allowed her to take control of her pace and how she approached problems, free from the pressures of always being the Black ambassador in her classes.

Nyla’s use of actuation capital encouraged her to discover resources that education institutions have for her benefit and, eventually, for the benefit of her students. She also learned that asynchronous classes gave her the opportunity to take charge of her own learning needs.

Confounding Capital

Nyla grew up in an environment where she was a unicorn. She was often the only Black student in her school or her class, she was athletically talented, and she was academically gifted. Nyla's use of confounding capital was because she was unique in her environment. We see her confounding capital activated when she defied the expectations of people who expected her to be aligned with negative stereotypes, or when she used her knowledge to resist microaggressions.

From a young age, Nyla was aware that she was different from almost everyone in her classes, and in her neighborhood and she would soon learn that different people had different opinions about her difference. Nyla gave the example of her White male peer who, when she and another Black girl broke county track records, claimed that it was because they were Black. She also talked about her White teacher who told a biracial student that her parents would go to hell because their interracial marriage was a sin. When these things happened, Nyla shared that it was

> hard because…you can't hold your own as well when you're 12, because you don't have the words yet to say why that's wrong, but of course, you know, what's wrong and you feel is wrong and you're hurt by it.

She never reported the teacher's comments to the school authority and, when she mentioned it to her mother, her mother, who had also been taught by that teacher, said that he had always been like that. Nyla also said that while her peers recognized that she was smart and good at math, they would still deliver back handed comments about how she was not like other Black people. These comments made it clear that they were operating from a deficit view of Black people. As she has gotten older, Nyla has learned how to recognize this deficit orientation in adults in various spaces and to take pride in their shock. Nyla shared that, at academic conferences, "when I'm presenting research, you see them go "Oh!'". She saw the same reaction when she would

introduce herself while giving campus tours, noticing the gasps when she would introduce herself as a “a math major …and I've done these academic conferences”.

Before attending her current university, Nyla attended a university where she “could walk around on campus… and not see another black person [for] a whole day”. Not surprisingly, the math department was “extremely White”, according to Nyla. It was in this space that Nyla took calculus III. She remembers being assigned to a group, with three White boys, for an assignment. Nyla remembered how the boys would leave her out of discussion about how they would complete the assignment. Nyla knew that their approach was incorrect but, when she brought this up to the group, “I just remember there being a look, that was thrown my way…a very nasty look”. Since she knew that their submissions were going to be graded individually, she decided to operate based on what she knew to be the correct approach. When the scores came back, as expected, Nyla had scored higher than the rest of her group. Nyla could tell that they were displeased but she was unbothered. Nyla said that “they're probably thinking ‘Oh, well, she knew stuff and didn't say it…but I said it… y'all don't want to listen”. Nyla let her knowledge be her response to this, and other, microaggressions she experienced. No longer the young girl who, in hurt silence, bore the brunt of negative expectations of being a Black girl, Nyla wielded her confounding capital to help her stand tall in math spaces.

Although Nyla’s confidence in her mathematical ability remained steady for the bulk of her journey, being a rarity in her learning environments threatened her engagement in math learning spaces. Nyla’s mathematical capital kept her rooted in the personal enjoyment of math, her fortifying capital showed her that there were peers, faculty, and staff who would invest in her persistence through math courses, her actuation and confounding capital helped her alter

negative situations to her benefit, and her expectation capital sharpened her focus the career she was looking forward and to the significance of her presence in math learning spaces.

CHAPTER 5: CROSS CASE ANALYSIS OF NARRATIVES

In this chapter, we look at the capitals that each preservice teacher references in their story, comparing and contrasting the specific ways in which the capitals were demonstrated in their narrative. Table 10 gives the breakdown of the capitals identified in the stories of the preservice teachers. Please see Appendix C for the description of the capitals including the related sub-codes and sample quotes.

Table 10

Distribution of capitals seen in PSMT narratives

Capital	Brandy	Scarlet	Gabi	Nyla	Yvonne
Expectation	*Present*	*Present*	*Present*	*Present*	*Present*
Mathematical	*Present*	*Present*	*Present*	*Present*	*Present*
Fortifying	*Present*	*Present*	*Present*	*Present*	*Present*
Actuation	*Present*	-	*Present*	*Present*	*Present*
Equanimity	*Present*	*Present*	*Present*	-	*Present*
Confounding	*Present*	*Present*	-	*Present*	-

Expectation Capital

Expectation Capital was common to all five Black female PSMTs in this study, but we see some differences when we consider the various ways it was manifested for each of them. In what follows the differences in the ways each expressed their expectation capital as the provision of a better math experience for future students, focus on future career, and better future for Black students will be discussed.

Give Students a Better Math Experience

While all five participants made statements about providing a better math experience for their future students, what they considered "better" varied. For example, one way of being

"better" was the provision of a safe learning environment for students by being a better, more aware, teacher. In Brandy's story, a teacher's racist and sexist comments infuriated her, thus strengthening her resolve to be a better teacher. She wanted to make sure her future students would not be harmed by demoralizing comments from a teacher. Gabi wanted to make sure that students in her future classroom felt that she, as a teacher, would be sensitive to their emotional and mental health needs in addition to their math instruction. Gabi wanted her students to feel seen because she did not always feel this way, especially when she was being bullied by her classmates. Yvonne wanted to create a space where students felt safe in asking questions without being ridiculed. Yvonne was disappointed and infuriated when one professor would make her friend feel stupid for not understanding an example that was placed on the board. Yvonne believed that it was the responsibility of a teacher to welcome and address the questions of students while safeguarding their self-esteem.

A second way of being better was a classroom where students could feel like budding mathematicians. Gabi wanted all her students to understand that perfection is not a requirement. She wanted them to know that making mistakes would not disqualify them from seeing themselves as mathematicians. Scarlet often found herself on the outskirts of what is usually considered mathematical thinking. She found that she took a different route that arrived at the same result, yet only a couple of teachers recognized her method as sound mathematical thinking. As a result, she wanted to create a math learning environment that would welcome students who thought in different ways.

The final way of being better was the presence of a Black teacher in a math classroom. Gabi believed that, by being a Black math teacher, Black students would see that "math is not just for …a White male, or whoever they think math is for. It's also for them". She wanted Black

students to know that they too possessed what is needed to thrive in mathematics. When Brandy reflected on her education and saw that, except for when she took a class at the community college, she had never been taught by a Black teacher. This was even more surprising for her since her father was a math educator. Her persistence was to at least be a Black math teacher that future black students can look up to and see as a possible career for themselves. Nyla expressed a similar sentiment when she saw, in the faces of her Black students, how much it meant for them to have a teacher who looked like them. Since she had also never been taught by a Black teacher, Nyla could not ignore how that impacted her. Like Brandy, Nyla wanted to be at least one Black teacher that some Black students will have. Gabi, Brandy, and Nyla wanted their presence in math classrooms to change Black students' perspectives on their belonging and their relationship to math and math-related careers.

Focus on Future Career

Several preservice teachers made statements that were focused on their future career as educators. Gabi and Yvonne had wanted to be math teachers from as early as they can remember. Yvonne can remember playing "teacher" with her neighborhood peers when she was in elementary school, and even being the summer teacher for her cousins because their parents knew that she would make sure they were on task. This primary focus not only helped Yvonne to stay the course, but it also influenced some curricular decisions. For instance, when Yvonne was preparing for her licensure exams, she knew that she had to work harder on geometry. While geometry was not her favorite part of math, she learned that early career teachers are more likely to be placed in algebra and geometry classes. This prompted Yvonne to make sure that she was prepared to be able to instruct students in geometry. Gabi also knew that she wanted to be a teacher by the time she was in middle school and, when the time came to select a major, there

was no question as to what to choose. When things became difficult during a math course, the simple fact that they wanted to be a teacher and have her own classroom was enough to keep them hanging on.

For Brandy, before deciding to be a teacher, she planned to pursue a degree in applied math since she felt it would be amenable to a variety of careers. When she did decide on teaching as a career, she realized that it was an important way to have a "broader impact", and this helped her bear with the temporary discomfort of the situation she was in. When Brandy found herself on the brink of changing her major, after considering other careers, she became convinced that there was nothing else that interested her more than being a teacher. Lastly, Nyla knew she wanted to be a teacher when, in high school, she had the opportunity to be the teaching assistant for her homeroom teacher who happened to also be a math teacher. At the university she attended, she was in a secondary methods course that challenged her to think like a struggling student. Since Nyla had not struggled much mathematically, she found this difficult to do, but she knew that she needed to be able to place herself in the shoes of a struggling student in order to better plan for instruction strategies and accommodations that would help them. In essence, preparing for her future career helped Nyla prioritize the skills that she needed to develop. The preparation for their future role as an educator encouraged the preservice teachers to target areas that needed improvement or to remain mindful of the broader impact that teachers have on students.

Black Students Need a Better Future

Scarlet was the only participant that made statements about wanting a better future for Black students, something beyond the mathematics learning experience. Scarlet shared, in her story, about some experiences that are disturbingly common for many Black girls who are raised

in urban communities. Since Scarlet worked as the head of a community center while working on her degree, she was more privy to the lives of students outside of their formal education settings. She talked about a girl in her community center who would do odd jobs for her, and who would give up her meager earnings to her mother who was addicted to drugs. Scarlet lamented how many Black children had to assume adult responsibilities before they were adults, just as she had to be responsible for taking herself to and from her medical appointments before she was a teenager. Scarlet also talked about how, like her, many young Black girls in urban communities are victims of sexual abuse. Scarlet's drive to be a teacher has a higher purpose, which is to "make the world a better place than I found it, and [better] than it was to me". Scarlet wanted to make sure that Black girls like her never go through the same things that she did. Scarlet saw her future as a math educator as a means to also impact the lives of Black girls beyond the activity of a math classroom.

Mathematical Capital

All the preservice teachers leveraged mathematical capital in their quest to become math teachers, but in three different ways: a simple love or interest in mathematics as a subject, an opportunity to infuse creativity or other learning modalities, or as a way to form math connections.

A Simple Love for Mathematics

Each preservice teacher expressed a love for math that kept them engaged in what they were learning, even when the content became more complex. Where Brandy's peers would question the greater purpose of any content that was being taught, Brandy found the math itself to be exciting. When Scarlet described the math courses that she took, her stories were punctuated with simple declarations of how much she liked or enjoyed the math content. The

other preservice teachers shared a love for the challenge that math affords. Gabi stated that she loved “getting headaches” in one of her math classes because, for her, headaches meant she had learned something. Nyla said that she enjoyed studying differential equations because there were so many different ways to solve them, and she would try multiple methods on one problem. Yvonne, similarly, appreciated that there were several approaches to solving problems and, even if the problem took many days to solve, she was gratified when she arrived at the final answer. In one way or another, each preservice teacher’s love or profound interest in math as a subject played a part in their use of mathematical capital.

Opportunities to Infuse Creativity or Use Other Learning Modality

Some preservice teachers complained of a lack of creativity in how math is taught, but creativity meant different things for them. Scarlet felt that being able to use her artistic skills while learning math helped her reinforce what she learned. She described how, in one of her math assignments, she used her knowledge of different types of functions to define the parts of a face that she created using Adobe Photoshop. Scarlet also used technology to take a creative approach to an assignment: while she and her classmates were instructed to write a summary of a math teaching segment they watched; Scarlet created a video where she provided her summary as voice-over commentary. As a result, she had more fun and created a more thorough analysis. Brandy also lamented a lack of creativity in math compared to how creative she could be when writing, as writing was another subject that she enjoyed. It was when she took a proofs course that she found that she could use her writing skills to describe her proofs. Brandy’s use of writing helped her offer a better description of her proof than with math symbols alone. In both stories, the preservice teachers added creativity to their math learning activities either by using artistic skills and technology or by using writing skills to support their learning.

Make Math Connections

When the preservice teachers said that they liked that being able to make math connections supported their learning and their persistence, they spoke of it either as making connections between math and other STEM subjects, or as finding connections between different types of math content. Scarlet's tale of how she reinvigorated her math self-efficacy began when she began to see the math in other STEM subjects like physics and engineering. She realized that as long as she could "find the math" or relate the content to a mathematical concept, she could have a firmer grasp of the math.

Yvonne, on the other hand, learned that reaching back to math content that she learned in the past gave her sure footing with new, more complex content. Yvonne noticed that one of her high school math teachers would always direct her and peers to consider where they might have first seen a version of what they were learning. Yvonne kept her notes from high school and each math course she took at the university. She made it a point to search her notes for an earlier exposure to the content and used this as a scaffold for the more complex material. By connecting new math content either to other STEM subjects or to previously learned math material, the preservice teachers wielded mathematical capital in difficult math courses.

Fortifying Capital

All the preservice teachers in the study used fortifying capital in five different ways, the first of which is the presence of supportive faculty or staff. The second way is experienced within a community of supportive peers, the third is by receiving help from family, the fourth is the feeling of kinship with a racial and or gender congruent teacher or staff member, and finally as the reinforcement that happens when the preservice teacher is recognized for their brilliance.

Supportive Faculty and Staff

The help from supportive faculty and staff is present in the stories of all five preservice teachers. One example from Brandy's story was when she was taking calculus II at her university. She was visibly nervous as she waited to take the test, but the teaching assistant comforted her and assured her that she would be fine. After the test, the TA followed up with Brandy to ask how things had gone during the test. Brandy found this show of concern to be very encouraging. Scarlet talked about two faculty members who shared one common trait, which was that they recognized and valued the fact that Scarlet had a unique way of approaching or conceptualizing math problems. This was very important for Scarlet because she had not experienced the same positivity from her peers. The faculty members validated Scarlet's identity as a mathematician.

During Gabi's first year at her university, she frequently went to her advisor's office to have a good cry when things were rough. Gabi appreciated how her advisor would listen to her woes and offer encouragement. Gabi also mentioned that the program coordinator at the college of education was also someone who made time for her and was a knowledgeable resource for her. Nyla's first experience with supportive faculty was when she was in high school. She had two math teachers, a married couple, who she described as authentic and open. Their openness with her encouraged Nyla to be herself in the classroom and to remain engaged with math. Nyla also had a strong relationship with her homeroom teacher and her guidance counselor who, together, helped Nyla navigate a difficult time in her life and facilitated an experience that awakened Nyla's interest in teaching. When she got to her university, Nyla had more positive experiences with math faculty members who allowed her to express her comical side so that she could be herself, and who informed her of opportunities to extend her learning through research.

Lastly, Yvonne had several examples of the K-12 teachers who supported her growth as a mathematician. She shared that most of her elementary and middle school teachers created a classroom community where students helped each other rather than competed against each other. She made special mention of her eighth-grade math teacher who went beyond teaching math content to helping her students value their culture and learn how to code switch when in diverse settings. Yvonne expected to have similarly invested teachers when she started at her university, but this was not her initial experience, especially with her math instructors. She eventually discovered that the math department was committed to the success of math majors. When she was on the verge of failing a math-focused computer programming class and finally reached out to her instructor, Yvonne received invaluable guidance that helped her pass the course. In these stories, the preservice teachers showed how university faculty and staff became a resource in providing guidance or encouragement and crucial moments in their journey.

Community of Supportive Peers

Most of the preservice teachers benefitted from having supportive peers who were either classmates or fellow students in their program. Brandy's first experience was when she got to high school. Prior to that, she often felt isolated and intimated because she was one of a few or the only Black girl in her middle school math classes. Brandy's high school had more Black students and, even though she was the youngest in her classes that were filled with upperclassmen, she felt more at ease and less like an outsider. She became less afraid to ask her peers for help, just as they would ask her for help. At her university, Brandy was initially propelled to the isolation she felt in middle school but, in her Calculus II class, she had a classmate with whom she had also attended high school. They studied together and comforted one another, so that they both passed the course.

Gabi's first experience with supportive peers was when she started at her early college. She had also been alienated in middle school mostly because she was an outstanding math student. Her early college math classes had a collaborative structure, and the students were similarly talented in mathematics, which made Gabi feel comfortable either asking for or receiving help from her peers. The peer support was intensified when Gabi's math courses were within the college of education. Gabi felt a stronger affinity with her classmates since they were all focused on preparing for careers in teaching, and this like-mindedness made her feel like part of a community.

Nyla, who was raised and educated in environments with very little diversity, was accustomed to being the only Black girl in her class or in her school. For the most part, Nyla got along with her peers since they attended the same schools from kindergarten to high school. Every so often, an incident reminded her that some of her classmates viewed her through negative stereotypes, and this made it difficult for Nyla to be herself. Once she got to high school, a couple more Black students joined, and Nyla finally had some people with whom she could be herself and who saw her as more than just a Black girl. Nyla found similar acceptance when she was at university. For example, Nyla's calculus IV classmates quickly formed an informal study group that blossomed into friendship. Even though she did not mind studying on her own, the acceptance she found within this group made her feel like she belonged.

Yvonne is the only preservice teacher that attended an HBCU, and this choice was intentional. Yvonne's entire K-12 education had been in schools that served predominantly Black and Hispanic students. Yvonne had such a positive experience in these schools because it felt like an extension of family, surrounded by peers who looked like her and supported each other. When the time came to apply to universities, Yvonne insisted on attending an HBCU so

that she could have the same feeling. The reality of the HBCU fell short of her expectations in a few regards, one of which was the collaborative classroom environment. In the first few math courses, Yvonne noticed that her peers viewed education majors as having lesser math ability. It was not until the end of her sophomore year that Yvonne began to recognize education majors in her math courses. In their shared academic track, Yvonne formed a peer support group with whom she was more at ease and no longer felt alone. Whether it was first leveraged before or during the teacher preparation process, each of the preservice teachers discovered that having even one supportive peer in the class made it easier to withstand many difficulties.

Help from Family

In the three of the PSMTs' stories (Brandy, Gabi, and Yvonne), help from family was either in the form of general moral support or in the form of actual math help. Brandy and Gabi both attended predominantly White institutions (PWIs) and were frequently the only Black person in their math classes, in the teaching program, and even in their residence halls. The George Floyd riots intensified Brandy's sensitivity to how her peers saw her, as a Black woman, and how they spoke about the education of Black students. When these conversations became a little too much to handle, Brandy would call home and decompress with her parents. Since both Brandy's parents were alumni at her university, they were able to give her some insight, and perspective, as to the racial environment at the university when they were students. Brandy would also sometimes call home for help from her father, who was also a math educator. Brandy had done this when she could not understand math content when she was in middle school and high school, and she continued to reach out to him for math help as a university student. Gabi had several family members who were also educators and, though this did not influence her decision to enter the profession, it helped when Gabi was struggling. Gabi reached a point when

she considered changing her major because she began to doubt her identity as a mathematician. Gabi's grandmother, a retired teacher, told her that she would stand by her, regardless of her profession, as long as Gabi chose what felt right for her. Her mother similarly assured Gabi of her unwavering support. When Gabi made her decision to continue with the teaching program, she did so with the knowledge of her family's backing. Yvonne's family were her first point of contact for assurance. When Yvonne was preparing for high school, she envisioned a scary place like what she had seen in a movie. Yvonne went to her older brother, and then to her parents, asking questions that helped her prepare her mind for what was to come. Yvonne described her father as a "*math person*" which made him a resource for help with math. In middle school, Yvonne was no longer in honors classes, and it made her feel unsure of herself. Even though she had a good relationship with her peers, she stopped asking them for help and would either struggle in silence or ask her father for help when she got home. In these stories, the preservice teachers drew from their family members to either find help in math or for bolstering to be able to press through trying and uncomfortable moments.

Racial/Gender Congruency with Teacher

In Gabi and Yvonne's stories, the preservice teachers were fortified by the presence of a teacher with whom they shared racial or gender characteristics. Early in Gabi's schooling, she had lost faith in her teachers because they did not intervene when she was being bullied by her peers. When she started taking university math courses as an early college student, she was taught by two Black female math teachers. Gabi commented that seeing those Black women teaching math empowered her mathematically and made her feel more comfortable talking to them. Yvonne also talked about how she was immediately drawn to teachers who were Black women. This first happened when Yvonne was in the first grade and immediately felt a

connection to her teacher because she "*could see herself in her*". Yvonne also felt this connection when her teachers were women because she saw them as mother figures, but that this feeling was stronger when the teachers were Black women. She was more willing to approach her teachers for help if they were women, but more so if they were Black women. For these preservice teachers, there was instant comfort with teachers with whom they share racial or gender congruence. The preservice teachers also felt that seeing these teachers helped them envision a possible future for themselves in a similar career path.

Recognize My Brilliance

The final way in which the preservice teachers benefitted from fortifying capital was when their brilliance was acknowledged or recognized by a peer. Brandy mentioned that she sometimes suffered from imposter syndrome when she was in her math classes and would keep to herself. When she was paired with a White male classmate, Brandy was surprised when this classmate valued her opinions and her contributions in the work they did together. Nyla's experience also involved a White male peer. Recalling that Nyla and several students in her Calculus IV class were a close-knit group who studied together, Nyla shared about a time that the group had studied together for a test. Nyla overheard one of the students tell another student, who had not been able to attend the study session, how Nyla had really helped him prepare. Nyla was surprised by this unsolicited compliment, and she felt even more accepted by her peers. In both stories, the recognition of their math ability made the preservice teachers feel validated.

Actuation Capital

Actual capital represents when the preservice teachers took action to alter a situation in their favor. This capital was demonstrated in the narratives of four PSMTs. There are three ways in which this was demonstrated in the stories told by the preservice teachers. The first relays how

the preservice teachers used their knowledge of the institutional system to find what they needed. The second shows how the preservice teachers became empowered by the anonymity of remote learning, and the last is how the preservice teachers found ways to lessen the pain from negative experiences by engaging in a personal passion.

Understanding the Intricacies of the System

This theme appeared in the stories of three of the four PSMTs with actuation capital. One example of how Brandy used what she knew about university systems to improve her situation was in course selection. When Brandy was trying to register for a differential equations course, she first accessed the university's website that showed which courses professors had taught and how students performed in those courses. She combined this information with an external site where students could rate their professors, and finally got added input from her father. Through this process, Brandy registered for the class with a professor whose students performed well and who had favorable feedback from past students. Even though the class was at a later time than she would have preferred, Brandy was pleased with her decision because she did like how the professor taught, and she passed the class.

In Yvonne's case, upon acceptance at the university, she applied to be a part of a program for students in STEM-related majors. Yvonne did so because the program would give her access to mentorship and tutoring services that were tailored to her major. By the time Yvonne was struggling with her math programming course, she was able to get priority help from the program's dedicated tutoring services.

Nyla's story is a little different from the others in the type of university service she took advantage of. Nyla struggled with mental health issues that led to a brief period of hospitalization followed by therapy. The therapy sessions, however, were courtesy of a school program, a

partnership with an organization that offered therapy sessions for students at the school. Nyla was able to meet weekly with a therapist so that she could manage the mental health issues that almost compromised her academic performance. Once she started at university, Nyla immediately sought out the counseling services that the university made available for its students, so that she could continue to get the help she needed. The preservice teachers, knowing that university institutions provide various resources and services, took advantage of one or more of these services to support their learning, their emotional and psychological stability and, ultimately, their persistence.

Empowered by Anonymity a.k.a. Opportunity for Remote Learning

The COVID-19 pandemic impacted the academic journeys of all the preservice teachers. For Brandy and Nyla, being forced into remote learning offered an empowerment they did not expect. Brandy expressed that she found that she enjoyed her math classes and performed better once the lockdown necessitated remote learning. She explained that when the cameras were off for synchronous classes, she suddenly felt the imposter syndrome dissipate because she was no longer able to see whether she was the only Black face in a sea of White faces. She said that she was also no longer scared to ask questions, and no longer worried about being perceived as the "*dumb Black girl*". The relief from the burden of fear of judgment helped Brandy focus on learning, leading to a better course outcome. Brandy subsequently opted for online courses when the opportunity presented itself, now that she had seen the difference it made.

Nyla also found that remote learning lifted the burden that she felt in many classes, the burden of constantly feeling like she had to represent her race. Recalling that, because Nyla was raised in a city with very little diversity, she was aware that she might be the only Black person many of her classmates interacted with. She was worried that her actions could either reflect

positively or negatively for her race. When her math classes were asynchronous, she was divested of the weight of being an ambassador for her race, allowing her to divert her energy to learning. Brandy and Nyla discovered that the anonymity of remote learning helped them to learn unencumbered by the pressures of imposter syndrome or of having to represent their race, empowering them to be the math scholars they knew they were.

Balance Pain from Negative Math Experiences with Personal Passion

When math classes became painful for some of the preservice teachers, they searched for a way to mitigate the pain so that they could persist with their courses. What Brandy and Gabi did was balance the painful experience by engaging in a personal passion that brought them joy. Brandy, in addition to math, had a passion for writing. When the painful math experiences brought her to the point of almost changing her major, she decided to, instead, add an English minor. This way, any negative math experiences would be offset by the English courses. For Gabi, artistic expression through painting had always been a source of joy. It became a source of healing when, because of the bullying she experienced in middle school, she had started to self-harm. When her math classes brought pain, Gabi would indulge in painting for catharsis. The act of painting was soothing, and the subject of her paintings revolved around teaching, for example, images of apples which are a common symbol for teaching and teachers. Both preservice teachers embraced pleasurable outlets to sweeten some of the bitterness experienced in their math courses.

Equanimity Capital

Equanimity capital captures the ways in which the preservice teachers turned inward to draw strength from an internal source, and it shows up in the stories of four PSMTs. This shows up in three ways in the stories told by the preservice teachers. The preservice teachers either

found a way to become self-sufficient, they drew from their faith or spiritual beliefs, or they resolved to be comfortable in uncomfortable situations.

Become Self-Sufficient

This theme was seen in the narratives of Gabi, Yvonne, and Scarlet. What we see in Gabi's story is that her decision to be self-sufficient first began as a way to not add her mother's burden in the fallout of her parents' divorce. When Gabi lost faith in her teachers' ability to protect her from the bullying she experienced, she extended this self-sufficiency to how she related to her teachers. She avoided them when possible, taking what she could from the lectures and figuring out the rest on her own. This continued into some of her university classes, especially in the first math classes she took. Gabi's self-sufficiency was her way of protecting herself.

In Yvonne's story, self-sufficiency was how Yvonne made sure that her academic needs were being met when the instructor's plan seemed to diverge from her needs. When Yvonne was in the two math classes that were supposed to prepare her and classmates for the Praxis content exam, she was concerned that the instructors' strategy would not allow her to target the specific content areas that she knew she needed to improve. She tried following their recommendations but, when those still did not help, she decided she would have to do things her way. Since her experiences in her geometry courses revealed it as a weakness, Yvonne purchased praxis preparation materials and other outside resources to design her own preparation curriculum.

Self-sufficiency shows up far more in Scarlet's story when compared to the other preservice teachers. Sometimes this manifested as a way to protect herself from the hurtful experiences with her classmates, and other times it was her way of learning math content in a way that better suited her learning needs. Scarred by the racist attitudes of her classmates when

she first transferred to a private middle school, Scarlet withdrew into herself as a protective measure from further hurt. When, in the private university she attended, she had negative experiences when she had to partner with a classmate, Scarlet resolved that she would not work with other students if she did not have to. The other way that Scarlet chose self-sufficiency was to make up for something that she felt was missing in how her instructor presented the material. This first happened in her differential equations class, where Scarlet decided that she would have to teach herself the content. She got a good grade in the course and, subsequently, kept teaching herself content when she encountered professors that she felt were "not meant to teach", or who could not cater to her academic needs. Across the PSMTs, becoming self-sufficient was necessary to either help protect the PSMT from external pain or to provide, for themselves, the help that was not forthcoming.

Faith/Spirituality

Both Brandy and Gabi profess Christianity as their faith. When Brandy first arrived at her university, she quickly made sure she was plugged into a community of fellow Christians on campus so that she could express her religious identity. Since Brandy also shared a racial identity with the members of this Christian community, it also became a space for her to navigate the racial challenges she experienced in her classes through the lens of her Christian faith. Brandy is also a Christian and believed that it was God who told her that teaching was her calling. When Gabi faced difficulties in her math courses, she would express her faith through prayer and then she would recall that God set her on this path. She trusted that God would let her know if the plan changed so, as long as God did not tell her differently, Gabi kept working hard towards licensure. Scarlet, on the other hand, did not profess any particular faith. She did, however, find spiritual guidance in a concept that is common to several religions. Scarlet stated that Buddhist,

Christian, and Islamic religious texts all upload that greatness is possessed within individuals. Scarlet would use this as a reminder for herself when she felt that her classmates treated her as though she were inferior to them. For these preservice teachers, their faith or their spiritual beliefs provided the internal fortitude to support their persistence.

Comfortable with Discomfort

The final manifestation of equanimity capital is when preservice teachers find ways to be comfortable in the midst of discomfort. This theme is present in Gabi and Yvonne's stories. After the bullying that Gabi experienced in middle school, she accepted that she is different and that some people might not like her or treated her badly because of it. She said that, as long as she is certain of who she is, she will be able to withstand and endure any discomfort. Yvonne also had some experiences with future teachers that served as a reminder that she could end up working with White colleagues who considered themselves to be her superior. She also accepted that people may not change their behavior to make her feel comfortable. As a result, Yvonne knew that she would need to find ways to be comfortable in those situations, while making sure not to conflate this comfort with the acceptance of disrespect. In both stories, once the PSMTs realized that there was no guarantee that the sources of their discomfort would ever be mitigated, they decided that they could not afford to let the situation tear them down.

Confounding Capital

Three PSMTs used confounding capital to resist or challenge negative ideas that are perceived or spoken, and this is demonstrated either as defying expectations that are informed by negative stereotypes or by using knowledge to stand against microaggressions.

Defying Expectations

We saw this theme across the stories of the three PSMTs who demonstrated confounding capital. When Brandy described her use of confounding capital, she recalled an incident from middle school, an award ceremony where Brandy amassed some of the more significant awards. Her parents heard other parents muttering, surprised that this Black girl had won for both most improved student and highest score. This was the first time that Brandy recognized how powerfully motivating it was to show that you could do something people did not think you were capable of. From that point, whenever Brandy was going through a particularly tough time with her classes, she ran a mental audit of how she was defying expectations: she reminded herself that she was a legacy student at her university, that she was taking classes in buildings named after men who were racist, and as long she kept going, she would continue to thumb her nose at people who did not think she belong there.

After years of being looked down on for being different, Scarlet learned to take pride in her differences and allow people's negative perceptions of her to lure them into a false sense of security. With her tattoos and long, manicured nails, Scarlet does not present as the reified image of a mathematician. Scarlet also noted that her White peers did not always credit her with knowing math content because she would speak in simple terms rather than math jargon. Knowing how little some people expected of her made Scarlet even more excited when she revealed her true prowess.

Nyla's experiences made her aware of spoken and unspoken ways that people express their shock about her math ability. She noticed that, whenever she would introduce herself as a math major, shock would register on the faces of many White people in the crowd, whereas there would be no shock when her White, male counterparts did the same. Nyla began to take more

pride in introducing herself as a math major and explained that she had also presented research at academic conferences, for added measure.

These preservice teachers, from a young age, knew that many people did not expect Black girls to be good at math. By persisting with the secondary math preparation program, Brandy, Scarlet, and Nyla were able to defy negative expectations.

Knowledge is My Weapon Against Microaggressions

Nyla is the only preservice teacher who used her knowledge as a counter to microaggressions as capital. When Nyla was in Calculus III, she was placed in a group with three White male peers who rejected her contributions in the task they were assigned. She let them know that they were taking the wrong approach and backed it up with evidence from what the professor had directed them to do. Nyla followed her plan, and she outscored the other members of her group. Nyla did not let her peers' blatant rejection of her knowledge dissuade her from presenting her solution, which turned out to be correct.

The uniqueness of each PSMT's story is not overshadowed by the similarities that gave rise to the capitals. Every capital in this study was defined by various overarching themes that were, themselves, a unification of similar ethos taken from the stories of the five PSMTs. Expectation capital, although common to all PSMTs, was expressed as three main themes with a unifying ethos of hope for the future. Mathematical capital represented the ways that the PSMTs love for the subject of mathematics revealed itself in their stories of persistence. Fortifying capital showed how, in spite of feelings of isolation, the PSMTs recognized that they were surrounded by numerous sources of strength. Equanimity capital demonstrated the willingness of the PSMTs to reach inward for support when external support proved elusive. Finally,

confounding capital highlighted the PSMTs resistance and disruption of negative stereotypes that were pervasive in their learning environments and their institutions of education.

CHAPTER 6: DISCUSSION

The purpose of this study was to learn about the types of capital that Black female PSMTs used to support their persistence in undergraduate mathematics courses enroute to program completion and licensure. Specifically, the study sought answers to the following research questions:

1. When sharing stories of persistence in undergraduate mathematics courses, what types of capital do Black women who are preservice mathematics teachers believe was instrumental in that persistence?
2. With respect to capital, what are the similarities and differences among Black women's stories of persistence in undergraduate mathematics?

Framed by Critical Race Feminism and by Black Feminism, I employed counternarrative inquiry for this endeavor. I spoke with five Black women (Brandy, Scarlet, Gabi, Nyla, and Yvonne) who, each, eagerly agreed to three narrative interviews where I was immersed in stories of their experiences as PSMTs over the course of about four to six hours.

The PSMTs unique experiences were varied in temporality (e.g., on either side of a global pandemic and different transitions from secondary to higher education), varied in place (e.g., situated in four-year institutions that were either public or private, PWI or HBCU), and varied in sociality with stories impacted by different personal and social conditions. Across the unique stories of the PSMTs, I was able to identify various capitals that these women leveraged to in pursuit of undergraduate degrees in mathematics and secondary mathematics licensure. Some capitals were common to all the PSMTs, although expressed differently, while others were unique in their infrequency within the stories of the PSMTs.

In the following sections I will share the summary of findings, discussing the capitals observed across the stories and connecting those findings to existing literature. I will continue with a contemplative discourse on the implications of these findings for math teacher educators who teach content and methods courses, for staff members in teacher preparation programs, and for researchers. This will lead to considerations for future research before presenting concluding thoughts.

Summary of Findings

"Age cannot wither her, nor custom stale

her infinite variety. Other women cloy

The appetites they feed, but she makes hungry

Where most she satisfies"

(Shakespeare, 1623/2018, 2.2.276).

This quote alludes to the dynamic, ageless, beauty and charm of Queen Cleopatra, qualities that were thought to make it impossible for Marc Anthony to ever quit, or desire to quit, their affair. In the time I spent with the PSMTs, I also found myself struggling to adjourn each interview as each tale could have veered into other revelations. The stories were as fascinating as they were unique, and, even if time was abundant, my insatiable curiosity would never be quenched. What I intended to do with this study was to learn about the capitals Black women, who are becoming math educators, felt were instrumental in their persistence, as I am unaware of any studies that are centered on this niched population. I begin by presenting the six capitals that emerged from the stories of the PSMTs in this study, which are: expectation capital, mathematical capital fortification capital, actuation capital, equanimity capital, and confounding capital.

I mentioned that, to my knowledge, there had been no studies about capital focused on Black women who were PSMTs. However, there have been studies about capital that is centered in people of color, such as the work of Yosso (2005). Yosso (2005) challenged Pierre Bourdieu's conception of cultural capital as something that resides in middle- and upper-class White society, which implied that people of color are lacking in the "social and cultural capital required for social mobility" (Yosso, 2005, p. 70). Yosso (2005) reimagined cultural capital as Community Cultural Wealth (CCW) and articulated six types of wealth inherent in communities of color: aspirational capital, familial capital, social capital, navigational capital, resistant capital, and linguistic capital.

Although my study is tightly focused on the Black community, I noticed that four out of six capitals in my study echoed Yosso's (2005) Community Cultural Wealth (CCW), at least on the surface. Yosso's (2005) study is similar to the present study in spirit, but the study populations and the theoretical lens differ in significant ways. Yosso's (2005) is guided theoretically by Critical Race Theory and, as a result, the CCW capitals are intended to apply to communities of Color, as a whole. My study, on the other hand, is guided by CRF and Black Feminism which helps to center the research on the experiences of women who are Black or African American. Secondly, unlike in Yosso's study, I further target the experiences of Black women in a particular educational pursuit (secondary mathematics education), where Yosso's CCW considers people of color in educational pursuits in general.

In what follows, I discuss the capitals that were found in this study compared to extant literature. I begin by discussing the capitals that appear to echo Yosso's (2005) CCW (expectational capital, fortifying capital, actuation capital, and confounding capital), comparing

and contrasting the capitals, and explaining choices of nomenclature. I will then present the final two capitals that bear similarities to the work of other researchers.

Expectation Capital

Expectation capital was one of three capitals to cut across the stories of all the PSMTs. It is also significant because it appeared to be the anchor for the PSMTs' use of the remaining capitals. I described expectation capital as the ability to focus on a future desire or goal. Expectation capital was expressed in the stories in three ways. We saw it expressed as a focus on the future career of teaching. For example, Yvonne had wanted to be a teacher ever since she was in elementary school, and it was that focus that helped her push past any obstacles. We also saw it take the form of a desire to provide a better math learning experience for future math students. This was either by protecting the math learning environment from racist, sexist, and demoralizing comments (as seen in Brandy and Yvonne's stories), or by attending to the development of budding mathematicians, as in Gabi's story, where she let her students know that making mistakes does not disqualify you from seeing yourself as a mathematician. Finally, we saw it expressed as a need to secure a better future for Black students. This was poignantly demonstrated in Scarlet's story, who saw her future as a math educator as a chance to make the world better, especially for Black girls like herself. The last two expressions of expectational capital not only demonstrate an awareness of the oppressive systems that created painful experiences in the math learning experiences of the PSMTs (racism, sexism, etc.), but a commitment to being an active force in disrupting the impact of the systems in the lives of their future students. These two expressions exemplify two shared tenets of CRF and Black feminism regarding the multiplicative impact of oppressive systems and the fact that action is necessary for transformation.

Expectation capital resonates with Yosso's (2005) aspirational capital. However, the expressions of what I came to refer to as expectational capital in the stories of the PSMTs helped me distinguish between what they were describing and the essence of aspirational capital. Yosso (2005) described aspirational capital as "the ability to maintain hopes and dreams for the future, even in the face of real and perceived barriers" (p. 77). In both my study and that of Yosso, the student drew strength from a focus on a future goal which "nurtures a culture of possibility" (Yosso, 2005, p. 78); the PSMTs in my study demonstrated this focus either as a simple desire for a career in education, a yearning to be the kind of teacher that helps students have a better math learning experience, or a longing to have a positive impact on the lives of Black students.

The reason I opted to label this capital as expectational in lieu of aspirational comes down to the difference between the definitions of the two words. *Aspiration* is defined as "a strong desire, longing, or aim; ambition" (Dictionary, n.d.), whereas *expectation* is "the act or state of looking forward or anticipating" (Dictionary, n.d.). As I poured over the interview transcripts during the coding process, expectation felt true to the intensity of the stories told by the PSMTs. Because I am bilingual in English and Yoruba, I often have to use Yoruba to determine the spirit of what I am trying to communicate, before I select the English word that best carries that spirit. The way that the PSMTs in my study voiced their hopes conjured the word ìrètí (Wiktionary, n.d.), which is usually described as hope or expectation. The verb "rètí" (Wiktionary, n.d.) means to expect or to wait for, which brought me closer to *expectation* than to *hope*. Finally, here is an example to drive the point home: someone who is *hoping* for a child is different from someone who is *expecting* a child. In the latter case, the child has been conceived and it is a matter of time (all things being equal) when the child can be held. Similarly, the PSMTs spoke of their desires as something that was assured, and all that was left was for them to

push forward to finally lay hold of the dream of being a teacher, the hope of giving students a better math learning experience, and the possibility of changing a Black student's life prospects for the better. They were not *hoping* to become teachers, they *knew* that they would be teachers.

Fortifying Capital

Fortification capital is also expressed in the stories of all the PSMTs, and it emerged either as help from family, from peers, and from university faculty and staff. First, it was realized as help from supportive faculty and staff. For example, by Gabi who mentioned that her advisor allowed her to come to her office to vent or to have a good cry whenever things had not gone well in her math class. Second, it shows up as support from a community of peers, whether the peers were other Black students, as in Nyla's story, or other high achieving math students, as in Gabi's story. Third, help from family, which we saw in Brandy's story. Brandy's family helped her with mathematical content (since her father was a math educator), or by helping her contextualize the racial climate at her university (since her parents were alumni). Fourth, interactions with math educators who were either racially or gender-congruent, were significant for Yvonne and Gabi. Gabi felt more comfortable and more willing to ask questions when her teacher was a Black woman. Similarly, Yvonne immediately trusted that her Black female teachers would look after her, but their presence also made her feel stronger about her own future as a math educator. Finally, when their mathematical brilliance was recognized by a peer, Nyla felt accepted by her peers, and Brandy felt some of the imposter syndrome she felt begin to dissipate. Of the six capitals in this study, fortifying capital was expressed with greater variety, yielding interesting connections to extant research.

Fortifying capital brought to mind two of Yosso's (2005) CCW: social capital and familial capital. Yosso's social capital is defined as "networks of people and community

resources" (p. 79), which is reminiscent of instances in the PSMTs stories where they were encouraged by peers (both within and outside the classroom), where they discovered that university faculty and staff could be a safe haven, a kind listening ear, or a fount of knowledge. Familial capital, on the other hand, is defined as "cultural knowledges nurtured among familia (kin) that carry a sense of community history, memory and cultural intuition" (Yosso, 2005, p. 79). This was observed, with the greatest clarity, in the story of Brandy, whose parents were both alumni at the same institution she attended, and whose father was a mathematics educator. Brandy's parents were able to give her insight into the racial history of the university, giving her a sense of how to navigate the heightened racial tensions due to the George Floyd riots. Her father, who also initiated and nurtured Brandy's love for STEM, continued to be a mathematical resource for her. I hesitated to adopt Yosso's (2005) capitals because of the unifying characteristic of reinforcement in the PSMTs' tales; the stronger sense from the stories was that the PSMTs felt stronger and more able to withstand their circumstances. This overshadowed the need to distinguish the types of capital between the numerous ways in which support was experienced. A second, and perhaps more important reason, was that they did not capture a significant source of strength.

When the PSMTs spoke of the support they received from faculty or staff, a particular nuance emerged which does echo literature from a different set of scholars: some PSMTs specified that they felt at ease when they interacted with faculty or staff with whom they shard racial and/or gender congruence. Scholars such as Papageorge et al. (2018), Fellus (2019) and Townsend et al. (2010) found that racial and gender congruence between students of color and teachers or staff impacted their academic achievement or attainment either by providing role models as aspirational targets, or by imparting self-assurance that the students may also reach

great heights. This sentiment is expressed in several stories, where the PSMTs voiced an instant comfort with Black female math teachers. In Gabi's story, she mentioned how she instantly felt more comfortable with Black female math teachers and would ask them more questions. Yvonne also spoke about how seeing the Black female math teachers in her life not only let her know that she could also be a math teacher, but she also felt a motherly embrace in their interactions, which let her know that they would give her what she needed to succeed. This manifestation of fortifying capital supports the tenet of Black feminism that rejects the destructive images of Black womanhood and urges Black women to a love of self, sisters and community (Combahee River Collective, 1977). Gabi and Yvonne saw the Black female teachers in their life as intelligent and supportive, and their ability to persist was reinforced by their interactions with these Black women.

In each PSMT's mention of finding help, there was the accompanying sense that they were bolstered or strengthened by having received this help. As a result, *fortifying*, which is defined as "to furnish with a means of resisting force or standing strain or wear" (Dictionary, n.d.), best captured the ethos of the PSMTs stories.

Actuation Capital

Actuation capital was exhibited in the narratives of four of the PSMTs, and it was enacted when the PSMTs took action to alter circumstances in their favor. Sometimes these steps required knowledge of institutional systems, like in Brandy's story where she used the university's faculty review site to determine which math classes to select. It also required adding an experience or course that brought pleasure to balance some of the pain in mathematics courses, which we saw in Gabi's story when she would make time to paint. Painting, for Gabi, had long been cathartic. Lastly, it required embracing the power of anonymity when taking

online math classes. For example, Brandy, during the forced shutdown of the global pandemic, discovered that synchronous and asynchronous math classes freed her from some of the strains of in-person classes. Brandy felt more comfortable asking questions in her synchronous classes because she could neither see other students' faces nor be seen. She was no longer afraid that, by asking questions, she would be seen as a dumb Black girl.

What I define as actuation capital is somewhat akin to Yosso's (2005) CCW: navigational capital. Yosso's (2005) description of navigational capital is the "skill of maneuvering through social institutions" (p. 80) to bolster or assist academic achievement. Navigational capital also requires agency on the part of the individual. Where navigational capital differs is in its specific focus on the ability to chart a path through, or locate resources within, social institutions to maintain academic success. The overarching essence of my actuation capital was the PSMTs need to *do something* to secure their persistence. My search for a name for this capital yielded *actuation*, which is defined as "the state or condition of being impelled or moved to action" (Dictionary, n.d.). Similar to navigational capital, actuation capital necessitates action on the part of the PSMT. Granted, one of the ways in which this was accomplished was by knowing how to navigate social institutions, but Navigational capital does not incorporate the other ways that the PSMTs took action, such as Gabi's seeking balance by immersing herself in her art.

Confounding Capital

Confounding capital demonstrates the motivation derived from being able to disrupt the negative perceptions the PSMTs either heard, expressed, or felt while taking undergraduate mathematics courses. This manifested as finding resilience in defying expectations, and by using knowledge to resist microaggressions experienced in math classes. We see the former

demonstrated by Scarlet, who, knowing that her physical appearance and aesthetics (Black woman with ornate acrylic nails, tattoos, and seemingly endless rotation of hairstyles) did not inspire confidence in her math ability, took pleasure in stunning her naysayers when she showed her math prowess; the latter, we see in Nyla's story. Her math knowledge was rejected by the White, male classmates in her small group, but this knowledge helped her get a higher score on the assignment with which they had been tasked.

This capital occurred the least frequently, showing up in the stories of three PSMTs, and is where I observed a final similarity with Yosso's (2005) CCW: resistant capital. The essence of Yosso's (2005) resistant capital is that it is "fostered through oppositional behavior that challenges inequality" (p. 80). I acknowledge that elements of resistant behavior were described in Brandy and Scarlet's stories, where they were propelled to persistence with the knowledge that it would defy the stereotypical expectations of Black girls in math and other STEM subjects. We also saw, in Nyla's story, that she was able to use her knowledge to oppose microaggressions in her math class. However, I opted to forego Yosso's label of resistant capital in favor of confounding capital because the definition conveyed an important aspect of the capital as it was expressed by the PSMTs in this study: disruption. Confounding is defined as "throwing someone or something into confusion or disorder" (Dictionary, n.d.). In both Scarlet and Nyla's story, there was a particular delight in seeing the bemusement on the faces of people who held low expectations of them. For Nyla, this happened whenever she introduced herself as a math major and as a researcher. Scarlet's awareness that people stereotyped her because of her aesthetic presentation (long nails, multiple wigs, visible tattoos) sweetened the moment when she revealed her mastery of math content.

Equanimity Capital

I defined equanimity capital as the inner reservoir that the PSMTs reached into when the difficulty they were facing was at its strongest. In the PSMTs' stories, this capital either manifested as a choice to find strength within themselves, such as Scarlet's opting to work alone when her classmates refused to be partnered with her or teaching herself when she felt that her math instructor was not giving her what was needed to support her learning. It also showed up as a spiritual grounding such as Gabi's belief that it was God who set her on the path to be a math teacher and that He would see her through. Lastly, it was a resolve to find comfort in uncomfortable situations, as seen in Yvonne's story. Yvonne recognized that people would not go out of their way to make her feel comfortable, and so she would need to find a way to thrive in the midst of that discomfort rather than becoming weakened by it.

Dumangane (2017) shared similar findings in his study regarding the importance of faith capital in a group of Black men as they pursued undergraduate degrees at universities in the United Kingdom. Most of Black men in Dumangane's (2017) study identified faith as "a source of support, strength, and protection" (p. 891) on their quest for academic success, self-improvement, and community involvement. One of the Black men in Dumangane's (2017) study expressed his belief that God would see him through any difficulties he encountered; specifically, if it was God's will, then God would assure his successful completion. This echoed Gabi's revelation that she believed that it was God that told her to be a teacher and that she would continue on the path as long as God did not alter his directive. Dumangane (2017) also learned, from two of the Black men in his study, that faith and spirituality had an "ongoing centering effect on their educational lives" (p. 895). This finding brings to mind Scarlet's

spiritual belief that greatness comes from within; this belief kept her grounded in her academic pursuits.

I chose not to name this capital faith or spirituality because neither word communicated the totality of what the PSMTs narrated. I vacillated between the words *assurance*, defined as "freedom from timidity; self-confidence; belief in one's abilities" (Dictionary, n.d.), and *equanimity*, defined as "mental or emotional stability or composure, especially under tension or strain; calmness" (Dictionary, n.d.). Equanimity won because of its history and origin: derived from the Latin word that roughly translates to equal mind, spirit, or feelings (Dictionary, n.d.), equanimity is commonly used in religious and philosophical contexts. I felt equanimity encapsulated the true essence of the PSMTs' stories.

Mathematical Capital

Last, but certainly not least, Mathematical capital was also expressed in every story shared by the PSMTs and it is unique because it is the only capital that is born purely out of a love for the mathematical discipline. We saw this show up as a declaration of love for mathematics in the stories of all the PSMTs, such as Nyla calling herself the *DiffEQ defender* because she enjoyed the topic and tutored others so that they could also be successful. We also saw it as an opportunity to use creativity to elevate her learning, which we saw in Scarlet's story where she used her artistic skills to enhance a math assignment. Finally, we saw it as the practice of making math connections to strengthening the understanding of new mathematical concepts. We saw this in Yvonne's story where she would refer to the notes, she took in earlier math courses to find content that would be used to scaffold her learning of new, more sophisticated, mathematical topics.

The definition of *mathematical* is "of, relating to, or of the nature of mathematics" (Dictionary, n.d.) which I use to represent the PSMTs' love of mathematics as a subject or appreciation for the challenge that mathematics provides. While there are few studies that focus on the ways that Black girls manifest their love of math, there are studies that note that Black girls do, in fact, enjoy math and other STEM pursuits (Collins et al., 2020; Leonard et al., 2020; Young et al., 2020). King & Pringle (2018) found that Black girls, after engagement in rich STEM out-of-school experiences, became agentic in seeking further interaction in formal learning settings; Leonard et al. (2020) found that Black girls have favorable attitudes towards the mathematical discipline.

A more interesting study is the one that found that the love and enjoyment of math is instrumental in shaping mathematical identities (Ibourk et al., 2022). Ibourk et al.'s (2022) study sought to understand how a Black girl built and sustained her science and mathematical identities through the stories she told. The researchers used a theoretical framework with three dimensions: science identity, the role of intersectionality in science and math identities, and emotions (Ibourk et al., 2022). I was drawn to the third dimension, emotions, because it spoke to the role of emotions in shaping one's experiences and identity (Ibourk et al., 2022), specifically, that joy is an emotion and that emotions are humanizing (Ibourk et al., 2022). The study found that the feeling of joy when engaging in math contributed to the Black girl's seeing herself as a mathematician. The fact that the feeling of joy is humanizing suggests that Black girls expressing a love for math, or joy when engaging in math, is an essential humanizing act. This humanization is a critical counternarrative to the dehumanization that, according to scholars (e.g. Gholson & Martin, 2019; Joseph et al., 2019), Black girls experience in math learning spaces. One insidious manner in which this dehumanization is enacted in the media and in classrooms is the portrayal

of Black women as being emotionless (Gholson & Martin, 2019), or as caricatures with a limited range of emotions (e.g. the angry Black woman trope) (Joseph et al., 2019; Townsend et al., 2010). The PSMTs were animated, even radiant, when they talked about doing math, learning math, and teaching math; this is testament to the infinite variety even in their communication of joy around a single topic. Gabi even shared that, while student teaching, she would spend her planning time just doing math, or a math-related puzzle, for her own enjoyment. The love of math is a personal joy, something the PSMTs would do even if they were not teachers.

Implications

The implications from this study fall into two categories: implications for undergraduate mathematics instructors who teach students who are PSMTs, and implications for faculty and staff in teacher preparation programs.

Implications for Undergraduate Mathematics Instructors

There were two key aspects of the findings that are worthy of consideration for undergraduate mathematics instructors – especially those who teach courses taken by PSMTs. The first is that there is a cost to the PSMTs' use of some of the capitals: because the use of some of the capitals (e.g. expectation capital, confounding capital, equanimity capital) are in response to negative stereotypes in the learning environment or feelings of isolation, frequent use of the capitals could lead to a fragile mathematics identity (McGee, 2015). The second is that the educator's perspective on the mathematics ability of Black girls and PSMTs influences the learning environment for the PSMTs.

Fragile Math Identity is the Cost of Capitals

Many of the capitals in this study were enacted because of pain and isolation, or as a protective measure against negative stereotypes in the learning environment. In the stories of the

PSMTs, we saw instances of racism, sexism, and classism in the math learning environment, and their negative impact their math learning experiences, supporting the shared tenets of CRF and Black feminism that the struggles of Black women can be attributed to their intersectional identities that oppose that of the dominant culture. It also highlights the impact of stereotype threat, the need to disprove the deficit dispositions about the ability and intellect of Black women.

According to McGee (2015), the constant vigilance against these systems of oppression and deficit stereotypes could harm or compromise the mathematics identity of high achieving African American students. For example, the PSMTs use of confounding capital was necessitated by a heightened awareness of pervasive negative stereotypes or microaggressions in undergraduate mathematics courses. Similarly, Equanimity capital was activated when the PSMT became overwhelmed by isolation and had to reach inward. McGee (2015) proposed a framework that defined the dynamic shift of the mathematics identities of high achieving Black college students between fragile and robust. In the study, participants reported a "weariness that comes from having to constantly prove oneself as worthy and competent" (McGee, 2015, p. 605) which is an indicator of a fragile math identity. This contrasts with a robust math identity where math learning brings joy and fulfillment (McGee, 2015). Mathematical capital was the only capital rooted in the kind of joy that supports a robust math identity.

While this study celebrates the ways that the PSMTs persisted through rough waters, we must consider the toll on their math identity. Unfortunately, a fragile math identity will not announce itself as such, nor will it show up as low achievement. In Nyla's story, she was hospitalized because of depression and burnout, which she stated was due to the pressure and impossibly high standards she placed on herself. Since her grades never faltered, even her mother

was not aware of the burden Nyla was carrying. Her silence in her classes was to avoid being perceived as combative towards her instructors or as a discipline problem. Indeed, in most of the PSMTs in this study, silence was the main precursor to the activation of a capital. The kind of silence I refer to is the general absence of the PSMTs' voice in the classroom; indeed, some students are just quiet or reserved by nature, while other Black female PSMTs fall into silence as a protective measure. The only way to know the difference is to know the student, and this will require intentionality. Math educators must pay attention to silence, changes in silence, or the context of the silence. Nyla only revealed her true self to supportive peers, or to math instructors who created a learning space that welcomed her curiosity and her social personality. As undergraduate mathematics instructors, we must consider ways to support Black female PSMTs with frequent immersion in the joy that they find in mathematics and all that it entails.

Disrupt the Tension in Math Classrooms

Taking a step back from considering the cost of the capitals, let us recall that most of the capitals are activated in response to what the PSMTs felt in the classroom. Black women who are PSMTs are doubly impacted by historical conceptions of who is valued in mathematics learning spaces. First, literature shows that Black girls are not usually expected to be strong mathematicians, and this perspective is perpetuated when math instructors succumb to the myth of neutrality (Darragh, 2014; Joseph et al., 2019). Secondly, some of the PSMTs in this study struggled against the perception that they were not true STEM majors, and perception was experienced within, and even outside, the math classroom. Within the math classroom, the PSMTs felt that their STEM peers looked down on them because they were education majors. For instance, Yvonne shared that she could feel one math instructor's disdain for education majors in the way he reacted when she and a peer preservice teacher asked questions in class.

The exclusion of secondary math education from STEM was also experienced outside the math classroom. For example, Gabi wanted to live in a dorm exclusively for women in math and science disciplines, yet she was not eligible because her major was secondary math education. This double bind impacted the comfort the PSMTs in this study felt, or did not feel, in math classes. What follows are two ways that learning spaces could be made more welcoming and comfortable, according to the PSMTs' stories: make room for difference, and welcome questions in the math classroom.

Make Room for Difference

For students, like Scarlet, who do reason differently than one might expect, it is vital to create a learning space that welcomes alternative mathematical representations and thought processes (Joseph et al., 2019). Scarlet often considered her way of thinking to be basic or elementary because of the looks she got from her peers when she explained how she arrived at an answer (which was correct). When she felt this way, Scarlet would leverage equanimity capital with the spiritual belief that greatness came from within. When one of her teachers recognized the uniqueness of her processing, and admitted to her that he did not have the skills to teach a student like her, it not only validated her math ability, but dismantled the impression that she was mathematically deficient. Instructors have the power to influence what is valued in the mathematics classroom, which means they need to be vigilant for opportunities to demonstrate their receptiveness to mathematical reasoning that is different from their own.

Welcome Questions

For both PSMTs, the math learning environment was not a safe space for a curious mind, and it was scary for a Black girl who did not want to confirm negative stereotypes about Black girls not being smart. Being in physical classrooms elevated the imposter syndrome Brandy

experienced in math classes, and she was afraid to ask questions in class because she did not want to be seen as a dumb Black girl. When Brandy took an asynchronous math class, she activated her actuation capital. She discovered that the anonymity of this asynchronous mode of learning empowered her to ask questions without succumbing to stereotype threat. This encouraged her to take another asynchronous math class. Brandy was fortunate that the pandemic lockdown gave her a taste of empowering anonymity, but what is to be done for students like Brandy, now that universities are back to offering in-person math courses?

Yvonne, on the other hand, was infuriated that her questions (or the questions of a peer educator) were met with the math instructor's ridicule, and this activated her expectation capital in her determination to be the type of teacher that made the math classroom a safe place for learning. As math educators, we must be intentional about creating a space where asking questions is not a taboo or source of anxiety. Joseph et al. (2019) noted that when teachers create a learning space that invites Black girls to share math ideas, "they are recognizing the value of positive social interaction" (p. 144) and this supports a relaxed learning environment. We can do this by repeatedly modeling gratitude when questions are asked (for example, "thank you for that question") and demonstrating receptiveness to questions that are asked by treating each question as something worth addressing. Joseph et al.'s (2019) study revealed that preserving the dignity of Black girls disrupts what many have experienced in schools and math classrooms. We can do this by providing anonymity for students like Brandy, such as discussion boards where submissions are anonymous. We can also let students show us what works for them. One surprising strategy that worked for a student of mine was the option to whisper questions that only I could hear. She would beckon for me to come closer so that she could ask her question rather than speaking it out loud.

Implications for Faculty and Staff of Teacher Preparation Programs

There are two implications, or opportunities, which are unique to faculty and staff in undergraduate secondary mathematics teacher preparation programs. The first is about the qualities that the PSMTs identified in the faculty and staff that become sources of fortification, and the second is about how we can support the PSMTs expectation capital.

Fortifying through Simple, but Impactful, Mentorship

Several PSMTs in the study listed faculty and staff as sources of fortifying capital. When asked what separated these faculty from others, Gabi and Brandy reported that they appreciated when faculty/staff members listened to them and allowed them to vent their feelings; Scarlet felt vindicated when faculty noticed her individuality and uniqueness; and Nyla felt free to be herself around faculty that they were always their authentic selves. What stood out was that the race and gender of the faculty/staff member was not always as important as the qualities that the PSMTs articulated. Sparks' (2018) study about the identity development for Black female preservice math and science teachers, found that while, racial and gender congruent role models are ideal, "it seems to be more important that these mentors care, give of their time, and encourage the students to finish their course of study" (Sparks, 2018, p. 251). There is a tremendous opportunity for faculty and staff in teacher preparation programs to be a well of fortifying capital for Black female PSMTs. While there are colleges and universities with formalized faculty mentoring initiatives, the faculty and staff that the PSMTs in this study were drawn to, became mentors when they showed that they cared about their wellbeing and about their goals. This mentorship can be a disruption of social injustices and inequities that historically denied Black women access to critical skills, knowledge and resources in institutions of education. This disruption is an important tenet of both CRF and Black feminism.

Supporting Expectation Capital

The college of education, or a department that houses the secondary mathematics teacher preparation program, is a hub for the community of educators, and a significant site for the PSMTs to feel that they belong to a community of educators. Most of the capitals that the PSMTs used were anchored in their expectation, their assurance that they would become math teachers. Being a math teacher was something that every PSMT in this study was passionate about, and being around peer PSMTs amplified feelings of belonging to the community of educators. Gabi was happiest in the classes she took within the college of education because she was learning with people who shared her passion for teaching and her commitment to doing what she had to so that she could be an effective teacher for her future students. She was especially thankful for what she learned in her methods courses because she felt that her instructors equipped her to be a good teacher. On the other hand, Yvonne, like the other STEM education majors at her university, took most of her preparation courses outside the college of education. By the time she took classes within the college of education, she felt like an outsider. Yvonne had to seek an external opportunity (i.e. the summer internship) to experience what Gabi found in her own program.

The opportunity here is to consistently reinforce the PSMTs' identity as mathematicians and mathematics educators. We, as a community of educators and math teacher educators, can support the Black female PSMTs by programming or mentorship that envelopes them into the community of practice (Wenger, 1998). If the curricular structure of the preparation program could create a situation like Yvonne's, then faculty and staff have two potential courses of action. One path is to provide extracurricular opportunities for PSMTs to interact, meaningfully, with the general body of preservice teachers in the preparation program. Another is to develop

Learning communities. Learning communities have been a valuable means of professional development for in-service teachers as it affords “opportunities to consider new practices in light of their existing repertoires to make them meaningful in their classrooms” (Horn et al., 2022). By extension, education learning communities can be spaces, for PSMTs, where “desired practices and knowledge are negotiated” (Hod et al., 2018, p. 491). A true learning community is where learning is an endeavor of the collective, not just a gathering of learners (Hod et al., 2018). While many institutions boast of such learning communities, Hod at al. (2018) caution against its vague application in education institutions.

Another way to promote membership in the community of educators is by involving the PSMTs in aspects of the work of faculty within and outside the classroom. Nyla valued the opportunity to do and present the research that she worked on with one of her math instructors; it became one of the ways that she defied negative expectations about her status as a mathematician. Inviting PSMTs to engage in research or to present at professional conferences (at the national and local level) brings them into fellowship with their peers and with seasoned educators. Encouraging PSMTs to attend conferences is fine, but the invitation to participate communicates to the PSMTs that their insights are valuable to the math education community. This solidifies their identity as an educator while awakening the possibility of a new identity as a researcher.

Black feminism recognizes that there is a social cost to being an intellectual Black woman and that the demonstration of this intellect can sometimes invite criticism and pushback (Combahee River Collective, 1977). If undergraduate math teachers incorporate the actions above, and if the faculty and staff in teacher preparation programs and other actions to mitigate the harmful weight of the oppressive systems within, and surrounding, the learning environment,

they become collaborators in the knowledge creation of Black female PSMTs. They also diminish the need for the protective use of capitals so that the PSMTs can dedicate their energy to the development of a robust mathematics identity within an environment that celebrates their humanity.

Limitations

There are five limitations to this study that I would like to address, the first is the limitation of narrative interviews, the second is the limitation quality measures, the third is the limitation of setting, and the fourth is the limitation due to cultural differences between the researcher and the PSMT. McAdams (2008) outlines six principles of narrative stories, one of which is that a story can change with each telling, sometimes because autobiographical memory is unreliable, and sometimes because each retelling factors in reflections from a previous narration. In this study, factual recollection of chronology (e.g. whether one math class was taken before or after another) was imperfect, which made it sometimes challenging to pinpoint the initial use of a capital. Where perfect chronology cannot be assured, the infusion of reflection yielded a richer understanding of the PSMTs motivations and their inner dialogue.

The second limitation is the limitation of quality measures. I hoped to be able to use member checking to increase the trustworthiness of the findings (Mertens, 2019; Willig, 2017). As seen in the interview protocol (see Appendix A), I promised to send the narratives to the PSMTs to verify the accuracy of my interpretation. I did not anticipate the length of time between the interviews and the drafting of the narratives, nor could I have imagined that the narratives would be longer than the two to three pages that I projected. Since the email addresses I used were the school email addresses, I did not have a way to reach the PSMTs with the narratives once I had them drafted. I was fortunate to be able to leverage peer debriefing through

the aid of two seasoned researchers who helped me while developing the codebook (Mertens, 2019). With their input in the definitions of the codes, and their help coding segments of data until we arrived at a satisfactory intercoder reliability, I secured alternative means to gauge the reliability of the findings.

The third limitation is one of interview settings. The interviews were conducted via zoom which was convenient due to a limited budget for transportation and because of the nationwide search for participants. The PSMTs did their best to locate quiet spaces but this was not always possible, which led to occasional interruptions to the flow of the conversation. While crucial insights might have been truncated, the participants did report feeling comfortable during the interviews. In their comfort, the PSMTs were generous with their time, and they honored me with the sometimes-painful stories that they shared with me.

A fourth limitation was the cultural differences between me (the researcher) and the PSMTs. As a naturalized American who is culturally Nigerian whose K-12 education was conducted outside of the US, I am an outsider to the lived and shared experiences of Black, African American women and of anyone educated in US public and private K-12 institutions. There were many elementary and secondary experiences described in the PSMTs stories that required more explanation since I had no frame of reference from which to draw. This difference allowed me to genuinely elevate the PSMTs as sources of valuable knowledge and insight. Our shared race, gender, passion for teaching, however, did afford an ease and willingness to be mutually immersed in this narrative relationship.

A final limitation was that similarities between the narrator and the researcher could lead to gaps in the data. A constant awareness of the researcher's reflexivity is critical for more complete data collection. Narrative inquiry necessitates a relationship between the storyteller and

the listener (the researcher). I found that, while similarities between the storyteller and the researcher could yield greater comfort and trust, it can also cause tacit communication. For example, when cleaning the interview transcripts, I noticed what appeared to be unfinished sentences. I realized that, because the PSMT presumed a shared understanding of what she was narrating, some things were left unspoken. It is difficult to analyze words that did not make it to the interview transcript.

Future Research

The findings from this study unearthed four considerations for future study either as an extension of the current study or as a consequence of it. First, there is the possibility that faith/spirituality is significant for some Black female PSMTs. Dumangane's (2017) study noticed that almost half of the participants listed faith as a capital that supported their progress as university students. Similarly, this study showed that, for most of the participants, faith or some spiritual belief supported their persistence, but I did not list it as a separate capital because its potential significance did not occur to me until I began analyzing the data. I did not probe the PSMTs about faith unless they happened to mention it; since only three PSMTs mentioned faith or spiritual beliefs, this means I have no information about the two PSMTs who did not. Although Dumangane (2017) focused on Black male students in the UK, the study was informed by the work of researchers who focused on the experience of Black students in the US, which makes me wonder if faith/spirituality could be a significant capital for Black female PSMTs in the US. Further investigation could be accomplished by extending the present study with an intentional raising of the issue of faith in the interview protocol, while still centering the experiences of Black female PSMTs.

Secondly, the type of institution might be more significant than this study revealed. I had hoped to recruit equal numbers of students from PWIs and HBCUs, but I was only able to recruit one who attended an HBCU. I reached out to several HBCUs, and I was surprised to find that, of the ones that had teacher preparation programs, most only prepared elementary teachers. With only one PSMT being prepared at an HBCU, I would like to continue this study with more PSMTs from HBCUs to get a clearer sense of the significance of the type of institution in the persistence of Black female PSMTs. The role that teachers, staff, and community played in the capitals suggests that this warrants more attention. For instance, Yvonne's narrative piqued my interest because she had the most positive and enriching math learning experience in K-12 schools with high populations of non-White students, which factored into her decision to attend an HBCU. Her early experiences were in stark contrast to Gabi's, who felt excluded from her Black peers during K-12. Once they were undergraduates at their respective institutions, Gabi, who attended a PWI seemed to have the better experience, especially within the college of education. Where some studies recognize that HBCUs have a unique approach to supporting Black STEM students (Farinde-Wu et al., 2020), I would like to consider if, and how, this support extends to Black female PSMTs in their preparation experiences.

Third, this study trained its focus on the experiences of Black female PSMTs taking a traditional, four-year university approach to licensure. This overlooks the experiences of Black female PSMTs who, through graduate certificate programs and license to masters programs, are in education as a pivot from a previous career. As these women are being educated within the same teacher preparation programs, one wonders whether they would exhibit similar or vastly different capitals as those in undergraduate programs.

Lastly, it could be revealing to learn the extent to which ethnic or cultural background impacts the capitals used or, if similar, the prioritization of these capitals. Black is not monolithic, yet this study does not delineate whether the Black female PSMTs are African American, Afro-Caribbean, or from the African Diaspora. In my reflections and conversations with teacher educators and K-12 teachers, ethnic background appears to be, albeit anecdotally, a significant lens for these individual experiences. I believe this warrants closer investigation.

Conclusion

The purpose of this study was to understand the capital within the toolkit of Black female PSMTs, capital that they used to sustain their progress through undergraduate mathematics courses to reach licensure. Rather that attending to recruiting more Black female PSMTs, the intentional focus of this study was on the experiences of Black female PSMTs who have persisted, so that we might learn how to provide better support for those currently in the teacher preparation pipeline. Through the rich and unique narratives of Brandy, Scarlet, Gabi, Yvonne, and Nyla, we saw six capitals that they leveraged to navigate environments and overcome obstacles that threatened to derail them from their goal. It is not always possible for math instructors to notice when a Black female PSMT is using any capital, but we can be intentional about creating math learning environments that protect their dignity as learners and invite positive social interaction. In these environments, Black female PSMTs can devote more time to their enjoyment of math as they prepare for their future as math teachers. There is much more to learn about the capitals that the PSMTs in this study relied on, and potentially more capitals awaiting discovery. The community of mathematics instructors and mathematics teacher educators need not wait, however, before taking action. There are simple things that can be incorporated into mathematics instruction and teacher preparation programs that would be highly

impactful. All that is required is intentionality, vigilance, and an authentic desire for successful program completion of Black female PSMTs.

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APPENDIX A: INTERVIEW PROTOCOL

RESEARCH PURPOSE AND STATEMENT

The purpose of this study is to explore the experiences of Black women who are preservice mathematics teachers (PSMTs) to understand the capital to which they ascribe their ability to persist through undergraduate mathematics courses en route to secondary mathematics teaching licensure. The following research questions will guide the study:

1. When sharing stories of persistence in undergraduate mathematics courses, which capital do Black women who are preservice mathematics teachers believe was instrumental in that persistence?
2. With respect to capital, what are the similarities and differences among Black women's stories of persistence in undergraduate mathematics?

This interview will use the McAdams (2008) Life Story Interview (LSI) method.

NOTE: "Nudges" are intended to sensitize me to some things I want to address in the research questions. I want to make sure I am prepared to follow-up when I hear important keywords (listed in tables).

PRE-INTERVIEW BLURB

Quick recap of process and consent form

- In this study, I am hoping to draw out the various skills, resources, strategies, or even people that Black women who are preparing to be secondary math teachers believe have been instrumental in supporting their persistence towards that goal.
- **3 interviews**: 1st focusing on math experiences prior to at undergrad institution, 2nd on math learning experiences at undergrad, particularly in the teacher preparation program and, lastly, an informal reflection and additional thoughts.
    - Currently you have (#) interviews scheduled. Would you like me to resend the scheduling link? I realize that during the week might be busy, so weekends are also a possibility.
- This is entirely voluntary, and, at any point, you can decide that you no longer wish to continue.

FIRST INTERVIEW PROTOCOL

(Expected duration: 60-90 mins)

Warm up Prompt: *Tell me about your earliest memories about learning mathematics or using mathematics? It can be in any environment, not just school.*

Nudge/follow up questions

- ➔ What was it about that experience that made it stand out amongst your other memories?
- ➔ Who were the important players? How so?

Prompt 1: (***Elementary math experiences***) *As you look back on your experiences learning mathematics around your elementary years, whether inside or outside of school, what are some moments that stand out? What happened in those moments? Who were the important players when you replayed the scenes in your head*?

Nudge/follow up questions: *I think I heard you say something about...can you talk about that little more*?

● Teachers	● Classmates/Peers	● Belonging/Inclusion
● Language	● Family (parents, siblings, fictitious family, etc.)	● Neighborhood
● School	● Discrimination	● Out of school experiences
● Race/Gender/Class	● Ethnic origin	

Prompt 2: (***Middle school math experiences***) *I'm curious to hear about what learning and using mathematics was like for you around your Middle school years, inside and outside of school. Can you tell me some stories about that time in your life? What were some typical experiences? What were some unusual experiences?*

Nudge/follow up questions:

● Teachers	● Classmates/Peers	● Belonging/Inclusion
● Language	● Family (parents, siblings, etc.)	● Neighborhood
● School	● Discrimination	
● Race/Gender	● Ethnic origin	

Prompt 3: (***High school math experiences***) *I would love to hear some more stories about your mathematics experiences during your high school years. Can you tell me some stories about what it was like being a mathematics learner around the time that you were in high school? It can include experiences outside of school.*

Nudge/follow up questions:

● Teachers	● Classmates/Peers	● Belonging/Inclusion
● Language	● Family (parents, siblings, etc.)	● Neighborhood
● Post secondary plans/Community College	● Discrimination/institutional racism	● AP/Honors classes
● Race/Gender/Class	● Ethnic origin	● Employment before college?

Concluding prompt: *Thinking about everything you've shared, has anything else come to mind that you would like to add or explain in more detail*?

Confirm appointment for second interview

SECOND INTERVIEW PROTOCOL

This interview will focus specifically on experiences in undergraduate mathematics courses.

(**Expected duration: 60-90 mins**)

Warm up Prompt: *How have you been since our first discussion? Did you replay any parts of our conversation? Which ones? Did these thoughts lead you to other interesting thoughts? Do you care to share?*

Prompt 1: *Tell me about your experiences as a mathematics learner in/during your undergraduate mathematics course (this can include your math methods courses). What was it? How did you feel going in? What did you expect from that course? What formed the basis for your expectations?*

Nudge/follow up questions: I heard you say something about…I would love to hear a little more about that.

● Teachers/Faculty/Administration	● Classmates/Peers	● Belonging/Inclusion
● Language	● Course expectations	● Career goals
● Institution/systemic racism	● Course/major selection	● Representation
● Race/Gender/class	● Ethnic origin	● Identity

Prompt 2: *Did you take any mathematics courses once you had completed the required math courses for your major?*

- ➔ If yes, how would you say those classes went, compared to the required mathematics courses?
  - ◆ How did your perspective of yourself as a mathematics learner change (if at all) when you took any additional mathematics courses?
- ➔ If not, how come?

Concluding Prompt: *Looking back on our conversations, what are some tips or pearls of wisdom that you would offer future mathematics learners like yourself*? *As a future mathematics educator, what would you do differently for the Black girls you either teach or have the opportunity to influence?*

Nudge/follow up questions

- ➔ What advice would you share with black girls when it comes to facing adversity in a math class?

- ➔ If you had the chance, what message would you send to your teachers (could be K-12, could be college, could be both)?
- ➔ How do you feel about who you are as a mathematician today?
- ➔ What would you do differently as a mathematics educator to change the experience of Black girls?

Concluding script: I have really been enjoying this time together. I truly appreciate your time and your openness. As a reminder, the final interview is just an informal conversation after you've had some time to think about everything that you shared in these two interviews. I would also like you to think about the things (strategies, people, special knowledge or wisdom) that you believe were critical in keeping you going with the teacher prep program when things became challenging.

Between now and that final interview, if you remember something or you reflect on the things we talked about, please do me a favor and make a note of it whether in a journal or a voice memo. I would really love to hear the thoughts or feelings this time brought up, and any other memories or reflections. Currently we have that interview schedule for (*current appointment*)...does that still work for you?

Also, after the final interview, start thinking about a pseudonym that you would like associated with you for my study. Do you already have something in mind?

THIRD INTERVIEW PROTOCOL

(**Expected duration: 60-90 mins**)

Warm up Prompt: It's been (# days) since we started this conversation. How are you feeling? Did you talk to someone about our conversations?

- Have you jotted down any thoughts since we last met? Do you care to share them?
- How would you define your identity as a mathematician? How about as an educator?
- I listened to our conversation a couple of times and there was something you mentioned that struck me as possibly important, so I wanted to ask you about…
- What does community mean to you or look like? How has that changed, if at all, through your journey?
- Do you have any questions for me?

Concluding script: Thank you so much for sharing your story with me. It has been extremely valuable for me, and I hope for you too. Here are the next steps:

1. Have you decided on a pseudonym? What did you select?
2. Once I transcribe the interviews, I will send them to you for your review - this could take a couple of weeks or a month. I will be using transcription software, and I want to make sure it accurately captures your words. I will send it as a word document where you will have the access to make comments. I will make corrections based on your comments. Are you comfortable with making comments in a word document or would you prefer another method?
3. After I analyze the data, my plan is to generate a 2–3-page narrative as a summary of the entire interview, kind of like a story. There could be a few months between the interview and the narrative. Would you like to see this narrative?
4. Lastly, you will receive your $50 gift card after you have reviewed the transcripts. It might happen earlier than that, but certainly at the latest. The gift card will be virtual so it will be delivered via email. Is this still a good email address for you (*show the email address I have on record*).

APPENDIX B: FULL CODEBOOK

Codename/Label	Definition
Balance pain from negative math experiences with personal passion	Participant states a decision to engage in an activity or course for which they have a passion in order to counter the pain from negative experiences in math classes.
Better math experience for my future students	Participant indicates that wanting to give their future students a better math learning experience than the participant's negative math experiences help them persist through a current math course and/or the teacher preparation program.
Better future for Black Students	Participants talks about striving for a better future for Black students, in general, or Black girls specifically
Comfortable with Discomfort	Participant indicates that becoming accustomed to the discomfort inherent in certain situations or institutions, especially as a member of a minoritized or historically marginalized population (and for other causes of discomfort) has helped them persist.
Community of Supportive Peers	Participant indicates that the presence of a supportive community of peers was a system of support for them (within or outside of math courses), helping them to continue towards course or program completion. The community could be along the lines of race/ethnicity, sex/gender, or even college major or concentration, as long as the community shared a mindset of helping each other.
Racial/Gender Congruency with Teacher	Participant states that having points of congruency with their teacher (whether sex, race/ethnicity, etc.) positively impacted their math learning experience.
Opportunities to infuse creativity or other learning modalities	Participant indicates that their math learning experience is enhanced when given opportunities to leverage creativity, artistic expression, or other learning modalities.

Codename/Label	Definition
Defying Expectations	Participant's desire to defy negative expectations; these negative expectations could be associated with racist, sexist, or other stereotypes that are either explicitly expressed or implicitly perceived.
Become Self-Sufficient	Participant states that they make a decision to self-isolate or become self-sufficient after negative experiences working with other students when they find themselves in a situation where no one is willing to help them in the class.
Faith/Spirituality	Participant makes statements about how their faith or spirituality enables them to persist either with a math course or in the teacher preparation program.
Focus on Future Career	Participant expresses that maintaining a focus on their future career as a math educator helps them endure current discomfort or negative experiences in math courses or the preparation program.
Help from ww-Family	Any mention from participates about receiving help from family members in a manner that supports persistence through a math course or the preparation program.
Knowledge is my weapon against microaggressions	Participant uses her knowledge as a weapon against microaggressions or overtly racist/sexist stereotypes experienced within math learning spaces
Love/Interest in Math	Participant expresses how the love or interest in the dynamic and challenging nature of math keeps them engaged and feeling capable in math courses, thereby supporting their persistence.
Make Math Connections	Participant indicates that the ability to see math connected to real life situations or to content learned in other courses (even non-STEM) improves their math learning experiences, thereby supporting persistence

Codename/Label	Definition
Prove Myself Worthy/Capable	Participant expresses a need to prove themselves either worthy of being in the mathematics course/class or capable of succeeding at something related to the mathematics course.
Recognize my Brilliance	Participant describes how the recognition of the participant's ability/brilliance, whether from a classmate or an instructor (especially one from the dominant society), or even from self, supported the participant's persistence through a math course.
Understanding the intricacies of the system	Participant demonstrates or expresses an understanding of the institutional system or classroom system as it relates to persisting with the program of study, or to placing themselves in the best position to be able to persist (e.g. leveraging institutional support services).
Supportive/Encouraging/Helpful faculty/staff	Participant mentions that the support (academic, emotional, or social, etc..) from the institution's faculty or staff enabled them to persist.
Empowered by Anonymity a.k.a. Opportunity for remote learning	Participant indicates that being able to be anonymous in a classroom setting (for instance, video conferencing with cameras off) supported their persistence.

APPENDIX C: CAPITALS, DESCRIPTIONS, CODES, AND QUOTES

EXPECTATION

Ethos: I have hope for the future

Description: The ability to focus on a future desire or goal

Dictionary Definition *"a prospect of future good or profit" or "the act or state of looking forward or anticipating"*

Codes Associated with Theme

- Focus on Future Career
- Better math experience for my future students
- Better future for Black Students

Sample Quotes from PSMTs

"my ultimate goal is to create this academy, this STEM Academy that uses … music, and art, and you know, the things that the kids like to do…to teach so they have practical applications" - ***Scarlet***

"And so I really wanted to … make sure that maybe more students would get to have a black math teacher by having me you know, and maybe being able to encourage other students who maybe want to be teachers, other black students to like continue. I think that was the thing that kept me going throughout that time. Just yeah, just because I just know that representation is so important" - ***Brandy***

MATHEMATICAL

Ethos: I love engaging with mathematics

Description: A fortitude that stems from the thrill of engaging with mathematics in various ways

Dictionary Definition*: "of, relating to, or of the nature of mathematics"*

Codes Associated with Theme

- Opportunities to infuse creativity or other learning modalities
- Love/Interest in Math
- Make Math Connections

Sample Quotes from PSMTs

"I just really had a love and interest for math. So like, it didn't really matter to me about like, when am I going to use this because, like, [math is] exciting in and of itself" - ***Brandy***

"Everybody hates DiffEQ. And I'm like, Listen, I'm a DiffEQ defender. Okay? I love differential equations…That was like my best class. I would go into those tests feeling pretty good. I'm not gonna lie. Like, I was always like, Alright, whatever. Let's crank this one out." - ***Nyla***

FORTIFYING

Ethos: I am surrounded by support

Description: Support that the participants receive from a variety of sources

***Dictionary Definition**: "to furnish with a means of resisting force or standing strain or wear"*

Codes Associated with Theme

- Community of Supportive Peers
- Racial/Gender Congruency with Teacher
- Help from Family
- Supportive/Encouraging/Helpful faculty/staff
- Others Recognize my Brilliance

Sample Quotes from PSMTs

"Another one was somebody who hadn't gone [to the study session]. And so he was asking us, like, 'oh, like how did the study session go?' And then like the person who was there with us… he was like, Oh, it was great. She basically tutored me for two hours…like throwing out his appreciation and the recognition of like, I recognize that you really have this…down and like, thank you for helping me" – ***Nyla***

"Yeah, most of the time I asked my dad at home because he taught geometry. I think a bit of algebra too. So like... so a lot of times I would like go home and ask him questions, and he would have like old textbooks and stuff that I could use and look through" - ***Brandy***

ACTUATION

Ethos: I can take action

Description: Participants take steps to alter circumstances in their favor

***Dictionary Definition**: "the state or condition of being impelled or moved to action"*

Codes Associated with Theme

- Understanding the intricacies of the system
- Empowered by Anonymity a.k.a. Opportunity for remote learning
- Balance pain from negative math experiences with personal passion

Sample Quotes from PSMTs

"I also got a tutor in that calc 3 class as well, and had been like, start with me at the beginning of the semester. And I met with him every week for the rest of the semester. So that helped a lot too because he really like made sure he was like, okay, draw this out so that way you can see it." - ***Brandy***

I remember my first year at [university] …I was like…I don't think I want to be a math education major anymore…as I started like, thinking about other majors, it's like, nothing, nothing interests me as much as math education and so it was like, … you're gonna have to suck it up … so I went back decided to add a minor in English to kind of help balance out some of those math and science classes" - ***Brandy***

EQUANIMITY

Ethos: I have help from within

Description: In moments when isolation or discomfort is felt strongest, participants draw strength from within.

***Dictionary Definition**: "mental or emotional stability or composure, especially under tension or strain; calmness"*

Codes Associated with Theme

- Become Self-Sufficient
- Faith/Spirituality
- Comfortable with Discomfort

Sample Quotes from PSMTs

"I learned to …try to find a way to be comfortable in discomfort if that makes sense…So like being comfortable with discomfort doesn't equate [to] tolerating disrespect. So I kind of have to understand that…I'll have a better like understanding of how to fully comfortable in those settings, but also not allowing that setting to like, mentally destroy me or anything like that." - ***Yvonne***

"I am Christian. And so I was saved. I went to church a lot. And heard God be like, "teach!". So I was starting to doubt this, like did God really say that? . But I was like, if he did, if he didn't say that, he'll push me in another direction. If he did say it, well, let's go!... I'm here and it's still working out…I'm not going to question it because something wrong happens" - ***Gabi***

CONFOUNDING

Ethos: I can resist

Description: Participants resist, challenge, negative ideas, spoken or perceived.

***Dictionary Definition**: "perplexing or bewildering", or "throwing someone or something into confusion or disorder"*

Codes Associated with Theme

- Defying Expectations
- Knowledge is my weapon against microaggressions

Sample Quotes from PSMTs

"Which is why I'm adamant about keeping my style. I have a gazillion tattoos. I like my nails to be long. That's what I want. Like I want you to walk in a room and assume that's what I'm going to be and when I open my mouth, and I speak, it's something completely different" - ***Scarlet***

"but a lot of people would kind of, you know, be like,... surprised, and there were some undertones of like, racism, …like, oh, wow... that black girl got… the highest math score out of all these kids. … I mean, it was, it's sad, but like, at the same time, I kind of, like, enjoyed defying expectations, or like, … proving people wrong…I found that like, actually being a really kind of big motivator for me" - ***Brandy***