

“A LEGACY THAT CAN GROW”: A CASE STUDY OF BLACK WOMEN SECONDARY
SCIENCE TEACHERS

by

JORDAN LARISSA HENLEY

(Under the Direction of Mary M. Atwater)

ABSTRACT

Though Black women have been shown to be effective teachers, they are still underrepresented as science teachers. By sharing and centering the needs, experiences, and wisdom of practicing Black women secondary science teachers, this study aimed to enhance the experiences, recruitment, and retention of Black women throughout their educational experiences and careers as science teachers.

The purpose of this study is to increase the understanding of the experiences, needs, and pedagogical approaches of Black women who choose to teach secondary science throughout their careers guided by the following questions: (a) What science experiences influenced Black women to become science teachers? What educational experiences influenced Black women to become science teachers?; (b) What are the experiences of Black women science teachers during their teacher preparation programs related to race and gender?; (c) What common and different occurrences related to race and gender have Black women science teachers experienced?; and (d) What pedagogies do Black women science teachers use in teaching science to students?

Black Critical Theory informed by Womanism framed this descriptive qualitative case study. Participants were four Black women teaching secondary science in the United States. Data

were collected using semi-structured interviews, journal entries, and lesson reflections.

Participants were between 26-45 years old with 1-19 years of teaching experience.

The study found that the participants each become a secondary science teacher as a backup plan, teacher education and classroom administrations did not understand the realities of Black women, participants cultivated classrooms that were liberatory spaces, and relationships with other Black women illuminated internalized bias and intragroup conflict but was inspirational and important to participants. This study concluded that both teacher education programs and school districts are not responsive to the needs of Black women teaching secondary science and that Black women teaching secondary science to incorporate liberatory practices into their pedagogies. Implications of these findings are expressed for teacher education programs with respect to recruiting Black women and changes in program curricula and for school districts and school administration with respect to retaining Black women science teachers. Implications and encouragement for Black women secondary science teachers were written as well.

INDEX WORDS: Science Teacher, Black Critical Theory, Womanism, Black Women
Science Teachers, Teacher Education, Science Teacher Education, Science
Education, Liberatory Pedagogy

“A LEGACY THAT CAN GROW”: A CASE STUDY OF BLACK WOMEN SECONDARY
SCIENCE TEACHERS

by

JORDAN LARISSA HENLEY

B.S., Tougaloo College, 2012

M.A.T., Belhaven College, 2016

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial
Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2022

© 2022

Jordan L. Henley

All Rights Reserved

“A LEGACY THAT CAN GROW”: A CASE STUDY OF BLACK WOMEN SECONDARY
SCIENCE TEACHERS

by

JORDAN L. HENLEY

Major Professor:	Mary M. Atwater
Committee:	Georgia Hodges
	Juanita Johnson-Bailey
	Dorothy Y. White

Electronic Version Approved:

Ron Walcott
Vice Provost for Graduate Education and Dean of the Graduate School
The University of Georgia
December 2022

DEDICATION

To my nieces and goddaughter who I hope will find only wonder and acceptance in science.

To my students, past, present, and future who inspired me to become a better educator.

To Iris, Dahlia, Clover, Raina, Willow, Ivy, Ms. Z, Ms. V, Ms. P, & Mrs. R. without whose vulnerability this work would not exist.

ACKNOWLEDGEMENTS

“Your real job is that if you are free, you need to free somebody else. If you have some power, then your job is to empower somebody else.” - Toni Morrison

My journey to this degree has been truly God led and I thank Him first for grace, health, and sustainment throughout this process. I am grateful to my ancestors who sacrificed for a future they never saw and whose persistence has placed me in a position to be successful.

To my grandparents, great grandparents, aunts, and uncles who helped raise me and to siblings and cousins who were raised with me I thank you for your continued belief in me and encouragement. Thank you for at a young age instilling in me “I’m a Henley” as a mantra and affirmation. To my friends who were always encouraging me, thank you for reminding me to take a break and for being systems of support.

To my parents who have never wavered in their support of any educational goal I expressed. I am sure there have been times during my educational career that you doubted what I was doing, or worried I was making the wrong choices. I thank you for never expressing your doubts to me and providing me with whatever support I needed. Thank you for raising me to understand the importance of knowing and understanding my history and showing me through your words and actions that liberation and care have been and always will be communal.

To those in the academy with me I thank you for your support and the wisdom you shared on this journey. To Kayla, thank you for helping me to learn and navigate this process. To Amber and Damaris, thank you for always being willing to chat about whatever topic I was wrestling with and always being willing to read and give feedback. To Jernita and Michole,

thank you for many nights of writing, talking, and laughter and reminding me I can do this work as my full self. To Qual Scholars, thank you for community and space to write. To the countless other without whom this experience would not have been joyful, I thank you for your care and support.

To the members of my committee, Dr. Georgia Hodges, Dr. Dorothy Y. White, and Dr. Juanita Johnson Bailey, thank you for your investment in my education and development. Thank you for your wisdom and guidance throughout this process. To my chair, Dr. Atwater, thank you for agreeing to work with me, the countless opportunities you have provided for me to learn and grow, your willingness to support and advocate for me, and your belief in my capabilities. I cannot express enough how grateful I am that you are my dissertation chair.

To the participants in the pilot study and the dissertation study, thank you for your vulnerability. Thank you for sharing your truth with me even when it was uncomfortable. Thank you for being willing to reflect on your experiences and practices. Thank you so much for your encouragement and commitment to Black women as a community. You are shining examples of how Black women support and provide community for each other.

To Black women science teachers, past, present, and future, we are building a legacy. We are building towards liberation and freedom. As we strive for a better future, care for yourself and remember your voice and presence are so very needed.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	v
CHAPTER	
1 INTRODUCTION	1
Background	1
Theoretical Framework	4
Purpose and Significance of Study	6
Research Questions	7
Definition of Terms	8
Summary	11
2 LITERATURE REVIEW	13
Introduction	13
Theoretical Framework	15
Marginalizing of Black People in Science & Science Classrooms	22
Black Women Science Teachers	30
Liberatory Pedagogy	45
Summary	49
3 PILOT STUDY	50
Purpose of Pilot Study	50
Method	51

Results.....	55
Discussion.....	68
Conclusion	71
4 METHOD	72
Introduction.....	72
Methodological Framework – Case Study.....	73
Research Design.....	75
Data Analysis	86
Validity & Reliability	90
Researcher Positionality, Subjectivity, and Reflexivity	92
Ethical Considerations	94
Assumptions & Limitations	95
Summary	96
5 FINDINGS.....	97
Participant Profiles.....	97
Themes	102
Summary	150
6 DISCUSSION AND FUTURE RESEARCH.....	151
Discussion of Findings.....	152
Conclusions.....	162
Recommendations.....	163
Future Research	172
REFERENCES	174

APPENDICES

A RECRUITMENT FLYER	197
B ELIGIBILITY SURVEY	198
C POST LESSON CHECKLIST	200
D JOURNAL PROMPT	202
E INTERVIEW PROTOCOLS	203
F RESEARCHER JOURNAL EXCERPT.....	210

CHAPTER 1

INTRODUCTION

Background

Across the African diaspora, science has always been integral to Black culture. This is evident in the significant contributions Africans and African Americans have made to scientific knowledge (Murfin, 1994) and evidence suggests the agricultural knowledge of enslaved Africans contributed to the success of plantations across the Americas (Gewin, 2017). Unfortunately, African and African American scientific practices and the advancements of science accomplished at the expense of Black people have been ignored and devalued by Western science. Examples of science accomplished at the expense of Black people include modern Western science flourishing because of the slave trade (Kean, 2019), enslaved Black women's bodies being used without their consent to advance medical science (Ojanuga, 1993), and Black people continuing to be subjected to unethical medical research post-Civil War such as the Tuskegee Syphilis Study (Brandt, 1978).

Science has often been used to uphold negative and derogatory perceptions of Black people. Scientific racism has been used to rationalize the subhuman treatment of Black people (Watkins, 2001). Though scientific racism is no longer explicitly accepted, the influence of it is still seen today with beliefs about Black people being genetically less intelligent than White people (Coastan, 2018; Stein, 2007) and the untrue beliefs some White doctors hold about Black people such as believing Black people do not feel pain in the same way as White people (Hoffman et al., 2016). Scientists are also beginning to recognize the effects of systemic racism

on the health of Black people has been attributed to non-existent racial genetic differences (Evans et al., 2020; Nature Medicine, 2020). These examples show how science has traditionally been used to marginalize and ignore the experiences of Black people and the bias of those performing scientific inquiry against Black people has resulted in that bias being incorporated into scientific beliefs. This marginalization has also resulted in science classrooms being sites of oppression and marginalization for Black students.

Despite the marginalization of Black people in modern Western science and society, scientific practices and knowledge are still visible in Black cultural practices such as home remedies passed down through families, hair care practices, and the ingenuity used to solve problems. Additionally, according to the 2015 National Assessment of Education Progress (NAEP), fourth grade Black students have a comparable interest in science to White students (U.S. Department of Education, et al., 2015). Unfortunately, Black students' interest declines by grade 12 (U.S. Department of Education, et al., 2015). Despite both an historical legacy of science and contemporary interest as young students, Black people are less likely to be in advanced science classes (Atwater, 2000b; Brand et al., 2006; Rodriguez & McGuire, 2019) and are underrepresented in scientific careers (National Center for Science and Engineering Statistics (NCSES), 2019). This discrepancy between Black students' cultural background in science and participation in science careers may be attributed in some part to their experiences in school. Teachers who do not share ethnic and cultural backgrounds with Black students are known to have lower expectations, hold them to lower standards than White students, and become a cause of Black students' low perspectives of their own academic potential (Brand et al., 2006; Collins, et al., 2019; Gershenson, et al., 2016).

In contrast, Black teachers have higher expectations for Black students (Gershenson, et al., 2016; Milner, 2006) and having just one Black teacher increases Black students' educational outcomes (Gershenson et al., 2018). Black teachers act as role models for Black students and generally have a better understanding of Black students' cultures and needs in the classroom (Mensah, 2009b; Milner, 2006). Black teachers are more likely to teach in schools with large Black student populations (Spiegelman, 2020). Black teachers' own experiences with racism and oppression may also result in them seeking to empower and equip Black students to address and overcome oppressive forces in their own lives (Milner, 2006). However, only 5% of high school science teachers are Black (Banilower et al., 2018). Thus, it is reasonable to suggest that improving Black students' outcomes and participation in science may be in some part accomplished through recruiting and retaining more Black science teachers.

Despite documentation of the positive impacts of Black teachers on Black students, few Black students have Black teachers (Rosen, 2018). A decline in the number of Black teachers was unfortunately one of the unintended consequences of the *Brown v. Board of Education* decision. In the wake of the Supreme Court decision outlawing segregation, Black teachers were driven out of schools and districts to be replaced by White teachers (Foster, 1997; Milner, 2006). Darker-skinned Black teachers were pushed out of schools all together, while lighter-skinned teachers were viewed as "less of a threat" for White teachers and students and allowed to stay (Milner & Howard, 2004, p.289). Before this elimination of Black teachers, teaching was seen as a good profession for Black people, but this perception of teaching as a career changed when Black students stopped seeing Black teachers in their schools (Milner & Howard, 2004; Milner, 2006). As Black teachers were moved from school to school, abused by White parents, students, and administrators, and pushed out of the teaching profession the perception of teaching as a

positive and stable career in Black communities changed (Milner & Howard, 2004). Recruiting teachers of color to teach science has the additional difficulty of low numbers of Black and Hispanic students completing STEM degrees, increased attrition of people of color from STEM fields, and the low number of students of color interested in entering the field of teaching (Mensah & Jackson, 2018). Retaining Black women science teachers has similar challenges as they deal with racism, sexism, dissatisfaction with their working conditions, and a higher likelihood of being laid off or transferred than White colleagues (Campoli & Conrad-Popova, 2017; Carver-Thomas, 2017; Hopper, et al., 2021).

As such, a deeper understanding of what attracts Black teachers to teaching science, their experiences in teacher preparation and early years of teaching, and what needs Black teachers have that are not being met is needed. There is a particular need to focus on the experiences of Black women who pursue careers in science teaching because Black teachers are overwhelmingly Black women. Of all public middle and high school teachers, 5.2% are Black women while only 6.8% of all public middle and high school teachers are Black (U.S. Department of Education & National Center for Education Statistics, 2020). Therefore, 76.5% of all Black public middle and high school teachers are women. It behooves us to consider Black women's experiences in science teacher education and science teaching, needs they feel are not being met, and their pedagogical approaches to teaching science.

Theoretical Framework

The theoretical framework for this study is Black Critical Theory (BlackCrit) informed by womanism. BlackCrit is an outgrowth and subset of Critical Race Theory (CRT) with the specificity of examining the racialized experiences of Black people. As BlackCrit was developed, theorists wanted to be careful to avoid regressive Black politics that had been present

in previous Black cultural movements and as a result BlackCrit rejects homophobia and heterosexism (Phillips, 1999). BlackCrit was justified as a necessity due to the work of Black people to preserve their culture and because Black people in United States of America have a particular and unique racialized experience and because of the presence of work by Black people to preserve their culture (Phillips, 1999). These factors were theorized as meaning it was a necessity to have BlackCrit as a theory to study the specificity of the experiences of Black people.

Within the field of human rights law, Lewis (2000) defined BlackCrit as scholarship “that addresses the significance of racial attitudes toward Africans and peoples of African descent in the structure and operation of the international human rights system” (p. 1076) and “highlights and resists the continued marginalization of Blacks in international human rights law and politics” (p. 1077). For the purposes of this study, Black Critical Theory in science education is defined as scholarship addressing the racialized experiences of members of the African diaspora and their marginalization within science education. In line with critical race theory (CRT), this framing recognizes and acknowledges the marginalization of Black people in science and science education as endemic to its practice and how science and science education are made sense of and provides space for Black liberatory fantasy and the resisting of “revisionist history” (ross, 2019, p.3).

BlackCrit actively works to reject homophobia and heterosexism and is an inherently intersectional framework. However, in this study BlackCrit is informed by womanism to better focus on the specificity of and the intersectional nature of Black women’s experiences. Womanism was first conceptualized by Alice Walker (1983/2006) who described a womanist as “a black feminist or feminist of color” who is “committed to survival and wholeness of entire

people, male *and* female” (p. 19). Phillips (2006) defines womanism as “a social change perspective rooted in Black women’s and other women of color’s everyday experiences and every day methods of problem solving in everyday spaces, extended to the problem of ending all forms of oppression for all people, restoring the balance between people and the environment/nature, and reconciling human life with the spiritual dimension” (p. xx). Alice Walker’s (1983/2006) assertion that womanists seek the wholeness of people lends it an intersectional lens on oppression with consideration for race, gender, class, and other marginalizing identities (Beauboeuf-Lafontant, 2002). Womanism is particularly appropriate to inform BlackCrit in this study because through a womanist lens the “experiences, thoughts, and behaviors of Black women” are centered for greater understanding (Beauboeuf-Lafontant, 2002).

Purpose and Significance of Study

The purpose of this study is to understand the experiences of Black women secondary science teachers during their teacher preparation and careers and to understand how they approach science instruction. This study is significant because it examines what attracts Black women who choose to pursue secondary science teaching and their experiences to better understand how recruitment and retention of Black women in science teaching can be increased. This is especially important as Black teachers are more likely to be dissatisfied with their working conditions or be laid off from their positions (Carver-Thomas, 2017). It is not enough to research how to recruit Black women as teachers if we are not invested in treating them as valued professionals and retaining them.

Addressing the needs Black women science teachers have that are not being met is significant to prevent both the marginalizing of Black women teachers and their potential Black students. As illustrated above, Black teachers have been shown to have a positive impact on

Black students, however, we must be careful not to assume they already know and have the necessary skills to teach Black students by virtue of being Black themselves (Gay, 2000). To do so ignores the intricacies and diversity of Black experiences and the confounding nature of class and additional marginalizing identities. It also ignores how Black teachers may struggle internally with enacting liberatory and social justice pedagogies (Rivera Maulucci, 2013). Therefore, we must learn more about the experiences of Black women secondary science teacher in order to address the needs Black women science teachers have that are not being met throughout their careers, to prepare Black women to be more effective science teachers, and to retain Black women in science teaching careers. Finally, through exploring the pedagogical approaches Black women science teachers use in teaching science, this study identifies and seeks to alleviate the marginalizing nature of science and science education on Black people.

Research Questions

To gain an understanding of the experiences of Black women secondary science teachers and the approaches they take to teaching science, this study was guided by the following research questions:

1. What educational experiences influenced Black women to become science teachers?
2. What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?
3. What common and different occurrences related to race and gender have Black women science teachers experienced?
4. What pedagogies do Black women science teachers use in teaching science to students?

This study was completed using descriptive qualitative single case study. It specifically studied the experiences of Black women who had been teaching secondary science for at least one year.

Definition of Terms

Secondary Science Teacher

Secondary science teachers are teachers who primarily teach high school science courses.

Black Women

Black women are individuals who identify as women and identify as descendants of African countries. This includes individuals who are descendants of enslaved Africans across the diaspora and recent African immigrants to the United States who identify themselves as Black.

Curriculum and Pedagogy

Pedagogy is defined as “the function or work of a teacher’ and “the art, science, or profession of teaching” (Random House, 2005) and curriculum is defined as “the totality of the experiences the pupil has” (Kelly, 2009, p.13). This includes experiences directly planned by teachers and the hidden curriculum “communicated often indirectly through attitudes, policies, observations, and behaviors” (Dziak, 2020, p.1). A teacher’s pedagogy influences the curricula that students will experience.

Culturally Relevant Pedagogy

Culturally relevant pedagogy was originally conceptualized by Dr. Gloria Ladson-Billings in 1995. She expanded her definition of culturally relevant pedagogy in 2014 and urged researchers to engage with culturally relevant pedagogy and expand it with the goal of creating spaces that “ensure that consistently marginalized students are repositioned into a place of

normativity” (Ladson-Billings, 2014, p. 76). Ladson-Billings (2014) offers three tenets of culturally relevant pedagogy:

1. Academic success or intellectual growth of students due to the curriculum they experience in class
2. Cultural competence where students are given the opportunity to “appreciate and celebrate their culture” and learn more about other cultures (p. 75)
3. Sociopolitical consciousness equipping students to use what they learn at school to “identify, analyze, and solve real-world problems” (p.75)

Black Liberatory Pedagogy

Changing the experience of science for Black students necessitates reconceptualizing what science classrooms look like and how science instruction is enacted. We can reach these aims through implementing Black Liberatory Pedagogy. In science education, Black Liberatory Pedagogy begins with the assumption that “Black students are brilliant” (Morton et al., 2022, p. 142) and includes:

1. Centering Black experiences and histories, Black cultural practices, and Black perspectives in curricula (Ladson-Billings & Henry, 1990; Morton et al., 2022; Noblit et al., 2007)
2. Preparing students for the world as it is while providing the knowledge and tools to resist and reject endemic oppression and marginalization (Ladson-Billings & Henry, 1990)
3. Making space and valuing student emotions and relationships with the teacher, each other, and science content (Castillo-Montoya, et al., 2019; Morton et al., 2022)

4. Critique of influence of white supremacy on students' lives and its influence on science and science classrooms to disrupt marginalization of Black students (Castillo-Montoya et al., 2019; Morton et al., 2022; Price & Ball, 1998)
5. Valuing students' *FULL* selves and everything they bring with them while understanding that Blackness is not a monolith (Castillo-Montoya et al., 2019; Morton et al., 2022)

Black Liberatory Space

Black liberatory spaces are conceptualized as spaces where students' academic success is valued and encouraged through valuing their culture, critical consciousness and critique of injustice and oppression is encouraged, students are taught and given opportunity to value other cultures, relationships and emotions are valued over rote discipline and behavior management, and all of students' identities are valued and given voice. This definition was developed through the integration of racially liberatory pedagogy and culturally relevant pedagogy (Castillo-Montoya, et al., 2019; Ladson-Billings, 2014).

Racism and Misogynoir

This study specifically examines how racism is enacted against Black women who teach high school science in the United States. I define racism and sexism against Black women as their positioning as an 'inferior other' due to their race and gender. This definition is derived from Mutegi's (2013) characterization of racism against Black people as the as the systematic belief and reaction to Black people as "inferior others" (89). The perception of Black people as inferior and somehow lacking manifests in the manner Black people are treated, assumptions about how and why Black people behave, and what Black people are believed to deserve.

Bias against Black people due to an ingrained and sometimes unconscious belief of Black people as inferior others is revealed in the disbelief and disregard of Black people's experiences,

disregard of Black people's emotions, needs, and humanity, and an assumption that Black people have nothing of intellectual value to offer. When decisions are made, laws and policies enacted, and actions taken based on blatant and implicit positioning of Black people as inferior others, it results in the oppression and marginalization of Black people across every facet of culture within the United States. This belief is so insidious that it has become a part of the norm in western culture to the point it becomes beneath the notice of most people. This enculturation of Black people as 'inferior others' is also embedded in their treatment in educational spaces.

Black women also experience a compounding oppression at the intersection of race and gender. Their value, needs, and humanity are disregarded due to both racism and sexism. Misogynoir is a term coined by Moya Bailey to describe how these oppressions intersect. She defines it as the "racialized and sexist violence that befalls Black women as a result of their simultaneous and interlocking oppression at the intersection of racial and gender marginalization" (Bailey, 2021, 1). Misogynoir is a product of Black women being positioned as the inferior other due to their race and gender and therefore being disregarded as lacking value and void of humanity.

Racialized Black Experiences

Racialized Black experiences refers to the experiences of that are particular to Black individuals and not universally experienced by people of color (Lewis, 2000; Phillips, 1999). These experiences may be caused by attitudes towards Black people or 'race-neutral' policies that marginalize Black people in science education (Phillips, 1999).

Summary

For many years, there has been a call for an increase in the number of Black teachers and to increase the retention of new teachers. This goal has been difficult to meet generally and

even more difficult to meet specifically within science education. In learning about the experiences of Black women science teachers, we will learn how they feel their science teacher preparation programs prepared them for teaching, improve the experiences of Black women in science teacher preparation and science teaching, and decrease the marginalization of Black people inside of the science classroom. To this end, the purpose of this study is to understand how Black women who are science teachers have experience science throughout their lives, experienced science teacher preparation, and have experienced being science teachers, as well as their pedagogical approaches to teaching science. In the following chapter, I expand on Black Critical Theory informed by womanism as the framework for this study and provide context for the study through a review of the literature.

CHAPTER 2

LITERATURE REVIEW

Introduction

Student diversity has been increasing across schools in the United States. Unfortunately, increasing diversity in the student population in US schools has not been matched by increasing diversity in the teacher population (Parsons, 2000) since the population of teachers in U.S. schools are overwhelmingly White women (U.S. Department of Education & National Center for Education Statistics, 2020). As a result of this mismatch, there have been calls to increase the number of teachers of color in U.S. schools (Eischens, 2020; Heubeck, 2020). One reason for this call is that Black students who are taught by Black teachers have improved academic outcomes (Gershenson et al., 2018). Since most Black teachers are Black women (U.S. Department of Education & National Center for Education Statistics, 2020) we must gain further understanding of Black women's experiences within science education.

Before attempting to increase the number of Black women in science education, it is our responsibility to understand the experiences of Black women who are currently in field of science teaching and to retain these Black women for three reasons. One, we should understand what needs Black women have that are not being met in science teacher education programs so they can be addressed. Two, Black people have historically been marginalized in science and science education. As such, we should understand Black women's experiences in science throughout their lives, during science teacher preparation, and during their science teaching careers to understand how they continue to be marginalized and address it. Third, though Black

teachers have been shown to improve Black students' outcomes in education, we must be careful not to make assumptions about Black women's ability to effectively teach Black students or diverse classrooms. It would be irresponsible of science educators to recruit Black women as science teachers without first ensuring we can properly prepare them and that they are entering into environments that will facilitate their retention.

The purpose of this study was to understand the experiences of Black women who are science teachers in science throughout their lives, during their science teacher preparation, and during their teaching careers, as well as their pedagogical approaches to teaching science. As calls are made for an increase of people from underserved and underrepresented groups as teachers and within science fields, it is important to examine what attracts these individuals to science and if current teacher education programs are meeting their needs. Further, we must consider the specifics of oppression against different underrepresented and underserved groups and how it interacts with their gender, class, and other identities. In order to undertake this challenge with a focus on Black women, this study was guided by Black Critical Theory (BlackCrit) informed by womanism.

To provide context for this project and situate it within existing literature, this chapter discusses (a) the development and history of BlackCrit and womanism and their application in this study, (b) how Black people have had specific experiences being marginalized in science both historically and contemporarily, (c) the current state of Black women in teacher preparation generally and within science education specifically, (d) the state of retention of Black women in education, and (e) an overview of the development of liberatory pedagogies.

Theoretical Framework

BlackCrit

Critical Race Theory (CRT) was initially theorized in the 1970s when legal scholars recognized that much of the forward progress of the Civil Rights Movement had stopped and, in some cases, regressed (Delgado & Stefancic, 2017). The three basic tenets of CRT are (a) racism is endemic and normal to society, (b) interest convergence has led to civil rights accomplishments, and (c) the establishment of the social construction thesis (Delgado & Stefancic, 2017). The first tenet, that racism is endemic and normal to society, means it can be difficult to address racism because racism is not acknowledged, equality is conceived of as being colorblind, or racism is so normal that policies and practices are not recognized as marginalizing forces (Delgado & Stefancic, 2017). The second tenet, interest convergence, states that advances in civil rights are often more about White self-interest than improving the circumstances of marginalized and underserved people (Delgado & Stefancic, 2017). This is illustrated by many of the advances of the Civil Rights Movement having been more beneficial for White people than for marginalized individuals. For example, Bell (1980) asserted the *Brown v. Board of Education* decision reflected the desire of the United States to appeal to Third World countries as the United States participated in the Cold War with communist countries. For this and other reasons, the decision to pass Civil Rights legislation had less to do with giving Black people equal rights and more to do with the interests of the White people in power (Bell, 1980). The third tenet, the social construction thesis, asserts that race is a social construct with no scientific basis (Delgado & Stefancic, 2017). Race is not a biological truth but is instead constructed by the social interactions and beliefs of people.

CRT was initially developed in the field of law studies and was later introduced to the field of education by Gloria Ladson-Billings and William Tate (1995) as a lens to study race and racism in education. Critical race theory is used as a framework to examine situations, policies, and practices in education through the lens of racism being an integrated part of society in the United States and thus appearing “normal and natural” to members of this culture (Ladson-Billings, 1998, p. 11). Critical race theory is used as a lens to expose the racism that has been integrated into cultural and societal norms. Integrated racism and inequities in science education are sustained through the oppressive structures of mainstream science teaching. As a result, Black science teachers are socialized into structures with embedded racism through their participation in school curricula, instruction, assessment, and school funding (Ladson-Billings, 1998).

As CRT grew as a field of study, extensions of it were theorized such as Latino Critical Theory, Asian Critical Theory, and an LGBT theory (Delgado & Stefancic, 2017). These groups developed in part due to a perception that CRT focused overly much on ‘Black’ issues (Dumas & ross, 2016). These more specific critical theories center the experiences and interests of each group (Delgado & Stefancic, 2017). As these theorizations developed, Black scholars began to discuss if a Black Critical Theory (BlackCrit) was necessary as a framework to study and examine the specifics of the experiences of Black people’s interactions with race and racism in contrast to CRT “as a general theory of racism” towards all marginalized people (Dumas & ross, 2016, p. 417). Black people in the United States of America have a particular and unique experience with racism and Black people have worked to preserve their culture leading law study theorists to assert the necessity of BlackCrit (Phillips, 1999). Legal studies theorists developed BlackCrit as an extension and enrichment of CRT that sought to examine being Black in a world

that marginalizes and oppresses Black people (Dumas & ross, 2016). In doing so, it is essential for BlackCrit to avoid the pitfalls of homophobia and sexism that have become characteristic of some Black Nationalist Movement (Phillips, 1999). Therefore, BlackCrit needed to be intersectional framework.

Like CRT, BlackCrit was eventually adopted by educational researchers. Black Critical Theory shares tenets and characteristics of CRT with a focus on the specific experiences of Black people with race and racism and how Black people are marginalized and experience racism within educational contexts. BlackCrit in science education is therefore conceptualized as scholarship addressing the experiences of members of the African diaspora and their marginalization within science education. In line with critical race theory (CRT), Black Critical Theory recognizes and acknowledges the marginalization of and racism against Black people in science and science education as part of how science and science education are made sense of and as normal to their practice (Delgado & Stefancic, 2017).

BlackCrit encourages and provides space for Black liberatory fantasy and resisting “revisionist history” (ross, 2019, p.3). Revisionist history describes the ways in which history is typically told in ways that ignore or discount the contributions of Black people. A BlackCrit framework seeks to correct this by describing history in ways that are more accurate to the experiences of Black people (Delgado & Stefancic, 2017). Black liberatory fantasy is the imagining of science education as a space where racism and marginalization have been disrupted. Through liberatory fantasy, we can imagine what equitable science education looks like and work towards those goals. Liberatory fantasy and the resistance to revisionist history also enable the critique of how science and science education have been traditionally practiced and the imagining of how science would be if different values had been incorporated into science

and science education. In recognizing marginalization, oppression, and racism as a normal part of science and science education, BlackCrit provides a lens to examine policy, practices, and experiences within science and science education.

Womanism

Feminism in the United States grew out of abolitionist and women's rights movements (Dicker, 2008; Johnson, 2015). Early feminists included Black women such as Sojourner Truth, Ida B. Wells, Mary Church Terrell, S. Willie Layton, and Josephine St. Pierre Ruffin (Signorella, 2020). However, as the feminist movement grew White middle- and upper-class women chose to ignore how the influences of race, class, and sexuality impacted the experiences of women from different backgrounds (Jones, 2007). Some White members of the first wave feminist movement were also overtly racist and many White feminists believed that the feminist movement should ignore race (hooks, 2015; Johnson, 2015; Signorella, 2020). They suggested that "White women's interests were juxtaposed against the concern of the 'colored' man" leading some White feminist activists to claim that "women's meetings were no place for questions of 'color'" because "the women's movement was a demanding enough endeavor" and "that neither women nor slaves should further degrade their standing by linking their causes" creating a reality where "black women were rendered politically invisible" (Jones, 2007, p. 92) by two causes influencing their wellbeing but ignoring their needs.

Even as they struggled against the dichotomy of race and gender, many Black women felt uncomfortable identifying with the feminist movement due to the dual oppressions they experienced. Despite this phenomenon, some Black women began to identify as Black feminists. However, this label felt uncomfortable for many Black women due to the reactions that the term feminist evoked even when paired with Black as an adjective (Collins, 1996). Historically and

contemporarily, the presentation of feminism in media has highlighted the positions and activities of White feminists while at times coopting and erasing Black women. Some White feminists only focused on issues that affect White women while excluding women who are members of marginalized and underserved groups (Collins, 1996; hooks, 2015; Signorella, 2020). While other White feminists were committed to advocacy that did not silence marginalized groups in favor of White women's interests, feminism was perceived as belonging to and serving the interests of White women. Many White feminists encouraged Black women to form their own movements and conflated the experiences of White American women with the experience of all women in America (hooks, 2015). Instead of bringing women of varied racial and ethnic backgrounds together, the women's rights movement made the divisions due to white supremacy glaring (hooks, 2015). As a result, many Black women did not want to identify themselves as feminists, did not affiliate themselves with the term Black feminism, and expressed concerns that Black feminism privileged gender over race (Collins, 1996).

Womanism is a term that disrupts the Black/White dichotomy that Black feminism evokes as contrast to 'White' feminism. In 1983, Alice Walker coined the term womanist as "a black feminist or feminist of color" who is "committed to survival and wholeness of entire people, male *and* female" and "loves struggle. Loves the Folk. Loves herself. *Regardless*" (p. 19). Womanism emphasizes the validity of women's lives, autonomy, and agency, resists respectability politics, embraces intersectionality, values community, and encourages self-care (Phillips, 2006).

Since Walker's initial conceptualization of womanism, the term has been defined and theorized by many scholars. Phillips (2006) defines womanism as "a social change perspective rooted in Black women's and other women of color's everyday experiences and everyday

methods of problem solving in everyday spaces, extended to the problem of ending all forms of oppression for all people, restoring the balance between people and the environment/nature, and reconciling human life with the spiritual dimension” (p. xx). Through a womanist lens the “experiences, thoughts, and behaviors of Black women” are centered for greater understanding (Beauboeuf-Lafontant, 2002). Womanism seeks to identify and alleviate all types of oppression for all people and because of this womanism is an inherently intersectional framework. Womanism considers the triple influences of race, gender, and class on oppression (Sheared, 2006).

Scholars disagree over the differences between Black feminism and womanism. However, Collins (1996) argues Walker used both terms interchangeably and the difference in naming highlights the diversity of viewpoints and perspectives among Black women. Further, womanism and Black feminism share many goals and engaging with either term “means engaging in the difficult task of working through the diverse ways that black women have been affected by interlocking systems of oppression” (Collins, 1996, p. 16). Though the terms are interchangeable in many ways, womanism has a more explicit connection to the intersecting identities of individuals, such as sexuality, and is grounded in “the concrete experiences of African-American women” (Collins, 1996, p.11). The anti-oppressive and intersectional nature of womanism along with how it focuses on the experiences and problem solving of Black women make womanism an appropriate framework to inform BlackCrit.

Currently, ‘anything that is outside the dominant culture, or anything that does not resemble the common and shared ‘world-view’ of preservice teachers and student teachers is prone to be a dangerous threat, unimaginable, deficient, unworthy of examination or validation (Brady & Kanpol, 2000, p.47). A womanist framework could be a solution for the disruption of

this norm in teacher education as illustrated by Evans-Winters (2015) argument that “Black women’s cemented status at the bottom of the social hierarchy enkindles a unique vantage point for understanding the sexist socialization and racist oppression in relation to education and schooling” (p.132). This makes Black feminisms and womanism useful frameworks to study science education and disrupt the narratives of the dominant culture and introduce new perspectives. This could result in a change in how science is done and how results are interpreted (Atwater, 1998).

Black feminisms and womanism are intersectional frameworks and intersectionality is a lens lacking within studies on science teacher education. Atwater (2000a) critiqued a gender and feminism issue of the *Journal of Research in Science Teaching (JRST)* stating “one might conclude from this issue that (a) White females are the norm for gender issues, or (b) gender has become a code word in science education that refers to White females’ ideas” (p. 387). It seems education has intentionally or through neglect has replicated the circumstances of Black women in the first wave feminist movement as a part of educational research. Black feminist, critical feminist, and womanist theories in education attempt to bring a more intersectional lens to studies that include gender to also consider class, sexuality, and other identities that influence students’ experiences in science education.

How Womanism Informs BlackCrit

BlackCrit is useful in reconceptualizing the policy and practice of science teacher education and of Black women science teachers by assessing how racism and marginalization directed at Black women who are teachers influences and causes inequities in science education (Mensah & Jackson, 2018). Mensah (2019) suggests that an intersectional lens is necessary for gaining a holistic view of teachers of color. Though BlackCrit is an intersectional framework,

womanism compliments BlackCrit for this study because it specifically focuses on the experiences and problem solving of Black women (Phillips, 2006). Further, womanism seeks to challenge “Eurocentric assumptions” (Fraser-Burgess et al., 2020) which aligns with how BlackCrit critiques the assumptions embedded in society due to the endemic nature of how Black people are marginalized. Womanism is an intersectional feminist perspective, and such a perspective in a science classroom “resists the dominant discourse and invites all students to learn science, but more important, it invites them also to critically analyze scientific systems and the relationship of those systems to power, oppression, and domination” (Mayberry, 1998). By using womanism to inform BlackCrit theory to study Black women’s experiences of Black women science teachers we can resist the dominant discourses in science teacher education and science teaching and create liberatory learning environments for students.

Marginalizing of Black People in Science & Science Classrooms

Historically

Science has always been an integral part of Black lives and Black culture. There are so many people of color from various cultures who have contributed to Eurocentric science. Unfortunately, in the United States, science classrooms have a “lack of representation of scientists of color and the overrepresentation of White middle-class male scientists” (Mensah & Jackson, 2018). We are not taught about African diasporic scientists and innovators for a variety of reasons. One is because traditionally non-European ways of knowing have not been valued by Eurocentric science and are thus not considered science (Murfin, 1994). A primary reason why these ways of knowing are not considered science is because of the difference between what is considered to be important in African cultures and what is considered to be important in Eurocentric culture.

Historically, science practiced across Africa has been based in humanistic practices, while science practiced across Europe often focused on things and knowledge for the sake of knowledge (Murfin, 1994). The accomplishments of traditional African science have not been valued because African scientists did not have the publish or perish paradigm of European countries and so African scientists did not document or keep records of discoveries (Murfin, 1994). Therefore, full appreciation of the historical contributions of science done across the African continent requires in depth historical and anthropological investigation because African science is not recorded and documented in the same way as European science. In contrast to the publish or perish paradigm of Eurocentric science, African science knowledge has traditionally been passed through families and not available for everyone (Murfin, 1994).

Finally, one of the biggest reasons African science is not valued is a historical disregard for the accomplishments of people across Africa by Western science. For example, the Dogon priests of Mali were accomplished astronomers and had documentation of a star invisible to human eyes. European scientists refused to believe the Dogon could have learned of this star on their own because the European scientists could not explain how the Dogon priests had knowledge of the star. Instead, European scientists came up with alternate explanations for scientific accomplishments of the Dogon priests of Mali. For example, famed astrophysicist Carl Sagan posited a European visitor told them and even stated that it was more likely that extraterrestrials had visited (Adams, 1984).

The lack of belief in Black science and intellect is perpetuated to this day through fictional television such as *Stargate: SG1* that suggest ancient African accomplishments were instead the work of visiting aliens or worse purportedly non-fiction television shows such as *Ancient Aliens* which popularize theories of aliens creating the pyramids and other African

accomplishments and is broadcasted on the History Channel (Bond, 2018). Popular media both fictional and non-fictional suggest the ancestors of Black people were incapable of intellectual and scientific contribution. It should also be no surprise when teachers don't believe in the capability of members of the African diaspora or consider African or Indigenous accomplishments important when a famous astrophysicist made it "readily apparent he is full of contempt toward any non-European contributions to human progress" (Adams, 1984).

Despite the disdain shown towards Black knowledge by mainstream Western science, Black people have always participated in scientific knowledge production. Evidence shows the knowledge of rice cultivation techniques abducted and enslaved people from Africa held was critical to the success of rice plantations across the Americas (Gewin, 2017; Sinclair, 1998). During and following enslavement, Black people developed expertise with technology because of agricultural, mechanical, forestry, and fishing jobs (Sinclair, 1998). Additionally, in Africa, botanical knowledge allowed some Africans to hide from slavers. Escapees and Africans who were avoiding slavers could monitor the mimosa plant for the 'drooping' reaction it had to touch to determine if slavers had been in the area (Mensah, 2019). Enslaved African's medicinal expertise was recognized and coopted by White people (Andreae, n.d.) and Black scientists in the 1800s used their scientific training to challenge racist science of the time (Rusert, 2017). Despite this plethora of scientific knowledge held in Black culture, how science is integrated into Black culture and experiences is not more well-known because of scientific racism and a distrust of science by Black people due to misuse of Black people by science throughout history.

Scientific racism grew as a response to colonialism by colonizers. As colonialism grew across the globe, Europeans framed themselves as 'superior' to the 'inferior' Black and Brown people whose lands they were colonizing, in part, to provide themselves rationalization for their

oppression of Indigenous peoples (Charles, 2020). This perspective spread amongst scientists with prominent Swedish botanist Carl Linnaeus proclaiming Europeans as inventive and reasoned in contrast to Black people as lazy and impetuous in the 1700s (Charles, 2020). Across the 18th and 19th centuries, scientific racism became more acceptable and White people claimed to be genetically more intelligent than Black people. The field of anthropology was founded in part to determine if “all human races” were “capable of rising to the same intellectual and moral level?” (Firmin, 2000, p.13). Charles Darwin’s book *On the Origin of the Species* was coopted to develop social Darwinism and provide White people with a justification for slavery and racism (Charles, 2020). The established stratification based on pseudoscientific beliefs about race persist to this day to the benefit of White people and to the cost of Black, Indigenous, and other historically marginalized groups (Walls, 2016).

Scientific racism can also take more subtle forms. Until relatively recently, it has been acceptable for scientists to believe that members of different races had genetic differences (Saini, 2019). This belief bled into medical science causing health disparities to be attributed to genetic differences between races instead of environmental factors caused by systemic racism (Evans et al., 2020; Nature Medicine, 2020). Though beliefs about genetic differences between races has fallen out of favor, many prominent scientists still express opinions about there being a genetic difference between races (Saini, 2019; Stein 2007). Saini (2019) asserts “it may be impossible...to completely shed the ideas of race prevalent in the early 20th century, particularly when society in general still lives with them today racial discrimination is still widespread in education and employment” (p. 43). Additionally, blatant use of science to uphold racist beliefs is still popular in White supremacist circles (Coastan, 2018; Price, 2018; Stein, 2007) and racist beliefs about Black people are still prevalent within the medical field (Hoffman et al., 2016).

Finally, medical science has been used to harm and oppress Black people and medical research has been conducted on Black people without their consent. This includes the ‘father of modern gynecology’ and his research on enslaved Black women (Ojanuga, 1993), the Tuskegee Syphilis experiment (Brandt, 1978), and neglecting to get consent for the use of HeLa cells (McDaniels, 2017).

The historic marginalization of Black people in science is rarely addressed or critiqued in science classrooms resulting in this marginalization echoing through science and science education today. We must explore how these echoes continue to have marginalizing effects on Black teachers of science and influences Black teachers understanding and teaching of science. Further, we need to understand the scientific past and critique it to make science classrooms and science spaces welcoming to marginalized and underserved people. Recognizing how bias and racist beliefs have influenced scientific practice over time makes it clear that the field of science needs to be more diverse and provide space for diverse perspectives so these biases can be identified and excised. To do this, we must improve science education and reexamine our current beliefs about what constitutes good science teaching and good science teacher preparation.

Contemporarily

Contemporarily, Black people are underrepresented across science fields (National Center for Science and Engineering Statistics (NCSES), 2019). This may be attributed to racism they experience in their careers (Funk & Parker, 2018) and is also connected to their educational experiences. Black students are less likely to be in advanced science classes than their White peers (Atwater, 2000b; Brand et al., 2006; Rodriguez & McGuire, 2019). Black students initially major in science at similar rates to White and Asian students but are much more likely to change majors even when the students have similar high school academic backgrounds (Riegle-Crumb,

et al., 2019). This is most likely due to the exclusionary nature of introductory science classes where students are told that half of them will not make it. In addition to the embedded exclusion of science classes, Black students must also deal with assumptions made about them based on stereotypes and biases making it no surprise that Black students are more likely to change to non science majors (Riegle-Crumb et al., 2019). The achievement of traditionally marginalized students on science achievement exams is often less than the achievement of students of European descent (US Department of Education et al., 2015). In 2015, 27% of White students scored proficient and 2% advanced on the 12th grade science achievement exam, in contrast, 5% of Black students scored proficient and the percentage scoring advanced rounded to zero (US Department of Education et al., 2015). Between 1996 and 2005 White students outperformed Black students by about 30 points at each 12th grade science assessment showing a consistent difference in the achievement of Black and White students (US Dept of Education et al., 2015).

Traditional science classrooms fail to interrogate how they may be marginalizing Black students. Critique of how scientists and scientific concepts, such as Carl Linnaeus and evolution, have been coopted by racists and to cause harm to Black people is not addressed in science classrooms. What does it mean to Black and Brown students to sit in a classroom that honors Linnaeus as the father of modern taxonomy without addressing and critiquing his classification of people by race, especially as the stereotypes he assigned to these races persist to this day (Cahan, 2020)? This question among others are topics that must be addressed to create equitable science classrooms.

Currently, the science classrooms Black students experience in school may make them believe science is not for them and belongs to White people (Mensah & Jackson, 2018). Science classrooms are often Eurocentric in nature and primarily share the accomplishments of White

people which may cause students of other backgrounds to feel that science does not include them or their cultures (Parsons, 1997; Stanley & Brickhouse, 1994). The ways in which science is taught to students centers reason and devalues Black culture in favor of White culture (Parsons, 1997). Parsons (1997) found Black high school girls most often identified scientists as White males with dominant cultural values and when the girls identified scientists as Black, they described scientists with Black cultural values. If we hope to increase Black students' interest in science, then we must be cognizant of how science instruction presents the discipline of science as inclusive or exclusive of students' culture (Parsons, 1997).

There is little research identifying how Black students understand and view science (Walls, 2012; Walls, 2016). Instead, many research studies take a colorblind approach to evaluating the nature of science, excluding how race and culture influence the experiences students have and potentially totally excluding Black students from these studies (Walls, 2016). By ignoring the implications of race in the understandings of science and the science classroom, there is a failure to connect the science classroom to the students' lives.

Further, classrooms with large Black student populations are often strict and punishing towards students (Emdin, 2016) to the point that some scholars question if in science classrooms there is a "real concern with helping students build deep [scientific] understanding exist, or is science teaching and learning just another way to box children into acting "correctly" ...under the mask of claims to cover the state and local science education standards?" (Noblit et al., 2007). With these negative experiences and a singular focus on the achievement of White people in science, it should not be shocking if Black students do not feel an interest or connection to science in school.

Additionally, many school districts do not teach science in elementary schools and middle and high school science teachers are most often White men (Mensah & Jackson, 2018). Individuals who go to college considering secondary science teaching careers may be discouraged from persisting in science coursework due to weed out courses, a lack of good counseling and advisement, and experiencing failure in science classes for the first time (Green & Glasson, 2009). These factors implore us to understand why Black secondary science teachers sustained an interest and felt access to science.

Each of these examples have shown how Black people have historically been and continue to be marginalized in science education. This marginalization of Black people within science and science education is damaging to everyone because it stifles innovation and prevents increased forward progress. How a lack of diversity prevents progress was illustrated when Hong and Page (2004) found that diverse groups were better problem solvers than homogenous groups. Lack of diversity similarly prevents progress due to homogeneity in who determines what is considered important in scientific research. Increasing diversity in science and science education will lead to changes within these fields, the research communities, and research agendas and funding priorities (Atwater, 1998).

Increased diversity could also lead to more creative solutions for the challenges in science education. Marginalized doctoral students have been found to complete more innovative research for their dissertations, but are less likely to be appointed to a faculty position or have their research ignored within their fields (Hofstra et al., 2020). Marginalizing forces in science are repressing innovation in science and it is likely that similar issues occur in science teacher education. The factors described show that Black people are not entering into science teaching for a variety of reasons. To develop creative, innovative, and impactful change to eliminate the

marginalization of Black students in science education, we need to center the voices of historically marginalized voices in science education to improve policy and practice across science education.

Black Women Science Teachers

Recruitment and Retention of Black Science Teachers

Currently, the teacher workforce is overwhelmingly composed of White women (U.S. Department of Education & National Center for Education Statistics, 2020). Black teachers have higher expectations for Black students (Gershenson, et al., 2016; Milner, 2006) and having just one Black teacher increases Black students' educational outcomes (Gershenson et al., 2018). For every Black student in the United States to have at least one Black teacher, the number of Black teachers would need to double (Rosen, 2018). Black teachers are important to classrooms because they act as role models for Black students and generally have a better understanding of Black students' cultures and needs in the classroom (Mensah, 2009; Milner, 2006). Their own experiences with racism and oppression may also result in them seeking to equip Black students and Black students to empower themselves to address and overcome oppressive forces in their lives (Milner, 2006).

In addition, teachers of color are more likely to want to teach in diverse schools (Gist, 2014) where they will be able to act as role models and create relationships with students of diverse backgrounds. The relationships Black teachers build with marginalized and underserved students help these students to navigate their interests and education in science (Mensah, 2009b; Moore, 2008). It is also important to note that having a marginalized science teacher likely increases the possibility that marginalized students will choose to pursue science teaching careers (Mensah & Jackson, 2018). Black science teachers have been found to encourage Black students

to understand science, use science to critique their worlds, and prepare for scientific careers (Mensah, 2009b). The large impact Black science teachers can have on Black students is known, but unfortunately only 5% of high school science teachers are Black (BaniLower, 2018).

The dearth of Black teachers can be traced back to the profound impact *Brown v Board of Education*. One of the results of the school integration that followed the *Brown* decision was Black teachers and administrators being driven out of districts and replaced by White teachers and administrators (Foster, 1997; Milner, 2006). Darker-skinned Black teachers were pushed out of schools entirely while lighter-skinned teachers were viewed as "less of a threat" for White teachers and students (Milner & Howard, 2004, p.289). Before this push out of Black teachers, teaching was seen as a good profession for Black people, but this view changed when Black students stopped seeing Black teachers in their schools (Milner & Howard, 2004; Milner, 2006). The best teachers and administrators in Black schools were moved into historically White schools depriving Black students of their resources (Milner & Howard, 2004). Black teachers were moved around, abused by White parents, students, and administrators, and pushed out the perception of teaching as a positive career in Black communities changed (Milner & Howard, 2004).

Prior to the *Brown* decision, four-fifths of Black students were taught by Black teachers (DuBois, 1935). Today over 80% of the teacher workforce is White, even as the underserved and marginalized student population rapidly approaches being the majority of students (Office of Planning, Evaluation, and Policy Development, 2016). The mismatch in the number of Black teachers to the number of Black students means many Black students do not have many or any Black teachers. Researchers theorize that the lack of teachers of color becomes a self-fulfilling cycle as students of color who do not have or see teachers of color do not view teaching as a

viable career (Graham & Erwin, 2011; Mensah, 2019). In an extension of this, Mensah (2019) asserts that female science teachers of color are needed to recruit future science teachers of color and that faculty of color may be a necessity in retaining preservice teachers of color.

The current climate and experiences of Black children in Black schools influences recruitment of Black teachers. Black male students felt that because they were not treated fairly as students they would likely not be treated well as teachers and that White parents would treat them negatively (Graham & Erwin, 2011). Though this study was conducted with Black boys, Black girls are criminalized and punished in schools as well (Morris, 2018). Therefore, these and similar factors may also be influencing the recruitment of Black girls into teacher education.

In less economically prosperous schools, teachers' ability to manage or control a classroom may be implicitly valued over content instruction resulting in traumatic school experiences for students (Emdin, 2016). A consequence of this may be seen in that Black male students felt becoming a teacher of a core subject, like science, meant selling out because curricula do not teach Black students about their history and make them invisible (Graham & Erwin, 2011).

The concern these students expressed about selling out and how the curricula made them feel invisible illustrates how Black students have to contend with bias in curricula and content that marginalizes them. Traditional western science curricula are Eurocentric, rarely include Black scientific achievements, and often ignore the context in which researchers came to their conclusions (Kean, 2019). School science may clash with the cultural norms of students of color and, in some cases, perpetuate racist norms (Gil & Levidow, 1987). Emdin (2016) argues that cultural clashes prevent teachers from seeing students as successful if they are "conditioned to perceive anything outside their own ways of knowing and being as not having value" (p. 11).

The result when students' cultures clash with the culture of the school and pedagogy teachers have been taught to enact they may be labeled as a troublemaker or unwilling or unable to learn (Emdin, 2016). The disconnect could be preventing Black students from being interested in science education as a career. The above information highlights the necessity of understanding Black women's experiences in science throughout their lives and what attracted them to science teaching despite their historical marginalization in the field.

Although the need to increase recruitment of Black science teachers has been established, many of the various recruitment models used by teacher preparation programs require GPA and/or test scores for admission despite research showing these measures do not accurately predict who will be successful teachers (Abell et al., 2006) and the awareness of bias in standardized testing against students of color (Rosales, 2018). The requirement of a particular GPA or test score may represent a barrier for potential STEM teachers of color. Ziols (2019) argues merit-based admission to programs only reaches students who were already immersed in school culture and already likely to become teachers. Thus, teacher preparation programs are not recruiting outside of the typical teacher candidate with these methods even if they are recruited using an alternate route (Ziols, 2019).

Few studies focus on the experiences of Black women in science teacher preparation for secondary grades (Despenza, 2018). Elementary preservice teachers are prepared to teach all subject areas (Lee & Glass, 2019) and often do not have a very deep understanding of science content (Bulunuz & Jerrett, 2010; Krall, Lott, & Wymer, 2009) and do not feel comfortable with teaching science (Santau et al., 2014). Middle grades and secondary grades teachers, however, are not educated as generalists and are taught content specific to the field in which they wish to teach. Black women who choose to teach science in middle or secondary grades have actively

chosen to teach science in contrast to elementary school teachers who may only end up teaching science due to necessity. Mensah and Jackson (2018) assert that science education in its current incarnation frames science as White property and not meant for marginalized people. Black women who choose to teach science in middle grades and secondary grades represent a population who have overcome marginalization present in science throughout their educational experiences to feel access and enjoyment of science. To increase recruitment and eliminate the marginalization of Black science teachers we should understand their experiences.

Teacher Preparation Experiences of Black Women Science Teachers

Milner (2008) argued that teacher educators are often focused on the needs and interests of White students and that even the goal of increasing diversity is often more about what White preservice teachers can learn from marginalized and underserved preservice teachers. This lack of consideration for the needs of Black and other marginalized and underserved preservice teachers means they are not adequately prepared and can potentially encourage deficit beliefs about their communities (Milner, 2008). It is the responsibility of teacher educators to interrogate courses to ensure marginalized and underserved students are not expected to “learn ‘by default’ or come into the learning environment with what they already need to succeed (Milner, 2008, p.338). Teacher educators must understand that Black and other marginalized preservice and inservice teachers do not have the pedagogical knowledge and skills to teach diverse groups of students by virtue of being marginalized (Cherry-McDaniel, 2019; Gay, 2000). In fact, some Black teachers can be actively harmful towards Black students due to socialization into dominant culture and their experiences in teacher education (Cherry-McDaniel, 2019). Mensah and Jackson, (2018) believe that multicultural teacher education for Black preservice teachers has been under researched and undertheorized. In attending to the experiences of Black women in

teacher preparation programs we can better identify how teacher education programs reproduce oppression and rebuild them to address the needs of a diverse, racialized population and disrupt oppression at the postsecondary and K12 levels.

Black preservice teachers attending historically White institutions may have to deal with racism and microaggressions as a part of their teacher education programs. Their voices are often undervalued within their teacher education classes, even during discussions of diversity and multicultural teaching (Mensah, 2019). Even most research on teaching in a culturally sensitive manner is primarily centered on White preservice science teachers (Mensah, 2019). When Black students are enrolled in historically White teacher education programs their White professors may buy in to stereotypes about and have lowered expectations of Black students (Hill-Carter, 2013).

Research suggests Black preservice teachers can benefit from having Black faculty (Mensah, 2019). Unfortunately, Black faculty also feel the impact of racism and microaggressions that can impact their retention and promotion prospects. Black faculty members are often unfairly evaluated by students, have their research agendas and approaches questioned, and may be excluded from mentoring and collaboration (Parsons et al., 2018). Each of these are factors that could influence a faculty member's tenure and retention at universities. Since evidence suggests Black preservice teachers benefit from having Black faculty, the potential loss of Black faculty due to racism would have a negative effect on the teaching and retention of Black preservice science teachers.

Experience of Black Preservice Teachers in Science Teacher Preparation

Preservice teachers of color may find their experiences during their teacher preparation to be isolating and may find their voices and lived experiences dismissed by faculty and other

students (Brown, 2014; Cheruvu et al., 2015; Mensah, 2019). Black preservice teachers may often find themselves the only or one of a few Black students in their teacher preparation courses and as a result feel uncomfortable addressing racist comments by their White peers or faculty members (Faison & McArthur, 2020). Mensah and Jackson (2018) argue for culturally relevant teaching for preservice science teachers of color and seeking to understand the experiences of preservice science teachers of color because “the experiences of PTOC in science are customarily not considered from a pedagogical perspective in science teacher education” (p. 5). Though some research exists on the specific needs of teachers of color during science teacher preparation, much of this research investigates preservice teachers of color experiences as a collective instead of focusing directly on the needs of Black women preservice science teachers.

Brand and Glasson (2004) showed how preservice teachers’ lived experiences influence their perspectives on the use and importance of diversity and multicultural education. The marginalization of Black women in science during their schooling can potentially result in an internalization of oppression and feelings of racial inferiority, wishing they were White, embarrassment of their families, or development of deficit views about their communities (Kohli, 2014). These feelings have been shown to develop in preservice teachers of color who attended schools that were majority White and at schools with a majority underserved and marginalized population (Kohli, 2014). Kohli (2014) found some preservice teachers felt these feelings and viewpoints were also engendered during their college and teacher preparation experiences and that their teacher preparation programs did not provide space for students of color to assess and unpack internalized oppression and how it manifests in their work.

Preservice teachers of color need to confront and challenge their beliefs as well (Moore, 2008). Being a member of a marginalized group does not mean preservice teachers of color do

not hold negative beliefs about marginalized students or about teaching science in multicultural ways. Mensah (2009a) showed the importance of preservice teachers of color participating in reflection on their assumptions and biases because they did not always see the relevance of diversity in science education. Preservice science teachers may hold deficit beliefs about marginalized or underserved learners or multicultural science teaching due to lack of experience in diverse environments or beliefs in stereotypes.

When Black preservice teachers attempt to address these experiences, they may come into conflict with White fragility or White people's resistance to addressing racism. DiAngelo (2011) defines White fragility as when "a minimum amount of racial stress becomes intolerable, triggering a range of defensive moves" including an "outward display of emotions such as anger, fear, and guilt, and behaviors such as argumentation, silence, and leaving the stress-inducing situation" that results in the recentering of the experience of White individuals (p. 57). Black people who attempt to address their negative experiences in schools or at their university may find themselves positioned as an aggressor and the White person positioning themselves as a victim (DiAngelo, 2011; Evans-Winter & Hines, 2019; Liebow & Glazer, 2019). Individuals involved in the conversation, sometimes including the Black person who originally expressed their experience, end up comforting the person who initially caused harm to Black people (Liebow & Glazer, 2019). This can cause further harm and marginalization of Black people in these environments (Evans-Winter & Hines, 2019; Liebow & Glazer, 2019). How these experiences and others throughout the lives of Black women influences their pedagogy and their perspectives on teaching Black children has been understudied and undertheorized in education as a whole and in science education specifically.

Science education researchers have recognized the need to increase science teachers of color, and some have identified teacher preparation as a site where preservice teachers of color have inequitable experiences (Mensah & Jackson, 2018). Both science and teacher education have been a traditionally White spaces ignoring race and intersections of class, sexuality, and other identities (Cheruvu et al., 2015; Mensah & Jackson, 2018) when developing policy and practice (Mensah & Jackson, 2018). This assists in the persistence of White supremacy and the marginalization of groups of people within science and science education (Mensah & Jackson, 2018). Reconceptualizing science teacher education to be more inclusive, disrupt the status quo, and understand and meet the needs of marginalized preservice teachers from an intersectional lens is an area that has been greatly understudied (Mensah & Jackson, 2018). As racism, individual and institutional, is addressed in science education, recruitment and retention of Black science teachers and Black people within science fields may also increase (Mensah & Jackson, 2018).

Attrition of Black Women Science Teachers

The period between 1988 and 2016 saw a 94% increase in science teachers specifically and a 65% increase in teachers overall, as well as a marked increase in the number of ‘new’ teachers, with approximately 43% of the 2015-2016 teaching force having a decade or less of teaching experience (Ingersoll, et al., 2018). Unfortunately, our largely novice teaching force is influenced by high teacher attrition as early career teachers are more likely than any other group to leave teaching. Ingersoll et al. (2018) found 44% of new teachers leave teaching within the first five years of teaching. The combination of a large portion of the teaching workforce being early career teachers and high attrition across early career teachers results in an unstable teacher

workforce. Additionally, high rates of teacher attrition mean the loss of the skills and perspectives these teachers bring with them into the classroom.

Early career teacher attrition occurs for a variety of reasons. These reasons include family issues such as moving, health, or pregnancy, being transferred to another school within the district, being laid off or terminated, and leaving the school or profession due to dissatisfaction with the conditions under which they work (Ingersoll et al., 2018). Teachers being let go from their jobs or choosing to move to a different school are included in teacher attrition rates because the effect of the relocation of the teacher affects the school they leave in the same way as if they left teaching permanently (Carver-Thomas, 2017).

Another factor found to influence new teacher retention or attrition is the quality of their teacher preparation programs (Carver-Thomas, 2017; Farinde-Wu & Griffen, 2019). Teachers who spent more time in classrooms during their teacher education programs have been found to be more likely to stay in the classroom longer (Carver-Thomas, 2017; Farinde-Wu & Griffen, 2019). However, long practicum periods typically only occur more traditional teacher education programs. Teachers of color are less likely to get this experience since teachers of color earn their teaching certification through alternative certification pathways at a rate of over 20% in comparison to about 10% of their White peers (Carver-Thomas, 2017). For Black teachers, alternative pathways are even more common. Almost half of new Black teachers earned their certification through an alternative pathway and were 28.7% more likely than other new teachers to have never participated in student teaching (Carver-Thomas, 2017). This may be in part because traditional certification programs often require the assumption of more debt by students and students then choose colleges and career paths based on the amount of debt they hold or are allowed to borrow (Carver-Thomas, 2017).

Furthermore, Black women have expressed that teacher education programs do not prepare them for the socioemotional costs of teaching (Farinde-Wu & Griffen, 2019). Black women are more likely to choose to teach at under resourced schools in areas with increased poverty and as a result they are also more likely to encounter issues of race and class in their classrooms (Farinde-Wu & Griffen, 2019). Encountering these issues may have a socioemotional cost of Black women and they may feel at a loss of what to say (Farinde-Wu & Griffen, 2019).

Black women are more directly affected by the factors increasing early career attrition. Additionally, they are affected by more factors that do not impact their White peers such as racism. As such, it is essential we learn about Black women's experiences in both science teacher preparation and during their early years as science teachers so we can understand their perspectives on what they need to be effective science teachers who will persist in the teaching profession. Finally, this is important because teachers of color are more likely to remain at a school where there are other teachers of color (Beard, 2020; Carver-Thomas, 2017) and students of color are more likely to be interested in science teaching if they have had a science teacher of color (Mensah & Jackson, 2018). Therefore, increasing retention of Black women as science teachers has the potential to increase the recruitment and retention of teachers of color generally.

Worryingly, rates of attrition due to being laid off or terminate and dissatisfaction with working conditions are increased in teachers who are Black women (Carver-Thomas, 2017). Black women are more likely to choose to work in under resourced schools with large populations of historically marginalized students because they mirror their educational experiences, they want to work in diverse schools, and they feel a call to give back to their communities (Beard, 2020; Carver-Thomas, 2017; Farinde-Wu, et al, 2017; Sun, 2018). As a result, they are more likely to be affected by budgetary issues and be laid off, are more likely to

lack resources, have insufficient support from administration, and less likely to have autonomy in their classrooms due to restrictions because of accountability for student test scores (Campoli & Conrad-Popova, 2017; Carver-Thomas, 2017; Hopper, et al., 2021). In addition, Black women in schools with better resources and funding still encounter racism and stereotypes from colleagues (Beard, 2020; Carver-Thomas, 2017). Black teachers in these schools also take on extra responsibilities as they feel as if they must provide extra support for Black students (Carver-Thomas, 2017; Farinde-Wu et al., 2017).

There have been few studies explicitly addressing the experiences of Black women in science education. Mensah (2009b) published research on Black science teachers generally and found the teachers in the study used culturally relevant practices in their teaching, had a strong relationship with science and express why it was important for students to know, and connected their personal lives and the community to their science teaching. Her participants included two Black women and each participant had at least four years of teaching experience. Olitsky (2020) wrote about the retention of Black women science teachers in case study research following a new teacher through her first three years of teaching science. Highlighted in this research are conflicts the new teacher felt between her preferred approach for teaching her students and the policies and feedback of the school where she taught (Olitsky, 2020). Olitsky's (2020) study highlights the importance of valuing the identities and expertise of Black women science teachers instead of viewing them through a deficit lens if schools wish to retain them.

Black Women's Teaching Practices

Womanist Pedagogy

While research specifically focused on the teaching practices of Black women is limited, several researchers have described repeatedly observing a Womanist pedagogical approach from

Black women teachers. Black women have been shown to be reflective of their beliefs about their students due to an awareness of the power dynamics of education, taking a maternal responsibility for their students learning needs, encourage students to question the status quo, to establish mutual responsibility between students and teacher in their classrooms (Beauboeuf-Lafontant, 2002; Watson & Devereaux, 2022). Beauboeuf-Lafontant (2002) describes the pedagogical practices often found in the classrooms of Black women as Womanist pedagogy. Womanist pedagogy includes (a) an embrace of maternal relationship with students to resist oppression, (b) caring for the whole child beyond just academics due to an awareness of how racism and other oppression effects students on social and educational levels, and (c) recognize that working against oppression is a mutual responsibility as liberation does not come from individualistic work (Beauboeuf-Lafontant, 2002).

Mentoring and Community

Mentorship, particularly from other Black women teachers, and community amongst Black women teachers have been shown in some studies to be integral to the teacher preparation and induction of Black women. This community building connects to cultural practices of knowledge within Black communities being shared intergenerationally “in which Black women attend to the development of younger generations based on their collective and individual experiences with oppression” (Dingus, 2008, 364). As teachers, Black women have sometimes found that their pedagogical approaches were different than their White colleagues and mentoring from other Black women was more valuable in informing and affirming their pedagogical practices (Dingus, 2008). Mentorship and community with Black women are opportunities for Black women an opportunity to vent about experiences with racism, sexism, and misogynoir, and to receive counsel on how to address experiences (Dingus, 2008). Many

Black women enter the teaching profession from altruistic intentions and to give back to their communities (Dingus, 2008; Rivera Maulucci, 2013; Mohorn, 2021). As a result, for some Black women teachers, mentoring other Black women is an important part of being a teacher (Dixson & Dingus, 2008).

Experiences and Teaching Practices of Black Women Science Teachers

Black women science teachers were often identified as smart as an early age and entered into secondary science as a second choice after barriers prevent them from pursuing a career in healthcare (Carlone & Johnson, 2007; Mohorn, 2021; Wong, 2015). These women saw science teaching as empowering students and a way to contribute to making science more inclusive (Mohorn, 2021). As science teachers, Black women enacted liberatory pedagogies and resisted educational norms that positioned Black children as unlikely to be successful in science (Mensah, 2009; Mohorn, 2021; Riley, 2022). These liberatory pedagogies include creating safe and caring environments where students feel comfortable making mistakes, introducing sociohistorical context into their instruction, and building critical consciousness in students (Mohorn, 2021; Riley, 2022). These teachers challenged deficit mindsets about their students, affirmed students' culture and ability, and resisted dominant school culture by creating classroom communities filled with joy (Mensah, 2009; Mohorn, 2021; Riley, 2022).

Black women science teachers across studies often showed characteristics of womanist pedagogy as described by Beauboeuf-Lafontant (2002), but most were not familiar with it as a theoretical approach to teaching (Riley, 2022). When introduced to what womanist pedagogy is, a large majority of Black women described themselves in alignment with it and found encouragement in learning about womanist pedagogy (Riley, 2022). Learning of research centering Black women and pedagogical approaches developed from the Black women's ways of

knowing made Black women science teachers feel seen and affirmed (Riley, 2022). This is particularly notable as Black women science teachers have reported experiences racism as a part of their jobs and feeling frustrated with the disconnect between their own teaching practices and administrative expectations (Mohorn, 2021; Olitsky, 2020; Riley, 2022).

Need for Further Research Centering Black Women Science Teachers

Black women's experiences during their science teacher preparation and throughout their careers impart powerful lessons and implications for the improvement of science teacher education programs and supporting Black women as science teachers. Unfortunately, there are few published studies focusing on this demographic. We need more research focusing on the knowledge and experiences of Black women secondary science teachers to improve science education as a whole to prevent the marginalization of Black women specifically.

One reason this research is needed is because it is essential that Black women are not viewed as inherently knowledgeable about teach Black students or diverse student populations. Like everyone else, Black women have grown up in a society governed by White supremacist norms and this affects their interactions and biases. Black women science teachers have valuable insights to offer us, but it is also important that we do not neglect preparing them for diverse classrooms or to teach students with similar racial or ethnic backgrounds because we assume they have intrinsic knowledge and connection to these communities. Black women need and deserve teacher preparation and resources that assist them in applying their skills and cultural knowledge to the science classroom (Farinde-Wu & Griffen, 2019).

Another reason we need more research on Black women secondary science teachers is because studies have shown Black women to be effective teachers (Gershenson et al., 2018). We need more research to understand what this effectiveness looks like in secondary science

classrooms. Studies that listen to the voices of Black women and other historically marginalized communities with a critical lens towards our current circumstances are sorely needed throughout science education. By taking this approach, this study will fill gaps on our knowledge about Black women choosing to teach science.

Liberatory Pedagogy

Culturally Relevant Pedagogy

Ladson-Billings conceptualized culturally relevant pedagogy in 1995 after studying the pedagogical practices of successful teachers of Black children. Culturally relevant pedagogy required students to not be passive learners of knowledge, but instead critique their textbooks and the realities of the world around them (Ladson-Billings, 1995). In defining culturally relevant pedagogy, Ladson-Billings (2014) states students in culturally relevant classrooms should grow intellectually as a result of their learning experiences, students should have opportunities to learn about and celebrate their own culture and the culture of others, and students should gain the skills to use and apply the knowledge they learn in school to problems they encounter outside of school. As culturally relevant pedagogy became popular and used across educational contexts, Ladson-Billings (2014) has encouraged the extension of her work to better meet the needs of students.

Mensah (2011) called for culturally relevant pedagogy to be used within science teacher education as well to improve instruction and model good instruction for preservice teachers. Similarly, Parsons (2000) asserted science teacher educators hold a responsibility to prepare preservice teachers to effectively teach diverse student groups. Research has found preservice teachers are more likely to adjust their beliefs based on what they see modeled in their own learning experiences and plan to enact what they saw modeled (Bravo et al., 2014; Rutt &

Mumba, 2020). In modeling culturally relevant pedagogy to preservice teachers, collaboration, support, and multiple opportunities for preservice teachers to be successful in teaching culturally relevant approaches are essential factors (Mensah, 2011).

One of the advantages of culturally relevant pedagogies is that they help prevent science teachers from making students feel like they do not belong in the science classroom (Boykin, 1986). Culturally relevant pedagogies require teachers to work with their students to consider deeply how students' cultures and lived experiences affect the science classroom (Tobin, 2006). As Atwater (2000b) points out, Black students come into the classroom with lived scientific experiences that can be utilized to improve science instruction. In science classrooms where teachers employ culturally relevant pedagogies, science is contextualized through the experiences and cultures of the students and the teacher and includes scientific practices and contributions from communities who have traditionally been excluded (Boutte, et al., 2010). In addition, culturally relevant science pedagogies do not approach science as value free, but instead acknowledge and discuss power structures and the influence of culture on the development of science (Boutte et al., 2010; Mensah, 2001; Parsons, 2000). Culturally relevant science teachers reflect on and intentionally disrupt the privileged position of White men in science across science curricula (Boutte, et al., 2010). Parsons and colleagues (2005) found when teachers infused Black culture into their science lessons the science achievement of Black students improved. Parsons (1998) also found the cultural values of Black girls influenced how they viewed scientific professions. This suggests that increasing interest in science and science careers can be influenced by culturally relevant pedagogies if students are provided opportunities to see science as inclusive and welcoming of their culture. Additionally, in a review of literature on culturally relevant education in science Aronson and Laughter (2016) found the use of

culturally relevant education improved student engagement with content and improved test scores.

Black Liberatory Pedagogy

Description of Liberatory Pedagogy

Liberatory pedagogies have a long history within education and Ladson-Billings and Henry (1990) described “culturally relevant teaching as a form of liberatory pedagogy” (p.82). Culturally relevant teachers may not identify themselves as such, but nevertheless understand their instruction is about the success of their students, families, and communities (Ladson-Billings & Henry, 1990). These teachers are teaching in opposition to the systems under which they work (Ladson-Billings & Henry, 1990). Black liberatory pedagogies center Black students’ experiences and seeks to prepare them for the world as it is while enable them to resist and reject oppression and marginalization endemic in society (Ladson-Billings & Henry, 1990).

A Liberatory Pedagogy in Science

A liberatory pedagogy in science means examining how power affects the science classroom, the intersection between individuals’ identities, the cultural capital affiliated with science, and what tensions are present in science learning in schools (Price & Ball, 1998). This is more than shallow cultural practices of adding rap or hands-on activities during one or two assignments to classrooms (Noblit et al., 2007). Instead, students’ cultural practices such as music and movement are intertwined with curriculum and present in teacher pedagogy (Noblit et al, 2007).

A liberatory pedagogy means valuing students’ emotional knowledge and experiences and their relationships with teachers and each other in the science classroom in concert with science content (Castillo-Montoya, et al., 2019). A liberatory science classroom would value

students' full selves and support them in using the strengths that their full selves bring to the science classroom (Castillo-Montoya, et al., 2019). Skills should be developed to critique the influence of white supremacy on students' lives and to critique its influence on science (Castillo-Montoya, et al., 2019).

Black Liberatory Spaces

Black liberation research in education focuses on “Black consciousness-raising, internally and externally” and “to trouble ways of knowing that focus on whiteness” (Stewart & Haynes, 2019, p. 1185). Castillo-Montoya and colleagues (2019) conceptualized a racially liberatory pedagogy as affirming and sustaining culture, raising critical consciousness, centering relationships and emotions, and emphasizing intersectionality aligns with the three tenets of culturally relevant pedagogy: academic success, cultural competence, and sociopolitical consciousness (Ladson-Billings, 2014). Through this alignment, science classrooms as Black liberatory spaces are conceptualized as spaces where students' academic success is valued and encouraged through valuing their culture, critical consciousness and critique of injustice and oppression is encouraged, students are taught and given opportunity to value other cultures, relationships and emotions are valued over rote discipline and behavior management, and all of students' identities are valued and given voice. Students should feel free to explore, make mistakes, and try again. They should feel welcomed and embraced by science and the science classroom. For Black K12 students, culturally relevant and liberatory pedagogies are a pathway for greater understanding of science and classrooms enacting these pedagogies “will sound, look, feel, and maybe even smell different from classrooms that privilege White, mainstream norms” (Noblit et al., 2007). By conceptualizing science classrooms as liberatory spaces, science

educators and science teachers resist the historical methods of oppression and truly welcome all students into science and science classrooms.

Summary

Historically and contemporarily, Black students have been marginalized in science and science education. The Combahee River Collective (1977/1983), a Black lesbian feminist group stated, “If Black women were free, it would mean that everyone else would have to be free since our freedom would necessitate the destruction of all systems of oppression” (p. 278). The interacting oppressions Black women experience make them an important population to study as we seek to increase recruitment of science teachers, improve science teacher education, and improve the experiences of Black students in science classrooms. BlackCrit informed by womanism is used as a framework centering the experiences and knowledge of Black women. The experiences, needs, and marginalization of Black women in science teachers have been under researched and undertheorized. By centering the experiences of Black women science teachers in intersectional ways, we create the opportunity to restructure science education to disrupt the oppression and marginalization endemic to science education and facilitate opportunities to improve the recruitment and retention of Black women specifically and marginalized groups in general in science education. In the following chapter, I describe the pilot study for this research.

CHAPTER 3

PILOT STUDY

The purpose of this study is to understand the experiences of Black women secondary science teachers in science, during science teacher preparation, and during their science teaching experiences, as well as to understand their pedagogies and how they approach science instruction. The research questions guiding this primary study in order to meet this purpose are:

1. What science experiences influenced Black women to become science teachers? What educational experiences influenced Black women to become science teachers?
2. What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?
3. What common and different occurrences related to race and gender have Black women science teachers experienced?
4. What pedagogy do Black women science teachers use in teaching science to students?

In preparation for completing this study, a pilot study was completed to assist in developing and refining the protocols. This chapter will describe and report the results of the pilot study conducted prior to beginning the research of the primary dissertation study to revise and refine protocols before commencing the primary study.

Purpose of Pilot Study

Pilot studies are smaller scale studies that seek to determine the feasibility of a subsequent primary study (Kim, 2010; Majid et al., 2017; Sampson, 2004) and to develop lines of inquiry the researcher had not previously considered. (Sampson, 2004; Yin, 2018). Pilot

studies allow researchers to test interview questions and study protocols (Kim, 2010; Majid et al., 2017; Sampson, 2004; Yin, 2018). Pilot studies also enhance the quality of the following primary study (Kim, 2010; Yin, 2018). Further, for researchers who are beginners, pilot studies are invaluable because they are an opportunity to practice interview skills and interview style (Kim, 2010; Majid et al., 2017) and refine their data analysis technique (Majid et al., 2017).

The principal purpose of this pilot study was to revise and refine the study protocols and data analysis technique to enhance the quality of the primary study. The secondary purpose was to understand the experiences of Black women who had post-secondary experiences in science and their views on science instruction. This secondary purpose will be the focus of this chapter and was guided by the following research questions.

1. How do women who have post-secondary experiences in science define science?
2. What experiences influenced Black women to pursue post-secondary science?
3. What experiences related to race and gender have Black women had during post-secondary science education?
4. What science instruction and pedagogies do Black women who have pursued post-secondary science view as effective?

Method

This pilot study utilizes descriptive qualitative case study, the same methodology as the primary study. Case study are investigations that delve into and describe a phenomenon (Yin, 2018). The researcher identifies and ‘bounds’ the case by describing what is and is not a part of the case (Miles, Huberman, & Saldaña, 2020; Yin, 2018). Descriptive cases studies include interviews, document reviews, and observation in order to understand the perspectives and worldviews of the members of the case. For this study, the case was defined as Black women

who have completed or are currently enrolled in post-secondary science degree program or were currently teaching middle or high school science. For this study, a post-secondary science degree program is defined as undergraduate, masters, and doctorate level programs.

Sample

Participant Criteria

Recruitment was completed through purposeful criterion sampling. The primary dissertation study was originally focused on preservice Black women secondary science teachers currently completing student teaching. In the 2017-2018 school year, Black women comprised only 6.7% of bachelor's degrees in education (U.S. Department of Education & National Center for Education Statistics, 2020). Due to this small population of Black women education graduates broadly, it was expected that there would be few Black women secondary science preservice teachers currently completing student teaching. Therefore, members of this group were not recruited for the pilot study as it would limit the availability of participants for the primary study. As a result, the criteria for participants were Black women who were:

- Current or former middle or high school science teachers
- Graduate students in STEM or STEM Education degree programs

Participants in this pilot study included Black women ages 22-31 who were currently teaching middle or high school science or were currently enrolled in a science graduate program.

Recruitment

Following approval of the pilot study on January 14, 2021, participant recruitment began on January 15, 2021. A flyer including details of the study was posted on the researcher's personal Facebook and twitter pages, shared in three graduate student GroupMe groups, and shared to a graduate student Facebook group. Potential participants could contact the researcher

via email with questions and were asked to complete an initial eligibility form through Qualtrics. Ten responses to the eligibility form were received within 10 days.

Participant Description

Seven participants completed the eligibility form and were determined to be eligible for the study using the participant criteria. One of them declined to participate before beginning the study. The remaining six women completed the study. Four participants were Black women without secondary science teaching experience currently enrolled in science graduate programs. Of those four participants, one had taught elementary school and college science courses and one had taught college science. The remaining two participants were Black women who were currently teaching middle or high school science. Both participants were enrolled in graduate programs, one in a Doctor of Education in Educational Leadership and one in a Master of Public Health with an emphasis on Biostatistics. Descriptions of each participant are included in Table 1.

Table 1

Description of Participants.

Pseudonym	Age	Teaching Experience	Graduate Program
Iris	29	Elementary school English & college science (previous position)	Ph.D. Chemistry
Dahlia	31	None	Master’s in Marine Science
Clover	23	None	Ph.D. Plant Science
Raina	30	High school chemistry	Master of Public Health Biostatistics
Willow	31	High school biology (previous position) Middle school exceptional education science (current position)	Ed.D. Educational Leadership
Ivy	22	None	PhD Geography & Climate Science

Data Collection

Participants completed an eligibility survey which provided information on participants' name, race, gender, age, and contact information. During this survey, participants provided information on what subjects they taught or programs in which they were enrolled, and participants received and electronically signed the consent form. Data were primarily collected during one to two interviews. Interviews were expected to take no more than two two-hour sessions. During the interviews, both interview questions and potential journal prompts were piloted with participants. Finally, participants completed the paperwork to receive their incentive payment.

Data Analysis

Interviews were analyzed to determine if the questions asked garnered answers about the topic I was investigating. Data were analyzed to determine if questions needed to be modified for clarity. This was done by reviewing interviews to see if interview questions had to be restated multiple times for participant understanding. Interviews of participants were compared to each other to compare how the order of questions asked influenced how participants answered. Finally, the overall data gathered in the pilot study were analyzed to determine if the interview protocol asked enough and appropriate questions to address the research questions of the primary study.

Data analysis of interviews began during transcription. As interviews were transcribed, I took notes on my understanding of the data. After transcriptions were completed, each interview was read and annotated multiple times (Creswell & Creswell, 2018; Simpsons & Parsons, 2009). Color coded highlighting was used to identify categories in the data and how the data answered the research questions (Creswell & Creswell, 2018; Simpson & Parsons, 2009). Transcripts were

coded inductively and the patterns in the data were identified. These patterns were compared and contrasted across the six participants and used to develop themes (Creswell & Creswell, 2018).

Results

This study generated two overarching themes: (a) curiosity and exploration are drivers towards science and (b) community is a necessity for Black women's pursuit of science careers.

Curiosity and Exploration are Drivers Towards Science

The Black women who participated in this study described curiosity and exploration as what drew them towards science, helped them to persist in science, and as characteristics of effective science instruction. Participants repeatedly described times when they were curious about a phenomenon, a parent or teacher provided opportunities for them to explore scientific phenomena, or how their teachers or mentors provided opportunities to them that sparked curiosity about the subject. This theme encompasses three subthemes: (a) Black women understood science as curiosity and exploration; (b) Curiosity and exploration draw Black women to science; and (c) Sparking student curiosity is effective science instruction.

Black women understood science as curiosity and exploration. When asked to define science, participants' answers tended to include 'science is everywhere and in everything.' The participants described science as a process incited through curiosity and exploration of the natural world around them. Their descriptions of what science is and their early experiences with science included investigation of phenomena and exploring the natural world. Clover described science in this way

I would define science as taking interest in the natural world from my perspective.

Because I, I study plant biology, or natural sciences. And so taking an interest in the outside world, taking an interest in how animals, people move, react to their outside

world, how they function internally and how they affect the outside world as well. That's how I, it's a very broad definition. But that's how I kind of view science, because it's a very general topic.

Clover's description of science as taking an interest defines science as an output of her inner curiosity about nature.

Clover's definition of science mirrors Dahlia's descriptions of her early experiences of science. For Dahlia, her earliest memories of science included taking an interest in the natural world and watching the development of tadpoles after reading the book *Frog and Toad*.

I think we just fed them and waited for them to grow and like transform. I'm sure my mom had me keep some type of notebook or something that we wrote like day one, this is what they look like. And just make like, general observations so that we could like, I guess really track their transformation.

When Dahlia reflected on her earliest memories in science, her memories focused on observing the natural world after her curiosity was sparked by a book she read. While she doesn't clearly remember recording data, her assumption that she must have done so speaks to her understanding of science as a process of exploration and investigation.

Raina's early memories of engaging with nature also reflect an understanding of science as exploring the natural world around her even before she understood or actively investigated the underlying scientific processes.

Growing up I always saw tadpoles. But I never made the connection of OK, I see all these tadpoles. And then you know, a couple of days later, where'd the tadpoles go? And I'd see all the frogs. Never made the connection. Nobody explained it to me, because, you know, my parents didn't, they weren't scientists, they're not fluent in science, but

just, you know, having a jungle in my own backyard...So I would say just me having an attraction to animals, you know, and not really knowing, you know, the history behind, you know, I guess the evolution of animals like, from here to here.

Raina's memory highlights how her surroundings as a child led her to explore the 'jungle' in her backyard and those explorations sparked her curiosity as she made general passive observations about her surroundings. Even though she did not have the opportunity to investigate her questions then or have her questions explained to her, those experiences form her understanding of science as a process of curiosity and exploration.

Curiosity and exploration draw Black women to science. Each of the women who participated in this study described their curiosity and participating in scientific exploration as drawing them to science. For Iris, interest in science began when she was gifted a science inquiry kit for Christmas one year. She found enjoyment in following the instructions and finding answers. This opportunity to explore drew Iris to science and is evident in how she describes her favorite part of science.

Just understanding how things take place and why they take place and the processes like the defined and undefined order of things, which is pretty cool. Like there's a, there's a rule book or something. There's information out there of why things happen in the way they do...All of this has kind of meaning. And that's pretty cool.

Iris' description of what she enjoys most about science centers on being able to investigate how and why things happen and gain an understanding. This is rooted in her curiosity and exploration of the natural world.

In addition to drawing the women to science, curiosity about their field was part of what helped them to persist in the field when they were discouraged. Ivy describes beginning her first

year of her PhD program in the midst of COVID as incredibly isolating and difficult. Ivy's interest in science has helped her to persist when she felt like quitting.

When I kind of looked back at the actual material and stuff we were learning, I was like, 'this is really interesting'. And like, you know, I'm getting paid, not much, but getting paid to learn about this and find out more about this and I sort of didn't really want to give that up. Because like, I would say a big point for me was the end of the semester, I was presenting at the AGA [pseudonym] fall meeting, online again, and I was going to a couple of just the virtual talks that I heard about, and I was like 'this is interesting'...and so it was like, if I left science or like left grad school, you know I wouldn't necessarily be getting to do that.

For Ivy, the opportunity to learn more about her field and to conduct scientific research were big motivators to persist in her program when things were difficult. Thinking about how interested she was in what she was learning and the exploration she gets to do as a scientist helped to keep her from quitting. The desire to keep exploring helped Ivy to persist in science when things became challenging.

Sparkling student curiosity is effective science instruction. The participants described effective science instruction as active, hands on, and sparking the curiosity of students. Raina, a high school chemistry teacher, described connecting to her students' interests in order to develop connections to chemistry. By connecting her female students' interest in becoming hairstylists or in cosmetics Raina helped her students to visualize the use of chemistry in a future career. In the following quote, she describes how an ideal science classroom would look.

I'm seeing students actually create. You letting their minds like create things, and not me having to tell them, I'm just letting them create. Different lab equipment, I can see, I can

see lab coats. I can see lab goggles. I can see you know, them creating distillation labs or do distillation labs of actually making their own products.

Raina's description of an ideal science classroom focuses on students being able to explore scientific concepts by encouraging student curiosity based on their interests.

For Willow, a middle school exceptional education science teacher, scientific exploration had been integral to her learning science. Willow describes deep learning occurring for her through scientific exploration in comparison to students who were only focused on getting the right answer.

So they would know what labs they were going to do, the teacher is going to do, and so they already knew the outcome. That's not good. Like scientists don't need to know the outcome. You don't need to make the outcome what you want to be you need to just kind of experience it and then you'll learn along the way. So one of the benefits of, yes, they always had the answer right, but then my group of friends, the Black kids or whatever, we kind of understood a little bit better. We didn't have the answer. We didn't know what the outcome was supposed to be... Well, one of the experiences was in microbiology, we had to test for unknown bacteria after hours without the teacher. With no- just relying on our notes. That's when the Black kids were doing very well because we understood the steps...it was no right or wrong answer. So the other kids that were freaking out because they didn't remember all these little tests and we kind of just knew cuz we kind of just learned it going, going from there.

Willow took exploration as an opportunity to learn science content deeply while she was in college. She noticed that her group of friends were looked down on for being Black and their lack of fear of failure by White students. As a result, Willow and her friends were not invited to

study groups. However, when it was time to show understanding of the content, Willow and her friends had an advantage because of the authentic exploration they experienced in lab. Willow applies this lesson in her classroom where she prioritizes hands on learning.

Even in instances outside of hands-on learning and investigating, the participants described effective science teachers as having the ability to spark curiosity about science in their students. In the following description, Dahlia discusses how her teacher sparked her curiosity about a topic she would have normally avoided.

I had found this weird worm in my backyard. And, oh, it's called a hammerhead worm by the way, and I didn't find that out until two years ago. But I actually took a picture of it and brought it into my biology classes. So my biology teacher, and he was just shocked. And he was like 'wow this worm is really cool.' And I hate worms. Like I will cross the street if I see a worm type. I'm that kind of person.

Even though Dahlia had an aversion to worms, her teacher's approach to instruction inspired Dahlia enough to interact with an animal she would normally avoid. Dahlia's teacher had created a culture of curiosity and exploration that reached outside of his classroom inspiring an excitement in Dahlia to share what she had found. Dahlia's example shows how the sparking of curiosity through science teaching was valued by the participants.

Community is a Necessity for Black Women's Pursuit of Science Careers

The Black women participants each described how their community supporting them helped them to pursue and persist in science and how exclusion from what should be a part of their scientific community negatively impacted them. The community the participants had that support them throughout their scientific journeys was essential in helping to mitigate the racism and sexism they experienced. These women learned during their experiences the importance of

cultivating supportive community. The necessity of community encompasses three subthemes: mentoring is foundational in science careers, Black women need care and support from community, and community serves as a space for resistance and liberatory fantasy.

Mentoring is foundational in science careers. Each of the women who participated in this study credit mentors as integral to their pursuit of careers in science. Mentors helped guide participants to opportunities and incited the participants to pursue careers in science. This is demonstrated in Iris' description of how her mentor has influenced her science career.

She gave me opportunity and exposure. She helped me get fellowships. [To] go have like international research experiences. Also, while being an advocate for me with professors and in different spaces. When I started to get into research, and I applied to like a research training fellowship program in undergrad. She was like a big advocate in that and while being a letter writer... We're still really close. And even while in grad school, like there's just moments where I just felt like 'ok, I'm over this, I don't need this' you know. But being able to pick up the phone and call her, send her an email what have you, and talk about whatever I'm going through at the moment. Her words have always been encouraging to have you persevere and continue on.

Support from mentors helped participants to view themselves as capable of doing well in science and they could keep going when they felt frustrated or considered quitting. Raina describes one of her mentors reaching out to her when Raina felt like she was falling behind and that she was unsuccessful.

She was just, you know, basically just, you know mentoring me and telling me her story... it was like, 'you're not the only one who felt this way or been in this particular predicament.' And I respect that coming from somebody who's not only Black, but

who's had issues. Who's had to basically fight her way through, who's been broke, who's been you know, who quit a job because she just refused to deal with it. Like she's been there. And to know that there are a lot of women out there, it's sad. But it's also comforting to know that there's somebody out there who know how you feel and can tell you what to do to get out of it...I was in a defeated place because I felt, and I still feel trapped where I am. But I'm believing that you know, because of that conversation and because of you know, my constant prayer... He will get me through whatever this is that I'm enduring.

Raina felt the support she received from someone she knew had similar experiences and shared her identity as a Black woman to be invaluable. This was the encouragement Raina needed to help her keep going at that time. The conversation with a mentor gave her strength to continue to persist and endure.

Black women need care and support from community. Lack of care and support from their scientific communities frustrated participants. Most of the participants descriptions of feeling excluded in science centered on people excluding them due to their race and gender. Ivy describes the following encounter she had in her biology lab with a White male student and her frustration with her White male friend who was also a part of the group.

Anytime I would make a suggestion or say like, 'maybe we should do this'.

Automatically, you know, [he'd] be like, 'huh, yeah maybe' and then like raise his hand and then have the TA come over who would say the exact same thing I had said. And I'm like *laughter*. And my friend I was in the lab group with which was another White guy, you know he really didn't notice the entire semester until like I said, 'do you realize what's happening and how frustrating it is for me to go through this like you know three

hours a week every day?’ And you know it wasn’t until I sort of called it out, called it to attention (that) he was like ‘Oh my gosh, like that’s so terrible’. And like you know [he] was able to watch it, but you know until I had drawn attention to it he didn’t notice it at all. And so it’s just like frustrating on both ends to like, you know, have a friend in that class and feel like, ok, this is someone that should like, I would, stick up for me and realize what’s happening.

Ivy was very frustrated by the lack of support from someone who she viewed as a friend and member of her community not recognizing the disrespect she was receiving because she was a Black woman or sticking up for her. Even in a space where she had a friend present, Ivy experienced exclusion from her scientific community.

As the only Black person in her department for the first two years of her master’s studies, Dahlia experienced complete exclusion from members of her cohort. Her cohort invited everyone to a study group but her. For Dahlia this was one of the most blatant incidents of exclusion and discrimination she faced. This experience almost drove her to leave the program.

When I went to go ask a question about the homework to somebody that was you know, the year above me, they’d be like, ‘Oh you weren’t in the study session with your classmates? They’re, they’re in rooms such and such right now, having like, going over the homework. And I would pop in and they would just look so shocked to see me, like, ‘oh how did she find out we were in here?’ And I was just like wow, they’re like purposefully excluding me. So you know, that exclusion it really sucks and it’s so hard and I don’t want to wish that on anybody... People like Jen, Troy, and James [pseudonyms], kind of like my support group are always there to like, kind of encourage me and push me on. And you know, tell me, well it’s just imposter syndrome, you’re

meant to be here at the time that you are here. You know, you're not less than you are just as good as the other people in your program. So it's really like having a strong support system is the only reason I'm still here. Yeah, that's the sole reason.

The exclusion Dahlia faced from members of her department were very demotivating and isolating for her further illustrating the need for a supportive community. She only chose to persist in her program due to strong relationships she had outside of her department. Without the strong community Dahlia had around her she likely would have left the program due to the discrimination she experienced as a Black woman.

Willow's experiences at her predominately White undergraduate institution echo Dahlia's experiences. White students would equivocate about when study groups were meeting to avoid allowing the Black students to participate. Willow was also very aware that the White students in her classes looked down on her and her friends. She dealt with this by creating strong community with other Black women.

I can remember that some of my other peers, they would have study groups. And we [Black women] weren't involved in these study groups. If you want a study group you need to get with your little Black friends because they are not going- They will never tell, the other people will never tell you the time they were gonna have these study groups.

For Willow, the discrimination she and her friends experienced from their peers was known and expected. As a result, they chose to build their own communities instead of trying to continue to participate where they had been excluded. Building community with other Black women and Black folks in general was essential to participants pursuit of science because they would have to contend with discrimination.

Community and care from members of the scientific community and outside of the scientific community was an essential part of each of these women's journey. Iris described how getting "plugged into" campus organizations helped her on her journey. Clover described how "going to different conferences, that opened my [Clover's] eyes to a lot of people in the plant bio field, because there, there are so many fields inside of plant biology that I didn't even know about." This included making participants feel less lonely as Black women in science. Iris attended a conference for a Black science conference and described the impact of attending the student congress for this organization.

That was really affirming because then I got to be around, like, a lot of other students who are in congress, like who were doing the same thing as me. Yeah, I was part of the Black science organization. But these were more of like, on a national scale, because they weren't from my school, they were from different parts of the world.

Being a part of professional organizations helped participants feel less isolated due to being Black women and helped them make connections in their fields. Ivy mentioned the importance of being a part of these organizations because she was able to "meet a lot of people that I [Ivy] was interested in working with." Being a part of professional organizations on campus and larger professional organizations helped participants visualize what was possible within their careers and become more aware of who was a part of their scientific communities.

Care from faculty who directed their research paired with care from friends and family was important in helping participants make decisions and making them feel like they belong and can succeed in their field. Clover describes how the researcher she worked with and her family members worked together to help her determine what she wanted to do.

It was like a joint conversation between talking to my PI, talking to my mom and my grandma who are not science minded. And so their [her mom and grandma] outlook especially as like the older Black outlook of like ‘what would this look like for you’ versus my PI who was a White woman and she’s just like opening my eyes to like, you can also do this over here. So it’s like everyone’s like actively research and helping me figure out a path that I can go.

Clover’s description illustrates how integral the support and care of the community she had was to her pursuit of her degree in plant science. Each participant had examples of how important this support was for them.

Community serves as a space for resistance and liberatory fantasy. These participants also developed chosen communities as spaces of resistance and of liberatory fantasy. When treated poorly by individuals in science, the participants sought refuge in their chosen communities for love, joy, and support. They also described this community as part of a welcoming science classroom as Willow illustrates.

It's all about a community and first like you have to really build a relationship. You have to make them comfortable at first because everybody is afraid of making mistakes...It had to be a process in which they felt like they could teach me some things. But that’s how they got my trust. Like I got their trust and they would let me teach them things because they feel, like you know it was a collaborative group. Like they could teach me certain things that I don’t know and I can teach them things in turn.

Willow’s description of her classroom is as a community where the teacher is not the sole holder of knowledge, resisting traditional concepts of schooling.

Chosen community was also a space of resistance for the Black women who participated in this study for them to seek support and to disconnect from toxicity in some science spaces. Clover chose her PhD program based on finding a community in her field where she believed her Black womanness would be fully supported and accepted. Clover described how her department respected her concerns.

I told them my fears, like straight up, like when I came here. I was just like I'm aware that we are in kind of the rural South, and I came from Cityville [pseudonym]. So, I'm like, this isn't a situation I'm used to. I recognize that I might be one of the only people of color here. That also frightens me. And so, they were like, telling me all of these programs that I can participate in as well as like just their willingness to like check in with me several times during the semester.

As Clover chose her community for her PhD studies, she resisted the social norms of not directly addressing the effects racism could have on her studies and asked for the supports she could expect. She built a community based on support for her identity instead of based solely on scientific pursuit.

These participants cultivated and participated in communities where they engaged in liberatory fantasy and constructing spaces where their identity was valued and their culture was the majority. Dahlia wondered if she “had been exposed to more Black people in high school, doing science, if I would be more successful now than I currently am?” She credited attending a Historically Black College and being surrounded by Black women in science to her own pursuit of science. Dahlia has committed herself to creating spaces for Black people in science and helped to create and is a founding board member of an organization focused on supporting Black

people in the marine sciences. Being a part of the organization's development was very affirming to Dahlia as she dealt with discrimination in her master's program.

When I actually saw Marine Science: For Us By Us (MSFUBU) [pseudonym] come to fruition. Being one of the organizers was so empowering. And to see that there were so many like me, so many others, male and female, that were going through the same things as me. I was just like, ok, now I really know that I'm meant to be here because I have to share my story. And I have to let people know that, you know, racism in the geosciences and diverse- the lack of diversity in the geosciences is not ok. And I'm here to make waves until you fix it. Like literal waves. Like tsunami style, I'm coming crashing down, like Miley Cyrus wrecking ball I'm in there. I'm tearing- everything that you thought was ok, I'm tearing it all down. I'm tearing down every single construct that you had and I'm going to force you to be rebuild it. Come hell or high water.

Dahlia engages in liberatory fantasy and the work of constructing liberatory spaces and finds that work to be empowering to her as a Black woman. Dahlia had many experiences with misogynoir in science and she felt compelled to engage in this work to improve circumstances for the people who will come behind her. This call became even more powerful as she saw how inherent the racism and sexism she was experiencing were to the experience of all Black people in marine science. Building community was central to the participants to engagement in resistance, seeing their own future possibilities, and engagement in liberatory work.

Discussion

For the six Black women who participated in this study, science was a subject they deeply enjoyed, but also a space where they experienced racism and sexism. They were excited by the opportunity to explore topics they were curious about and frustrated that they were treated

as if they did not belong by people who should have been a part of their scientific community. The two themes, curiosity and exploration as drivers towards science and the necessity of community emerged as integral components of the participants' experiences in science.

Theme 1 – Curiosity and Exploration are Drivers Towards Science

The Black women who participated in this study all remember having a deep enjoyment of science for most of their lives. Most remembered being exposed to experimentation, science museums, or being curious about nature from a young age. These women were driven to pursue science by their curiosity about the world around them. Each of these women defined science as a process based on the curiosity and exploration that was foundational to their own experiences with science. The curiosity these women had and opportunities to explore phenomenon drew them to science and even helped them to continue to pursue science in the face of setbacks. A womanist orientation of science based on the descriptions of the participants could be defined as driven by the curiosity, exploration, and problem solving of Black women.

Each of the participants also described good science teaching as founded in student curiosity and exploration. In descriptions of their ideal science classrooms, the participants included hands on activities, investigations, and freedom for students to explore based on their interests. When they reflected on science teachers who were impactful on them, these women remembered passionate, engaged teachers who sparked student curiosity.

Theme 2 – Community is a necessity for Black women's pursuit of science careers

Each of the participants in the study relied heavily on the communities they were a part of and cultivated to be successful in science. Community is central to Black culture (Boykin, 1986), womanism (Phillips, 2006; Walker, 1983/2006), and BlackCrit (Phillips, 1999). Mentorship and the care of community brought these women into science careers and that same care is what kept

them there. This community is especially essential for Black women in science due to the marginalization and discrimination these women experienced as a normal part of pursuing science. These women learned from mentors who appreciated their Black womanness and advised them with their identities in mind. When community did not show care for the participants in the study, it was often due to the inherent nature of marginalization and discrimination of pursuing a career in science, a field historically dominated by White men and their culture (McGee, 2020). These women addressed the problem of racism and discrimination by clinging to and reaching out to their communities for support and encouragement.

Unfortunately, being a Black woman has meant facing exclusion throughout careers in science (Funk & Parker, 2018; Parsons et al., 2018). Black women have found multiple ways to cope with this reality including forming supportive communities inside and outside of science. Community also serves a space for Black women to engage in Black liberatory fantasy and resistance to the status quo in science fields. When they are experiencing racism, sexism, or the combination of discrimination Black women face termed as misogynoir, these women relied on communities outside of science as spaces of resistance where they gathered the joy and space they needed to be able to reenter sometimes toxic spaces to succeed in science. Additionally, these Black women engaged in liberatory fantasy about the future of science. They visualized themselves and others like them as central to science and as examples of scientists. Finally, they worked to build structures or to participate in communities where Black women were present and successful in their fields. Therefore, a womanist orientation of science might be refined as driven by the curiosity, exploration, and problem solving of Black women and their communities, resisting the status quo, and constructing liberatory futures in science.

Conclusion

Curiosity and exploration were integral to how the Black women in this study understood science and how they were inspired to pursue careers in science. The curiosity and exploration that these women identified as part of science were also found in their descriptions of good science teaching. These women were intimately aware of how they were perceived as Black women in science and that it led to a lack of support and care. As a result, they described how important mentorship, community, and care were to their persistence in science when they were frustrated and tempted to quit. Comparing these themes to what emerges in the primary study may be useful in understanding the experiences of Black women science teachers.

Further research based on this study, should investigate how curiosity and exploration manifest Black girls, how to encourage curiosity and exploration outside of direct inquiry, how Black women and girls navigate mentor relationships, how Black women and girls can be supported in developing communities in science, and how Black women and girls in science engage in liberatory fantasy and construct liberatory futures. Further research should also focus on a womanist orientation of science and science instruction. Further understanding of these topics may emerge through the primary study. In the following chapter, I discuss the methodology of the primary dissertation study.

This chapter reported the results of the pilot study conducted prior to beginning the dissertation research on the experiences of Black women in post-secondary science. In the following chapter, I describe the methods of the dissertation study and discuss how the pilot study and allowed me to revise and improve the protocols for the primary dissertation study.

CHAPTER 4

METHODS

Introduction

The purpose of this study is to understand the experiences of Black women who are science teachers in science throughout their lives, during science teacher preparation, and during their careers in science teaching, as well as their pedagogical approaches to teaching science. The research questions guiding this study are:

1. What science experiences influenced Black women to become science teachers? What educational experiences influenced Black women to become science teachers?
2. What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?
3. What common and different occurrences related to race and gender have Black women science teachers experienced?
4. What pedagogy do Black women science teachers use in teaching science to students?

For years a stated goal of education in the United States has been a more diverse teacher workforce. Conversely, teacher education continues to center the needs of White women (Mensah & Jackson, 2018; Milner 2008) and be marginalizing and oppressive to teacher candidates from marginalized communities like Black women (Mensah & Jackson, 2018; Seriki, et al., 2015). This occurs even within teacher education programs that profess to specifically address diversity and social justice (Souto-Manning & Emdin, 2020). To remedy these issues, we need an increase in scholarship focused on the unique experiences of members of marginalized

groups, including Black women, in teacher preparation programs and how those teacher preparation programs are perceived by members of these groups. Black women teach in schools with primarily White teaching faculty which requires them to navigate racism and sexism as well as the endemic nature of oppression in school systems. Understanding Black women science teachers' experiences is valuable to understanding how science education can be improved. In this research, I sought to understand the experiences and needs of Black women secondary science teachers and their perspectives on science and science teaching. This chapter will describe the methodology, methods of data collection, and methods of data analysis that were used in this study.

Methodological Framework – Case Study

This study is a descriptive qualitative single case study. Yin (2018) defines a case study as “an empirical method that investigates a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident” (p. 15). A case can be defined by the researcher providing boundaries as to what constitutes the case (Miles, et al., 2020; Yin, 2018). The researcher defines the case for their study by describing the individual, organization, or phenomenon they intend to study. After the identification of the case, the researcher places boundaries on the case which guide what data will be collected, where and from whom data will be collected, and the time over which data collection will take place (Yin, 2018). A descriptive case study creates “a complete, detailed portrayal of some phenomenon” and includes “document review, participant observation, and in-depth interviews to understand the experiences, perspectives, and worldviews of people in a particular set of circumstances” (Schwandt & Gates, 2018, p. 346).

Case study is aligned with the purpose and frameworks of this study because it allows the exploration and description of the experiences of the participants and analyzes them as a collective unit. A single case is bounded by how the researcher defines the boundaries of the case (Miles, et al., 2020; Yin, 2018).

The case being studied in this research included the experiences of Black women certified to teach science in grades 6-12 in the United States, were currently teaching secondary science, and had at least one year of experience teaching secondary science. There are five rationales for conducting a case study: critical, unusual, common, revelatory, or longitudinal (Yin, 2018). As noted, Black women are not a common demographic in science teacher preparation programs and constitute an unusual case. Examining unusual cases “may reveal insights about normal processes” (Yin, 2018, p. 50) and examining the experiences of Black women in science teaching revealed insights about the endemic racism and marginalization of Black women face in becoming science teachers and during their careers.

Case studies develop in-depth and comprehensive descriptions of a phenomenon (Yin, 2018). However, case studies as a methodology do have some limitations. Concern over the rigor of case studies can be addressed by keeping clear records of data collection and through triangulation of data (Yin, 2018). This study triangulates data from relevant websites, interviews, lesson plans, journal, and participant lesson reflections through use of a post lesson checklist. Case studies are limited in the ability to generalize the results to other populations. This is not a major limitation, however, because the goal of case studies is less about the generalization of the sample and more about the development of generalizable theories which can be strengthened or amended via further research (Yin, 2018). While this study is not generalizable, it adds to and strengthens existing literature about Black women who teach high school science. Case studies

should produce ‘thick’ descriptions of phenomenon (Yin, 2018). A thick description “captures and communicates someone else’s experience of the world in his or her own words” and provides context so readers “know what it was like to have been there” (Patton, 2015, p. 54). These thick descriptions make the explanation of phenomenon more realistic and help readers to visualize what occurred (Simons, 2009). Generalizability is not the only value a study can have, and the rich descriptions of phenomena generated by case studies are valuable in other ways (Flyvbjerg, 2006). This study provides context to participants’ responses in order to give readers a fuller understanding of what the participants experience as Black women teaching high school science.

Research Design

Sample

Participant Criteria

Participants of this study were selected using purposeful sampling. Criteria for participation were: (a) identifying as a Black woman; (b) having at least one year of secondary science teaching experience; and (c) currently teaching biology or chemistry in a high school. Participants were required to have at least one year of teaching experience because the study began at the beginning of the school year. First year teachers were excluded because they would not have experience teaching to describe as the study began. Teachers were required to teach biology or chemistry because they are the subjects in which the researcher has the required expertise to understand submitted lesson plans and lesson context.

Participant Recruitment

Participants for the study were recruited through social media and snowball sampling. A flyer for this study was shared on organizational list serves, in GroupMe Groups, and on social

media (Appendix A). In addition to sharing the flyer on social media, I contacted individuals who may have known eligible individuals and asked them to share the flyer for the study with individuals they thought would be eligible and interested. This included individuals who worked with teachers but are not teachers themselves. Snowball sampling was used, and participants were asked to pass along information about the study to anyone they knew who may be eligible and interested in participating. This recruitment strategy was used during an earlier pilot study and the strategy was found to be effective, so it was replicated for the dissertation study. Potential participants completed a short survey to determine their eligibility for the study (Appendix B). At the beginning of this survey, participants read the consent form and signified their consent.

Participant Description

I received 14 responses to the eligibility and demographic survey. Of these 14 individuals, 12 were determined to be eligible according to the criteria for participation. Nine of the eligible individuals responded to being contacted to participate in the study and eight scheduled at least one interview. One of these individuals completed only one interview and three of them completed two interviews. These five individuals then stopped responding to requests to complete the study. The remaining four individuals completed the study and are the members of the case for this study. Each of the participants in the study were currently teaching secondary science. Participants experience teaching science ranged from 1-19 years. Each of the participants were Black women and identified themselves as such on the eligibility survey. The pseudonym, years of teaching experience, subject(s) taught, and the current state teaching in of each member of the case are listed in Table 2.

Table 2

Participant Information

Pseudonym	Years of Experience	Subject Taught	State
Ms. Z	1	Chemistry & Biology	Georgia
Ms. V	2	Biology	Georgia
Ms. P	3	Biology	District of Columbia
Mrs. R	19	Biology	New Jersey

Though Mrs. R may seem like an outlier in the study due to her location and years of experience, she was included in the study because the case study bounds included the United States and did not limit the number of years of experience if the participant was still a practicing teacher. Additionally, Mrs. R’s inclusion strengthens the trustworthiness of the findings. While case studies are still not generalizable, Mrs. R expressing similar sentiments and having similar experiences as the other three participants suggests the findings of this study are more likely to apply to other Black women who teach high school science.

Data Sources and Collection

Data Collection

Data collection began in August 2021 and concluded in January 2022. Data were collected in the form of two to three semi structured interviews, a researcher journal, participant journals, post lesson checklists completed by participants, and lesson plans. The researcher journal includes the researcher’s notes and thought processes throughout the study and served as a unit of analysis and an audit trail (Creswell & Creswell, 2018; Galman, 2016; Maykut & Morehouse, 1994). Participants kept personal journals once a week for four weeks and shared the relevant lesson plans (Creswell & Creswell, 2018). Table 3 identifies how different data sources were used to answer the research questions.

Table 3

Research Questions & Data Sources

Research Question	Data Sources
What science experiences influenced Black women to become science teachers? What educational experiences influenced Black women to become science teachers?	Interview
What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?	Interview
What common and different occurrences related to race and gender have Black women science teachers experienced?	Interview; Post Lesson Checklist; Journal
What pedagogy do Black women science teachers use in teaching science to students?	Interview; Journal; Post-Lesson Checklist; Lesson Plans

Documents

Document analysis is the practice of evaluating both printed and electronic documents to learn more about what is being studied (Bowen, 2009). In case study research, documents are used “to corroborate and augment evidence from other sources” and when documents conflict with other data it notifies the researcher that further inquiry should be completed (Yin, 2003, p. 87). Documents were used in this study to corroborate participants’ accounts and to develop further interview questions to delve deeper into their experiences in science teaching.

After participants were identified, I examined the websites and other publicly available information about the school or schools where they teach and have taught based on the information participants provided during their interviews (Bowen, 2009; Simons, 2009). I also used <https://archive.org/web/> to find versions of the websites that would have been available when the participants were at the institutions I was reviewing. Participants also provided the name of the program they attended for teacher education and the year they graduated from these programs. Ms. Z, Ms. V, and Ms. P each completed their teacher education programs in the previous three years and I visited the teacher education program websites to corroborate the

details they provided about the nature of the classes they took during their program, the expectations of and resources provided by their program, and to gain further insight about the demographic makeup of the institutions they attended. Mrs. R's teacher education program had been completed decades earlier and she did not recall the name of it, so I was unable to do the same for her.

Additionally, I analyzed the websites of the schools and school districts where each participant was currently teaching at and had previously taught. These sites provided information about the leadership of the school and district, mission and goals of the school district, perspectives and plans regarding diversity and inclusion, and publicly viewable resources available for teachers. This information was used to deepen the understanding of participants' experiences as Black women teaching high school science and how school and district expectations and goals compared with the pedagogies participants enacted. I do not include the specific websites because each of the participants taught in schools and districts where they are one of few Black women teaching science. Including the name of the schools or districts in which they work could compromise their anonymity. I visited the National Center for Education Statistics, <https://nces.ed.gov/ccd/schoolsearch/>, to corroborate participant responses about the size and demographics of the student populations of their schools.

Prior to scheduling the final interview, each participant submitted four post lesson checklists with reflections about a lesson they taught (Appendix C) and four journal entries describing a significant event in their class (Appendix D). Both the journal entries and post lesson checklists were used to develop interview questions for the participant's final interview. This allowed me to clarify my understanding of their lesson reflections and journal entries and to

ask participants to elaborate on their intention, what happened in their classroom or school, and their perspectives on their instruction.

Interviews

Two to three open-ended, semi-structured interviews were conducted with each participant using interview protocols (Appendix E). These interviews provided the opportunity to probe participants' perspectives, values, and feelings (Creswell & Creswell, 2018; Patton, 2015; Simons, 2009; Yin, 2018). Through the interview process, the interviewer and interviewee constructed meaning through both of our perspectives with the interviewer acting as a learner and the interviewee acting as an expert on the subject the interviewer is researching (deMarrais, 2004). The focus of the interviews in this study were to obtain historical information about the participants' experiences in science, experiences with formal and informal science learning, to understand the participants' perspectives and beliefs about science and scientific practice, to comprehend the participants' perspectives on effective science pedagogy, and to ask participants to elaborate on what they've written in their journals and lesson reflections. The first two interviews focused on the participants' teacher preparation experiences, participants' views on science, and the participants experiences teaching. The final interview was conducted following the participants' completion of their journals and lesson reflections. This final interview focused on the participants current experiences and reflections on teaching and included questions constructed using participants journal entries and lesson reflections. Table 4 includes some examples of the interview questions and what research questions they were constructed to address.

Table 4

Research Questions & Interview Questions

Research Question	Interview Question Examples
What science experiences influenced Black women to become science teachers? What educational experiences influenced Black women to become science teachers?	<ul style="list-style-type: none">• What are your favorite parts of science and doing science?• What are your earliest memories of doing or watching someone do science?• Who are science teachers that had positive impacts on your scientific experiences? What made them good science teachers?
What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?	<ul style="list-style-type: none">• Do you think your teacher education program prepared you to teach a diverse group of students?• How do you think being a Black woman influenced your experiences in teacher education?• Have you experienced racism or sexism while in science or science teacher preparation?
What common and different occurrences related to race and gender have Black women science teachers experienced?	<ul style="list-style-type: none">• How do you think being a Black woman has influenced your teaching experiences?• What are factors that have made you want to quit science or science teaching?• In your journal, you mentioned...
What pedagogy do Black women science teachers use in teaching science to students?	<ul style="list-style-type: none">• Imagine you have been asked to create a science course. What would you teach? What would a lesson look like?• In your journal, you mentioned...• In your checklist, you described...

As suggested by deMarrais (2004), interview questions were clear and concise, asked about specific experiences to elicit fuller data, and were open-ended guiding questions that provide time and space to ask follow-up questions to probe elaboration about participants' answers.

Many of the questions used in the final interview protocol were initially asked during the pilot study to ensure they elicited answers that addressed the research questions, were clear to

participants, and to determine the best order to ask the questions. During the pilot study, questions were placed in different orders for participants who had been teachers and for participants who had not been teachers. This allowed me to determine what question order tended to elicit the most thorough answers. One example of this is when participants in the nonteacher participants were asked to define what science is at the beginning of the initial interview they struggled to answer the question but referenced back to it later during another question. In contrast, teacher participants were not asked this question until after they had already been asked to speak about their early memories and experiences in science. These participants were able to answer the question more readily and in greater detail. Finally, many of the pilot study participants spoke of the importance of community and participating in conferences and organizations in their fields. As a result, the question ‘Do you participate in professional teaching organizations?’ was added to the interview protocol.

Interviews were conducted over Zoom and audio recorded using the Zoom software and an audio recorder in case of either failing to record the interview properly. Interviews were initially transcribed using otter.ai. Otter.ai is an automated transcription service that produces a transcript from audio using artificial intelligence. I reviewed the transcripts produced by otter.ai and edited them for accuracy. Table 5 shows each participant, the total number of pages of transcripts from their interviews, and the number of lines in their totaled interviews.

Table 5

Interviews by Participant

Participant	Pages	Lines
Ms. Z	60	2603
Ms. V	76	3298
Ms. P	57	2445
Mrs. R	54	2339

Throughout the transcription process, I added notes from the interview to each transcript. Following the completion of the transcription, the audio file was deleted from otter.ai which does not access or retain data (otter.ai, 2020). Each participant except for Mrs. R completed three separate interviews following the interview protocol. Mrs. R completed two interviews with interviews two and three being combined after she had completed the four weeks of journals and checklists. Mrs. R’s final interviews were combined due to Mrs. R having medical issues and scheduling conflicts.

Post Lesson Checklist

Participants completed a post lesson checklist, found in Appendix C, following four lessons. Participants completed the checklist in lieu of observation due to COVID-19 restrictions on research. The checklist required participants to reflect on how one lesson during a week incorporated high expectations, equitable and supportive classroom culture, best practices for science teaching, and what historical or contemporary figures were incorporated into their lessons. Participants were then asked to attach their lesson plan and write a few sentences elaborating on what they checked and about their lesson. Some examples of items on the checklist were "I held all students, regardless of race or gender, to high expectations that I communicated to them", "The lesson included real-world issues related to race and gender that are relevant to students, the school, and/or the community", and "If historical or contemporary

figures are highlighted in the classroom or lesson, please include their names, gender, and race/ethnicity.” Following the completion of the four post lesson checklists, I analyzed the checklists for trends in what participants checked and analyzed lesson plans for evidence of their pedagogical practices. Participants checked and written responses on the checklist and the attached lesson plans were used to develop questions for the final interview to get a further understanding of their pedagogical practices and classroom experiences.

Researcher Journal

A researcher journal includes notes taken by the researcher, analytic memos, flashes of inspiration, and more (Maykut & Morehouse, 1994). Another part of the researcher journal are jottings that “hold the researcher’s fleeting and emergent reflections and commentary on issues that emerge during field work and especially data analysis (Miles, et al., 2014). These jottings include the researcher’s inferences about observations, notes on how to conduct further data collection, or the researcher’s reactions to what they are observing (Miles, et al., 2014). The researcher journal was integral to the process of reflexivity as I considered how my experiences may be influencing how I analyzed data (Creswell & Creswell, 2018; Saldan a, 2016). This journal is useful in the process of data analysis and maintaining an audit trail (Maykut & Morehouse, 1994). My researcher journal included my written impressions following each interview and data analysis session, notes I wrote on a paper copy of the interview protocols during interviews, notes I made while I was completing interview transcriptions, jotting down flashes of inspiration or curiosity, printed screenshots of websites, notes about websites, and questions and musings I had that were not relevant to the current study but arose during the research.

The researcher journal included post interview and post data analysis journal reflections that are called analytic memos. Analytic memos are recordings by the researcher about the research process and how the researcher developed themes and codes (Creswell & Creswell, 2018). Analytic memos encourage reflection on the coding process, consideration of connections between datum, and what questions or further explorations come to mind (Saldan a, 2016). Following the first two interviews, during my initial analysis and annotation of the transcripts I took note of datum that caused confusion and tracked where I found a disconnect between different data sources. These notes and the analytic memos summarizing my thoughts about these data analysis sessions served as a crucial resource in developing follow-up questions for clarification in the final interview. An excerpt of an analytic memo from the researcher journal is in Appendix F. Throughout the course of the study, I wrote 57 analytic memos. The full researcher journal exceeds 500 pages and includes annotated transcripts, analytic memos, annotated website print outs, annotated journals and checklists, and annotated lesson plans. If my annotations, musings, reflections, and analytic memos were compiled separately from the other documents, they make up about 100 pages.

Data Management

Managing and recording data are important parts of the research process, particularly in preserving an audit trail and ensuring reliability and validity of the work. All collected data were labeled with the participant's pseudonym, date of data collection, type of data collected, and location of data collection. An example would look like: Sarah, 01.19.21, interview, Zoom, page 1 of 10. Data were sorted and stored by participant and then by type of data. All data were kept in a password protected one drive folder electronically and any physical data were kept locked in a file cabinet.

The compilation of these materials is called the case study database (Yin, 2018). The case study database includes any notes taken by the researcher, any documents, analytic memos, and anything else related to the study (Yin, 2018). The case study database is essential to keeping data organized and being able to maintain an audit trail for the study. Yin (2018) calls the audit trail “maintaining a chain of evidence” (p.135) that links together the case study findings, case study database, protocols, and case study questions.

All electronic data, including audio files, were saved in a password protected folder on OneDrive and a password protected external hard drive. Physical copies of data, including labeled and printed transcriptions, were stored in a locked file cabinet at my home.

COVID-19 Considerations

I began planning this study in January 2020. At the time, I had intended to complete the study with in-person interviews and observations of participant classrooms. Unfortunately, the COVID-19 pandemic was also beginning at this time and was officially declared a pandemic on March 11, 2020. As a result, all in-person research ground to a halt and was no longer allowed by the time I began collecting data for the pilot study in January 2021. Although the University of Georgia allowed in-person research to resume without restriction as of July 2021 and this study began in August of 2021, I chose to continue to keep the data collection protocols in place to lessen the chance of either myself or study participants contracting or passing along COVID. As a result, interviews were conducted over zoom and participants were asked to complete reflections on their lessons as a stand-in for observations.

Data Analysis

Data analysis was ongoing throughout the study (Creswell & Creswell, 2018). This allowed for the opportunity to recognize new lines of inquiry and explore them (Miles, et al.,

2020) and provided the opportunity to evaluate collected data and refocus the study as needed (Miles, et al., 2020).

Interview data and journal data were analyzed in line with the process outlined by Creswell and Creswell (2018) and Simpson and Parsons (2009). Analysis began with notes made during interviews and during the transcription of interviews. This was followed with multiple readings and annotations of the data (Creswell & Creswell, 2018; Simpsons & Parsons, 2009). Inductive line by line open coding followed these readings and differing concepts were sorted and used to distinguish categories and identify patterns in the data (Creswell & Creswell, 2018; Simpson & Parsons, 2009). These categories were compared and contrasted across the participants' answers and data sources to develop the themes used to describe the case (Creswell & Creswell, 2018). Data were also coded deductively against the framework of Black liberatory pedagogy. Data were compared and contrasted across data sources and used to develop and further support themes (Simpson & Parsons, 2009). Themes were organized into a narrative written describing each theme with supporting data, figures, and images as appropriate (Creswell & Creswell, 2018). This analysis technique was used and refined during the pilot study. During the pilot study, I gained experience coding inductively, identifying patterns, and comparing across participants and found that the technique I was using was overall effective.

Post-lesson checklists used the same analytical approach for the reflection but required a different analytical approach for the checklist section. For the checklists, I noted which lines each participant checked frequently and which were rarely or never checked, if any scientific figures were discussed which ones were talked about and their race and gender, and compared the checklist with the lesson plan attached to determine if there was evidence of the checked boxes in the written lesson plans. This information was then used to develop follow up interview

questions for the participant's final interview. Participants were asked to elaborate on checked boxes that were not supported by the lesson plan, elaborate on their perception of the lesson, and describe how the checked practices were enacted in their classroom. For example, a Mrs. R checked that students were not afraid of making mistakes or were comfortable asking questions in the classroom. In the final interview, she was asked how she facilitates an environment where students feel this comfort and how she can identify that the students are not afraid of failure in her classroom.

Websites were analyzed to corroborate participants responses and provide depth and context to their experiences. The websites of the schools and school districts where participants teach or have taught in conjunction with 'The Wayback Machine' found at <https://archive.org/web/> and the National Center for Education Statistics found at <https://nces.ed.gov/ccd/schoolsearch/> were used to gain information about the demographics of the student populations and the demographics of school administrations when available. School and school district websites were also analyzed for how they represented diversity and inclusion efforts, opportunities and resources for teachers, and missions and goals in comparison to how participants expressed their treatment by their schools and districts and participants pedagogical approaches. This included mission statements, publicly available statements about district approaches to science teaching, and publicly available curricula in the subject the participant taught.

A similar approach was used in the analysis of the websites of teacher education programs attended by participants. Analysis of these websites were used to corroborate participants interview responses about what type of courses they took during their teacher preparation, their impressions of the demographics of the faculty, and how the teacher education

program's websites presented their positions on diversity and inclusion in comparison to participants' experiences.

In my researcher journal, I made a note of what I found, where the data were originally found, and my analysis of the data. A screenshot and printout of the screenshot of this data were kept in a secured electronic data file and a locked physical data file for my records in case of removal or change from the website. Information on these websites were compared to participants' interview responses, post-lesson checklists, lesson plans, and journal entries to analyze overlaps and divergences.

To ensure reliability a codebook was developed and refined. The codebook increased internal reliability of the research by defining codes so that codes were applied consistently across the data. The codebook includes "a list of codes, a code label for each code, a brief definition of it, a full definition of it, information about when to use the code and when not to use it, and an example of a quote illustrating the code" (Creswell & Creswell, 2018, p. 197). The development of a codebook was used during the pilot study as well. The pilot study illustrated how patterns began to emerge. I also learned to be less stringent about the codebook and to keep it as a living document throughout the entire study instead of waiting to complete all of the coding. Within this study, as data were distinguished into categories and patterns, codes were reexamined to determine if each piece of datum were coded correctly, if some codes should be combined or separated, and if codes should be redefined more specifically or broadly throughout the entire coding process due to my experiences during the pilot study. The data were coded multiple times to ensure codes were used consistently across the data. This allowed me to code more consistently and increase the reliability of the study.

Validity and Reliability

Case study quality was ensured through the use of rich, thick descriptions, triangulation of the data, the development and use of a codebook, and researcher reflexivity. Rich, thick descriptions add validity to the study by providing detailed descriptions to help the reader better understand what is being described (Creswell & Creswell, 2018). In addition to sharing participant responses, context around the participants experiences is shared to provide more detail and to assist the reader in comprehending the depth of what participants are describing.

Construct validity is ensured by maintaining the case study database, an audit trail, and data triangulation (Yin, 2018). Data triangulation in the practice supporting findings with evidence from multiple sources to strengthen the validity of claims (Creswell & Creswell, 2018; Yin, 2018). Data were triangulated throughout the analysis of this study in multiple ways. Data from the websites of the schools and school districts where the participants were teaching and had taught in the past were used to corroborate participant responses about their experiences in the district and their characterization of district and school curricular approaches. The National Center for Education Statistics website was used to corroborate participants' perceptions of the demographics of schools. Data from the teacher education programs they attended were used to corroborate Ms. Z, Ms. P, and Ms. V's recollections of the types of courses they took and what the curricula include. Mrs. R's responses were not able to be corroborated because she was not sure of the name of the program and the amount of time that had elapsed since she completed the program.

Data about participants' pedagogies and experiences teaching were triangulated through interview data, journal entries, and the post lesson checklist. Interview two included questions asking participants to share about their approaches to teaching science. Examples of the

questions they were asked during that interview include “describe your teaching philosophy”, “what are some experiences that influence your approach to teaching”, and “how do you make your classroom feel welcoming?” Their answers to these questions were compared to their responses on the post lesson checklist and journal entries. Perceived discrepancies were noted and followed up on in the final interview. During the final interview, participants were also asked to elaborate on their journal entry responses and their post lesson checklists to gain a clearer understanding of participant meaning. Prior to the final interview, the initial interviews had been transcribed and been initially analyzed and annotated. Follow-up questions on participant responses in prior interviews were asked during the final interview as well.

Additionally, to increase the validity of the study data that contradict overarching themes are presented and discussed in the context of the overall study (Creswell & Creswell, 2018). Presenting contradictory information and providing context for how it fits into the study increases the trustworthiness of the study. Use of a codebook increased reliability by ensuring that codes are applied consistently throughout the research (Creswell & Creswell, 2018). The codebook was a living document and updated throughout the study. Data were coded and recoded multiple times to ensure that each piece of datum matched the code attached to it as the codebook was updated. Reliability is also ensured by using protocols, the case study database, and the audit trail (Creswell & Creswell, 2018). Researcher reflexivity is an honest examination of the bias the researcher has and how it influences their interpretations of the findings (Creswell & Creswell, 2018). To complete this study in an honest and forthright manner I include a statement of my subjectivity, reflexivity, and positionality.

Researcher Positionality, Subjectivity, and Reflexivity

Merriam and colleagues (2001) state “what an insider ‘sees’ and ‘understands’ will be different from, but as valid as what an outsider understands” and that being aware and stating positionality acknowledges the limits and advantages of each position forcing an awareness of the subjectivity involved in the work (p. 415). In a case study, the researcher is the instrument of data analysis and thus my positionality influences the analysis of the data. To mitigate this influence and be transparent about how my subjectivities may influence me, I outline my positionality and experiences with science education, science teacher education, and science teaching.

Patricia Hill Collins (1986) discussed the concept of the outsider within as dynamic Black women have participated in as a part of their work roles since they were enslaved. Black women who worked inside of White homes became privy to the inner workings of those households and saw “White power demystified” (Hill Collins, 1986, p. S14). Despite this insider knowledge Black women were not accepted as fully human parts of these groups and thus sustained their outsider status. The line Black women have straddled within their careers and the dynamics of their multiple oppressions provide them with a distinct perspective of both their lived experiences and the institutionalized structures they work within (Hill Collins, 1986).

A similar experience occurs within academic settings where Black women have to contend with their lived experiences, their various forms of oppression and marginality, and the “white male insiderism” that is characteristic of academic worldviews (Hill Collins, 1986, p. S27). Black women academics status as outsiders within can be “the source of both frustration and creativity” (Hill Collins, 2000, p. 268) because they face the choice of assimilating with the White male worldview or risking their work being rejected by the academic community but have

a unique perspective through which to view their work. Black women may deal with this dilemma by developing a secondary work persona rejecting their cultural knowledge and best interests in order to assimilate (Hill Collins, 2000). Other Black women “manage to inhabit both contexts but do so critically, using perspectives gained from their outsider-within social locations as a source of insights and ideas” but this straddling often comes at a cost for the individual (Hill Collins, 2000, p. 268).

As a Black woman working as a high school teacher to primarily Black and Brown students as well as researching and publishing in academic contexts, I inhabit the outsider-within dynamic. The intersections of my marginalities and my lived experiences have directly influenced my research interests. Hill Collins (2000) states “many Black women scholars invoke our own lived experiences and those of other African American women in selecting topics for investigation and methodologies used” (p. 258). My lived experiences as a Black high school science teacher have directly influenced the topic I chose to investigate for this study. During my first three years as a high school science teacher, I recognized that even though my students and I shared a racial background and mostly grew up in the same city our experiences and influences were different. It was a steep learning curve to figure out how to connect with my students and integrate their lived experiences into my classroom. Further, despite our school’s faculty being over 80% Black and our student population being over 98% Black the way our students were treated by Black faculty and some of the structures inherent in the school made me uncomfortable in ways I couldn’t quite communicate. I just knew we were not quite providing our students the education they deserved.

Over the past few years, I have had the opportunity to reflect on what I experienced through critical perspectives. When I was teaching prior to beginning my PhD studies, my

colleagues and I were able to develop deep relationships with students and to help them grow even as the internalized beliefs of my colleagues and I influenced how we treated our students and created conflict that needed to be overcome. We may have shared racial backgrounds and some cultural aspects with students and held them to high expectations, but we still held some deficit views of our students. Individually, I figured out ways to resist the structures I felt were oppressive to my students in the ways that I could, but in other ways I contributed to my students' marginalization in science education. These experiences inspired the topic of this study and are central to my subjectivity and positionality as a researcher.

In the context of this study, I am inhabiting the space of the outsider within as a Black woman high school science teacher and as a member of the academic community that has traditionally not valued Black or female voices. Having been a Black high school science teacher provided me the experience to recognize a problem which would have been unlikely to be apparent to someone without a similar experience. As a PhD candidate I have become an insider to the academic community, however, my research interests, and this study, seek to challenge the insider worldview of academic research. This study does this through the prioritization of Black experiences and a critical view as to how academic spaces prepare Black women science teachers, how Black women experience careers in science teaching, and how Black women visualize effective pedagogy.

Ethical Considerations

Participants' data have been and continue to be kept confidential. Participants' identities were masked using pseudonyms of Ms. and a random initial. Participants' actual names were not used on any of their data. Any other identifying information about participants including the university they attended, schools where they teach, etc. were anonymized. Participants signed an

informed consent form informing them of the commitments of participation and were allowed to withdraw from the study at any time at their discretion.

Participants did not experience any physical risks while completing the study. Risks to participants experiences at their schools due to sharing potentially negative experiences were minimized by keeping information anonymized. There may be some discomfort experienced by participants as they were asked to recall experiences that may have been uncomfortable for them. However, participants expressed an enjoyment of traveling down memory lane, clarity as they discussed their experiences, and comfort that their experiences were being heard. As such, the study did not only take and learn from the participants, but the participants also received some benefits from participating in the study.

Assumptions and Limitations

As this study is framed through the lens of BlackCrit informed by womanism there are several assumptions underlying the analysis of data. This study assumes that Black women have experiences that are unique to being Black women, that marginalization, oppression, and racism are woven into policy and practice throughout science teacher education, and that the participants' intersecting identities influence how they perceive the world around them and how they are perceived by the world around them. The study assumes Black women have a unique and valuable perspective to offer and that we can learn from Black women's ways of knowing and problem solving.

This research is limited in its ability to generalize because of a small number of participants but it is strengthened by the quality and depth of the data. Despite these limitations, this research informs considerations for science preparation, schools, and Black women science teachers, as well as insight for future research on Black women who are preservice and inservice

science teachers. Additionally, qualitative research is reliant on the interpretation by the researcher which can result in biased conclusions. This is mitigated through researcher reflexivity and continued reflection. This research was also limited due to the constrictions of COVID-19 preventing in person research.

Researcher reflexivity is the influence the researcher may have on participants' responses (Stake, 1995), how the researcher's experiences may help them to understand the participant or site (Creswell & Creswell, 2018), and how my experiences may have influenced how the I interpreted the data (Creswell & Creswell, 2018). I mitigated this bias by being continuously reflective throughout the research process and how I may have been influencing participants (Creswell & Creswell, 2018). These reflections were documented so as the researcher, I can be aware of bias I may hold during data collection and data analysis.

Summary

In this chapter, I discussed the methodology and methods I used to explore the experiences of Black women secondary science teachers with science and their pedagogical approaches to teaching science. I used qualitative, single case study as methodology. Black women who teach secondary science in grades 9-12 and had completed at least one year of teaching were the case studied for this research. Data were collected via documents, semi-structured interviews, and the researcher journal. Data were kept confidential and stored using passwords and lock and key. Data collection occurred from August 2021 to January 2022. Data were analyzed through inductive and deductive coding and multiple measures were used to ensure validity and reliability. My positionality and continued reflexivity, ethical considerations of the study, and assumptions and limitations were addressed. In the following chapter, the findings of this study will be reported.

CHAPTER 5

FINDINGS

The purpose of this study is to deepen understanding of the experiences of Black women secondary science teachers during their teacher preparation and teaching careers as well as understand the approaches they take towards science teaching. This study was guided by the following research questions:

1. What science experiences influenced Black women to become science teachers? What educational experiences influenced Black women to become science teachers?
2. What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?
3. What common and different occurrences related to race and gender have Black women science teachers experienced?
4. What pedagogies do Black women science teachers use in teaching science to students?

In this chapter, I describe the findings of this case study research. I begin with a description of each participant's background and teaching experience.

Participant Profiles

In this section, I describe the background and pedagogies of the participants of this case study. Participants have between 1 and 19 years of experience teaching high school science. Each participant teaches biology or chemistry in a high school. In order to maintain the privacy and anonymity of participants, pseudonyms were assigned to all names and schools referenced throughout the study. When asked for a pseudonym, the participants referenced the names their

students call them. This often circled around names like ‘Miss’ or Ms. and the initial of their last name. As a result, each participant was assigned a pseudonym of Ms. or Mrs. and a random initial. In Table 6, each participant’s years of experience teaching, subject area taught, and in which state they teach are listed.

Table 6.

Participant Information

Pseudonym	Age	Years of Experience	Subject Taught (High school courses)	State
Ms. Z	26	1	Chemistry & Biology	Georgia
Ms. V	26	2	Biology	Georgia
Ms. P	29	3	Biology	District of Columbia
Mrs. R	45	19	Biology	New Jersey

Alternate Route Programs

Each of the participants completed an alternate route program to earn their teacher certification. Alternate route programs are teacher certification programs for individuals who have already graduated with a bachelor’s degree in a field outside of education. Alternate route programs vary widely but must be approved by the teacher certification agency of the state in which it operates. Alternate route programs include programs that grant certification over the course of a summer, programs that include a series of graduate level education courses, and programs ending in a master’s degree (Abell et al., 2006). Some of these programs require prospective teachers to complete all requirements before entering a classroom as the primary

teacher and other programs allow participants to receive a limited emergency or provisional teaching license while they complete the licensure requirements (Abell et al., 2006). Alternate route programs tend to have a more diverse prospective teacher pool than traditional teacher education programs and is a path into teaching for individuals who began a different career before deciding to teach (Abell et al., 2006).

Since the participants are Black women it is unsurprising that each of the participants in this program earned their teaching license through an alternate route program. Mrs. R earned her teaching certification through an alternate route program model that required her to take classes after work twice a week and on Saturdays for 18 months and have a mentor. Following the end of the program, she took an exam to earn her standard certification. The other three participants each earned their teaching license through alternate route programs that led to master's degrees. Ms. Z and Ms. V were both full time practicing teachers on provisional licenses throughout their teacher education. After completing the classes required for certification, Ms. Z and Ms. V were able to upgrade to a standard license. Completing the master's degree was not required, though both chose to complete it. Ms. P's alternate route teacher education program was a yearlong master's program more like a traditional teacher education program. She was required to participate student teaching in both semesters of that year. However, unlike the other programs, Ms. P initially received a stipend for her participation and was able to secure a graduate assistantship after losing that stipend.

Ms. Z

Ms. Z grew up in a family where everybody either worked in the family mortuary, were in politics, or were in education. As a result, Ms. Z was introduced to science and the importance of education at an early age. Some of her first memories are witnessing her family members

preparing bodies for burial which engendered a fascination in the underlying science. She grew up performing some of this mortuary science from the age of three or four.

Ms. Z attended a predominately White high school and despite of her love of science she was told her dreams of becoming a doctor or scientist were unrealistic as a Black girl. However, Ms. Z was determined to pursue her goals and successfully completed her undergraduate degree in biology and a master's degree in biochemistry. Ms. Z achieved her goal of working in science when she became a laboratory technician at a university. During her time working as a laboratory technician, Ms. Z's department asked her to teach a class when they were short-staffed. Ms. Z fell in love with teaching, but felt she wanted to teach high schoolers instead of college students. This led to her pursuing a Master of Art in Teaching to become a high school science teacher.

Ms. V

Ms. V was a curious child who asked many questions. This curiosity led her to a love of science and math. While Ms. V always did well in school, as a child she was not someone people would assume would have a career in education because Ms. V got in a lot of trouble in school growing up and clashed with some of her teachers. However, Ms. V's 12th grade science teacher saw how talented Ms. V was in science and pushed her to pursue a career in science.

Ms. V was a first-generation college student pursuing the goal of going to physical therapy school. While in college, she completed a physical therapy internship and realized physical therapy was not a career she wanted to pursue. During her senior year of college, Ms. V had the opportunity to teach a lab at a high school and really enjoyed it, but was hesitant to pursue teaching. By the summer following her college graduation Ms. V was unsure on what she should do and chose to enroll in a Master of Art in Teaching program.

Ms. P

Ms. P's first memories of science include Bill Nye episodes and doing labs. Growing up, Ms. P didn't particularly like science more than any other subject, but she was good at it. She was encouraged to become a doctor by her family because of her talent in science. Ms. P felt the only accessible science careers were careers in healthcare, so she chose to major in biology with a premedical focus.

College was the first time Ms. P struggled in science and felt like she might not be good enough anymore. During her senior year of undergraduate education, Ms. P realized she did not want to go through the stress of applying to medical school and she did not want to be a doctor. Her family expressed disappointment in her decision, but Ms. P knew she had to do what was best for her.

Two years after graduating with her Bachelor's in Biology, Ms. P saw an ad recruiting people to join an alternate route teaching program with a stipend in return for teaching Georgia for three years. She enrolled in this program, and it was during her microbiology and nature of science classes that Ms. P first began to enjoy science. She also fell in love with her experiences in the classroom. Though she was released from the program providing a stipend and tuition, a professor advocated for her allowing Ms. P to receive a graduate assistantship to pay her tuition and receive an income while she completed her degree and became a teacher.

Mrs. R

Mrs. R spent a lot of time in hospitals growing up, but not because she was ill. Mrs. R was the child of a single mother who took Mrs. R with her to school as she became a nutritionist. After graduating, Mrs. R's mom brought Mrs. R along to her job as a nutritionist at the hospital

often. Mrs. R remembers being a young girl, not really understanding what was going on and trying to participate in her mom's science classes and coloring in her mom's biochemistry book.

Science always came easily to Mrs. R, and she went to college with the intention of becoming a doctor. Unfortunately, her stepfather became terminally ill while she was in college and her family did not have the funds to pay for medical school. Due to this, Mrs. R chose to become a teacher. Mrs. R enrolled in an alternate route program and volunteered as a counselor with Upward Bound to gain some teaching experience.

Themes

Four themes that emerged from this study. Each of the four themes are then further divided into subthemes as displayed in Table 7.

Table 7

Study Themes & Subthemes

Theme 1: ‘I could kind of do this’: Black Women Pursued Science Teaching as a Backup Plan.	
	‘I was good at it’: Black Women Experienced Success in Science from an Early Age.
	‘You can either be a teacher or a nurse’: Black Women Took Untraditional Paths to Becoming Science Teachers.
Theme 2: ‘Invisible’: People in Positions of Authority Do Not Understand the Realities of Black Women during Teacher Education and in the Classroom.	
	“They make it hard”: Teacher Preparation Programs Missed Some of the Realities of Black Women in The Program.
	“Is this something uncommon?”: School Administration Neglected to Understand or Support the Realities of Black Women Teaching Science.
Theme 3: ‘Working with Black kids is a privilege’: Black Women are Developing Classrooms that are Liberatory Spaces.	
	“We got to take this, if we’re there or not”: Black women are frustrated by micromanagement and lack of autonomy in their classrooms.
	“Like a place of home”: Black Women Seek to Cultivate Classroom Communities with High Expectations Where Students Feel Safe .
	“Don’t give up we on the brink of greatness”: Black Women are Enacting Liberatory Pedagogies and Resisting Revisionist History
Theme 4: ‘We not starting from the ground up anymore’: Being in Community with Other Black Women is Impactful.	
	“They’re showing me the future”: Black Women Mentors and Supporters are Inspirations.
	“And she tells me I should quit”: Black Women Can Be Obstacles.
	“Direct inspirations, the women I work with”: Black Women Seek Community with Other Black Women.

Theme 1: ‘I could kind of do this’: Black Women Pursued Science Teaching as a Backup Plan.

The first theme that emerged in this study is that Black women pursued science teaching as a backup plan. Ms. V, Ms. P, Mrs. R, and Ms. Z did not go to their undergraduate institutions

with the intention of becoming science teachers. For most of the participants, teaching had not crossed their mind as a career path. Science teaching became a career for them when money or opportunities became scarce or when opportunities to teach crossed their paths. In exploring this theme, I begin by describing the participants' relationships with science followed by the paths that led them to becoming a science teacher when it was not their original career plan.

'I was good at it': Black Women Experienced Success in Science from an Early Age.

Each participant expressed having been identified by themselves or others as 'good at science' prior to entering college. Mrs. R was great at science in high school, and she was very confident in her science abilities as she discusses here.

Science was always my easiest subject, but never my best grade. I was always nervous for math. So, I used to study and practice more in math, knowing that the extra time that I put in math, I probably, I'm probably taking away time for science. But I could get through the science much easier. So, if I had A plus in math, then I probably had like a B plus in science. But I mean, I was good with that in mind, because I knew that I needed the extra practice. Like, I need to practice. I needed to practice more in math, and I did not need to spend that time in science. So even back then I- you know, even in high school, I understood my cognitive abilities, girl, that I was able to rationalize that and say, well, I already know how to do this [science].

Mrs. R was so confident about her own abilities in science that she put less effort towards doing well in science and more towards math, a subject in which she was less confident. Even with this reduced effort in her science classes, she was still able to do relatively well in science courses.

Ms. P did not really like or dislike science. However, she was good at it which led her to pursue a career in science.

I didn't always necessarily like science. I kind of had a goal in mind. I was good at it. I could be good at it, I guess. Um, and so I wanted to be a doctor. So, I just was taking all these science classes. And in college, I took microbiology and that was like, Ooh, this is cool. Um, I mean, I think in like K-12. Science was okay. It was interesting. But I don't think I was like, specifically drawn to science back then.

Although Ms. P didn't like science at the time, she felt like she could have a successful career in medicine due to her talent in science. Ms. P chose medicine because it felt like an accessible career in science.

Yeah, I was more so like, I want to be a doctor. So, I think that back then, you know, science was like anatomy, healthcare. Undergraduate. That's when I started thinking about labs. Like working in labs and things like that. But I still wasn't sure how to get into that [laboratory science] ... Like, it seemed like you had to be a genius in science to do it or something like.

In high school, Ms. P conceptualized accessible science careers as careers in healthcare. At the time she did not consider teaching as a potential career in science. Ms. Z also dreamed of a career in science. However, she was able to visualize careers outside of healthcare.

Ms. Z always loved science, even having a science-themed 6th birthday party.

Unfortunately, she was exposed to racism in high school where she was discouraged from pursuing her dreams.

I went to high school in a majority White county. And, you know, we will get to a lot of things, and they'll be like, hey, what do you want to be? And I'm like, okay, you know, I want to be like a doctor, I want to be a forensic pathologist. So those are my aspirations, then in high school, and you know, a lot of people be like, well, you're Black, that that

ain't gone work, you know. Like, that don't happen, like, who, who does this, you know, Black people don't do this.

Ms. Z attended a high school with a majority White student population and where she had few Black teachers. She remembers having two Black science teachers in middle school, but none in high school. Although her middle school science teachers encouraged her to pursue science, her high school teachers that her dreams were unattainable because she was Black. However, she did continue to pursue her dreams and became a laboratory technician due to her passion for science.

I have that passion for science. So, I feel my passion needs to be transferred in a very more layman terms to kids and to students or anybody to understand that science is not just this, it is what it is factor. It's our life, you know, without understanding it, you know, how can we move forward? How can we change? When we talk about change, we're talking about science regardless whether you want to talk about it, because to change your thinking you're changing some form of science in your body. So, my why it has to be on understanding the love the passion that I have, for teaching for learning, and being able to get it out there to the world to build people up as well.

During her time as a laboratory technician, the university Ms. Z worked at asked her to teach an undergraduate course. Ms. Z really enjoyed the experience and felt as if she was called to share her passion for science to high school students by becoming a high school science teacher.

Each of the participants experienced success in science and identified themselves as good at science from a very young age. They each desired careers in science and three of the participants originally desired careers in healthcare. However, their paths diverged from these dreams leading each of the Black women who participated in this study to become high school science teachers.

‘You can either be a teacher or a nurse’: Black Women Took Untraditional Paths to Becoming Science Teachers.

Participants' talent in science put them on paths to medical school, physical therapy school, and working as lab scientists. However, along the way to these paths a diversion occurred that redirected the participants to teaching. For two participants, Ms. V and Ms. P, their original plans of pursuing healthcare careers no longer felt like a good fit during their undergraduate years.

Ms. V majored in biology during college with the plan of becoming a physical therapist. During her studies in biology Ms. V had the opportunity to teach a high school lab. When Ms. V realized she was no longer interested in pursuing physical therapy, the opportunity she had to teach a lab drove her towards a teaching career.

It was that gap year after graduation where, you know, the typical, ‘I thought this was what I wanted to do when I graduated.’ But this year, finding a job is really hard. Just sitting down trying to figure out what it is that I wanted to do. Cuz actually my senior year of college... We had to go to a high school and teach, build a lab. So, with that, I was just like, ‘cool, I could kind of do this, I like it.’ And they're like, ‘you should be a teacher.’ And I was like, ‘girl nall. I'm finna graduate and I ain't finna take no more classes. No ma'am.’... And then with that last internship, honestly, with physical therapy, I was like, this is not what I want to do at all ... And I was like ‘you want to teach’.

Ms. V had the opportunity to do a small bit of teaching during college. When she reevaluated her post-graduation plans for a career the experience teaching in a high school classroom inspired her to become a teacher.

Ms. P graduated from college and knew she no longer wanted to pursue a medical degree after feeling imposter syndrome in college.

Imposter syndrome. I felt that a lot. I didn't know that all the kids were like cheating on their tests and stuff. Like I didn't know. At the time, I'm just like, wow, I'm, I'm struggling a little bit. And I just felt so overwhelmed. And everything was so new. Like going to undergraduate was a whole new world. So, thinking about medical school.

Having references? Talking to people, right? Oh, I don't know if I can do this.

Ms. P felt overwhelmed from her experiences majoring in biology in her undergraduate studies and decided against pursuing a career as a medical doctor. Instead, Ms. P chose to try a career in teaching.

I was thinking about going back to school. I didn't know what I wanted to do. And I saw an ad that was like, 'Hey, do you want to be a teacher?' And I was like, maybe, I guess, possibly. And I started to take the classes, and I was like, 'Oh, wow, this is actually great.'

Ms. P decided to try teaching after seeing an ad. When she was introduced to the classroom she fell in love with the profession.

Mrs. R went into teaching still feeling a desire to become a doctor. Unfortunately, her stepfather becoming terminally ill meant that her family was dealing with high medical bills. This reality derailed her from pursuing her plans of becoming a medical doctor.

Okay, so when I didn't get into medical school, because my parents were like, "No, we don't have any money for that. You can either be a teacher or a nurse." I was like, 'mmm I don't wanna be a nurse.' I was like, 'Okay, well, I'm gonna take the teacher exam, and I'll just teach for a couple years and forgive my student loans. And then I can see if I

saved enough on my own to qualify for a loan or, you know, to get into medical school.’ But then once I started doing it, I just fell in love. And I was like, ‘Well, this is for me.’ I just stayed here. 20 years later here I am. I’m gonna get the doctor but not the MD I’m gonna get the EDD.

Financial obligations prevented Mrs. R from pursuing her original goal of becoming a medical doctor. So, she became a teacher to save money to go to medical school. However, she fell in love with teaching and realized it was the career she wanted to stay in.

In contrast to each of the other participants, Ms. Z achieved her goal of being a working scientist when she was hired as a laboratory technician at a university. During her time as a laboratory technician, Ms. Z taught undergraduate science courses and as a result fell in love with teaching resulting in her eventual pivot from lab scientist to high school teacher.

I want to be a teacher and I don't want to be a college professor. I want to actually be a teacher in the public schools with the kids who need someone to actually build that relationship with them to show them the science. Kind of show them what is there to love about science.

Ms. Z loves science and enjoys sharing that love with students. Having the opportunity to teach an adjunct course allowed her to view herself as a teacher and influenced her to pursue becoming a high school teacher.

Theme 2: ‘Invisible’: People in Positions of Authority Do Not Understand the Realities of Black Women during Teacher Education and in the Classroom.

The second theme that emerged in this study is that Black women felt that teacher preparation programs and administration at the school and district levels do not understand the realities of teaching. The participants expressed feeling exposed to discrimination, frustration

with the lack of autonomy, and unprepared for some of the realities of teaching secondary science as a Black woman.

“They make it hard”: Teacher Preparation Programs Missed Some of the Realities of Black Women in The Program.

Each of the participants became teachers through alternate route or master’s programs following the completion of their undergraduate degree. As a result, their needs from their graduate programs are different than students who are completing an undergraduate education degree. Ms. P did not want to have to take out loans to pay for her teacher preparation. She felt her program did not take into account her need to support herself financially.

For students who are like financing themselves and working, it's- they make it hard to live. They don't really take that into consideration. And they want you to work and go to school full time. And also pay for it. So, it's a lot... I had to work 20 hours. I think it felt full time to me. So, it might not have been 20 hours, but I know I had to work every day. Um, and yeah, getting transportation. Like you pick your county. But Bolton County [pseudonym] is big. So, I was going to the other side of Bolton County at one point [and] going to another side at another point. And still going to school. And I also was a GRA (Graduate Residential Assistant) so working that job. And then also, I had to do Uber too. Yeah. Flexible enough. So yeah, to work. It's like working three jobs.

Ms. P was overwhelmed with everything she needed to do to support herself and complete her program. She felt like her program did not understand her financial obligations or provide ways for her to balance her needs and her teacher preparation.

Like Ms. P, Ms. V and Ms. Z attended an alternate route program. However, Ms. P experienced student teaching, while Ms. V and Ms. Z took two to three classes before being the

primary teacher of their own classroom. Ms. V and Ms. Z completed their teacher education while in their first years of teaching. Ms. V identifies not considering the reality that some alternate route teaching candidates do not experience student teaching as a flaw.

It wasn't designed for one, teachers who are already in the field. And then two, the stuff that we really needed to learn to be better teachers. The program wasn't designed to teach you- like you can tell me how to fill out a lesson plan all you want. But if you're not modeling, like, how to effectively teach this lesson, and how to gauge students understanding and all of that sort of thing. I mean, I can feel- I can type in a document all day, I can critique a document, I can say I did the lesson. Did the lesson go like I wanted it to? Nine times out of 10 probably not.

Ms. V felt that her classes taught her how to manage paperwork but did not give her clear instruction on teaching science. Since some students in alternate route programs will never student teach because they are already in the classroom, Ms. V felt modeling of instruction was missing from her program. Ms. Z echoes the desire for more applicable strategies from teacher preparation for students who have already identified a full-time teaching position.

I think the beforehand of that, give me pointers that- I need a replica of classroom before I go be in the classroom. Just how do you teach science? Not necessarily how but, um, different strategies of teaching science. Um, different thinking models or different, better really teaching strategies to teach science. So sometimes, I know you're supposed to see that I think sometimes in the science methods, teaching class. But actually having that space beforehand to kind of get it out.

Both Ms. V and Ms. Z's observations are supported by the description of required coursework by their teacher education program. The course descriptions assume students in the program will not

be fulltime teachers and describes observing other teachers and reflecting on their observations before taking full responsibility for the classroom. Although the program allowed Ms. V and Ms. Z to meet the program requirements in other ways, it did not provide them the opportunity to observe and reflect on others teaching. Alternate route teachers desire more applicable instruction for their classrooms and the space to practice them in the introductory classes they take before entering the classroom.

Conversely, Mrs. R had primarily positive experiences in her teacher preparation program. These positive experiences were created by a strong sense of community between students and faculty that her program cultivated.

You went to class from three to five, and then you had or maybe four to six, and then there was like a little bit of break. And then you went until 830, like there was a break. And then you went back to class, and you finished at 830. So, during that break, we had lots of conversations with the professors, there was like a little cantina. So, we would all go and eat and, and talk. So, it was a lot of fellowship. So that was awesome.

Mrs. R's program made space for her cohort to fellowship and get to know one another. Additionally, the faculty members interacted with students outside of the courses cultivating a deeper sense of community in the program.

The participants also experienced racism and microaggressions during the course of their teacher preparation and their careers. Ms. P describes a classmate saying racist comments and not being reprimanded or addressed adequately by the professor.

I do remember, like we had like, it was in practicum. So, it was like a lecture hall. And it was tense topics being talked about, because we have to talk about culture and values. And I just remember this White man saying ignorant things. And I have to just sit here,

because it's an open dialogue. And so, it's kind of like, I know that if I stood up and said, my thoughts, it will not be receptive. Right. It's not an open dialogue anymore if I stood up and said my thoughts. So, I would say, you know, that, that invisible invisibility thing I felt...But I just feel like it was kind of like a, let's remain calm. And let's, you know, give people space. And here's a routine of what you're supposed to do when someone says something that you don't- you disagree with. You know that whole, like, thing, professionalism type. And it's like, he's being racist. That's not professional.

Ms. P felt as if she was made invisible by her program's insistence on calm and letting everyone share their thoughts when they neglected to confront racist comments. In the program's attempt to expose students to deeper understanding of culture and values in order to meet the goal of developing teachers that are responsive to student diversity and are equitable in their instructional practices, Ms. P's program inadvertently marginalized Ms. P. She did not remember which professor led this conversation but did note that having Black women professors in other spaces showed her what the future could look like and made her feel inspired in the face of experiences in classes led by other faculty that made her feel invisible.

“Is this something uncommon?”: School Administration Neglected to Understand or Support the Realities of Black Women Teaching Science.

Teacher preparation programs either did not prepare or were unable to prepare their students for some of the realities of teaching science. School administration either did not know how to support Black women who experienced racism or neglected to provide adequate support. Despite this lack of preparation, Mrs. R believes Black women's prior experiences may be what allows them to remain in environments that could drive other teachers away because they are unprepared for the situation.

You hear a sound [and] you don't know if it's shots or if it's firecrackers. So, you know, we had to get low in the classroom. The kids knew the- they knew better than us. Yeah. So that kind of thing. It didn't prepare us for dealing with that. But, I mean, they're our people so you're not- I guess my life prepared me to deal. Like I know how to deal with people that look like me, you know? So. But if you weren't one of us, and you had to deal with that, that would have for sure sent you running.

Mrs. R felt her own life experiences prepared her to respond to the sound of gunshots in her classroom and other experiences she dealt with while teaching at an economically disadvantaged, primarily Black school. She felt that the experiences that many Black women encounter throughout their lives may help to prepare them for experiences that their teacher preparation programs do not. However, Mrs. R noted that being unprepared for such experiences could drive someone who didn't have life experiences to pull away from teaching in such an environment.

Ms. Z is a Black chemistry teacher in a community that is 63.1% White, 33% Black, and 0.9% Asian and was not familiar with a reality where Black women were chemists (National Center for Education Statistics NCES, 2022).

I had parents say, "Oh, my child has a Black chemistry teacher, they've never had a Black science teacher" ... That was like, oh, I'm so you know, I was just like, okay, is this something uncommon? ...I have to be able to prove to the community that, you know, I can live up to any other White co- person who teaches the same thing as me. I'm just as smart, just as capable as they are. So, I do think that takes a lot into the preparation as far as in teaching. it makes it emotional because you feel like you can't fail, when you know, there are mistakes that will be made...I feel like it put more of a target on me, because before me, there was only one other Black person in my department. And then I was the

second person to be Black in the department. So, I felt like it was just all eyes on me and her as well.

Ms. Z did not feel prepared for the shock community members would have at seeing a Black science teacher or for the pressure she felt due to community reactions. As she entered her first-year teaching, Ms. Z was also confronted blatant racism when she was called a racial slur during an open house with little response by her administration.

I only had maybe one time where it was blatant. And that was the one parent who had [at] open house definitely said it on a recorded live stream. “We have a nigger for teacher” and I was like, “okay”, yeah. Yeah, I've had that comment. Um, so, and that parents, the kid stayed in my class with the whole entire year...The child even came to school with racist comments on their mask and everything. And, you know, I reported, nothing happened. But another teacher reports it and something happens. And I'm just like, okay, like, it's the same report it's just two different teachers. I do feel like my principal put it under the rug, you know, it was more so like, ‘Hey, we're sorry, we're gonna talk to the parent. You know, tell the parent, this isn't acceptable. But at the end of the day, you know, there's nothing I can do’ is what I got from her. Or nothing I'm going to do...I did ask to get the kid removed. I clearly kept the kid the whole entire semester, um. But I felt kind of discouraged for a while, because I'm just like, Okay, if I have one kid like this, am I gonna have 20 other kids like this? ... I was always feeling like I was on edge. Not saying the wrong thing, or not to do the wrong thing.

Ms. Z was teaching in a school that had a student population that was 51.8% White, 44.1% Black and 1.1% Asian (NCES, 2022). Additionally, she taught honors and advanced classes that were primarily filled with White students. This encounter left Ms. Z feeling unsettled and

apprehensive of the environment she would deal with as she taught primarily White students in a school and county that had a majority White population. Yet, Ms. Z's principal, a White woman, offered little support to Ms. Z, understanding of how this experience would color Ms. Z's interactions with students and parents, or care as to how this experience made Ms. Z feel. Ms. Z's teacher preparation program had not prepared her for the possibility of facing such virulent racism as a part of her career or strategies on how she could address it. As a result, Ms. Z was left to process this experience on her own and without support or previously taught skills.

As Black women, the participants dealt with racism and sexism in their classrooms and a part of interacting with parents and colleagues. Mrs. R describes how racism and sexism inevitably come up in conversations and feeling like it would be disruptive for her to leave the conversation. She mentions not wanting to let her colleagues feel like they've gotten to her as the only Black woman in the sciences at her school and one of very few Black professionals in her building.

But now, you know, the things that are discussed, like politics. You know, my district is very political right now. Or nepotism? You know, things like that. Yeah. Yeah. I never what, what I've noticed is, I never say anything, I just like, kinda, you know, because when you're in the group, the conversation that drew us together was not necessarily about politics, or nepotism, or sexism or racism, but somehow it always finds its way in, and I'm already sitting at the table. It's gonna be awkward if I get up. So, I kinda, you know, you just sit there and sip your tea. Right?

Mrs. R is a Black woman working in a school where the teacher population is 79.8% White, 7.1% Hispanic, 4% Black, and 9.1% Asian and her administration is 92.9% White and 7.1% Hispanic (New Jersey Department of Education, 2022). When Mrs. R experiences

microaggressions in conversations with colleagues she feels like she must endure them in order to keep the peace at her job. She understands that making a fuss could result in retaliation, especially as she is one of few Black teachers in her building.

Theme 3: ‘Working with Black kids is a privilege’: Black Women are Developing Classrooms that are Liberatory Spaces.

As expressed in the previous theme, the participants experienced much frustration as a part of their jobs. The third theme expresses how the participants’ cultivated classrooms that are spaces of resistance to the norms and expectations of a high school science classroom.

“We got to take this, if we’re there or not”: Black women are frustrated by micromanagement and lack of autonomy in their classrooms.

Each participant expressed some level of frustration with the lack of autonomy they held as teachers. Multiple participants also expressed being annoyed at being micromanaged and not being able to do what they know is best for their students. Ms. V described frustration over micromanagement and a lack of autonomy at her current school. She and her team member work with a district coach who is very involved in their collaboration. They had more oversight than other instructors due to teaching biology which is a state tested subject in Georgia.

I was like, ‘Well, what do you think about for opening?’ The instructional coach started answering before my co collaborator did. It was like you’re not teaching and stuff. So, like when we talk about the planning process, I’m asking her specifically. And then if you want to comment on the strategy sides of it, then like, you can do that. But you’re not going to be teaching the class, or like sometimes just sit back, and let us engage in the conversation and in jumping where you need to.

Ms. V teaches biology which is a course that includes a test students must take at the end given by the state. This test is used as a measurement of the quality of education students are provided by the school and school district (Georgia Department of Education, 2022). Due to this requirement, Ms. V felt she was micromanaged greatly as the school's goals for improvements include improvement on student performance on the state test and participation in common formative assessments for state tested subjects. Ms. V felt she was not given the opportunity to truly collaborate with her team member and that as a team they were not given the opportunity to use their expertise. She is frustrated at the lack of trust in her expertise as a teacher and how her district restricts her ability to be responsive to her students' needs.

There is zero autonomy in our classrooms. At all. I can't set the standards the way that I want to set them, I got to teach them ABCDE. Even though it doesn't make sense. I cannot make my own assessments. You already told me what formatives I had to give. You made [the] assessments. There was zero teacher input on the formatives that were made. And the exams that we have to give each unit, no teachers were brought in to construct those exams either. So, I got to teach the standards, the way that you want me to teach them, I have to give the formative the way you want me to teach them...And you don't have the autonomy to change it. Because if you don't give those formatives that week then it's going to be a problem. Because it's district required to give two of them... So, these kids are taking multiple formatives every week in the same platform. And then it's just like, they're tired.

Ms. V is overwhelmed by the requirements of her district. Ms. V chafes at how the district requirements are not aligned with her teaching style and prevents her from doing what she feels

is best for her students. This frustration has built to a point that Ms. V began looking for a new position for the following school year as she expressed in this journal entry.

I'm just having to rush through the material for the sake of pacing and being micromanaged. The kids have absolutely no break. I told my admin that I felt like we couldn't just have a day where we were like, "we're tired, let's just play catch up and give our brains a break" without it being an issue. She said that wasn't true, but deep down, we all know how that can go. The two CFAs (common formative assessments) a week are... OMG!!! It's a lot, it's a lot, it's a LOT!!! It's so hard to listen when they say we can take a break when our collaborative meetings are filled with the teachers, instructional coach, assistant principal, and the district Biology PLS (professional learning specialist). All the school seems to care about is data and more data. If I hear the word self-care one more time, I might lose my mind. It's absolutely impossible to take care of yourself when you're constantly being watched and asked questions about every single detail of the day. Can I please just come to work, close my door and teach for one week without somebody breathing down my neck? If I'm being honest, weeks like this make me contemplate wanting to switch districts. I can't deal with this amount of micromanaging. I have ZERO autonomy in my classroom.

Ms. V found the requirements of the district at odds with both the needs of her students and her own needs. In particular, she expressed frustration at the school encouraging teacher self-care while continuing to micromanage her and schedule her planning time with a variety of meetings. This hypocrisy from her school made it difficult for her to believe her principal's assertion that Ms. V could respond to her students need for a break when the school seemed focused on data without giving Ms. V room to respond to that data or her knowledge of her students. Ms. V's

disbelief is also supported by the school's improvement goal of increasing the participation of students taking common formative assessments. As a result, Ms. V was seriously considering changing school districts in the upcoming school year.

Ms. P also expressed frustration at the misalignment of her school's requirements for the pacing of the biology class and her knowledge of her students' needs.

We have these, like, required performance tasks. And they're on a schedule, which you are- you know how that can go for on a schedule. That means it's like, take it or leave and I'm- we got to take this, if we're there or not. Um, but my, my professionalism is assessed based on how many of these we complete, so it's not authentic learning [or] student interest. [It] is more so like, let's just get this. Like, let's do what we got to do.

Ms. P desires more flexibility to be able to shape the pace of the curriculum to fit the needs of her students, but the lack of autonomy she has due to required performance tasks prevents her from changing her pace. Within her journals, frustration with pacing and lack of autonomy appear several times with Ms. P writing, "I wish I had more flexibility to truly have students break this down" and noting feeling like she didn't do the best job she could in completing the instruction of a unit.

I am not proud of this week, as I felt students still struggled with the concepts. Normally, these concepts could take a week each MINIMUM. At my current network, Replication, Transcription and Translation had to essentially be taught in a single week. I did okay for the time I had, but I believe students had major misconceptions by the end of the topic. I don't feel comfortable just moving on, so I am thinking of ways to cycle this information in through the end of the term

Ms. P's frustration with having to rush through content and not having the time to really give students the opportunity to work with the content is directly related to the lack of autonomy she has due to the strict pacing she must follow. Ms. P identifies this lack of autonomy as what will likely drive her from the classroom into full time consulting.

I have a side job. Consulting schools and building curriculum. And the freedom, the respect, the pay, it just doesn't compare. Like, it's a virtual job, I get paid very well. And it's like, flexible. And I like that. I think schools aren't trying to be flexible with teachers, you know, they're not trying to be- it's like a jail.

Ms. P feels freedom in her consulting job that she doesn't experience as a part of her teaching job.

Conversely to the experiences of the other participants, Mrs. R is in her 20th year of teaching and has been granted much autonomy in her classroom. However, she still wishes there was some more flexibility in the curriculum to enable her to be more responsive to student needs and the reality of the COVID-19 pandemic.

I wish we had some guidance where, where our supervisor could actually say, you know, alright, focus on these three, and then everything else may fall by the wayside, but you know, you'll get a good chunk of it completed.

Mrs. R believes the most important part of teaching science are the skills students walk away with because they will forget many of the details. As a result, she chafes some at the breadth of material she is expected to teach when students are struggling to return to school after remote learning due to COVID. Like the other participants, Mrs. R desires increased autonomy for curriculum and pacing, even if it is only at the school level.

“Like a place of home”: Black Women Seek to Cultivate Classroom Communities with High Expectations Where Students Feel Safe.

Each of the participants described classrooms where students feel safe and are held to high expectations as classrooms that were impactful on them as students and as classrooms they try to cultivate now. When Mrs. R reflected on the environment of the science teacher who had the greatest impact on her, she remembered a space where she felt safe and comfortable and where she was held to high expectations. Her former teacher, Ms. Barnes, was one of the few Black women science teachers Mrs. R had as a K12 student. Mrs. Barnes began implementing the structure in her classroom on day one by having students clean and organize lab equipment. This made Mrs. R feel safe and comfortable in her new science class.

I was very comfortable, you know, once you know the names, and I guess that was her way of teaching us policy and procedure. Because once we did that, I mean, I felt like you know, it wasn't any questions on when she said to go and get a thermometer or when she said to go and get a hose. You know, I felt like I was comfortable. Knowing the room, so my environment or the environment. It was very approachable.

The structure of the classroom meant Mrs. R didn't have to guess about where things were or what she was supposed to be doing. This provided her comfort. Further, the high expectations her teacher set made her want to meet them.

She didn't come assuming that we needed to be coddled and that, you know, needed special assistance. She didn't come with those assumptions. You know, I felt like my physics and my chemistry teacher after that. They made a lot of excuses for the, for the kids who didn't do their work...she made us responsible. And I think because she had those high expectations for us. And she never actually verbally said, 'Hey, I got high

expectations for you.’ It was just her actions in the class and how she ran the class. I mean, her life, her lab coat was impeccable. The room was impeccable. You know when you stepped in there, you just felt a different aura. And girl. I’m 45 and I remember this lady from 10th grade. I can see her right now. So, she left an indelible impression on my life.

The classroom environment of Mrs. R’s teacher created an environment where students drove themselves to meet the high expectations she set. She created an environment where the classroom spoke for itself. Mrs. R replicates this structure and high expectations in her own classroom as she teaches biology to create a similar environment for her students. Mrs. R high expectations and the student response to her expectations is illustrated in how students interact with each other.

I push peer reflection and self-reflection. If you [a student] feel as though you’re not 100% clear, you know you did your project, you looked over the rubric, you feel as though you have full credit, ask a neighbor and see, you know for them to check it. And let me tell you something Jordan. They are so hard on each other. I can’t believe how hard they are on each other. ‘Nah man, that don’t look right. That’s foolishness. Mrs. R gonna give you a zero.’...So we spend a lot of time in the beginning of the year talking about active listening. So we roleplay it, we role play the opposite of it. We have charts, I have each group create a chart to tell us how active listening looks... so that kind of sets the tone early and then they follow that.

Similar to the interaction Mrs. R described in her interview, in her journal she describes requiring students to reflect on their learning needs. In doing so, she is setting the expectation that they take responsibility for their own learning. Mrs. R’s students hold each other to the same

high expectations that Mrs. R holds them. Mrs. R's expectations have created a classroom environment where students want to meet her expectations, reflect on their own learning and express their needs, and encourage other students to do so as well. She creates and embeds these expectations by practicing with students and reinforcing them continually from the beginning of the school year.

Ms. V similarly cultivates a classroom culture where students feel safe and excited about science. One of the ways she encourages students to feel safe to try new things and experience failure during biology class is by reminding students that everyone learns at their own pace and in their own way.

I believe firmly that every student is capable of doing. Whether they have IEP or they didn't do [well] before, it does not matter. Like they are capable and nobody's going to tell me that they can't do it. The amount of assistance that I give them to help them get there will vary, but everybody's gonna get there at the end of the day. Um like, I tell them there are microwaves and crock pots. We all gonna get cooked. At the end of the day, some of us cook a little bit faster. Some of us, we have to, you know, slow marinate a little bit.

In addition to keeping students encouraged about their capabilities, Ms. V cultivates a classroom culture of support and safety by knowing her students very well, allowing students to express themselves, and by being responsive to students' emotions and needs.

Like, if you're having a bad day, I understand. But I can't understand what you don't let me know. So, if you're having one of those days, where you just really are having a day and don't need to be bothered, I'll let you put your head down. I'm not gonna keep poking at you because I know it's some days when I come in here and I don't want to do nothing

because there's too much going on. Or it's like, whatever happened outside the door, don't bring it up in here. If you got problems with little Pookie down the street that ain't got nothing to do with what we're doing up here...they just like know to leave all that stuff at the door and I'm a just be good vibes and you know, you know, the vibes. And we just be chilling in there. So, it's just like a real lax, but still high expectations environment.

Ms. V identifies that she can hold high expectations for students and hold space for their emotional needs as well. In three of four of her post lesson checklists, Ms. V notes providing students opportunities to express their thoughts and feelings connecting to her efforts to help students be ok with making mistakes and her efforts to connect with students. She also cultivates an energy of “no drama” in her classroom. Disagreements are left at the door and students interact kindly with each other. By doing this, her classroom becomes a safe space for students to be themselves.

Ms. P cultivates a safe high school biology classroom for her students by getting to know her students' interests, connecting to student interests, and allowing her students to express their interest through their work. She believes this is how students become interested in learning.

Respect for others and for oneself leads into the overarching goal, not only of my classroom, but of biology. Diversity of people, ideas, perspectives, ethnicities, cultures, languages, abilities—all this diversity transforms a room into a classroom. Realizing each student has his or her own sets of cultures, experiences, and prior knowledge is the first step in differentiating content knowledge...The relevance aspect of learning begins with students' prior knowledge and lived experiences. Getting to know and understanding my students allows me to begin to conceptualize the topics that interest them. I do not aim to

only understand how my students learn, but what interests them to want to learn... I learn from my students' diversity and lived experiences.

One example of how Ms. P connected students' lived experiences to content was by connecting genetics to students' experiences with racism. In her post lesson checklist discussing a lesson from the genetics unit in biology, she discussed "the science behind our difference" and discussed how human bias against skin color "can result in higher suspension rates and longer prison sentences." Through introducing this discussion as she taught genetics, she connected students' lived experiences with discrimination and encouraged the development of critical consciousness.

Ms. P does not make assumptions about what students are interested in and tries to avoid letting bias influence her interaction with students. Ms. P does not appreciate when stereotypes are used in an attempt to make content relevant for students and feels strongly teachers must learn about their students individually beyond those stereotypes to make an inclusive classroom.

So, allowing, like the students to put their own identity into their work, and not trying to be like, Black kids do this, and Black kids do that. I hate when people do that. 'Let's put some more rap in it' and it's like, actually, these kids, they listen to BTS (a Korean pop group). Like, have you asked them? So just try not to be overly stereotypical and letting it be individually.

Ms. P looks beyond stereotypes and assumptions about her students to connect with students' actual interests and needs. She believes strongly that students should receive personalized learning where they have truly understood the material in a classroom where students can be their full selves.

Learning should be personalized. So, I don't want my students to just kind of like regurgitate the content. I want them to personalize the content. So, there should be some kind of like individual processing going on. So, if I notice a student is kind of like- What's the term? Like if a student can't be themselves, if they're not like being them, their unique self. If they're kind of just like, I'm answering the questions, but their personality isn't really showing. Or I don't feel that community building, then I'm kind of like digging a little bit. Um, so to make sure they feel a part of the space.

Ms. P believes students should be able to learn science while being their full selves and showing their whole personalities. In her lesson plans, Ms. P provides multiple opportunities for students to express how they are feeling, formatively collects data on how well students think they understand the material, and opportunities for students to share their understanding of what they are learning in their own words. Although Ms. P is limited in how much she can adjust her pacing or content, by incorporating these strategies into her lessons she still provides opportunities for students to make what they are learning their own.

On her post lesson reflection checklist, Ms. Z recorded that she gave students multiple options for how they would turn in assignments and elaborated during her interview. Ms. Z described how she supports students being their full selves in chemistry class as well by encouraging student creativity and encouraging them to turn in assignments in a variety of ways.

So just keep that open minded. And always, if you know the science, there's 1000s of ways you can teach it. Just um, see what who your kids are, and then use what your kids are to be able to teach those skills...When I say tap into the creativity of you and your kids is like, even now kids are allowed to do science and tik tok, I mean, you know. So

just keep- science is everywhere. So, I always would love to tell kids like, be open minded. Keep the open minded so then if you know the science, you can teach science. In her teaching, Ms. Z tries to stay open minded to encourage students to be comfortable in being their full selves in her classroom. She allows students to use social media apps they are already interested in like tik tok to complete academic work. Ms. Z encourages her students to feel safe in her classroom by giving them multiple ways to ask questions if they are nervous about speaking in class.

To create that way of being able to talk about or answer anything in a safe space in the classroom, I tell kids, email me your questions. There's also a place where they have sticky notes and all you have to do is write your question on your sticky note, you place it on my desk, or, and they know that you know, my desk is my personal space, so don't read nothing on my desk or anything on this. So, they they're able to place that sticky note there... I want every question to be asked... So always tell them find a way to ask it and that way we can get an answer. And when I answer questions that they asked and asked me, you know, in a private way, I never say a name. We just- I just answer the question. And we, you know, that way kids will know like This is always a way to learn our best way for them learn. Don't ever feel like you can't learn because you can't ask a question.

Ms. Z creates a safe and stable classroom for her students by giving them multiple paths by which to ask for help and respecting the nervousness some students may feel. By keeping who asked questions confidential, she makes her classroom feel safe for her students while reinforcing her expectations that students ask questions.

“Don’t give up we on the brink of greatness”: Black Women are Enacting Liberatory Pedagogies and Resisting Revisionist History

Each of the participants descriptions of their classrooms and ideal classrooms include aspects of liberatory pedagogies and the resistance of revisionist histories. For Ms. V, her own experiences as a student have shaped her resistance to making assumptions about students and their behaviors.

I was a student that had behavioral issues. In school. I was very smart, had A's and B's and everything. But I got wrote up like every other month. I stayed in ISS, but I still made A's and B's. So, a lot of them just saw the behavior. And just thought like, well, I'm just a bad child. So, I'm not even gonna try, like, would just send me out of class or something. Like, didn't really take the time to ask questions to get to know me. It was just like, especially because a lot of them were White.

Ms. V’s K12 experiences taught her that teachers may prejudge students or refuse to see the student behind the behavior. Due to her teachers not getting to know Ms. V, she is intentional about getting to know her students and making each day a new chance.

Mrs. R disrupts the notion of teacher as the arbiter of correctness and the provider of knowledge by supporting students in their understandings and learnings in her biology classes.

Explain me what you did' you know? And then they self-correct. Girl, I don’t give answers No. "Miss, just tell me." "No, I'm not telling you, you got to figure it out." So that's where we are with that. That's my favorite part when they take ownership, and it's embedded in them through experience.

Ms. V also disrupts the idea of the teacher as a fount of information by connecting with students and intentionally making mistakes in front of her students. She positions herself as learning

alongside her students as illustrated in her journal where she describes teaching as “clos[ing] my door when the bell rings and enjoy learning with my kids!” She does this as a normal part of her teaching practice across all her high school biology classes.

You don't have to be so strict and make this feel like they're in prison for 90 minutes. And they [students] can't do anything. Like, you have to make it a welcoming environment. So, you have to make it a place where they feel like learning is fun by being like a fun teacher. You also have to make it a place where like, it's okay to make mistakes. Like, let's laugh about it, correct it. Because sometimes I mess up on purpose. And I'm like, “Oh, yeah, I messed up, oooo look at me.” And I'm like, “let's fix it. Like it's okay if we mess up like.” You know, so that you have to like, relate to them, you have to make yourself a relatable teacher.

Ms. V shows her students that not only are failure and mistakes ok and fixable, but that she makes mistakes as well. She finds this important in helping students to open up in her classes. While teaching in her biology class, Ms. V makes an effort everyday to make connections to students to increase participation during instruction.

Because if you're just standing up at the front, standing up all the time on your platform, they're just looking at you like you're on a pedestal. And it's like you're talking at them instead of talking to them or with them... when I'm standing up at the board talking and I'm asking questions and none of them are answering versus when I sit on the table. I'm talking with them. Now I got a whole conversation with a whole heap of students. But standing up at the board, I feel like I'm talking to them when I'm- or at them. When I'm sitting down, and I'm talking with them. Now it's like a whole conversation between us.

Ms. V resists the norm of the teacher as separate or above students by intentionally making mistakes and connecting to students on their level. She is aware that classrooms can feel like a prison to students and Ms. V resists this by making her classroom an engaging environment where students can laugh and joke with her. Further, she creates space for students to be her equal in their learning by moving away from a position of authority at the board to a place of collegiality sitting with the students.

Throughout her high school biology classes, Ms. P also resist this norm. One way she resists this norm is by including opportunities in her lessons for students to give feedback on her instruction. Another is by inviting students to joke with her.

I welcome the goofy jokes. Like I think it actually makes the classroom cooler and like, less stress if we can make jokes as we're working. So, I would say definitely inviting laughter. And inviting truth in like, even if it's something- like be honest, if I didn't explain it in a good enough way, or if you need some more resources, or if I said I was going to do something and I did not, speak up. It's okay. Adults are not always right... The ability to make mistakes and it's not life or death. I just like anybody, not just kids. But when anyone makes a mistake, I'm just like, okay, no big deal. However, you got to pick this up and move on. Like, if it's not a major offense, it's not a big deal. So even when I'm upset at my students, like, I'm really upset, I've given them like three extra chances to do something. And also, like, maybe you haven't done it yet. Even after the third chance, no big deal, you can get back up you can. Because I still think it's important to have that positive narration.

Like Ms. V, Ms. P recognizes the importance of helping students see failure as a part of life and that no one is exempt from making mistakes. She knows her students will make mistakes and

strives to give every student multiple chances. Through inviting students to give her feedback, joking with students, and letting them know they can always come back from a mistake, Ms. P creates a more welcoming classroom environment and positions herself as more of a facilitator or co-learner instead of the teacher as the holder of all knowledge.

Ms. P also resists the tradition of ‘drill and kill’ instructional strategies and encouraging students to memorize material. She wants to be sure students are learning the Biology content and not only memorizing. When teaching Ms. P asks herself “are we memorizing here or are we learning science? You know, like, I kind of asked myself, whatever I'm asking my kids to know. Why is it relevant? I ask myself that.” In her lesson plans, she includes space for students to reflect on what instructional strategies they felt did or did not work for them and provide feedback to her. Her lesson plans also illustrate how she encourages students to think conceptually about what they are learning and discourages student guessing. She incorporates modeling and labs into her lessons to help students understand the concepts instead of only memorizing terms related to the concepts.

Similarly, Mrs. R resists the same tradition by valuing skills students can use across content areas and as adults.

These skills are not specifically only for science, especially when you're talking about CER [claim, evidence, reasoning] or measurement or communication, analysis. Those skills are not specifically for science, you know, they go into other content areas, and they go into the real world.

Mrs. R describes students being able to develop an argument, accurately take measurements, or analyze data and information as important. Practical scientific skills such as observation, quantitative and qualitative data collection, data analysis, graphing and data presentation, and

self-reflection were common across the lesson plans she shared. In the lessons she shared, Week 1 included conducting qualitative observations, Week 2 included planning and carrying out investigations, Week 3 included research skills, collecting qualitative and quantitative data, and scientific communication, and Week 4 focused on graphing. Mrs. R feels that building scientific skills is important for students because those skills will be useful to students long after they have left her classroom.

Mrs. R resists the norm of solely focusing on academic standards by inviting community members with careers in science into the classroom to speak about their experiences. During their talks, Mrs. R asks them to discuss their career but also asks them to emphasize their socioemotional journeys. By doing so, Mrs. R illustrates her commitment to students learning more than just the academic content or encouraging students to pursue careers in science. Mrs. R shows she wants her students to build socioemotional skills for their lives and to understand the socioemotional factors in pursuing a career in science.

I have a keynote speaker for the classes. So last year, for February for Black History Month, I had Dr. Brian Davis, he is the President of the Georgia Aquarium. I had him we did a teleconference with him. Yeah. And then in March for Women's History Month. Ivory Williams, she is the Vice President of STEM at the Liberty Science Center...And so I had her come on and talk about her journey. And we tied it into social emotional learning because I wanted her to talk about her failures. So, she talked about, because she actually failed out of dental school, she didn't fail out, she dropped out of dental school because she, when she was there, she didn't like it. And so, she started teaching. And she taught for maybe 10 years and realized that wasn't for her. And then the next thing she became the Vice President of STEM. And then Dr. Brian Davis talked about self-

reflection, how, as he went through his journey, he actually is from New Jersey, he went to Rutgers, and all of the times where he had to stop, self-reflect, reevaluate his life and move on.

Instead of focusing solely on the biology content or test scores, Mrs. R prioritizes giving students opportunities to develop skills they can use in and out of science and encouraging students to value their socioemotional skills and needs. In each of her journals and lesson plans, Mrs. R mentions what the socioemotional learning theme is for that week providing further evidence of how much she values developing student socioemotional skills and needs. Ms. P also focuses on students social and emotional needs and resists the idea that she must rush past students' emotions to make sure they learn the curriculum. She shared in her journal that she saw "students encouraging another when that student expressed that they expected to get a low score on the quiz. I witnessed my students building community without me leading it" and further described how the moment influenced her during an interview.

I saw my student, encouraging my other student and I'm like, it's always time to make time. Like you can always make time for that community aspect. And encouraging. And I think, like another day, you know how you ask, like how students are feeling and stuff, my students, some will say, I'm having a great day. And I don't know exactly where to take it after that, because I don't want to get into their, you know, issues in public. But I think that instance is just- it just showed me like, it's really, it's really, it's really enough time to let them kind of do it for each other. So, I will say, does anyone have any encouraging words? Right now? We have someone in our community who's really not in a good space. What do you do when you're not in a good space? What? Like, do you have any encouraging words?

Ms. P originally felt pressure to neglect students' emotions in order to keep pace with the required curriculum. However, she resists the notion that there isn't enough time by making space for students' emotions and needs. On each of her post lesson checklists Ms. P recorded facilitating opportunities for students to express their thoughts and feelings. In creating this space, she found that students began to develop and build community amongst themselves without her facilitation. Ms. P's willingness to learn from her students also resists the positioning of the teacher as the sole knowledge giver and students as solely knowledge receivers or that nothing matters outside of students learning the content.

Each of the participants resisted the norm of revisionist scientific history by providing sociohistorical context to their content. They asked students to interrogate how science is used and if it has been used in an equitable way. In her journal, Ms. P discussed talking to students about the science behind skin color and wishing she had more time to explore them with students.

This week focused on Inherited Traits in Biology. It was a unique opportunity to express to students the science behind our differences...especially race. It all boils down to about 1% differences in our genome. Humans often take these small differences as huge differences. I even got to speak on colorism (very slightly). Humans have bias against darker skin people, when the only scientific difference is our proteins produce more melanin. This can result in higher suspension rates and longer prison sentences. How did we get from science to here? This is an important topic to me as a dark skin person, but I wish I had more flexibility to truly have students break this down. Variation of Traits is the perfect standard to discuss the science of racism. I would even enjoy discussing sex vs gender identity.

Ms. P finds this very important to bring up this topic and others with her students even if she doesn't have time to fully discuss them with students. In doing so, she resists common ideas about what race is and how the 'science' behind racism is still used as an oppressive tool today.

Ms. P also develops a liberatory pedagogy and resists revisionist history by encouraging students to be critical of any source they encounter.

I tell them, your observation can't be wrong, but your observation can be biased...I try to teach them that. Yes, there's bias. Even like when we are researching, I've kind of tricked them a little bit. Like using biased research. Um, what was it that I use as an example? It was like, uh, oh, pheromones, you can buy this, these pheromones and it can increase your romantic interest or whatever. So, I just, sometimes I'll use things like this just to see what they- what happens. Like, if they just go with it. Or if they're like, hey, this is weird, or, hey, this is biased, or hey, this is flawed. So, I kind of like, I want them to question even if it's coming from an authority source, or Google or whatever, like, question, the perspective.

Ms. P resists the positioning of the teacher or any one source as unimpeachable. She encourages her students to recognize all research, including their own, is influenced by the biases of the researchers.

Participants resisted revisionist history by incorporating historical figures and events who are not always found in scientific curricula. Ms. V reflected on how she introduced real world issues related to race, gender and class during her biotechnology and ethics unit on a post-lesson reflection checklist.

We did a lesson about ethical considerations in the advancement of biotechnology, specifically the fields of forensics, medicine, and agriculture. We discussed Henrietta

Lacks and the infamy surrounding her case. To truly understand the ethics surrounding it, we discussed the treatment of African Americans during the 1950s in the US, especially the South. We also discussed what proper measures should be taken to ensure ethics were considered if testing were to occur today. We also discussed a case about a working class Caucasian male who was wrongfully convicted of murdering his wife in the 1990s. The students were able to reflect on whether individuals of a lower class receive equal treatment, or the treatment they deserve from law enforcement and the justice system in general. This is always one of my favorite lessons to teach because the real world application is so great, and student engagement is usually so high.

Ms. V intentionally fostered conversations with her students as to how biotechnology can be misused to treat people of particular racial backgrounds or who are considered lower class. She asked students to critique what occurred in the past and what their expectations would be if a similar situation occurred today. Ms. V reached beyond what is typically included in science curricula to situate student learning into real-world examples and stakes.

During one of the lessons Ms. Z reflected on she checked that she included real-world issues related to race and gender that are relevant to students, the school, and/or the community. In the lesson, she discussed the Flint Water Crisis as a problem understandable and potentially solvable with chemistry. On her checklist she reflected that she “was on eggshells bringing this topic up.” When we discussed this incident during an interview, she described how students connected the Flint Water Crisis directly to racism and to discrimination within their community.

So, Flint water crisis is definitely a topic that I realized my kids had no idea about. And we were talking about acids and bases for that week. And I was like, “You know what, here's a relatable topic, let me get you to something that you can understand in the real

world.” ...How do we solve it as chemists? Let's move on. But lo and behold, my kids decided to really read into it. And they realized, oh, this African American population have these people controlling this. And so, you know, it turned more into now we're not solving the chemistry problem we're talking about, like, we're not helping the situation. These are people who really are in a bad situation. And it's because you know, people are not listening, not helping. So, it became relatable, because of the fact that I'm- where I work at in Barnes County [pseudonym], there are issues that are underlying that they're talking about. “Well in this neighborhood, things look different. But this neighborhood has these resources. And it's just a railroad track that splits the line.” So um, I came more comfortable once they started talking about it and were respectful about it and didn't decide to argue with each other. And was just like, honest with the fact that they see this going on too. Not just in the water situation, but it's going on in their neighborhood, too. So, what can they do to solve it, but that's one of my ways of just putting in relatable topics. And I didn't want to bring the race into it. But they, they understood the assignment as far as what to do but go further down in discussion with it.

As a second-year teacher in a majority White school where she has already experienced racism, Ms. Z is hesitant to directly bring up race and ethnicity and how science is influenced by discrimination in her classroom. However, despite Ms. Z's hesitance due to the racist experience she had and her nervousness about bringing up issues related to race in her classes that are majority White students, she intentionally introduces topics where the influence of discrimination is clear. Though Ms. Z does not bring up the discriminatory context of these topics herself, she encourages her students when they analyze what occurred and is willing to pause her lesson plans to make space for student conversations. Ms. Z directs students to

consider how they can use what they are learning in class to address the problems. Ms. Z also writes in her journal having classroom discussions “why some people or cultures may be missing from history within chemistry” and how “students realized that the moment in science history we were discussing did not always include women or even black women.”

When describing their liberatory fantasies for an ideal science class, participants had very similar desires. Each described students working together on topics they are interested in and imagined themselves as facilitator more than teacher and with students having comfortable seating. For example, Ms. P described her ideal science class as letting students be comfortable in their space while pursuing their learning experiences.

I know I want a lab but like the actual class vibe- Could it feel like a mall? Okay. Like the, um, like the cafeteria. So, it's like different vibes. Like, here's the coffee store vibe over here. We got like some music and like some incense. And then we have another side, maybe they have the game on. Okay, and, you know, like different sections for different vibes, depending on how people like to work. Um, it could be the silent, you know, like the silent discos. Like that kind of vibe in one area. Like, don't talk to me, but we can rock out together while we work. Yeah, just kind of like, I will want room for people to have unique learning experiences.

Another commonality among their liberatory fantasies is that students build more research skills over content knowledge as described by Ms. V.

Like I don't care whether or not my students remember what osmosis is. I care whether or not my students come out better critical thinkers. Better questioners. Ones that even if they have questions, they can use their critical thinking and research skills to try to figure out answers to that question. Like and that's like my overarching part. So, if you have like

the science and society class, they can look at things that are going on in society, look at the science behind it and do like their own research. And then that like help gauges the critical thinking process which they need for everything because these can't think. They can't. So, I think I would design a course around that.

Ms. V is aware that students won't remember every piece of biology content they are taught. As a result, in an ideal science course she would prioritize students' building skills to successfully complete the Next Generation Science Standards (NGSS) scientific and engineering practices and developing critical thinking skills over teaching them specific scientific content. This is important to her because she feels strongly those skills will have more practical influence for her students' future. Each participant also valued collaboration between students as illustrated by Ms. Z.

We all have some sort of like area where you can go talk to another person. You may start out with this group, but then you realize this group over here has something even better so now we're all together. Um very talkative, but good talk. Not bad talk. Um not you know, unnecessary chatter. But very fun, relaxing, discussion based.

Each participant envisioned a classroom where students discuss their science learning and challenge and critique each other.

Theme 4: 'We not starting from the ground up anymore': Being in Community with Other Black Women is Impactful.

The fourth and final theme to emerge in this study is the nature and importance of community between Black women. Each participant referenced how Black women held and supported them throughout their careers. However, they also had stories of being mistreated by Black women as a part of their careers. Despite this dichotomy, each participant expresses a need

and desire for a community of Black women science teachers and believe such a community would be useful and impactful.

“They’re showing me the future”: Black Women Mentors and Supporters are Inspirations.

Each of the participants credit mentorship relationships with other Black women as important parts of their educational and teaching journeys. Black women inspired them in school and inspire them as teachers. Ms. Z first felt she could be successful in science due to the influence of her middle school science teacher who was a Black woman.

She was the one who really started getting me into the biology, life science aspect of science that gave me more ... So I was in middle school, I think I was in the seventh grade when that happened. And she was definitely critical into laying that foundation of, you know, where science can take me in how useful it can be. And even though I'm a Black female, that we still could be scientists that was her aspect. Cuz [where] I went to school, Wade Middle [pseudonym], at that point in time, was a underrated- an underperforming...but it was on its way up, but she was still, you know, when I was in middle school it wasn't the greatest of times in that county, so she was definitely big on building me up and saying that, you know, if this is what I love in science, I can definitely go forward with it...Even when I moved on past her class in seventh grade, she always made an effort to see what I was doing helped me get into science summer camps, or if there was some type of, she helped me with my science fair projects every, even when I moved to another campus, she was still very involved in the science things that I did.

Mentorship by her seventh-grade science teacher even years after Ms. Z had left the class encouraged Ms. Z to pursue science.

Even though Ms. V had many negative experiences with teachers, her senior year science teacher was a Black woman who saw Ms. V's success in science and encouraged her. This teacher still assists Ms. V now as a teacher.

And then my senior year with anatomy, the teacher that, um, I had that I actually work with now at Marshall [pseudonym] she was very motivated about Black girls in science. And she kind of helped push me into like, into the science field. And now she's like, still having a positive impact, because she's still kind of like my teacher. She definitely helps like with instructional practices and thinking about the rigor, like this is what you say you want to get from students, but does this assignment actually match it.

Now a teacher, Ms. V has interacted with multiple Black women in authority positions as a part of her job. These Black women are also encouragements to Ms. V.

The principal that I interviewed with, she was a Black woman too. And she was like, 'just from this conversation that we had I see leadership written all over you, and you're destined for greatness.' So, I've been carrying that with me. And then working with her my first year and how helpful she was. And she was so encouraging to tell me like, 'you're going to be so great in this profession, like, don't let the struggles dim your light'. I mean, like carrying that with me too. Um, I can't let like all these other factors, like get in the way of the purpose that I came into education.

Words spoken to Ms. V in her job interview by the Black woman who interviewed her for her teaching position are words she carries now as encouragement when she feels discouraged.

These words are affirming for Ms. V and continue to be words she can lean on. These sentiments coming from a Black woman were particularly affirming for Ms. V.

Ms. P experienced mentorship from a Black woman faculty member named Dr. Matthews (pseudonym). Dr. Matthews is an tenured faculty member of science education at the university Ms. P attended for her teacher preparation program. The strong relationship Ms. V built with Dr. Matthews during her teacher preparation program helped her to continue when things became difficult. Ms. P says that Dr. Matthews “encouraged me to who I am.” When Ms. P was dismissed from her the program funding her teacher preparation, Dr. Matthews advocated for her. Ms. P felt for the first time that “teachers could be part of my community. So, Dr. Matthews, she got me a job on campus to help me stay in school. So, I felt like she was actually part of my support system.”

“And she tells me I should quit”: Black Women Can Be Obstacles.

While Black women are sources of encouragement and inspiration, they can also act as obstacles specifically for other Black women. Ms. V describes how another Black woman she works with in the biology department of her school who is frustrated with Ms. V for not meeting the expectations she has for Ms. V.

Because she'll say that she struggles with something. And then if you try to give ideas, she says that you're being condescending, and talking down to her. So, I think that she feels insecure about her abilities, and seeing other people in the same position, such as me being another Black woman and me having the same amount of teaching experience as her not having the same struggles...I think me just being a Black woman in the same position as her and younger than her to is a lot of what factors into it

Ms. V's colleague had an expectation of what Ms. V should be experiencing and doing as a teacher. As a result, Ms. V experienced pushback and ire for being successful and younger than

her colleague. Ms. P also had a negative experience with a Black woman because she did not meet her expectations.

Ms. P was the only Black woman in her teacher preparation program who was a part of an initiative that paid them a stipend. She was provided very vague rules about attendance that were established after Ms. P joined the program and after Ms. V had already made other plans which would cause her to be in violation of the newly established rules. Ms. P discussed these rules with her mentor teacher who counseled Ms. P to miss the days and make them up later. As a result of Ms. P breaking these rules, Ms. P was kicked out of the initiative despite multiple individuals supporting Ms. P's inclusion.

She [the program director] was like Ms. P, to be honest. You seem like you're not invested. You seem like you're not um in this program like other students. And I think you should just quit now. And I said, Excuse me, ma'am...I made As on everything. I did everything. Like I'm killing it. And like, I'm actually being like falling in love with teaching... And she tells me I should quit. I'm like, ma'am, excuse me, you must not know who I am. Like, that's what I'm thinking. I don't quit...As my superior, the first thing you say is I should quit. Not like, I'm going to give you a disciplinary action or something, but just pushing me out... So, the next day, she came with all these people I had never even seen before. They sat down in front of me, and she was just like, Ms. P, you are being kicked out of this program...I'm like, wow. And my teacher she tries to break in and say, "well, she's doing so amazing" ...And she's [the director] like, "Excuse me, your input is not necessary." Like that's what she gone put your hand up, you didn't see my hand go up. And I'm like so what is it that you just hate us? You just hate what is it?... Only Black woman on the science team in that program. And I'm like, is it because is it

that? She was Black. I was Black. She was coming for me. What I did was wrong, though. I can't. That's why I say I can't give it all to her. I should have just listened to her and been obedient.

Ms. P was kicked out of the initiative that funded her program after breaking rules that had been very unclear and being counseled by her mentor teacher to break them. Ms. P and the director were unable to communicate effectively with each other and each had an expectation of the other they did not meet. Ms. P felt the initiative's director wanted control and this control meant there was a lack of flexibility. Ms. P also felt the director was stricter towards her because Ms. P was a Black woman.

Ms. V also experienced disdain from a Black woman professor for asking for clarification about who she should be reporting to as a part of her program.

It was one meeting where I was like, "I'm a bit confused because I'm not understanding like I'm not clear of Dr. Torn's [pseudonym] role versus your role, and I'm not sure who I need to direct certain questions to. I'm not sure like, what part of the class pertains to you versus what part pertains to her." And she felt some type of way about that. She said that I was disrespectful by asking those questions. And it was inappropriate and embarrassing for her for me to ask and I was like, Okay. So then like one, what made me feel like she was being petty was when we- It was after we did an observation, and um, she was like, "You have yet to apologize for like the way that you said something" or blah blah blah. And I was just like "well it wasn't meant to be disrespectful, but I apologize." It was kind of like she forced me to apologize for the sake of because she felt some type of way...It was just like very- her tone and attitude like from that point on it was just like the interactions with her weren't very positive.

Ms. V's supervisor treated her negatively due to a perceived slight. Ms. V was compelled to apologize for desiring clarity because her questioning was perceived as a challenge.

“Direct inspirations, the women I work with”: Black Women Seek Community with Other Black Women.

Although Black women have alternatively served as mentors and inspirations or obstacles, the participants still felt like community with Black women to be important. Each participant expressed how valuable the presence of other Black women was in their lives. Ms. P felt disconnected from her classmates and faculty during her undergraduate studies. She did not find a mentor until graduate school when she met Dr. Matthews (pseudonym). This mentorship was the beginning of building community for Ms. P.

But there were not Black women around me. In high places, like even that one chemistry teacher, I had we, we didn't know each other. She was just one lady, you know. Um, I would say that that influenced me. Like, you know, like I talked about Dr. Matthews, she was my first like, mentor, in 2018. After I've pretty much finished school, she was kind of like my first mentor. So, I think I felt disconnected. Um, it just felt like, all of the professors and everyone around me, it just seemed like they just knew so much and they're doing so much and I kind of wasn't in on that inside language or something, I don't know. So, I think if I would have had maybe like a mentor or someone in undergrad, like, 'Hey, girl, let's chat', I think [that] kind of would have changed my experiences.

Ms. P believes a stronger community with Black women, particularly Black women who were further ahead in their careers, would have contributed to more positive experiences for her. Ms. P described herself as “petrified” of going to office hours and that there was no “personal

connection” in her classes. Community with successful Black women would have helped her feel less lost in school and more connected to her university.

Ms. P found a strong community with Black women as a teacher at a school where the entire STEM department was composed of Black women. She credits this community for enabling her to be a successful science teacher.

So, the chemistry, the physics, like, in their own way, I looked up to all of them.

Especially anatomy, chemistry, physics. Going into the classroom and trying to pick up on things that they do. And trying to bring it into my classroom, especially my first year, second year, it's like, yeah, so I would say those are my like, direct inspirations, the women I work with.

This community of Black women science teachers helped Ms. P to learn and develop as a teacher. They were incredibly supportive of her, shared resources with her, and modeled instructional strategies.

Similarly, Mrs. R's first teaching job was as 5th grade teacher at a school where the principal and most of the teachers were Black women.

I mean, now at Southeast High School [pseudonym], you know, they see me first as a Black woman and then I'm a science teacher. Right? But because most of us were Black women, I think that kind of, you know, it canceled out that you were just a teacher, which was pretty liberating... You weren't put in a box, you were able to have more risks, like I felt more secure to try, you know, if we learned about reciprocal teaching on Monday, then I was gonna try it on Tuesday. And I knew that I felt comfortable. You know, I was supported. My principal, she was a Black woman...And she would come in and she would be on- if I'm sitting on the floor, she's on the floor next to me. And we would, it

was just, you were able to feel safe to take risks, positive risks, if it didn't work out, you had people that you could bounce ideas off and feel comfortable with criticism, knowing that it was supportive criticism, right? You're not always trying, you know, now, I always have to be my best self. You know, if I'm walking out of my, my room, my classroom and I'm in the hallway, I have to make sure that I'm my best self, because I'm representing every Black person in the whole world. Because my school is majority non-Black. So, I didn't have that. I didn't have to worry about that in that setting.

At her current school, Mrs. R feels a heavy weight due to being one of the few Black women in science that her students and colleagues may ever meet. However, at her first teaching position, she felt a freedom from being judged or having to be a representative of Black women. As a result, she felt supported and able to take risks.

Being in community with Black women at different career stages is impactful for participants because it allows them to visualize themselves being able to climb higher in their own careers. Seeing Black women specifically in powerful positions is motivating for Ms. V and let her know that success for Black women is possible.

Seeing the amount of Black women in power, who have been at my first school, and this one. Like both of the principals were Black women, both of the instructional coaches at the schools were Black women, both at the science district, the district science- I don't know, the official title, like the person who's over the science courses for the district. In both schools, they were Black women. So even when I interviewed at this school, like I was interviewed by four Black women, so just being like, that is possible. It's not just a White man's world. Like that has been like a help. And I'm like, okay, you got this.... So, seeing Black women in those positions just affirms that like, I can get there one day, like

with the Black man is like, okay, you're Black, you got there, but men have always kind of been dominated the positions. So, seeing the Black women in the lead is definitely motivating.

Ms. V is aware of the sociohistorical forces at work in society. She knows that it is more difficult to succeed as a Black woman. However, being in a community with Black women who have been successful and who have reached positions that Ms. V thinks she may one day want to hold helps Ms. V to believe she can successfully reach similar positions in the future.

Ms. V's reflection on the importance of seeing Black women in positions of authority relates to how Ms. P describes the potential impact of a peer group of Black women science teachers. Ms. P envisioned that a peer group of Black women science teachers could be incredibly impactful for Black women.

Like if I had maybe like 10 other Black women, teachers, science teachers in DC that I knew, and we all communicated, I mean, I think that'll be very effective for us. And on the other side, like job security wise, we have like an ear out for places to avoid in places that are more welcoming. And then that whole aspect of just like, peers pulling you up, like, so I feel like that would be good... I guess, just in places in people to avoid, but I don't know. Just thinking about that. I don't think it's solving the problem is having just necessarily more Black women in power, like it doesn't fully solve everything. If the systems that we're in are still anti-Black woman, you know.

Even as Ms. P desires a space for Black women science teachers to support each other, she still recognizes that the systemic issues affecting Black women would not make it enough. However, she still believes such a space to be a good idea, only that it would need to be monitored and moderated. The concept of building together with other Black women is described by Mrs. R as

legacy building. She believes through our work and community building today we create a ladder for Black girls and Black women in the future to climb.

I'm talking about Black women scientists, that's the legacy I'm leaving. Many of us believe that we have to build from the ground up. But imagine that we build on the back of Ms. Terry [pseudonym]. And then you build on the back of Mrs. R. And then my daughter built on the back of Jordan. We not starting from the ground up anymore.

Right? We have a foundation. And that's what's going to be our legacy. So that's what I believe.

Mrs. R views her career as a building block for developing the community of Black women scientists. She believes that raising as we climb is essential to preventing the coming generations from experiencing the hardships that previous generations have had to experience.

Summary

The purpose of this study is deepening the literature on the understanding of the experiences of Black women secondary science teachers. Each of the four participants had rich varied experiences with science and science teaching. Their experiences overlapped through several commonalities that were expressed in this chapter in four themes. These four themes are: (a) Black women pursued science teaching as a backup plan; (b) People in positions of authority do not understand the realities of Black women during teacher education and in the classroom; (c) Black women are developing classrooms that are liberatory spaces; and (d) Being in community with other Black women is impactful. In the next chapter, I discuss the relevance of the themes and their connection to prior research, implications for practice based on this research, and future research based on this study.

CHAPTER 6

DISCUSSION AND FUTURE RESEARCH

For many years there have been calls to increase diversity in the teacher workforce, yet the teacher workforce remains composed of overwhelmingly White women (U.S. Department of Education & National Center for Educational Statistics, 2020). This dichotomy is echoed by education research suggesting Black women are incredibly successful teachers, even as they continue to be underrepresented across educational research disciplines and most particularly in science education (Gershenson et al., 2016; Gershenson et al., 2018; Rosen, 2018; U.S. Department of Education & National Center for Educational Statistics, 2020). In conducting this study, I sought to fill some of the gaps that exist in research on Black women science teachers in science education and prevent erasure of Black women's experiences through understanding Black women's experiences throughout their careers in science education and how they approach science teaching. This purpose was guided by the following research questions:

1. What science experiences influenced Black women to become science teachers?
What educational experiences influenced Black women to become science teachers?
2. What were the experiences of Black women science teachers during their teacher preparation programs related to race and gender?
3. What common and different occurrences related to race and gender have Black women science teachers experienced?
4. What pedagogies do Black women science teachers use in teaching science to students?

Four major themes emerged from the data collected in this study: (a) Black women pursued science teaching as a backup plan; (b) People in positions of authority do not understand the realities of Black women across their careers in science teaching; (c) Black women developed classrooms as liberatory spaces; and (d) Being in community with other Black women is impactful. In this chapter, I discuss these findings and connect them to previous literature, summarize this study and offer my conclusions, outline recommendations for practice, and discuss my plans for future research.

Discussion of Findings

Theme 1: ‘I could kind of do this’: Black Women Pursued Science Teaching as a Backup Plan.

In the aftermath of slavery, education was viewed as a pathway to stability and respectability (Tillman,2004). Black educators were valued for their role in helping the children in Black community navigate this pathway and being a teacher was a leadership for Black women (Tillman, 2004). Black teachers felt their job was integral to preparing Black children to navigate and be successful in a racist world and supported and mentored each other. Black children were taught by primarily Black teachers and those teachers were viewed as integral and respected members of Black communities. Overall, teaching was seen as a wise career choice for Black women. When the Brown v. Board of Education case reached the U.S. Supreme Court, Black teachers expressed anxiety about its effect on their positions as teachers (Tillman, 2004).

Following the repercussions of the Brown v. Board of Education decision this anxiety was shown to be founded and the perception of teaching as a career changed. Black teachers and administrators were mistreated and forced out of schools and the teacher workforce became startlingly White. Teaching was no longer a source of financial stability and job security. Black

students in many places saw fewer and fewer Black faces as their teachers. The teacher workforce has never recovered from this pushout and devaluing of Black teachers. The legacy of this period in history is reflected in the theme of Black women choosing science teaching careers as a backup plan.

Each of the women in this study experienced early academic success in science. When Black women are identified as smart, they are counseled to pursue careers in healthcare (Mohorn, 2021). Aligning with this, three of the four women originally sought to pursue careers in healthcare and the fourth woman pursued a career in lab science. It was not until a barrier was erected to their goal career or they realized the career they were seeking did not fit did the participants consider science teaching as a career. This finding suggests deep reflection on how Black girls are treated in school influences their likelihood of becoming science teachers and creating environments where Black girls are encouraged and able to see themselves as successful in science.

Research has shown that Black women teachers are much more likely to gain their teaching certification through an alternate route program than their White counterparts (Carver-Thomas, 2017). This finding is replicated in this study where all participants became teachers through alternate route programs because they chose to go into teaching when their plans fell apart or they had the opportunity to experience teaching and realize they enjoyed it. These findings suggest there is work to be done in situating a science teaching career as a career worth aspiring to and attractive to Black women and their families.

Finally, each of the participants changed their original career goals in response to systemic barriers, not feeling a fit in the culture of the original career goal, or racist and sexist experiences. Further, each expressed really enjoying and often falling in love with teaching

within their first few experiences. This finding of teaching as a backup plan for Black women who were science majors suggests science departments may be an ideal location to recruit Black women into secondary science teaching. As these women matriculate through college, they began to consider careers they had not before. Opportunities for teaching experience during a summer camp, participating in a lab with students at a school, or even experiences providing some instruction to other college students in lower-level courses may be an effective way to spark the interest of Black women reconsidering their original career plans towards secondary science teaching.

Theme 2: ‘Invisible’: People in Positions of Authority Do Not Understand the Realities of Black Women during Teacher Education and in the Classroom.

Due to our positioning in society as a group marginalized by both our race and gender Black women’s experiences navigating the world differs from other groups. These differences are often neglected by teacher education programs that cater to the needs of White women (Milner, 2008). Black women came to teaching through alternate route programs after they had already graduated from their undergraduate programs and expanded responsibilities. Participants needed to prioritize being able to support themselves financially over attending a full-time program where they would have the opportunity to student teach. The only participant who did complete student teaching was able to do so because she was in a teaching program providing her a stipend, held a graduate assistantship, and held two ‘gig’ or contract jobs as well. This finding suggests increasing the number of Black women teachers is more than simply attracting them to the profession, but also understanding the financial realities they may be dealing with.

As a result of completing the alternate route program while being a practicing secondary science teacher, three of the four participants did not have any experience student teaching

before being the teacher of their own classroom. This lack of student teaching meant participants had few opportunities to practice instructional strategies or observe modeling of effective instruction prior to entering the classroom. Participants expressed that their programs prioritized teaching theory over modeling and practice which would have been more useful to them as practicing teachers. This finding suggests that though each of the women had strong science content knowledge from being science majors they could have benefited from more robust practical pedagogical education before entering the science classroom. Teacher education programs may be able to address this by developing curricula that include large amounts of modeling and instructional classes in the first few classes for students who are already practicing teachers.

Finally, both teacher preparation programs and school and district administrations are traditionally White spaces that value the needs of White students over the emotional repercussions of Black women teachers (Cheruvu et al., 2015; Mensah & Jackson, 2018). Centering White people in teacher education means Black women are expected to tolerate racist and discriminatory comments in the name of ‘fairness’ and the education of White students. Black women science teachers in this study were also aware that if they responded emotionally in classes or at their jobs, they would be perceived as unprofessional or overly sensitive which aligns with prior research on preservice teacher experiences showing Black preservice teachers felt violence against Black women was allowed in the name of educating White teachers (Brown, 2014; Evans-Winter & Hines, 2019; Faison & McArthur, 2020; Liebow & Glazer, 2019; Mensah, 2019).

Teacher education programs can be proactive in being responsive to Black women’s needs by addressing the reality that many Black women will experience racism and sexism in

student teaching and as inservice teachers. These programs should have plans in place for supporting Black women who encounter discrimination during student teaching and providing information on who to contact and where to find support if they experience discrimination as inservice teachers.

This reality was also true in how administration at the school level dealt with discrimination against Black women. Administration either did not recognize discriminatory actions or failed to address them. Black women again are expected to endure even blatant racism with little or no support (Mohorn, 2021; Olitsky, 2020; Riley, 2022). This finding suggests a need for both teacher education programs and district and school administrations to interrogate their practices and develop actual plans to address racism and discrimination from other teacher candidates, other teachers, parents, or students. None of these institutions can afford to shy away from these topics or pretend they don't exist. Further, it is insulting to Black women for these institutions to react to racist and discriminatory incidents that are endemic to the institutions themselves with bewilderment and weak platitudes. Having plans in place and communicating those plans across the school and district will express a value for Black women as teachers.

Theme 3: 'Working with Black kids is a privilege': Black Women are Developing Classrooms that are Liberatory Spaces.

The women who participated in this study cultivated classroom communities that had the characteristics of liberatory spaces. Liberatory spaces are classrooms encouraging academic success, critique of injustice, oppression, and the status quo, valuing of other cultures, and valuing of relationships and emotions. The liberatory spaces were cultivated through the enactment of these women's pedagogies. Each of their pedagogies included characteristics of liberatory and womanist pedagogies.

Each woman enacted pedagogies that created classrooms where students' emotions are valued and where students felt safe. This was done by getting to know students and allowing students to get to know the teacher, making themselves relatable to students and willingly making mistakes, and creating structure so students knew what to expect. This finding is aligned with other research on Black women science teachers that found Black women attended to the socioemotional needs of their students (Mohorn, 2021; Rackley, 2017; Riley, 2022). The findings of this study additionally align with established research that Black women teachers hold students to higher expectations and are more likely to believe in students' ability (Gershenson et al., 2016; Milner, 2006). The pedagogical approach of high expectations and belief in all students' abilities aligns with Black liberatory pedagogy and beginning with the assumption that Black students are brilliant. Participants not only held students to high expectations and assumed students were capable, but also expressed to students that they knew every student was capable.

Participants pedagogies further aligned with prior research and liberatory pedagogies in their encouragement that students be themselves in the classroom and the valuing of students lived experiences (Castillo-Montoya et al., 2019; Ladson-Billings & Henry, 1990). Participants connected content to students' lives and interests and made time for students to discuss and explore topics outside of the specifics of the standards. This pedagogical approach flowed nicely into how the participants connected the content to its sociohistorical context and the critique of existing structures. Though participants had different levels of implementation of critique and introducing sociohistorical context, they each felt strongly for students to be exposed to them.

Enacting liberatory pedagogies was an act of resistance by the educators who participated in this study against the educational norms of the United States. These educational norms are

rooted in White supremacist structures and discourage communality in the classroom, ignore student emotions, value objectivity, and discourage student movement during class (Boykin, 1986; Noblit et al., 2007). These norms leave little space for students to critique the material or wider society, to forge relationships between students and teachers, or connection to students lived experiences and cultural knowledge. Through these pedagogies, participants resisted the marginalization of Black students in science classrooms by encouraging students to be their full selves and valuing students lived experiences. Participants resisted the traditional classroom norm of the teacher as the giver of knowledge and students as receiver by reminding students that teachers are not infallible and inviting student feedback and critique on their teaching practice. Further, they resisted a revisionist history presenting science as objective and primarily created by White Western societies by encouraging students to consider how bias influences scientific discovery, introducing historical figures not included in their curriculum, encouraging students to critique their surroundings, and discussing how science could contribute to systemic structures and racism

Unfortunately, since these are acts of resistance the pedagogical practices of participants were often misaligned with district and school level values and requirements. This misalignment becomes more pronounced when participants were micromanaged and had their autonomy as professionals decreased. This micromanagement and lack of autonomy could drive talented Black women teachers away from schools or teaching altogether. While school and district administration often value test scores, the participants of this study valued students' socioemotional well-being and students learning skills they would be able to use throughout their lives.

Theme 4: ‘We not starting from the ground up anymore’: Being in Community with Other Black Women is Impactful.

Mrs. R discussed interactions with other Black women and her practice as a science teacher as legacy building. She identified this legacy building as important to creating a better future for the Black women that will follow. This construction is descriptive of this study and of the theme of the importance of community between Black women. Black women experience the dual oppression of being discriminated against for being Black and discriminated against for their gender (Collins, 1996; Evans-Winters, 2015). As a result, Black women have a unique experience navigating life and careers of which only other Black women understand the specificity. This results in community with other Black women being impactful in unique ways.

Black women in education hold roles as mentors, coworkers, and leaders to other Black women. This community with other Black women is inspirational and helps Black women in schools feel less alone. Since Black women are aware of the systemic barriers influencing their careers and lives, seeing Black women in advanced roles provides encouragement that those systemic barriers are not insurmountable. Black women as mentors and coworkers can provide advice for Black women science teachers on navigating racism and sexism they experience and affirmation that their experiences are real.

Unfortunately, Black women can also serve as obstacles for Black women science teachers. Having grown up in White supremacist systems Black women may internalize stereotypical beliefs about Black women, hold higher expectations for other Black women, and have less grace for Black women who do not meet their expectations or be angry at Black women who do not hold themselves to the same standards (Hill Collins, 2000; Leath & Mims, 2021). These standards are referred to as respectability politics and were developed in response

to systemic racism and sexism to improve upward mobility and to overcome stereotypes, discrimination, and systemic oppression (Higginbotham, 1993). Though participants did not specifically speak of respectability politics, they spoke of Black women becoming obstacles when those women perceived the participant did not meet a standard or expectation the woman held. While I did not have the opportunity to interview those individuals as a part of this study, those experiences point to cultural expectations for interactions between Black women that went unmet.

Respectability politics are a manifestation of internalized oppression that affects all individuals socialized into a society that marginalizes them. One definition of internalized racial oppression for Black individuals is

“the process by which Black people internalize and accept the dominant White culture’s oppressive actions and beliefs toward Black people (e.g., negative stereotypes, discrimination, hatred, falsification of historical facts, racist doctrines, White supremacist ideology), while at the same time rejecting the African worldview and cultural motifs. Black people experiencing internalized racial oppression will replicate this same internalized oppressiveness, through beliefs and behaviors, toward people within their own racial classification” (Bailey et al., 2011, p. 481-482).

Internalized oppression manifests in victims of oppression questioning if the oppression they experience is real, blaming themselves for their own oppression, anger at individuals who share oppressed identities, and a desire to not be associated with others who share the oppressed identity (David & Derthick, 2014). Within education, teachers of color have been found to hold internalized racist beliefs about communities they were apart of and had to actively work against those internalized beliefs affecting their classrooms and preservice teachers of color sometimes

viewed discussing race as unnecessary (Kholi, 2014; Moore, 2008; Mensah, 2009b). Additionally, Black women's relationships with other Black women may also be impacted by 'Queen Bee Phenomenon' which is described as women tend to view other women as less capable and distance themselves from other women (Faniko et al., 2020). The Queen Bee phenomenon is an example of internalized gendered oppression that can occur among women. Black women do not escape internalized oppression or its effects. Even as we build community for Black women science teachers, we must be careful to interrogate White supremacy's influence on our beliefs and practices and how we, Black women, interact with each other and with our students.

Despite the times Black women had been obstacles, the participants of this study still spoke of how important Black women had been in their career journeys. Each mentioned specific Black women who encouraged and inspired them and had long lasting impacts on their lives. Two participants had experiences teaching in a school or department consisting only of Black women and expressed how much that experience allowed them to learn and to be their full selves at work. Through our reflection on ourselves and relationship with other Black women, community building of Black women science teachers is an essential part of building a legacy of Black women in science. Developing teacher education programs and schools that value and appreciate the contributions of Black women science teachers will be a long arduous process. White supremacist structures, disregard for the needs of Black women, and disbelief in the capabilities of Black women and is endemic to the practice of science education and dismantling them will be met with resistance. Through community with other Black women, we create support to withstand and confront these experiences and create a better legacy for future Black women.

Conclusions

Historically, Black women have been underrepresented in science education research and there is little research that focuses on the experiences of Black women who teach secondary science (Despenza, 2018). When this segment of the population is ignored or under researched science education suffers by losing the insights and wisdom Black women have to offer especially with respect to their unique positioning in society. Across educational disciplines, research has shown Black women are effective teachers, and by not listening to the voices and experiences of Black women teaching high school science, science education prevents itself from garnering a deeper understanding on how to improve science education and how to recruit and retain Black women as high school science teachers. This study exists to help begin to fill in this gap.

The Black women in this study pursued science careers after experiencing success in science from an early age and having had at least one encouraging science teacher. It was not until they had negative experiences in their chosen field or realized they were not interested in the career that the women pivoted to science teaching and pursued teacher certification through alternate route programs. This finding suggests natural science departments may be a fertile ground to recruit Black women into careers in science teaching.

The participants found teacher preparation programs were not responsive to their financial needs that are created by a legacy of systemic racism. Participants are not having these financial needs out of a lack of planning or foresight, but due to the impacts of redlining, the legacy of slavery, and the consequences of continuing racism on the ability of Black families to build savings and generational wealth. These findings suggest a need for an overhaul in teacher

education programs to meet the educational and financial needs of Black women in science teacher education programs.

In both their teacher preparation programs and as practicing teachers, Black women experienced microaggressions and blatant discrimination. Black women looked to other Black women as inspirations and for encouragement, but Black women could also be obstacles due to unmet expectations from both parties and due to internalized racial and gendered oppression. These findings suggest a need to interrogate teacher education programs, schools, and school districts to weed out the endemic marginalization of Black women. In the meantime, Black women should be supported in forming affinity groups for solely Black women to provide each other support and encouragement.

As practicing teachers, Black women teaching science found they were micromanaged and had a lack of autonomy in their classroom. They noted these factors as reasons they changed schools and could potentially drive them from teaching in the classroom. Despite frustration with a misalignment between school policy and their personal pedagogies, Black women continued to enact Black liberatory pedagogies with a womanist ethic. These findings suggest allowing for greater autonomy and providing more support to Black women science teachers is important to retaining Black women as science teachers. Finally, these findings suggest further research is necessary to understand the liberatory pedagogies enacted by some Black women science teachers.

Recommendations

Though this research is not generalizable, the findings are aligned with other research on Black women secondary science teachers specifically and Black women teachers broadly. Within the context of this research and its connection to prior studies, I provide recommendations to

teacher education programs and district and school administrations. Finally, I include a letter written to Black women who teach secondary sciences.

Recommendations for Science Teacher Educators

Black women continue to be underrepresented in teaching and in science teaching specifically. When Black women chose to enter a career in teaching, it is likely to be after they have already completed a bachelor's degree and to complete their teaching certification through an alternate route program. Further, practicing teachers have identified pieces missing from teacher preparation programs. Currently, Black women have expressed feeling undervalued, silenced, and discriminated against in their teacher education programs (Brown, 2014; Bheruvu et al., 2015; Faison & MacArthur, 2020; Liebow & Glazer, 2019). Science teacher educators should carefully consider what messages they are sending to Black women considering teaching, their roles in recruiting, teaching, and retaining Black women science teachers, and their roles in sustaining or disrupting White supremacist norms that have become enculturated into teacher education. I make the following recommendations for practice for science teacher educators as they develop science teacher preparation programs and courses that meet the goals of cultural responsiveness, diversity, and inclusion that most of these programs express.

Recruitment

There are two recommendations from this research regarding the recruitment of Black women into science teacher education programs. The first recommendation is to partner with natural science programs to encourage students to participate in working with children to teach them science. Black women who have been successful in science are most likely to be found in natural science majors with an emphasis in a pre-healthcare field. Many of these women have been counseled to pursue healthcare careers from their loved ones and may have never

considered a teaching career. Throughout their college matriculation, some of these women realize they no longer want to pursue their original career goal due to a lack of funds, systemic structures, blatant racism and sexism, or realizing they do not enjoy the field after an internship or shadowing a professional in the field. Therefore, exposing Black women in natural science majors to experiences teaching could spark an interest in teaching and increase recruitment of Black women into science teacher education programs.

The second recommendation for the recruitment of Black women into science teacher education programs is to increase flexibility in alternate route programs and provide funding and stipends for individuals pursuing science teaching especially during student teaching. Black women are more likely be impacted by significant student loan debt and less likely to have the generational wealth needed to support their education or pay off loans than their White counterparts (Jackson & Williams, 2022). Black women are more likely to attend alternate route programs and need to support themselves financially. As a result, Black women are less likely to experience student teaching and may even be the primary teacher of a classroom while in their teacher education program (Carver-Thomas, 2017). Creating financial supports so Black women can support themselves financially during teacher education is a strategy to increase recruitment into both alternate route programs and more traditional teacher certification programs.

Curriculum and Retention

Teacher preparation programs tend to center the needs and experiences of White women (Milner, 2008). Black women are sometimes made to feel invisible within teacher education programs. Curricula of teacher education programs should be evaluated to prevent this from occurring. Multicultural education can target the needs of White women at the expense of Black women by silencing them and making Black women endure harm in the name of expanding the

cultural understandings of White teacher candidates. Teacher preparation programs should interrogate their discussion protocols to ensure this is not happening.

Most Black women gain teacher certification through alternate route programs and are less likely to get student teaching experience (Carver-Thomas, 2017). Teacher education programs should be intentional about modeling instructional practices and providing the opportunity to practice instruction for students who will not have student teaching experiences.

Finally, Black women science teachers experience racism and sexism from students, parents, and other faculty. Unfortunately, due to societal stereotypes and biases this is likely to be an experience many Black women science teachers have. Teacher preparation programs should create affinity groups for Black women specifically to discuss their experiences and support each other. Teacher preparation programs should also be frank in their discussions of racism and sexism in K12 schools and support Black women in preparing to deal with such discrimination in schools. Further, programs should assist all teacher candidates in recognizing their own biases, how these biases influence their perceptions and interactions with others, and supporting other teachers when they are dealing with discrimination in their careers.

Recommendations for Science Education Researchers

Currently, there is little published research in science education on Black women who teach science. Of that research, only a small amount focuses on Black women who teach high school science. To improve science education, science education researchers must be intentional about being inclusive and specific about which groups are included in research studies. Black women have experienced oppression due to both their race and gender and often discrimination and oppression against Black women is exaggerated in scientific spaces (CITE). To conduct

science education in an equitable and just way with particular respect to Black women, I make the following recommendations.

1. Conduct research with Black girls and women at every level of science education. This includes Black girls in K12 taking science classes, preservice science teachers, inservice science teachers, retired or no longer practicing science teachers, and science teacher educators.
2. Use critical, womanist, and Black feminist frameworks for analysis to examine the systems creating the experiences Black girls and women have and how they may be unknowingly replicated even in systems that profess commitment to diversity.
3. Be reflective and honest about personal bias and subjectivities. Be careful to not perpetuate harm in the conducting of research.
4. Support and develop research focused on the pedagogies of Black women teaching secondary science.
5. Support and develop research focused on Black women only affinity spaces.
6. Support and develop research focused on the expression of internalized oppression and intragroup oppression among Black women in science education.

For each of the recommendations, it is essential that science education researchers value the voices of the Black girls and women they work with and do not disregard their experiences. Researchers must be careful not to speak over Black women and girls or view them as a box to check in order to be antiracist or inclusive. This research should be valued and those findings incorporated into ongoing research and practice.

Recommendations for Districts and School Administration

Recruiting and retaining Black women teachers are essential to preventing the self-fulfilling cycle of Black students not having Black teachers and thus not believing teaching is a viable future career (Graham & Erwin, 2011; Mensah, 2019). This is important because Black women teachers have been shown to have a large impact on students of all backgrounds and an even larger impact on Black students (Cherng & Halpin, 2016; Gershenson et al., 2016; Milner, 2006). Further, having other Black women faculty within a school increases the likelihood of retaining Black women faculty in schools (Mensah, 2019). Breaking this cycle through the recruitment and retention of Black women teachers is even more important in science where there are even fewer Black women teachers. With the understanding of the success and influence of Black women as teachers I make the following recommendations for practice for school districts and school district administration.

1. Increase teacher autonomy and decrease micromanagement and trust the expertise of Black women science teachers. Black women science teachers have identified these factors as making them feel undervalued and that these factors can lead to leaving a school or the profession.
2. Support community building for Black women teachers at the school and district level. Black women science teachers have identified having spaces where they can be their full selves without repercussion as a source of relief. Having these spaces limited to Black women allows them to discuss their experiences with people who are navigating the same oppressive forces.
3. Make sure Black women teachers feel safe and valued within schools and districts. Black women teaching science are often one of few or the only Black woman in their

departments. Further, science is a field viewed as objective and unrelated to diversity and equity. Both parents, students, teachers, and administrators may perform microaggressions or blatant racism against Black women due to endemic perspectives that Black women don't belong in science. Valuing Black women in schools means providing safe methods for Black women to report microaggressions and blatant racism as well as creating a plan for addressing racism and sexism by students, parents, and other faculty. Share this plan with all stakeholders to make it clear discrimination against Black women will not be tolerated.

A Letter to Black Women Secondary Science Teachers

Dear Black women teaching secondary science,

First and foremost, thank you. Thank you for enduring the misogynoir embedded in pursuing a degree in science and participating in the scientific field and I'm so sorry you had to experience it. Thank you for making the best choices you know to do for your students and making a way out of no way in classrooms with various amounts of resources. Thank you for committing to schools where other folks don't want to go.

Five years ago, I began studying for a PhD because I was frustrated at how my students were treated and frustrated because I did not feel I was getting the support I needed. I've learned a lot over the past five years, but it often still felt that Black women were being left out of the conversation. Dr. Natalie King, a Black woman who researches science education wrote, "we must guard against the erasure of our experiences or misrepresentation of our narratives" and that the documenting "Black girls and women in STEM education is an act of resistance" (2021, 3). Though when I began this research, I had yet to read those words, it was with this spirit that I

embarked and took this journey, and it is in the spirit of appreciation that I write directly to you now.

For Black women, we are intimately familiar with the idea that ‘we all we got.’ We know a compliment from another Black woman just hits different than from anyone else. In the same way seeing Black women in advanced positions is inspiring in a manner that is different from seeing anyone else. We know that this is because we know the forces they must have struggled against to achieve what they have achieved. It is the knowledge of the specificity of our experiences as Black women that makes community with other Black women so incredibly impactful for us.

This deep expectation of community between Black women means misunderstandings between Black women or obstacles put in our way by other Black women feel so much more damaging. We do have to recognize that, in the immortal words of Zora Neale Hurston, all our skinfolk ain’t kinfolk (2006). However, we have all been raised and socialized into White supremacist systems and reacted to those systems in various ways. Despite our best efforts, we may become perpetrators of the same oppression we labor under due to the ways bias against Black people and Black women has become baked into society. We respond to the systemic oppression and violence against us can lead to misunderstandings and conflict. We must be aware that each of us wrestles with how bias and oppression has embedded into our beliefs and actions. We must stay reflective because being in community with and fully supporting each other and our students requires us to interrogate how we have been influenced by White supremacy and how it raises its ugly head in our interactions and practices.

This work has been, is, and will continue to be difficult, yet it is worth it. Many of us walk into school buildings where we hide parts of ourselves to be palatable to our coworkers and

administration. We have been expected to sit and smile quietly as barely veiled racist comments are laughed at. When you were in your teacher education program, you may have been asked to do the same thing. Yet, it is within our communities that we find the space to be our full selves. Our community supports us as we dream and build a liberated future where we don't have to figure out which pieces of ourselves are acceptable and which ones are not and a future where instead of being micromanaged, we are trusted. With each of us we build towards a better future and in the words of Mrs. R, one of the study's participants, "we build on the back of Miss Thomas [pseudonym], and then you build on the back of Mrs. R, and then my daughter built on the back of Jordan. We not starting from the ground up anymore right. We have a foundation. And that's going to be our legacy."

Building a liberated future and building a legacy are difficult endeavors. Therefore, as we continue to build community with each other, we should remember to be reflective and extend grace to Black women including ourselves. We are building on the legacy of Black women in the past for the Black women who are our contemporaries, the Black women who are following behind us, and the Black women who have yet to be born. So, keep introducing your students to histories not included in our curricula. Keep encouraging students to be critical of sources of information and critique systems of power. Keep creating classroom communities where students where students feel safe, supported, and joyful. Dream and build in community. Most importantly, ignore the pressure to put yourself last. Take care of and value yourself.

With love, respect, and gratitude,

Jordan Henley

Future Research

This dissertation has been an eye opening and affirming experience for me. Black women have been under researched and undertheorized across educational contexts, but this is especially true within science education. Completing this research adds to the understanding of Black women's experiences and I hope will contribute to meaningful change. No one study is the end of research on a topic and this study will contribute to the literature on Black women teaching secondary science. It will be in conversation with past studies and what I hope will be many future studies on Black women teaching secondary science to come. My own research will continue to explore the experiences of Black women secondary science teachers during teacher preparation and throughout their careers. I have three primary lines of research I plan to explore following this research.

1. The first line of research will center on improving teacher preparation for Black women pursuing secondary science teaching. This research will encompass further studies on how Black women perceive their needs are being met in science teacher education programs and how teacher preparation programs can better address discrimination and bias so Black women are not made invisible. Finally, this research will study recruiting Black women to teach science from natural science programs.
2. The second line of research will center on the influence of Black women science teachers on Black girls. Each of the participants in this study remarked on how their own experiences influenced their teaching or their desire to make science more inclusive. I plan to further explore this by studying if Black women teaching Black girls improves Black girls' experiences in science classes and how this may influence Black girls career goals. As a part of this research, I would also explore if having Black women teachers

with liberatory pedagogies increases the likelihood of Black girls being interested in science teaching as a career.

3. The third line of research will center on deepening the framework of Black liberatory pedagogy with a womanist ethic in secondary science classrooms. The Black women who participated in this study exhibited a combination of liberatory and womanist pedagogies. I intend to extend the study the pedagogical approaches of Black women teaching secondary science. This research will include observational research and longitudinal studies. Through this research I intend to develop a more thorough framework of what Black liberatory pedagogies with a womanist ethic in a secondary science classroom, understand barriers to its implementation, and to understand what influences Black women who take this type of pedagogical approach and those who do not take this type of approach.

It is my goal that the pursuit of this research will result in an inclusive science education that values Black women leading to increased numbers of Black women pursuing careers in science and science teaching. This research and my future research are my contribution to a legacy of Black women scientists and science teachers that will continue to grow and thrive.

REFERENCES

- Abell, S., Boone, W., Arbaugh, F., Lannin, J., Beilfuss, M., Volkmann, M., & White, S. (2006). Recruiting future science and mathematics teachers into alternative certification programs: Strategies tried and lessons learned. *Journal of Science Teacher Education*, 17(3), 165-183. doi.org/10.1007/s10972-005-9001-4
- Adams, H. H. (1984). African Observers of the universe: The Sirius question. In Van Sertima (Ed.), *Blacks in science: ancient and modern* (pp. 27- 46). New Brunswick: Transaction Books.
- Andreae, C. (n.d.) *Slave medicine*. Monticello.org.
<https://www.monticello.org/sites/library/exhibits/lucymarks/medical/slavemedicine.html>
- Aronson, B. & Laughter, J. (2016). The theory and practice of culturally relevant education: A synthesis of research across content areas. *Review of Educational Research*, 86(1), 163-206. doi.org/10.3102/0034654315582066
- Atwater, M.M. (1998). Science literacy through the lens of critical feminist interpretive frameworks. *Journal of Research in Science Teaching*, 35(4), 375-377.
doi.org/10.1002/(SICI)1098-2736(199804)35:4<375::AID-TEA7>3.0.CO;2-N
- Atwater, M.M. (2000a). Females in science education: White is the norm and class, language, lifestyle, and religion are nonissues. *Journal of Research in Science Teaching*, 37(4), 386-387. doi.org/10.1002/(SICI)1098-2736(200004)37:4<386::AID-TEA6>3.0.CO;2-M

- Atwater, M.M. (2000b). Equity for Black Americans in precollege science. *Science Education*, 84(2), 154-179. [https://doi.org/10.1002/\(SICI\)1098-237X\(200003\)84:2<154::AID-SCE2>3.0.CO;2-R](https://doi.org/10.1002/(SICI)1098-237X(200003)84:2<154::AID-SCE2>3.0.CO;2-R)
- Bailey, M. (2021). *Misogynoir transformed: Black women's digital resistance*. New York: New York University Press.
- Bailey, T.M., Chung, Y.B., Williams, W.S., Singh, A.A., & Terrell, H.K. (2011). Development and validation of the internalized racial oppression scale for Black individuals. *Journal of Counseling Psychology*, 58(4), 481-493. doi.org/10.1037/a0023585
- Banilower, E.R., Smith, P.S., Malzahn, K.A., Plumley, C.L., Gordon, E.M., & Hayes, M.L. (2018). *Report of the 2018 NSSME+*. Horizon Research Inc. <http://horizon-research.com/NSSME/2018-nssme/research-products/reports/technical-report>
- Beard, A. (2020). *Teacher of color retention: Stories of staying from teachers of color in a suburban school district*. Publication No. 27831919 [Doctoral dissertation, Concordia University, St. Paul]. ProQuest Dissertations & Theses Global. <https://digitalcommons.csp.edu/edd/7>
- Beauboeuf-Lafontant, T. (2002). A womanist experience of caring: Understanding the pedagogy of exemplary Black women teachers, 34(1), 71-86. doi.org/10.1023/A:1014497228517
- Bell Jr., D.A. (1980). Brown v. Board of Education and the interest-convergence dilemma. *Harvard Law Review*, 93(3), 518-533. doi.org/10.2307/1340546
- Bond, S. (2018, November 13). *Pseudoarchaeology and the racism behind ancient aliens*. Hyperallergenic.com Retrieved from <https://hyperallergenic.com/470795/pseudoarchaeology-and-the-racism-behind-ancient-aliens/>

- Boutte, G., Kelly-Jackson, C., & Johnson, G.L. (2010). Culturally relevant teaching in science classrooms: Addressing academic achievement, cultural competence, and critical consciousness. *International Journal of Multicultural Education*, 12(2), 1-20.
doi.org/10.18251/ijme.v12i2.343
- Bowen, G.A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27-40. doi.org/10.3316/QRJ0902027
- Boykin, A.W. (1986). The triple quandary and the schooling of Afro-American children. In U. Neisser (Ed), *The school achievement of minority children: new perspectives* (pp.57-92). Lawrence Erlbaum Associations, Publishers.
- Brady, J.F., & Kanpol, B. (2000). The role of critical multicultural education and feminist critical thought in teacher education: Putting theory into practice. *Educational Foundations*, 14(3), 39-50. www.proquest.com/scholarly-journals/role-critical-multicultural-education-feminist/docview/205235506/se-2?accountid=14537
- Brand, B.R., Glasson, G.E., & Green, A.M. (2006). Sociocultural factors influencing students' learning in science and mathematics: An analysis of the perspectives of African American students. *School Science and Mathematics*, 106(5), 228-236.
doi.org/10.1111/j.1949-8594.2006.tb18081.x
- Brand, B. R., & Glasson, G. E. (2004). Crossing cultural borders into science teaching: Early life experiences, racial and ethnic identities, and beliefs about diversity. *Journal of Research in Science Teaching*, 41(2), 119-141. doi.org/10.1002/tea.10131.
- Brandt, A. (1978). *Racism and research: The case of the Tuskegee Syphilis Study*. (The Hastings Center Report) 8 (6), 21-29. doi.org/10.2307/3561468

- Bravo, M. A., Mosqueda, E., Solis, J. L., & Stoddart, T. (2014). Possibilities and limits of integrating science and diversity education in preservice elementary teacher preparation. *Journal of Science Teacher Education*, 25(5), 601-619. doi.org/10.1007/s10972-013-9374-8.
- Brown, K. D. (2014). Teaching in color: A critical race theory in education analysis of the literature on preservice teachers of color and teacher education in the US. *Race Ethnicity and Education*, 17(3), 326–345. https://doi.org/10.1080/13613324.2013.832921
- Bulunuz, N., & Jarrett, O.S. (2010). Understanding of earth and space science concepts: Strategies for concept-building in elementary teacher preparation. *School Science and Mathematics*, 109(5), 276-289. doi.org/10.1111/j.1949-8594.2009.tb18092.x
- Cahan, E. (2020, July 2). *Amid protests against racism, scientists move to strip offensive names from journals, prizes, and more*. Science Mag. https://www.sciencemag.org/news/2020/07/amid-protests-against-racism-scientists-move-strip-offensive-names-journals-prizes-and
- Campoli, A.K. & Conrad-Popova, D. (2017). Invisible threads: Working conditions, interpersonal relationships, and turnover among Black female teachers. In A. Farinde-Wu, A. Allen-Handy, & C.W. Lewis (Eds.), *Black Female Teachers (Advances in Race and Ethnicity in Education, Vol. 6)* (pp. 117-134), Emerald Publishing Limited. doi.org/10.1108/S2051-231720170000006007
- Carver-Thomas, D. (2017). *Diversifying the field: Barriers to recruiting and retaining teachers of color and how to overcome them*. Learning Policy Institute. https://learningpolicyinstitute.org/sites/default/files/product-files/Diversifying_Teaching_Profession_REPORT_0.pdf

- Castillo-Montoya, M., Abreu, J., & Abad, A. (2019). Racially liberatory pedagogy: A Black Lives Matter approach to education. *International Journal of Qualitative Studies in Education*, 32(9), 1125-1145. doi.org/10.1080/09518398.2019.1645904
- Charles, J.M. (2020). The slave revolt that changed the world and the conspiracy against it: the Haitian revolution and the birth of scientific racism. *Journal of Black Studies*, 51(4) 275-294. doi.org/10.1177/0021934720905128
- Cherng, H.S. & Halpin, P.F. (2016). The importance of minority teachers: Student perceptions of minority versus white teachers. *Educational Researcher*, 45(7), 407-420. doi.org/10.3102/0013189X16671718
- Cherry-McDaniel, M. (2019). Skinfolk ain't always kinfolk: The dangers of assuming and assigning inherent cultural responsiveness to teachers of color. *Educational Studies*, 55(2), 241-251. doi.org/10.1080/00131946.2018.1500912
- Cheruvu, R., Souto-Manning, M., Lencl, T., & Chin-Calubaquib, M. (2015). Race, isolation, and exclusion: What early childhood teacher educators need to know about the experiences of pre-service teachers of color. *Urban Review*, 47(2), 237–265. doi.org/10.1007/s11256-014-0291-8
- Coaston, J. (2018, March 21). *National Review's weak attack on affirmative action*. Vox. <https://www.vox.com/policy-and-politics/2018/3/21/17143150/conservative-scientific-racism-national-review>
- Collins, P.C. (1996). What's in a name? Womanism, Black feminism, and beyond. *The Black Scholar*, 26(1), 9-17. www.jstor.org/stable/41068619

- Combahee River Collective. (1983). The Combahee River Collective statement. In B. Smith (Ed.), *Home girls: A Black feminist anthology* (pp. 272-282). New York: Kitchen Table: Women of Color Press. (Original work published 1977).
- Creswell, J.W., & Creswell, J.D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). Thousand Oaks, CA: Sage Publications.
- David, E.J.R. & Derthick, A.O. (2014). What is internalized oppression, and so what? In E.J.R. David (Ed.), *Internalized oppression: The psychology of marginalized groups* (pp. 1-30). New York: Springer Publishing Company.
- Delgado, R., & Stefancic, J. (2017). *Critical race theory: An introduction* (3rd ed). New York: New York University Press.
- deMarrais, K. (2004). Qualitative interview studies: Learning through experience. In S.D. Lapan & K.B. DeMarrais (Eds.), *Foundations for research: Methods of inquiry in education and the social sciences* (pp.51-68). L. Erlbaum Associates.
- Despenza, N. (2018). *Missing in action: A critical narrative study of the absence of Black female secondary science teacher*. [Doctoral dissertation, Loyola Marymount University]. Digital Commons LMU.
<https://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1532&context=etd>
- DiAngelo, R. (2011). White fragility. *International Journal of Critical Pedagogy*, 3(3), 54-70.
- Dingus, J.E. (2008). "I'm learning the trade": Mentoring networks of Black women teachers. *Urban Education*, 43(3), 361-377. doi.org/10.1177/0042085907311794
- Dicker, R.C. (2008). *A history of U.S. feminisms*. Berkeley, CA: Seal Press.

- Dixson, A.D. & Dingus, J.E. (2008). In search of our mothers' gardens: Black women teachers and professional socialization. *Teachers College Record*, 110(4), 805-837.
www.tcrecord.org/Content.asp?ContentId=14630
- DuBois, W.E. (1935). Does the Negro need separate schools? *The Journal of Negro Education*, 4(3), 328-335. <https://doi.org/10.2307/2291871>
- Dumas, M.J., & ross, k.m. (2016). "Be real Black for me": Imagining BlackCrit in education. *Urban Education*, 51(4), 415-442. doi.org/10.1177/0042085916628611
- Dziak, M. (2020). Hidden curriculum. *Salem press encyclopedia*. Retrieved September 27, 2020 from <http://search.ebscohost.com.proxy-remote.galib.uga.edu/login.aspx?direct=true&db=ers&AN=119214079&site=eds-live>.
- Eischens, R. (2020, February 20). 'Increase Teachers of Color Act' clears House committee. Minnesota Reformer. <https://minnesotareformer.com/briefs/increase-teachers-of-color-act-clears-house-committee/>
- Emdin, C. (2016). *For White folks who teach in the hood...and the rest of y'all too: Reality pedagogy and urban education*. Boston, MA: Beacon Press.
- Ending systemic racism in medicine. (2020, July 10). *Nature Medicine*, 26, 985.
doi.org/10.1038/s41591-020-0993-2
- Evans, M.K., Rosenbaum, L., Malina, D., Morrissey, S., & Rubin, E.J. (2020). Diagnosing and treating systemic racism. *New England Journal of Medicine*, 383(3), 274-276.
doi.org/10.1056/NEJMe2021693
- Evans-Winters, V.E. (2015). Black feminism in qualitative research: A mosaic for interpreting race, class, and gender in education. In V. Evans-Winters & B.L. Love (Eds.), *Black*

- feminism in education: Black women speak back, up, and out* (pp. 129-142). New York, New York: Peter Lang Publishing, Inc
- Evans-Winters, V.E., & Hines, D.E. (2019). Unmasking White fragility: how whiteness and white student resistance impacts anti-racist education. *Whiteness & Education*, 5(1), 1-16. doi.org/10.1080/23793406.2019.1675182
- Faniko, K., Ellemers, N., & Derks, B. (2020). The queen bee phenomenon in academia 15 years after: Does it still exist, and if so, why? *British Journal of Social Psychology*, 60(2), 383-399.
- Faison, M.Z., & McArthur, S.A. (2020). Building Black worlds: revisioning cultural justice for Black teacher education students at PWIs. *International Journal of Qualitative Studies in Education*, 33(7), 745-758. doi.org/10.1080/09518398.2020.1754489
- Farinde-Wu, A. & Griffen, A.J. (2019). Black female teachers on teacher preparation and retention. *PennGSE Perspectives on Urban Education*, 16(1), 1-17.
- Farinde-Wu, A., Allen-Handy, A., Butler, B.R., & Lewis, C.W. (2017). The urban factor: Examining why Black female educators teach in under-resourced urban schools. In A. Farinde-Wu, A. Allen-Handy, & C.W. Lewis (Eds.), *Black Female Teachers (Advances in Race and Ethnicity in Education, Vol. 6)* (pp. 73-92), Emerald Publishing Limited. doi.org/10.1108/S2051-231720170000006005
- Firmin, A. (2000). *The equality of the human races* [Translated by Asselin, Charles & Introduction by Fluehr-Lobban, Carolyn]. Garland Press.
- Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12(2), 219-245. doi.org/10.1177/1077800405284363
- Foster, M. (1997). *Black teachers on teaching*. New York: The New Press.

- Fraser-Burgess, S.A., Warren-Gordon, K., Humphrey, D.L., & Lowery, K. (2020) Scholars of color turn to womanism: Countering dehumanization in the academy. *Educational Philosophy and Theory*, 1-18. doi.org/10.1080/00131857.2020.1750364
- Funk, C., & Parker, K. (2018, January 9). *Blacks in STEM jobs are especially concerned about diversity and discrimination in the workplace*. PewSocialTrends.org.
<https://www.pewsocialtrends.org/2018/01/09/blacks-in-stem-jobs-are-especially-concerned-about-diversity-and-discrimination-in-the-workplace/>
- Galman, S.C. (2016). *The good, the bad, and the data: Shane the lone ethnographer's basic guide to qualitative data analysis*. New York, NY: Routledge.
- Gay, G. (2000). *Culturally, responsive teaching: Theory, research, & practice*. New York: Teachers College Press.
- Gershenson, S., Hart, C.M.D., Hyman, J., Lindsay, C., & Papageorge, N.W. (2018). The long-run impacts of same-race teachers. *NBER Working Paper*
<https://www.nber.org/papers/w25254>
- Gershenson, S., Holt, S.B., Papageorge, N.W. (2016). Who believes in me? The effect of student-teacher demographic match on teacher expectations. *Economics of Education Review*, 52, 209-224. doi.org/10.1016/j.econedurev.2016.03.002
- Gewin, V. (2017, January 12). *Rice reveals African slaves' agricultural heritage*. Sapiens.org.
<https://www.sapiens.org/culture/african-rice-new-world/>
- Gil, D., & Levidow, L. (1987). General introduction. In D. Gil & L. Levidow (Eds.), *Anti-Racist science teaching* (pp.1-11). London: Free Association Books.
- Gist, C.D. (2014). The culturally responsive teacher educator. *Teacher Educator*, 49(4), 265-283.
 doi.org/10.1080/08878730.2014.934129

- Graham, A., & Erwin, K.D. (2011). "I don't think Black men teach because how they get treated as students": High-Achieving African American boys' perceptions of teaching as a career option. *The Journal of Negro Education*, 80(3), 398-416. www.jstor.org/stable/41341142
- Green, A. & Glasson, G. (2009). African Americans majoring in science at predominately white universities (A review of the literature). *College Student Journal*, 43(2), 366-374.
- Heubeck, E. (2020, June 30). *Recruiting and retaining teachers of color: Why it matters, ways to do it*. Education Week. <https://www.edweek.org/ew/articles/2020/06/30/recruiting-and-retaining-diverse-teachers-why-it.html>
- Higginbotham, E. B. (1993). *Righteous discontent: the women's movement in the Black Baptist Church, 1880-1920*. Harvard University Press.
- Hill-Carter, C. (2013). No one told us: Recruiting and retaining African American males in the college of education program from the urban and rural areas. In C.W. Lewis & I.A. Toldson (Eds.), *Black male teachers: Diversifying the United States' teacher workforce* (pp. 107-116). UK: Emerald Group Publishing Limited. [doi.org/10.1108/S2051-2317\(2013\)0000001012](https://doi.org/10.1108/S2051-2317(2013)0000001012)
- Hill Collins, P. (1986). Learning from the outsider within: The sociological significance of black feminist thought. *Social Problems*, 33(6), S14-S32.
doi.org/10.1525/sp.1986.33.6.03a00020
- Hill Collins, P. (2000). *Black feminist thought* (2nd ed). New York, New York: Routledge.
- Hoffman, K.M., Trawalter, S., Axt, J.R., & Oliver, M.N. (2016). Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. *Proceedings of the National Academy of Science of the United States of America*, 113(16), 4296-4301. doi.org/10.1073/pnas.1516047113

- Hofstra, B., Kulkarni, V.V., Galvez, S.M.N., He, B., Jurafsky, D., & McFarland, D.A. (2020). The diversity-innovation paradox in science. *Proceedings of the National Academy of Sciences*, *117*(17), 9284-9291. doi.org/10.1073/pnas.1915378117
- Hong, L., & Page, S. E. (2004). Groups of diverse problem solvers can outperform groups of high-ability problem solvers. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(46), 16385–16389.
<https://doi.org/10.1073/pnas.0403723101>
- hooks, b. (2015). *Ain't I a woman: Black women and feminism* (2nd ed). New York: Routledge.
- Hopper, E.B., Robinson, D., & Fitchett, P. (2021). Early career African American teachers and the impact of administrative support. *Urban Education*, *57*(3), 401-431.
doi.org/10.1177/0042085920988335
- Hurston, Z.N. (2006). *Dust tracks on a road*. HarperCollins Publishers.
- Ingersoll, R.M., Merrill, E., Stuckey, D., & Collins, G. (2018). *Seven trends: The transformation of the teaching force – updated October 2018*. CPRE Research Reports.
repository.upenn.edu/cpre_researchreports/108
- Jackson, V. & Williams, B. (2022). How Black women experience student debt. *The Education Trust*. <https://edtrust.org/wp-content/uploads/2014/09/How-Black-Women-Experience-Student-Debt-April-2022.pdf>
- Johnson, L. (2015). From the anti-slavery movement to now: (Re) examining the relationship between critical race theory and Black feminist thought. *Race, Gender, & Class*, *22*(3-4), 227-243. www.jstor.org/stable/26505358

- Jones, M.S. (2007). *All bound up together: The woman question in African American public culture, 1830-1900*. Chapel Hill: University of North Carolina Press.
doi.org/10.5149/9780807888902_jones
- Kean, S. (2019). Science's debt to the slave trade: historians confront the tainted origins of key plant and animal collections. *Science*, *364*(6435), 16-20.
doi.org/10.1126/science.364.6435.16
- Kelly, A.V. (2009). *The curriculum: Theory and practice* (6th ed.). Sage.
- Kim, Y. (2010). The pilot study in qualitative inquiry: Identifying issues and learning lessons for culturally competent research. *Qualitative Social Work*, *10*(2), 190-206. doi.org/10.1177/1473325010362001
- King, N. (2021). Toward an equity agenda for Black girls and women in STEM learning spaces and careers: Noticing, validating, and humanizing. *Journal of African American Women and Girls in Education*, *1*(2), 1-9. doi.org/10.21423/jaawge-v1i2a93
- Kohli, R. (2014). Unpacking internalized racism: teachers of color striving for racially just classrooms. *Race, Ethnicity, and Education*, *17*(3), 367-387.
doi.org/10.1080/13613324.2013.832935
- Krall, R.M., Lott, K.H., & Wymer, C.L. (2009). Inservice elementary and middle school teachers' conceptions of photosynthesis and respiration. *Journal of Science Teacher Education*, *20*(1), 41-55. doi.org/10.1007/s10972-008-9117-4
- Ladson-Billings, G. (1995). But that's just good teaching! The case for culturally relevant pedagogy. *Theory into Practice*, *34*(3), 159-165. doi.org/10.1080/00405849509543675

- Ladson-Billings, G. (1998). Just what is critical race theory and what's it doing in a nice field like education? *International Journal of Qualitative Studies in Education*, 11(1), 7-24. doi.org/10.1080/095183998236863.
- Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: a.k.a. the remix. *Harvard Educational Review*, 84(1), 74-84. doi.org/10.17763/haer.84.1.p2rj131485484751
- Ladson-Billings, G., & Henry, A. (1990). Blurring the borders: Voices of African liberatory pedagogy in the United States and Canada. *The Journal of Education*, 172(2), 72-88. doi.org/10.1177/002205749017200207
- Ladson-Billings, G., & Tate, W.F., IV (1995). Toward a critical race theory of education. *The Teachers College Record*, 97(1), 47-68. doi.org/10.1177/016146819509700104
- Leath, S & Mims, L. (2021). A qualitative exploration of Black women's familial socialization on controlling images of Black womanhood and the internalization of respectability politics, *Journal of Family Studies*, 1-18. doi.org/10.1080/13229400.2021.1987294
- Lee, T.D., & Glass, B. (2019). Developing the next generation of elementary science teachers. *Journal of College Science Teaching*, 49(2), 18-23. doi.org/10.2505/4/jcst19_049_02_18
- Lewis, H. (2000). Reflections on "BlackCrit theory": Human rights. *Villanova Law Review*, 45(1075), 1075-1090. <https://digitalcommons.law.villanova.edu/vlr/vol45/iss5/9>
- Liebow, N., & Glazer, T. (2019). White tears: emotion regulation and white fragility. *Inquiry*, 1-22. doi.org/10.1080/0020174X.2019.1610048
- Majid, M.A.A., Othman, M., Mohamad, S.F., Lim, S.A.H., & Yusof, A. (2017). Piloting for interviews in qualitative research: Operationalization and lessons learnt. *International Journal of Academic Research in Business and Social Sciences*, 7(4), 1073-1080. doi.org/10.6007/IJARBS/v7-i4/2916

- Mayberry, M. (1998). Reproductive and resistant pedagogies: The comparative roles of collaborative learning and feminist pedagogy in science education. *Journal of Research in Science Teaching*, 35(4), 443-459. doi.org/10.1002/(SICI)1098-2736(199804)35:4<443::AID-TEA14>3.0.CO;2-A
- Maykut, P., & Morehouse, R. (1994). *Beginning qualitative research; A philosophic and practical guide*. London: The Falmer Press.
- McDaniels, A.K. (2017). *Henrietta Lacks's family wants compensation for her cells*. The Washington Post. https://www.washingtonpost.com/local/henrietta-lackss-family-wants-compensation-for-her-cells/2017/02/14/816481ba-f302-11e6-b9c9-e83fce42fb61_story.html
- McGee, E.O. (2020). Interrogating structural racism in STEM higher education. *Educational Researcher*, 49(9), 633-644. doi.org/10.3102/0013189X20972718
- Mensah, F. M. (2009a). Confronting assumptions, biases, and stereotypes in preservice teachers' conceptualizations of science teaching through the use of book club. *Journal of Research in Science Teaching*, 46(9), 1041-1066. doi.org/10.1002/tea.20299.
- Mensah, F.M. (2009b). A portrait of Black teachers in science classrooms. *The Negro Educational Review*, 60 (1-4), 39-52.
- Mensah, F.M. (2011). A case for culturally relevant teaching in science education and lessons learned for teacher education. *The Journal of Negro Education*, 80(3), 296-309. www.jstor.org/stable/41341135
- Mensah, F.M. (2019). Finding voice and passion: Critical race theory methodology in science teacher education. *American Educational Research Journal*, 56(4), 1412-1456. doi.org/10.3102/0002831218818093

- Mensah, F.M., & Jackson, I. (2018). Whiteness as property in science teacher education. *Teachers College Record*, 120(1), 1-38. doi.org/10.1177/016146811812000108
- Merriam, S.B., Johnson-Bailey, J., Lee, M., Kee, Y, Ntseane, G., & Muhamad, M. (2015). Power and positionality: negotiating insider/outsider status within and across cultures. *International Journal of Lifelong Education*, 20(5), 405-416. doi.org/10.1080/026013701
- Miles, M.B., Huberman, A.M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed). Thousand Oaks, CA: Sage Publications.
- Milner IV, H.R. (2006). The promise of Black teachers' success with Black students. *Educational Foundations*, 20(3-4), 89-104.
- Milner IV, H.R. (2008). Critical race theory and interest convergence as analytic tools in teacher education policies and practices. *Journal of Teacher Education*, 59(4), 332-346. doi.org/10.1177/0022487108321884
- Milner, H.R., & Howard, T.C. (2004). Black teachers, Black students, Black communities, and Brown: Perspectives and insights from experts. *The Journal of Negro Education*, 73(3), 285-297. doi.org/10.2307/4129612
- Mohorn, O. (2021). *Science identity development of Black female secondary science teachers* (Publication No. 28722807) [Doctoral dissertation, University of Illinois at Chicago]. ProQuest Dissertations & Theses Global.
- Moore, F. M. (2008). Preparing elementary preservice teachers for urban elementary science classrooms: Challenging cultural biases toward diverse students. *Journal of Science Teacher Education*, 19(1), 85-109. doi.org/10.1007/s10972-007-9083-2.
- Morris, M.W. (2018). *Pushout: The criminalization of Black girls in schools*. New York: The New Press

- Murfin, B. (1994). African science, African and African American scientists and the school science curriculum. *School Science and Mathematics*, 94(2), 96-103.
doi.org/10.1111/j.1949-8594.1994.tb12299.x
- Mutegi, J.W. (2013). “Life’s first need is for us to be realistic” and other reasons for examining the sociocultural construction of race in the science performance of African American students. *Journal of Research in Science Teaching*, 50(1), 82-103.
doi.org/10.1002/tea.21065
- National Center for Science and Engineering Statistics. (2019). *Women, minorities, and persons with disabilities in science and engineering*.
<https://nces.nsf.gov/pubs/nsf19304/assets/digest/nsf19304-digest.pdf>
- Noblit, G., Hwang, S., Seiler, G., & Elmesky, R. (2007). Forum: toward culturally responsive discourses in science education. *Cultural Studies in Science Education*, 2(1), 105-117.
doi.org/10.1007/s11422-006-9046-5
- Office of Planning, Evaluation, and Policy Development, Policy and Program Studies Service, & U.S. Department of Education (2016). *The State of Racial Diversity in the Educator Workforce*. <https://www2.ed.gov/rschstat/eval/highered/racial-diversity/state-racial-diversity-workforce.pdf>
- Ojanuga, D. (1993). The medical ethics of the ‘father of gynaecology’, Dr. J. Marion Sims. *Journal of Medical Ethics*, 19(1), 28-31. doi.org/10.1136/jme.19.1.28
- Olitsky, S. (2020). Teaching as emotional practice or exercise in measurement? School structures, identity conflict, and the retention of Black women science teachers. *Education and Urban Society*, 52(4), 590-618. doi.org/10.1177/0013124519873676
- Otter.ai. (2020, May 20). *Otter.ai Privacy Policy*. <https://otter.ai/privacy>

Parsons, E.C. (1997). Black high school females' images of the scientist: Expression of culture. *Journal of Research in Science Teaching*, 34(7), 745-768. doi.org/10.1002/(SICI)1098-2736(199709)34:7<745::AID-TEA5>3.0.CO;2-M.

Parsons, E.C. (2000). Culturalizing science instruction: What is it, what does it look like and why do we need it? *Journal of Science Teacher Education*, 11(3), 207-219.
www.jstor.org/stable/43156246

Parsons, E. (1998). Black high school females' images of the scientist: Expression of culture. *Journal of Research in Science Teaching*, 34(7), 745-768.
[https://doi.org/10.1002/\(SICI\)1098-2736\(199709\)34:7<745::AID-TEA5>3.0.CO;2-M](https://doi.org/10.1002/(SICI)1098-2736(199709)34:7<745::AID-TEA5>3.0.CO;2-M)

Parsons, E.R.C., Bulls, D.L., Freeman, T.B., Butler, M.B., & Atwater, M.M. (2018). General experiences + race + racism = Work lives of Black faculty in postsecondary science education. *Cultural Studies of Science Education*, 13(2), 371-394.
doi.org/10.1007/s11422-016-9774-0

Parsons, E.C., Travis, C., & Simpson, J.S. (2005). The Black cultural ethos, students' instructional context preferences, and student achievement: An examination of culturally congruent science instruction in the eighth grade classes of one African American and one Euro-American teacher. *The Negro Educational Review*, 56(2&3), 183-204.
www.proquest.com/scholarly-journals/black-cultural-ethos-students-instructional/docview/219034716/se-2?accountid=14537

Patton, M.Q. (2015). *Qualitative research & evaluation methods* (4th ed.). Thousand Oaks, CA: Sage Publications Inc.

Phillips, L. (Ed.). (2006). *The womanist reader*. Routledge.

- Phillips, S.L. (1999). The convergence of the critical race theory workshop with LatCrit theory: A history. *University of Miami Law Review*, 53(4), 1247-1256.
digitalcommons.law.buffalo.edu/journal_articles/269
- Price, M. (2018, May 22). 'It's a toxic place.' How the online world of white nationalists distorts population genetics. *Science Mag.* <https://www.sciencemag.org/news/2018/05/it-s-toxic-place-how-online-world-white-nationalists-distorts-population-genetics>
- Price, J.N., & Ball, D.L. (1998). Challenges of liberatory pedagogy in mathematics and teacher education. *Theory into Practice*, 37(4), 256-264. doi.org/10.1080/00405849809543814
- Rackley, R. (2017). The Impact of the Ethic of Care on the Teaching and Learning of Science by Middle School Science Teachers and EL Students. [Doctoral dissertation, University of Georgia]. University of Georgia Repository.
- Random House. (20045). Pedagogy. In *Webster's college dictionary* (2nd ed., p. 905).
- Riegle-Crumb, C., King, B., & Irizarry, Y. (2019). Does STEM stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. *Educational Researcher*, 48(3), 133-144. doi.org/10.3102/0013189X19831006
- Riley, A. (2022). Lifting as We Climb: Womanist Pedagogy and Anti-Racist Teaching as Discussed by Black Women Science Teachers [Doctoral dissertation, Columbia University]. Columbia Academic Commons. doi.org/10.7916/wm9y-9a70
- Rivera Maulucci, M.S. (2013). Emotions and positional identity in becoming a social justice science teacher: Nicole's story. *Journal of Research in Science Teaching*, 50(4), 453-478. <https://doi.org/10.1002/tea.21081>

- Rodriguez, A., & McGuire, K.M. (2019). More classes, more access? Understanding the effects of course offerings on Black-White gaps in Advanced Placement course taking. *The Review of Higher Education*, 42(2), 641-679, <https://doi.org/10.1353/rhe.2019.0010>.
- Rosales, J. (2018). *The racist beginnings of standardized testing*. NEA.
<http://www.nea.org/home/73288.htm>
- Rosen, J. (2018, November 12). *Black students who have one Black teacher are more likely to go to college*. The Hub. <https://hub.jhu.edu/2018/11/12/black-students-black-teachers-college-gap/>
- ross, k.m. (2019). Revisiting BlackCrit in education: Anti-Black reality and liberatory fantasy. *Center for Critical Race Studies in Education at UCLA Research Briefs*, (17), 1-4.
https://issuu.com/almaiflores/docs/kmr_blackcrit_final
- Rusert, B. (2017). *Fugitive science: Empiricism and freedom in early African American culture*. New York: New York University Press.
- Rutt, A.A. & Mumba, F.M. (2020). Developing secondary pre-service science teachers' instructional planning abilities for language and literacy integrate science instruction in linguistically diverse classrooms. *Journal of Science Teacher Education*, 31(8), 841-868.
<https://doi.org/10.1080/1046560X.2020.1760431>
- Saini, A. (2019). The long reach of race science. *New Scientist*, 242(3230), 40-43.
[doi.org/10.1016/s0262-4079\(19\)30873-5](https://doi.org/10.1016/s0262-4079(19)30873-5)
- Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed). Thousand Oaks, CA: Sage Publications.
- Sampson, H. (2004). Navigating the waves: the usefulness of a pilot in qualitative research. *Qualitative Research*, 4(3), 383-402. doi.org/10.1177/1468794104047236

- Santau, A.O., Maerten-Rivera, J.L., Bovis, S., & Orend, J. (2014). A mile wide or an inch deep? Improving elementary preservice teachers' science content knowledge within the context of a science methods course. *Journal of Science Teacher Education*, 25(8), 953-976.
doi.org/10.1007/s10972-014-9402-3
- Schwandt, T.A., & Gates, E.F. (2018). Case study methodology. In N.K. Denzin & Y.S. Lincoln (Eds.), *The Sage handbook of qualitative research* (5th ed., pp. 341-358). Sage.
- Seriki, V.D., Brown, C.T., & Fasching-Varner, K.J. (2015). The permanence of racism in teacher education. *Teachers College Record*, 117(14), 74-102.
doi.org/10.1177/016146811511701406
- Sheared, V. (2006). Giving voice: An inclusive model of instruction – A womanist perspective. In L. Phillips (Ed.), *A womanist reader* (pp. 269-279). Routledge.
- Signorella, M.L. (2020). Toward a more just feminism. *Psychology of Women Quarterly*, 44(2), 256-265. doi.org/10.1177/0361684320908320
- Simons, H. (2009). *Case study: Research in practice*. Thousand Oaks, CA: Sage Publications Inc.
- Simpson, J.S., & Parsons, E.C. (2009). African American perspectives and informal science educational experiences. *Science Education*, 93(2), 293-321. doi.org/10.1002/sce.20300
- Sinclair, B. (1998). Teaching about technology and African American history. *OAH Magazine of History*, 12(2), 14-17. www.jstor.org/stable/25163200
- Smith, W.A., Allen, W.R., & Danley, L.L. (2007). "Assume the position... you fit the description" Psychosocial experiences and racial battle fatigue among African American male college students. *American Behavioral Scientist*, 51(4), 551-578.
doi.org/10.1177/0002764207307742.

- Souto-Manning, M., & Emdin, C. (2020). On the harm inflicted by urban teacher education programs: Learning from the historical trauma experienced by teachers of color. *Urban Education*. doi.org/10.1177/0042085920926249
- Spiegelman, M. (2020). *Race and ethnicity of public school teachers and their students*. National Center for Education and Statistics. <https://nces.ed.gov/pubs2020/2020103.pdf>
- Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage Publications.
- Stanley, W.B., & Brickhouse, N.W. (1994). Multiculturalism, universalism, and science education. *Science Education*, 78(4), 387-398. doi.org/10.1002/sce.3730780405
- Stein, L. (2007, October 17). *World-renowned geneticist draws fire for claims that Africans are intellectually inferior*. ScientificAmerican.com.
<https://blogs.scientificamerican.com/news-blog/world-renowned-geneticist-draws-fir/>.
- Stewart, S., & Haynes, C. (2019). Black liberation research: qualitative methodological considerations. *International Journal of Qualitative Studies in Education*, 32(9), 1183-1189. doi.org/10.1080/09518398.2019.1645912
- Sun, M. (2018). Black teachers' retention and transfer patterns in North Carolina: How do patterns vary by teacher effectiveness, subject, and school conditions? *AERA Open*, 4(3), 1-23. doi.org/10.1177/2332858418784914
- Tillman, L.C. (2004). (Un)intended consequences? The impact of the Brown v. Board of Education decision the employment status of Black educators. *Education and Urban Society*, 36(3), 280-303. doi.org/10.1177/0013124504264360
- Tobin, K. (2006). Aligning the cultures of teaching and learning science in urban high schools. *Cultural Studies of Science Education*, 1(2), 219-252. doi.org/10.1007/s11422-005-9008-3.

- U.S. Department of Education, & National Center for Education Statistics. (2020). *National Teacher and Principal Survey (NTPS) 2017-2018*. National Center for Education Statistics. Retrieved September 28, 2020 https://nces.ed.gov/surveys/ntps/tables_list.asp.
- U.S. Department of Education, Institute of Education Science, National Center for Education Statistics, & National Assessment of Educational Progress (NAEP). (2015). 2015 science assessments. [data set] https://www.nationsreportcard.gov/science_2015/#acl?grade=12
2015 NAEP
- Walker, A. (2006). Womanist. In L. Phillips (Ed.), *A womanist reader* (18-19). Routledge. (Original work published 1983).
- Watkins, W.H. (2001). *The white architects of Black education*. Teachers College Press.
- Watson, W. & Devereaux, C.A. (2022). Keeping it relevant: Student-centered reflections, choices, and actions of critical race womanist pedagogues. *Urban Education, 57*(4), 571-599. <https://doi.org/10.1177/0042085920979687>
- Walls, L. (2012). Third grade African American students' views of the nature of science. *Journal of Research in Science Teaching, 49*(1), 1-37. doi.org/10.1002/tea.20450.
- Walls, L. (2016). Awakening a dialogue: A critical race theory analysis of U.S. nature of science research from 1967 to 2013. *Journal of Research in Science Teaching, 53*(10), 1546-1570. doi.org/10.1002/tea.21266
- Yin, R.K. (2003). *Case study research: Design and methods* (3rd ed). Thousand Oaks, CA: Sage Publications.
- Yin, R.K. (2018). *Case study research and applications: Design and methods* (6th ed). Thousand Oaks, CA: Sage Publications.

Ziols, R. (2019). Teacher preparation programs, teacher diversity, and STEM: Considering a “race-centered” political economy perspective. In J. Leonard, A.C. Burrows, & R. Kitchen (Eds.), *Recruiting, preparing, and retaining STEM teachers for a global generation* (pp. 190-216). Koninklijke Brill NV. doi.org/10.1163/9789004399990_008

APPENDIX A

RECRUITMENT FLYER

Recruiting Volunteers for a Dissertation Study on **Black Women Secondary Science Teachers**

The goal of this study is to research and understand Black women's experiences in science, science teacher preparation, and science teaching. This study will be completed virtually through zoom.



Who Is Eligible?

Black women who are certified in and teach secondary science.

Description of Study

If you agree to participate, you will be asked to complete a survey, participate in 3 90-minute interviews, share some lesson plans, reflect on four lessons, keep a weekly journal, and complete a payment log. You may also be asked to clarify your responses. We anticipate this study taking no more than 6 hours of time.

If selected to participate you will be contacted by phone or email according to your preference.

Upon completion of this study, you will be compensated \$75. If you are unable to complete the full study, you will be compensated at \$10/hour.

If you're interested in participating:

Please complete the eligibility survey at <http://bit.ly/ECBWST>

You can also contact Jordan Henley at **762.499.2367** or **jlh67128@uga.edu** or Mary Atwater at 706.542.4647 or **atwater@uga.edu**



Mary Frances Early
College of Education
UNIVERSITY OF GEORGIA

APPENDIX B
ELIGIBILITY SURVEY

Please download a copy of the consent form for your records at

<https://drive.google.com/file/d/14ZwpySNjwo4WpBx1c1TKhLXIdPK7lKQI/view?usp=sharing>.

After reading the consent form, if you consent to participation in this study please type your name.

Having read the consent form, what type of recordings do you consent to?

Audio & video

Audio only

No recording

What is the name you prefer to be addressed by?

How old are you?

How do you describe your race and gender?

What university or program did you attend to receive your teaching certification?

What type of teaching certification do you have and in what state(s)?

How many years of teaching have you completed?

What is your teaching certification in?

What grade levels and subjects have you taught? Please note if any of these courses are advanced or gifted.

What is the name and city of the school where you currently teach?

If you have taught at other schools, please provide the names and what year(s) you taught there.

What is your phone number and email address?

How do you prefer to be contacted?

Email

Phone

Text

If you prefer a phone call or text, what time of day is best to contact you? Please include your time zone

APPENDIX C

POST LESSON CHECKLIST

Post Lesson Checklist/Short Response

Instructions: Please check which elements below were included in your lesson today and your classroom culture.

- I held all students, regardless of race or gender, to high expectations that I communicated to them.
- I encouraged students to respect one another and build positive relationships in the classroom across racial and gender differences.
- During instruction, students had opportunities to express their understanding in their own words and in 'scientific' language.
- Students collaborate with each other across racial and gender differences.
- I facilitated opportunities for all students to express their thoughts and feelings regardless of race or gender.
- I incorporated knowledge and respect of diverse racial and gender groups into my instruction.
- The lesson included the opportunity for students to investigate or critique real-world issues relating to race and gender.
- The lesson included real-world issues related to race and gender that are relevant to students, the school, and/or the community.

- During instruction, students were given the opportunity to make choices about assignments and/or what they are learning.
- I included low-stake, formative assessment during instruction.
- I cultivated a supportive classroom environment where students were not afraid of failure such that all students, regardless of race or gender differences, are comfortable answering questions or making mistakes.
- If historical or contemporary figures are highlighted in the classroom or lesson, please include their names, gender, and race/ethnicity. (i.e. Gregor Mendel, Mae Jemison, etc.)

- If students work in groups, please estimate the gender and racial/ethnic makeup of the different groups. Please also include if the groups were student or teacher selected. Ex. Groups tended to be 3:1 boys to girls or 1 Latinx: 1 Black: 1 White

Please write a few sentences elaborating on your responses and reflecting on your lesson today.

Please attach the lesson plan relevant to this lesson.

APPENDIX D

JOURNAL PROMPT

Journal Instructions

Please journal at least once a week. In your journal, write about an impactful experience you have had while teaching that week. Share your experience and your thoughts and feelings about the experience. What about this experience stood out for you?

APPENDIX E
INTERVIEW PROTOCOLS

Interview 1:

This will be a semi-structured interview. These questions serve as a guideline and may change as fits responses.

Introduction

Thank you for participating in this study and coming to this interview. The purpose of this study is to understand the experiences of Black women who have chosen to become science teachers.

During this interview you will be asked to speak about your beliefs about science, your memories and experiences in science, your educational experiences, and being a Black woman in science/science education.

You agreed in your consent form to recording this interview. Do you have any questions about the consent form or recording? I will begin recording now.

Remember that there are no right or wrong answers, so please be honest in helping me understand your experiences and perspectives.

1. How do you define science?
2. What are some informal examples of science?
3. What are your favorite parts of science and doing science?
4. What are your earliest memories of doing or watching someone do science?
5. When did you first begin to like science?
6. Did you ever do science outside of school?

- a. Do you ever now?
7. Did you have any friends or family in science or STEM growing up?
8. Do you ever talk to friends or family about science now?
9. Please use the google slides to create a timeline of your educational experiences. Include formal and informal education experiences.
 - a. Please add what you remember about the demographics of these experiences.
 - b. When along this timeline do you remember taking your first science class?
 - c. Did you have any Black science teachers?
10. Please describe your support systems while in school.
 - a. How do they support you?
11. Who were science teachers that had positive impacts on your scientific experiences?
 - a. What about those teachers made them good science teachers?
 - b. What was their approach to teaching?
 - c. How did they differ from teachers who didn't have such a positive impact on you?
12. What are some of your worst experiences in science?
13. Have you ever had a science teacher who attempted to use your home or cultural experiences in the classroom?
14. What are factors that have made you want to quit science or science teaching?
15. Have you ever been in a science classroom or science space that felt really welcoming?
What were characteristics of that space?
16. What are some affirming experiences you've had as a Black woman in science?
 - a. Science education?

17. When you got to undergrad did you feel prepared in your science classes? What have your experiences been in undergrad science classes?
18. Imagine a scientist. What do they look like? What does their workspace look like?
19. Do you consider yourself to be a scientist?
 - a. If yes - When did you first feel like a scientist? If no - why not?
20. When did you decide to be a science teacher?
 - a. Why did you decide to become a science teacher?

Interview 2:

This will be a semi-structured interview. These questions serve as a guideline and may change as fits responses.

Introduction

Thank you for participating in this study and coming to this interview. The purpose of this study is to understand the experiences of Black women who have chosen to become science teachers.

During this interview you will be asked to speak about your teacher education program and your experiences during it and your beliefs about science teaching.

You agreed in your consent form to recording this interview. Do you have any questions about the consent form or recording? I will begin recording now.

Remember that there are no right or wrong answers, so please be honest in helping me understand your experiences and perspectives.

1. Tell me about your teacher education program?
 - a. What was the makeup of your cohort? What was your relationship between you and your classmates?
 - b. What types of courses did you take?

- c. Why did you choose that program?
 - d. Were faculty been supportive? Did you have any Black faculty?
 2. Do you think your teacher education program adequately prepared you to be a good science teacher?
 - a. To teach a diverse group of students?
 - b. What do you think your teacher education program missed?
 3. Please tell me what you remember about the classroom where you student taught.
 - a. Was it similar to the type of classroom where you teach now?
 4. Have you ever felt excluded in the science classroom or other science space? What were characteristics of places that felt unwelcoming?
 5. How do you think being a Black woman influenced your experience in teacher preparation?
 - a. Please provide examples.
 - b. How did these experiences make you feel?
 6. Have you experienced racism or sexism while in science or science teacher preparation?
 - a. Was it blatant?
 - b. Please do not name the person. What was your relationship with the person it came from?
 - c. How did you feel?
 7. Describe your teaching philosophy.
 8. What are some experiences that influence your teaching philosophy?
 9. What are some experiences that influence your approach to teaching?
 10. What were obstacles for you in becoming a science teacher?

11. How does your approach to science instruction make science more accessible to students?
 - a. What about Black children and Black girls in particular?
12. What are some of your worst experiences in science teacher education?
13. Who are your role models in science and science education?
14. Imagine you have been asked to create a science course. You are told you have access to anyone you need, an unlimited amount of money and resources, and however much space you need. Please use the google slides to illustrate as needed.
 - a. What would you teach?
 - b. How would the classroom be set up?
 - c. Describe what a lesson might look like?
 - d. How do students interact with each other?
 - e. Who would you work with?
15. What type of support do you think new teachers need to be successful?
16. How do you make your classroom feel welcoming?
17. Do you participate in professional teaching organizations?
18. Do you plan to be a teacher until you retire?

Interview 3:

This will be a semi-structured interview. These questions serve as a guideline and may change as fits responses.

Introduction

Thank you for participating in this study and coming to this interview. The purpose of this study is to understand the experiences of Black women who have chosen to become science teachers.

During this interview you will be asked to speak about your teacher education program and your experiences during it and your beliefs about science teaching.

You agreed in your consent form to recording this interview. Do you have any questions about the consent form or recording? I will begin recording now.

Remember that there are no right or wrong answers, so please be honest in helping me understand your experiences and perspectives.

1. Please tell me about the demographic makeup of the classes you currently teach.
2. Please describe your relationship with your administrators. If you have any experiences with racism or sexism please do not name the individual.
3. Please describe your relationship with your coworkers. If you have any experiences with racism or sexism please do not name the individual.
4. How do you think being a Black woman has influenced your teaching experiences? If you have any experiences with racism or sexism please do not name the individual.
 - a. Please provide examples.
 - b. How did these experiences make you feel?
5. Please tell me how you feel about the school where you currently work.
 - a. If you have worked at other schools please tell me why you moved.
6. What are supports you think would improve your teaching experience this year?
7. What do you think are the most important aspects of teaching science?
8. How do gender, race, and ethnicity impact your teaching?
 - a. Did your teacher preparation program ever discuss this?
9. What are things you think your teacher preparation program did not prepare you for that you think it should have?

10. Questions about journal entries, lesson plans, & checklists

11. If I have clarifying questions or make plans to continue this study, are you ok with being contacted for follow-up?

APPENDIX F

RESEARCHER JOURNAL EXCEPRT

Ms. Z's deciding to address the Flint Water Crisis feels very brave considering she had already had multiple interactions with blatantly racist parents and students. This is especially true considering how little her administration did to support her. It makes it clear how important she feels it must be to address real world issues related to race in her classroom. I think it's interesting that students were unaware of the Flint Water Crisis or that cities have dealt with contaminated water. She noted that they learned more than their original goal which highlights how flexibility and real life examples can enhance student learning. Ms. Z also talked about having discussions with students about who is missing from history in chemistry. I really wish I could have been in the classroom to observe these discussions! In general, Ms. Z's journals really show a dedication and interest in her students. You can tell she feels proud of them. Some of the codes from journaling including 'going beyond curriculum', 'resisting revisionist history', and 'engaging student interest.' I'm beginning to consider if everything coded as 'going beyond curriculum' could fit into a different code that would give me a better idea of HOW participants are going beyond curriculum.

Questions I have for Ms. Z after reading her journal –

- What students are in her class? I know she mentioned the school being pretty evenly split between Black and White student populations, but she teaches honors. Advanced classes often

don't have many Black students. And I'm curious about which students are having these conversations.

- How did the conversation about Flint and the conversation about who is missing in the history of chemistry come about? How did those conversations make her feel?

- Her journal entries all mention how engaged students are. What does she think sustains that in her classroom?

- She mentions deviating from the curriculum some. How often does this happen? How does she manage time and school/district expectations?