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Krystal L. Williams

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Abstract

This chapter focuses on the experiences of Black undergraduate women, with an emphasis on factors that hinder and help to promote their successful progression to STEM degrees. In doing so, the chapter explores existing research concerning how their experiences may be shaped by their gender and race, as well as the combination thereof. The chapter begins with some important contextual information to frame the discussion of literature that follows. This entails defining STEM as a concept, as well as a discussion of the national STEM policy agenda. The second section of the chapter provides a thematic review of current higher education literature concerning Black women's experiences in STEM, detailing frameworks that are common in the literature and covering issues such as the complexities of race-gendered stereotypes in STEM, along with Historically Black Colleges and Universities (HBCUs) and Black women's STEM experiences. The third section of the chapter proposes a conceptual framework that combines the literature concerning Black women's challenges pursuing STEM degrees and their sources of support to better understand how both can ultimately impact their STEM success. The chapter closes by highlighting important limitations in existing research and offering suggestions for future work.

Keywords

Black women · Higher education · Intersectionality · Critical Race Feminism · Double bind · Black Feminist Thought · Role strain and adaptation · Equity · Broadening participation in STEM · STEM education · Undergraduate students · National STEM policy · Underrepresented groups · HBCUs · Higher education environments · Race · Gender · Resilience · Stereotypes · STEM

Introduction

I'm in this lecture that is like 300–400 students. I know I'm going to walk in and be one of five Black students, almost certainly going to be the only Black woman in the room. . . We wanted to make sure that Black women were (at) the center because the issue at hand was being Black and a woman. (Gabrir, 2023)

In 2022, a group of Black women undergraduates at Arizona State University (ASU) took a trailblazing, space-creating step to establish a student organization focused on addressing the needs of and creating community for Black women pursuing STEM majors. The opening quote from the organization's Vice President (Debbie Kariuki) provides context for why this organization was desperately needed. Similar to ASU, many Black women pursuing STEM degrees at other universities find themselves in academic spaces where they are one of only a few Black students in the room, and the only Black woman—underscoring the need to center their unique experiences as being Black and woman simultaneously.

The representation challenges concerning Black undergraduate women in STEM exist within a larger, global context of gendered and race-gendered inequities. Many parts of the world have entered what is commonly referred to as the Fourth Industrial Revolution—an era in which technologies (e.g., artificial intelligence and the Internet of things) are changing the way that people live, work, and interact (Schwab, 2017). Despite the increasing entwinement between technology and everyday life, there is a growing global concern about the educational and professional opportunities for women in many STEM fields that are at the forefront of technological advancements. Content from a recent World Economic Forum Annual Meeting illustrates this point by noting the global underrepresentation of women in STEM, the critical connection between gender equity and economic stability, and the need to ensure women's STEM equity and inclusion for future economic sustainability (Özdemir, 2023). While the report warns of general issues concerning the global underrepresentation of women in STEM fields, it also notes the particular underrepresentation of “women of color.”

Unfortunately, the educational and workforce patterns of (under)representation and gender (in)equities that manifest in many STEM fields on a global level are also prevalent within the United States. This is true when considering the representation of all women; women from racially marginalized groups (Rincon & Yates, 2018); and Black women in particular. For instance, women's underrepresentation in engineering has been longstanding. However, the number and share of women earning bachelor's degrees in engineering has increased over time—albeit not to a point of equitable representation. In 2008, women earned almost 13,000 bachelor's degrees in engineering, a number that more than doubled by 2018. Also, the share of all engineering undergraduate degrees conferred to women during that period increased almost 4 percentage points (National Center for Science and Engineering Statistics, 2021).

For Black women, the data tells a slightly different story. Similar to all women, Black women also have well-documented representation challenges in engineering. In fact, this field has one of the lowest shares of Black women among the various STEM disciplines. The number of Black women who earned bachelor's degrees in engineering increased from a little under 900 in 2008 to a little over 1200 two decades later. Despite this increase in the number of Black women who earned engineering degrees, the share for this group decreased from about 1.4% in 2008 to about 1.1% in 2018—both estimates are abysmally low given the general representation of Black women within the US population (National Center for Science and Engineering Statistics, 2021; United States Census Bureau, 2022).

At a high level, this data points out a very important takeaway: while there are some overall representation challenges for women in certain STEM fields, this group is not monolithic. Specifically, the representation inequities for Black women can differ from those of women in general. Similarly, Black women's (under)representation and related experiences in STEM fields can also differ from their Black male counterparts (Charleston et al., 2014b). Because of these important distinctions, a particular body of literature has emerged to explore the unique educational experiences of Black women pursuing undergraduate degrees in STEM—experiences that

are not only shaped by their gender but also by their race and often their race and gender combined. This chapter synthesizes key aspects of this corpus of research and related topics. The chapter focuses on the experiences of Black women who are undergraduate students with an emphasis on factors that hinder and help to promote their successful progression to STEM degrees as opposed to an explicit focus on particular outcomes (e.g., degree attainment or employment). Accordingly, the discussion of existing literature allows for a critical examination of important factors that ultimately shape the student outcomes that are a common focus of higher education discourse. Furthermore, the chapter discusses existing literature concerning the experiences of Black women as defined by other authors' use of terms such as "women" and "females" to describe the participants in their studies. The discussion that follows is organized in four distinct sections.

The first section begins with some important contextual information to frame the discussion of literature that follows. This entails a close examination of STEM as a concept, including a discussion of how it has evolved over time, the ways it is operationalized within various contexts, and how such operationalization can shape discussions about Black women's STEM representation. Next, this section outlines the importance of STEM education issues within the USA by discussing the national STEM policy agenda and legacy of federal support in this area. Also, examples of Black women's contributions to federal STEM policy agendas are provided, as well as a discussion of the ways that these agendas have the potential to shape opportunity structures that impact this demographic. Afterward, various rationales for an increased national emphasis on STEM outcomes are discussed as a way of framing some of the prevailing issues regarding the need to increase STEM participation for diverse populations—especially Black women. The final section of contextual information utilizes recent data from the National Science Foundation (NSF) concerning STEM degree attainment to examine Black women's representation challenges within specific STEM fields relative to similarly situated demographics that are often marginalized in these disciplines due to their gender (i.e., all women) or their race (i.e., all Black individuals).

The second section of the chapter outlines current higher education literature concerning Black women's experiences in STEM. It begins with a primer on theory, detailing frameworks and concepts that are common in the literature on the college experiences of Black women in STEM. Next is a discussion of literature concerning race, gender, and the complexities of intersectional marginalization based upon Black women's race and gender. It follows with a discussion of research concerning the stereotypes that many Black woman college students experience in STEM fields (i.e., gender norms, being treated as mummies or jezebel, etc.) and how they work in service to their overall marginalization. Then studies concerning Black women's isolation and subordination within collegiate settings are discussed, as well as how unwelcoming institutional environments can ultimately create a sense of loneliness and onliness related to their underrepresentation. Thereafter, research findings concerning Black women's resolve as college students in STEM are considered, with an eye toward their sources of resilience and the unexpected negative consequences of being resilient. The final part of this section of the paper closely examines

the literature concerning Historically Black Colleges and Universities (HBCUs) and Black women in STEM, outlining the ways in which these institutions have helped to foster successful outcomes for these students, as well as areas for improvement.

The third section of the chapter proposes a conceptual framework (i.e., the role strain and adaptation model for Black women's STEM success in college) which combines the literature concerning Black women's challenges pursuing STEM degrees and their sources of support to better understand how both can ultimately impact their STEM success. The chapter closes by highlighting important limitations in existing research and offering suggestions for future work.

What Is STEM?: Defining a Complex Concept

As context for discussing extant literature about the collegiate experiences of Black women in STEM, it is helpful to review important background information about the STEM concept, the complexities therein, and how it is commonly defined. The term "STEM" is generally used to refer to science, technology, engineering, and mathematics, and its origins are somewhat convoluted. Some credit the NSF for initially coining the term as SMET (i.e., science, mathematics, engineering, and technology) and later replacing it with STEM—the acronym commonly used today (Salinger & Zuga, 2009). Given the NSF's role in creating the concept, its definition is often employed as a guiding framework for what fields are encompassed under the STEM umbrella. This definition includes psychology and social sciences (e.g., anthropology, economics, and sociology), along with fields traditionally framed as core sciences (e.g., math, physical science, and computer sciences) and engineering (National Center for Science and Engineering Statistics, 2021). In addition to the NSF, other federal agencies offer a definition of STEM such as the Department of Homeland Security (n.d.) which includes four core areas—engineering, biological sciences, mathematics, and physical sciences—as well as related fields that involve "research innovation or development of new technologies using engineering, mathematics, computer science, or natural sciences."

Just as the STEM concept is used by multiple entities to represent a collection of various fields, variations of the acronym have emerged to emphasize other fields that are either within this overarching moniker or related to the fields therein. Alternate acronyms include things such as STEMM (i.e., science, technology, engineering, and medicine) which underscores aspects of health sciences ("National Academies", 2022) and STEM/CS which specifically denotes the inclusion of computer science in science, technology, engineering, and math (US Department of Education, n.d.). Moreover, other related acronyms emphasize connections across disciplines not generally affiliated with science, technology, engineering, and mathematics. For instance, STEAM (i.e., science, technology, engineering, arts, and mathematics) highlights the benefits of infusing art techniques in STEM subjects (Catterall, 2017).

It should be noted that the overarching STEM concept aggregates a number of fields that have specific subdisciplines. For example, the "E" in STEM includes several areas within engineering such as electrical engineering, chemical

engineering, computer engineering, petroleum engineering, mechanical engineering, etc. Such nuances can be overlooked when the overarching STEM concept is the focus. However, within education, some note the utility of the overarching moniker in facilitating integrated learning contexts that combine the principals of two or more STEM domains to enhance student learning and facilitate real-world problem-solving (Kelley & Knowles, 2016).

While STEM is a complex concept that can be defined in multiple ways, it is important to note that a specific approach to defining STEM may ultimately shape larger discussions about Black women's representation within these fields. As detailed in a subsequent section, Black women's representation varies within the different underlying disciplines included within the STEM umbrella. For example, the NSF definition of STEM includes psychology and the social sciences which have larger numbers of Black women. However, the definition provided by the Department of Homeland Security focuses more on engineering, biological sciences, mathematics, and physical sciences where there are fewer Black women represented. Hence, the nature of how STEM is conceptualized can ultimately be a defining characteristic of how related discourse about (under)representation in STEM manifests.

Given the varying STEM definitions, the discussion of extant literature later in this chapter will focus on STEM defined in the broadest terms, largely driven by the framing which authors employ in their writing. The studies considered in this review focus primarily on the "core sciences" mentioned previously. In some research, authors specifically note the STEM umbrella and discuss the experiences of Black women across different STEM disciplines. In other instances, authors focus on specific STEM fields (e.g., physics or biological sciences) or even STEM content areas that may cut across various STEM disciplines (e.g., computing which may include computer science, information technology, computer engineering, etc.). To offer the most comprehensive discussion of existing literature, each of these bodies of work are included in the research that is reviewed.

The National STEM Policy Agenda and Legacy of Federal Support

In the past year alone, Federal strategic plans and reports have called out the importance of STEM education to achieving national goals in areas including national security, artificial intelligence, cybersecurity, quantum information science, and advanced manufacturing. There can be no doubt that STEM education continues to be a significant priority for the United States. (The National Science and Technology Council, 2018, p. 3)

STEM and STEM education issues have a longstanding history of federal investments, albeit to varying degrees based on prevailing national concerns and changes in administration. The discussion that follows outlines key aspects of the national STEM policy agenda and related investments. In doing so, special attention is given to federal foci on STEM equity issues from various national offices and agencies that either help to shape national STEM and STEM education policy or support existing

STEM policy agendas. Moreover, examples of Black women's contributions to those efforts are provided, along with a discussion of the ways in which STEM policy agendas have the potential to shape opportunity structures that impact this demographic. While a detailed discussion of Black women and their overall involvement in the national STEM policy agenda is beyond the scope of this paper, examples of Black women who are often underacknowledged in these areas are discussed to illustrate their contributions to these critical areas of national need.

Tracing Components of the Federal STEM Policy Agenda

Some scholars trace the emphasis on STEM education in the USA to the colonial era and Benjamin Franklin's suggestions to incorporate topics such as planting, mechanics, and grafting in youth education in Pennsylvania (Salinger & Zuga, 2009). Moreover, the Morrill Acts of 1862 and 1890 resulted in the establishment of land-grant institutions which emphasized mechanical arts and agriculture—subjects generally included within STEM content areas (Gonzales & Kuenzi, 2012). An increased federal emphasis on STEM is often affiliated with the Sputnik Era and its focus on the USA's international competitiveness in relation to technology and innovation. Russia launched the world's first artificial satellite, Sputnik I, on October 4, 1957, marking the start of a space race between the USA and USSR (NASA History Division, n.d.). In response to Sputnik's launch, the National Defense Education Act (NDEA) was passed in 1958 to foster educational advancements in science, mathematics, and modern foreign languages, as well as training in technology. Provisions of this act included authorization of the first federal student loan program, along with state funding for (1) instruction in science, mathematics, and foreign languages and (2) programming for gifted students (Gonzales & Kuenzi, 2012). Also, the space race was instrumental in the development of the National Aeronautics and Space Administration (NASA) under the Eisenhower Administration. President Kennedy continued the push for innovation, expanding the space program in 1961 and committing the nation to landing a man on the moon by the end of the decade (John F. Kennedy Presidential Library and Museum, n.d.). Each of these developments was shaped by scientific advancements in another country. The USA's response illustrates the ways in which international competition has helped to inform federal STEM policy agendas and investments.

While the importance of the space race and its influence on technological development is often discussed, what is less known are the important contributions that Black women made to these efforts and, by extension, to meeting federal policy agendas concerning scientific advancements. Black woman scientists were instrumental in helping to advance these policy aims, although their contributions were often hidden. In recent years, popular press has made some of these efforts more visible by highlighting the work of individuals such as Mary W. Jackson, Katherine Johnson, and Dorothy Vaughan whose technical expertise was critical to the initial space missions (National Aeronautics and Space Administration, 2017a). Additionally, other Black women have been acknowledged recently for their role in the

overall success of the space program. This includes Dr. Christine Darden, a NASA aeronautical engineer renown for her research on sonic boom reduction (National Aeronautics and Space Administration, 2022), and Dr. Patricia Cowings, a NASA psycho-psychologists who studied space sickness among astronauts and ways to control it (National Aeronautics and Space Administration, 2017b). Each of these Black women served as trailblazers whose work supported federal goals in STEM-related areas.

Today, key aspects of the federal STEM policy agenda are reflected within the work of the White House Office of Science and Technology Policy (OSTP)—an office established in 1976 to coordinate federal science and technology policy and to provide the President with guidance on advances in science and technology. The mission of this office is to “maximize the benefits of science and technology to advance health, prosperity, security, environmental quality, and justice for all Americans” (The White House, n.d.-b). Anchored by this overarching objective, the OSTP includes policy teams to advance critical federal science and technology priorities in areas such as energy; health and life sciences; and national security. While each of these policy teams focus on important issues of national concern, the Science and Society Team has a more tailored emphasis on equity issues in science and technology. A more recent addition to OSTP, the Science and Society Team “advances the President’s commitment to ensuring all of America can participate in, contribute to, and benefit from science and technology” by directing efforts to broaden participation in STEM and to “ensure that all Americans have equitable access to the benefits of new and emerging technologies and scientific innovation” among other priorities (The White House, n.d.-a). Furthermore, this team directs an initiative, The Time is Now, which is designed to advance equity across the science and technology ecosystem by removing structural barriers to equitable participation for marginalized and underserved populations (The White House, n.d.-a). Part of this initiative included a series of roundtables to foster public engagement and have candid and robust conversations “to gather valuable feedback that can assist OSTP in assuring that our national science and technology ecosystem is preeminent, equitable, and inclusive” (The White House, 2021c). One roundtable focused on diversity, equity, inclusion, and anti-racism in STEMM (The White House, 2021b), while another focused on the impacts of COVID-19 on women in STEM, noting that “women of color” occupy multiple marginalized identities and have encountered long-standing structural barriers in their STEM career pursuits (The White House, 2021a). Neither roundtable was specifically tailored to examine the unique experiences of Black women in STEM; however, the insights offered may have implications for this demographic.

Another important White House science and technology organization that informs current federal STEM education policies is the National Science and Technology Council (NSTC) whose objectives include ensuring that “science and technology policy decisions and programs are consistent with the President’s stated goals” and preparing “research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals” (The National Science and Technology Council, 2018). In 2018, NSTC published a

5-year strategic plan for STEM education titled *Charting a Course for Success: America's Strategy for STEM Education* (The National Science and Technology Council, 2018). This plan is guided by a desire for all Americans to have lifelong access to high-quality STEM education, and for the USA to be the global leader in STEM literacy, innovation, and employment. Its purpose is to strengthen the federal commitment to equity and diversity; evidence-based practice; and engagement with the national STEM community via nationwide collaborations with key stakeholders (i.e., learners, families, educators, communities, and employers) (The National Science and Technology Council, 2018). The plan includes three aspirational goals: (1) build a strong foundation in STEM literacy for all American citizens via opportunities to master basic STEM concepts; (2) increase diversity, equity, and inclusion in STEM, with an emphasis on historically underserved and underrepresented groups in STEM fields and employment; and (3) prepare the future STEM workforce via authentic learning experiences that encourage young people to pursue STEM careers (The National Science and Technology Council, 2018). While the stated goals do not explicitly target Black girls and women in STEM, they illustrate the ways in which the White House has recently taken up issues regarding STEM representation and increased outcomes as the US citizenry becomes increasingly diverse.

Agencies, Cabinet Departments, and Federal Investments in STEM Equity

In addition to organizations affiliated directly with the White House, various federal agencies play a prominent role in advancing aspects of the national STEM policy agenda. In doing so, many of these agencies include support for equitable STEM outcomes within their larger portfolio of work. For instance, the NSF has been instrumental in helping to shape conversations regarding STEM and related education issues, increasingly with an emphasis on expanding opportunities in these fields. In 1950, the NSF was created during the Truman Administration to “encourage and develop a national policy for the promotion of basic research and education in the mathematical, physical, medical, biological, engineering, and other sciences; to initiate and support basic scientific research in the sciences; and to evaluate the scientific research programs undertaken by agencies of the federal government” (The National Science Foundation, n.d.-c). Currently, the agency continues to make substantial contributions to “basic research and people to create knowledge that transforms the future,” noting that this type of support helps to drive the US economy, enhances national security, and generates knowledge that sustains global leadership (The National Science Foundation, n.d.-c). To this end, Congress allocated \$8.8 billion to NSF during fiscal year 2022, and this agency supported a quarter of all federally funded basic research conducted by American institutions of higher education. Moreover, the NSF is the major source of federal support in some STEM fields such as mathematics, computer science, and the social sciences (National Science Foundation, n.d.-a, n.d.-b).

While the NSF generally supports basic research in many STEM areas, the agency also provides targeted funds to broaden participation in STEM. The organization's portfolio of work in this area cuts across various programs, and specific investments include things such as research centers, capacity building awards, and funded partnerships (National Science Foundation, [n.d.-b](#)). Moreover, the NSF review criteria attends to the ways in which proposed projects and activities align with the agency's efforts to broaden STEM participation. Although the NSF's broadening participation portfolio includes programs where such an emphasis is one of many, other programs focus specifically on this objective. For example, NSF ADVANCE focuses on equity for STEM faculty and provides grants to "enhance the systemic factors that support equity and inclusion and to mitigate the systemic factors that create inequities in the academic profession and workplaces" (National Science Foundation, [2019](#)). Moreover, the NSF notes that all ADVANCE proposals "are expected to use intersectional approaches in the design of systemic change strategies in recognition that gender, race and ethnicity do not exist in isolation from each other and from other categories of social identity" (National Science Foundation, [2019](#)). Such framing provides fruitful opportunities to explore the experiences of Black women in STEM at the intersection of their racial, gender, and other identities.

Similarly, a more recent NSF funding stream, Racial Equity in STEM Education, supports "bold, groundbreaking, and potentially transformative projects that contribute to advancing racial equity in STEM education and workforce development through practice and/or fundamental or applied research" (National Science Foundation, [2022b](#)). Some NSF programs to broaden participation build upon the contributions of minority-serving institutions and provide specific funding for these colleges and universities. This includes programs such as the Tribal Colleges and Universities Program (National Science Foundation, [2021](#)); Improving Undergraduate STEM Education: Hispanic-Serving Institutions (National Science Foundation, [2022a](#)); and the Historically Black Colleges and Universities Undergraduate Program (National Science Foundation, [2023](#))—all of which support institutions that disproportionately educate racial/ethnic groups that continue to be underrepresented in many STEM areas.

As discussed, the NSF offers multiple funding opportunities to explore and address STEM inequities at various levels. Although such foci are not specific to Black women, the broad nature of the content areas and specific attention to intersectional approaches provide opportunities to examine the experiences of this particular group. While these opportunities are an important aspect of a larger emphasis on broadening pathways into and through STEM areas, research suggests the need for more attentiveness to not only what is studied (i.e., the research topical areas and a need to focus on expanding opportunities) but also who is provided NSF support to conduct those studies (i.e., the demographic makeup of Principal Investigators (PIs)). Literature highlights persistent disparities in funding opportunities that advantage White PIs over non-White PIs (Chen et al., [2022](#)). Hence, although

the topical areas for funding have increasingly afforded opportunities to explore STEM barriers for underrepresented groups such as Black women, evidence suggests a need for more focused attention on diversifying the backgrounds of scholars conducting the research that the NSF funds.

In addition to the NSF, the US Department of Education (DOE) is a cabinet department that plays an important role in federal STEM investments. The DOE executes the President's educational policies and coordinates most federal assistance in educational arenas (US Department of Education, 2010, 2018). While education is often contextualized as a state and local responsibility (US Department of Education, 2021), the DOE supports and complements the efforts of states, local school districts, and other state instrumentalities (US Department of Education, 2018). As noted previously, the expanded federal role in education can be traced back to larger national concerns about science education across the country after the successful launch of Sputnik. Currently, several offices in the DOE support STEM education issues across the education spectrum including the Office of Planning, Evaluation, and Policy Development (OPEPD); Office of Career, Technical, and Adult Education (OCTAE); Office of Elementary and Secondary Education (OESE); Office of Special Education and Rehabilitative Services (OSERS); Office of Postsecondary Education (OPE); and Office of Non-Public Education (ONPE), among others (US Department of Education, n.d.). Moreover, a STEM Newsletter was created in February of 2020 to "increase the Department's audience and reach and better serve and communicate with our STEM stakeholders."

The DOE makes substantial financial investments in STEM which align with the national policy agenda concerning educational outcomes in these fields. During the 2020 fiscal year, the DOE awarded \$578 million to STEM projects (US Department of Education, 2020). The specific STEM initiatives that were funded varied; however, one which focused on higher education and has specific implications for Black women is the Minority Science and Engineering Improvement Program (MSEIP) which "assists predominantly minority institutions in effecting long-range improvement in science and engineering education programs and increasing the flow of underrepresented ethnic minorities, particularly minority women, into science and engineering careers." In fiscal year 2020, \$12.6 M was provided to MSEIP (US Department of Education, n.d.). DOE support for equity in STEM education is further illustrated by the guidance the US Secretary of Education, Dr. Miguel A. Cardona, provided regarding discretionary grant programs. Within this guidance, Secretary Cardona outlined six strategic priorities, one of which specifically notes the need for investments in equitable access to rigorous, engaging, and well-rounded approaches to learning which are inclusive across various domains (e.g., race, ethnicity, culture, language, and disability status) and prepare students for college, career and civic life in STEM (US Department of Education, n.d.). Collectively, the work of cabinet departments like the DOE and agencies like the NSF illustrate various aspects of the federal government's focus on STEM education policy issues, with an increasing emphasis on diversity issues.

Framing the Issue: Prevalent Rationales Supporting an Increased Emphasis on STEM Participation

Various rationales have been offered which undergird and support the aforementioned federal emphasis on increasing STEM participation. Two that are especially prevalent include the need to (1) maintain the USA's international competitiveness in innovation and technology and (2) develop talent (i.e., students) that has experienced long-standing opportunity barriers to prepare and succeed in STEM. The former rationale has a more general focus on increasing the number of students from all backgrounds in STEM, and the latter emphasizes opportunities for those that are highly underrepresented in these fields. Despite their general utility, neither rationale has been employed broadly to address the unique need to increase STEM participation for Black women. The discussion that follows outlines each of these rationales, noting their limitations with regard to expanding STEM opportunities from an intersectional perspective that impacts Black women.

The *maintenance of US competitiveness rationale* builds upon the narrative which dominated the Sputnik era, focusing on international competitiveness and the USA maintaining a leadership role in technology and innovation. This rationale provides the logic often undergirding many policy discussions regarding the need to chart a different path within the new global environment—one that invests more heavily and intently in the STEM enterprise. The *maintenance of US competitiveness rationale* is often used to bolster a general push to include more students of all backgrounds in STEM pathways—a point that reflects (1) the limited number of individuals pursuing professions in critical STEM fields of national importance within the USA and (2) an overall need to increase the number of people in those STEM professions regardless of their backgrounds. Examples of this rationale abound. For instance, in a testimony before the US House of Representatives Committee on Science, Space, and Technology titled *Losing Ground: US Competitiveness in Critical Technologies*, Dr. Diane L. Souvaine, chair of the National Science Board, shared the following insight: “In this new global context, relying on an ever-increasing influx of individuals from other countries is not a sustainable long-term strategy for maintaining a thriving, competitive US S&E enterprise. Our ability to discover, invent, and innovate relies on our ability to develop, attract, and retain our domestic S&E talent while continuing to welcome researchers from around the world” (National Science Board, 2020). A report by the RAND National Defense Research Institute—a federally funded research and development center—echoes the *maintenance of US competitiveness rationale*. This report titled *US Competitiveness in Science and Technology* was produced by the Office of Security Defense. In it, the following policy recommendation was suggested which speaks to education and the country's need for heavy STEM investments to sustain its leadership in science and technology: “Continue to improve K-12 education in general and S&T education in particular, as human capital is a main driver of economic growth and well-being” (Galama & Hosek, 2008). Both examples illustrate an underlying concern about maintaining what is often perceived as a deteriorating US advantage in global STEM competitiveness. However, a general focus on

expanding opportunities for all may be an insufficient approach to address the needs of Black women in race-gendered ways.

The limited number of individuals pursuing STEM professions within the USA has prompted some to advocate for immigration policies that emphasize adding more highly skilled non-US residents to the workforce (Galama & Hosek, 2008). However, as opposed to talent importation, another prevalent rationale for increased STEM educational investments focuses on developing untapped talent within the USA (The National Science and Technology Council, 2018). While there is a general need to increase the number of individuals who pursue STEM professions in many fields, the STEM participation for women and individuals from certain racial/ethnic groups is especially abysmal. The *untapped talent rationale* illustrates that the push to increase STEM participation and maintain US competitiveness is ultimately undermined by neglecting an important and expanding demographic within the country—those from racially marginalized groups. This rationale is often part of larger narratives regarding social justice and STEM equity (Ireland et al., 2018). It is apparent in testimony given before the US House of Representatives Committee on Science, Space, and Technology in 2019. During this session, Dr. Shirley Malcom, a senior adviser at the American Association for the Advancement of Science (AAAS) and the director of AAAS' SEA Change Initiative (i.e., an institutional transformational initiative), remarked that having a workforce that will deliver future innovation and meet tomorrow's challenges will require "expanding the pool of talent, tapping into the vast well of women, minorities, racial and ethnic, and people with disabilities currently underrepresented in STEM." Dr. James Moore III, Vice Provost of Diversity and Inclusion at the Ohio State University, shared similar sentiments during his testimony concerning the need for early interventions for specific groups often left on the margins of opportunity in STEM, "We need to be innovative and inclusive in the way we recognize talent. . . We are missing too many promising students before they even reach our doorstep simply because of their zip code" (Hoy, 2019). Moreover, the logic undergirding the NSF broadening participation in STEM initiative also reflects aspects of the untapped talent rationale. A key component of the initiative is to increase underrepresented communities' involvement in science and engineering and to "unleash STEM talent" by developing a more diverse STEM workforce (National Science Foundation, n.d.-b).

While the untapped talent rationale highlights the need to expand opportunities for groups that have historically been underrepresented in many STEM areas, it has generally been used to focus on the need to bolster opportunities for either women or individuals from underrepresented racial/ethnic groups. What is less often considered are the unique opportunity barriers for individuals at the intersection of multiple oppressed identities within STEM—such as Black women whose experiences may be different because of their race and gender combined. There have been some recent attempts to highlight these challenges in a more nuanced way. For example, guided by an intersectionality framework, the most recent National Center for Science and Engineering Statistics (NCSES) report titled *Women, Minorities, and Persons with Disabilities in Science and Engineering* discusses specific degree outcomes for women that are Latinx, Black, Native Hawaiian/other Pacific Islander, and Asian.

In doing so, the report notes the importance of analyzing differences in science and engineering degree outcomes by race/ethnicity and sex because experiences with racial discrimination and sexism can make racially marginalized women's experiences with inequality different from that of White women or men from the same racial/ethnic group. While this approach to data reporting may fall short of fully explicating combined forms of oppression in STEM in nonadditive ways, it represents a much-needed movement toward examining the unique experiences of certain groups of women (including Black women) in STEM. Building upon that focus, the next section of this chapter takes a closer examination of data from NCSES with an emphasis on undergraduate outcomes for Black women across various STEM fields, noting how outcomes for this group compares or differs from all women, as well as the general Black populous.

Who Is Underrepresented and Where?: Exploring the STEM Representation Terrain for Black Women at the Discipline Level

As previously discussed, the term “STEM” is multifaceted and represents a concept in and of itself, in addition to the underlying disciplines therein. Some scholars note the importance of taking an interdisciplinary and integrative approach to thinking about STEM. Instead of thinking of STEM as four related but distinct disciplines, the suggestion is to think of it as an overarching concept that individuals draw from to generate or validate new knowledge, engage problem-solving, or produce products (McComas, 2014). While it is important to acknowledge the benefits of an interdisciplinary approach that connects various STEM disciplines conceptually, especially in relation to instructional approaches and advancing students' overall STEM literacy, from an equity perspective, it is also important to disaggregate the data across STEM disciplines for a more detailed examination of representational issues and barriers for certain demographic groups—especially Black women who are substantially underrepresented within many STEM disciplines.

While the larger narrative around diversity issues in STEM suggests a general trend of underrepresentation for women and many individuals from racially marginalized groups, STEM diversity issues can often vary within specific STEM fields. Moreover, the representation challenges can differ for specific underrepresented groups.

Figure 1 provides some insights into these differences by illustrating baccalaureate degree attainment within specific STEM fields by gender and racial/ethnic background, with a particular focus on all females, all Black individuals, and Black females. This data is displayed for 2018—the most recent year available at the time of this writing via the NSF NCSES. Given the various definitions of STEM previously discussed, this figure focuses on key fields often emphasized by the NSF.

In addition to information about representation for these groups, the figure includes estimates of their general demographic representation within the USA as reference points. For example, during 2018, females represented about 51% of the overall US population (United States Census Bureau, 2022); hence, this reference

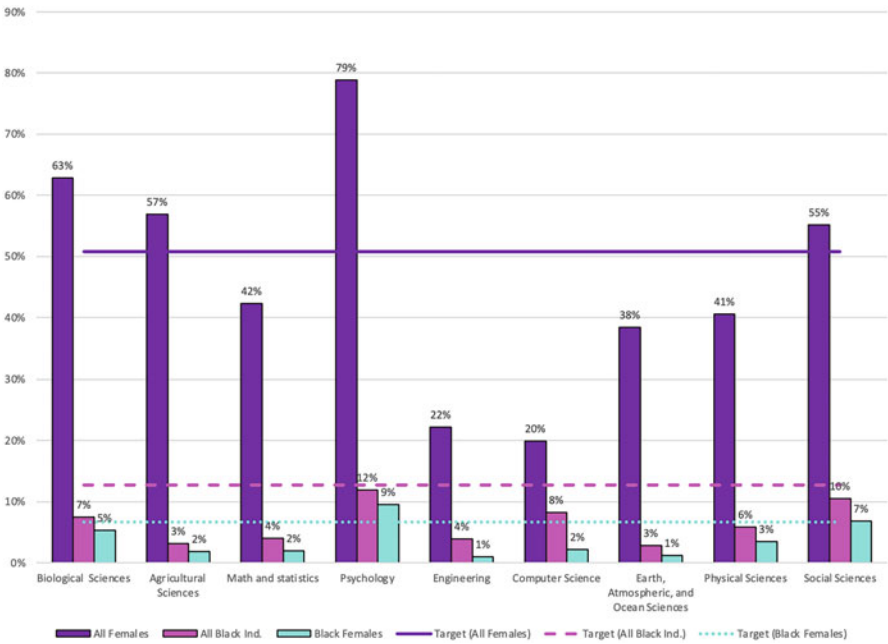


Fig. 1 Gender and racial/ethnic representation in STEM fields (2018). (Data sources: NSF National Center for Science and Engineering Statistics and United States Census Bureau)

point (i.e., target) is used as a comparison to determine if their representation within particular STEM disciplines aligns with their general demographic representation. Ideally, a group’s representation in a given STEM discipline will be similar to its overall representation within the USA. The data in Fig. 1 allows for a more nuanced examination of representation issues by gender and race/ethnicity within specific STEM fields based upon degree attainment data for a cohort of recent college graduates.

Figure 1 suggests that while the noted groups are underrepresented as graduates within many STEM fields, there is some variation across fields and across groups. Issues concerning representation challenges for Black women can differ from all women, as well as the general Black populous. The data concerning all women suggests that this group is overrepresented among graduates within a number of STEM areas—biological sciences, agricultural sciences, psychology, and social sciences—with the proportion of degrees conferred to this group exceeding 51%. For instance, in 2018, women earned 79% of bachelor’s degrees in psychology and 63% of bachelor’s degrees in biological sciences. In all of the other fields considered, females are generally underrepresented, with their representation being especially low in engineering and computer science where females earned 22% and 20% of bachelor’s degrees in these fields, respectively.

Unlike all females, Black females are only overrepresented among graduates in one STEM discipline—psychology. During 2018, Black females comprised about

7% of the overall US population and earned 9% of bachelor's degrees in psychology—a 2 percentage point difference. Unlike females overall, Black females' representation among graduates in social sciences was on par with their general population representation, suggesting representational parity. In all other STEM fields considered, Black females are underrepresented. In many instances, Black females only earned 1% or 2% of bachelor's degrees in specific fields, suggesting a 5 or 6 percentage point difference between their representation within STEM disciplines and their general representation in the population. To put these numbers into context, in engineering that would be equivalent to an additional 7500 Black female engineers among 2018 graduates if representation inequities did not exist. In computer science, this would represent a gain of almost 4000 Black female computer scientists.

Regarding a within race/ethnicity comparison, Fig. 1 suggests representational differences in degrees conferred for Black women compared to all Black individuals. During 2018, Black individuals were underrepresented in each of the STEM fields considered, including slight underrepresentation in psychology—a field where Black women are slightly overrepresented as previously discussed. The representational differences between Black women and all Black individuals reflect a difference in STEM degrees conferred to Black women and Black men. These statistics highlight the benefits of disaggregating data not only by race **or** gender but by race **and** gender to better explicate representational challenges for specific underrepresented groups. Moreover, it highlights the need for a more nuanced discussion of individual STEM disciplines and the representational challenges of particular demographics therein. Given that Black women occupy a position of dual underrepresentation in STEM resulting from their race and gender, this chapter seeks to better understand existing literature regarding their unique experiences.

A Primer on Theory: Frameworks and Concepts Common in the Literature on Black Women in STEM

Before delving deeply into the literature about the collegiate experiences of Black women in STEM, it is helpful to begin with a primer concerning the theories and frameworks that undergird much of this research. Although some studies employ frameworks such as cultural border crossing and resiliency (Ferguson & Martin-Dunlop, 2021), and others rely on theories regarding organizational culture and student engagement to investigate the nature of college campuses (Lockett et al., 2018), many studies on Black women's STEM experiences are situated within critical traditions that critique power and structural subordination. The discussion that follows outlines various frameworks and theories that are central in shaping research concerning Black women collegians in STEM. This includes a discussion of the double-bind concept (Malcom et al., 1976), Critical Race Feminism (Wing, 2003), Black Feminist Thought (Collins, 1990, 2000), and Intersectionality (Collins & Bilge, 2016, 2020; Crenshaw, 1989, 1991). While not an exhaustive treatment of

these concepts, the following provides important insights about how these schools of thought have helped to inform extant literature on Black women in STEM.

The Double Bind: Framing Issues of Underrepresentation

The term “double bind” is often used in literature concerning the experiences of Black women and other women from racially marginalized groups in STEM (Cross et al., 2017; Ireland et al., 2018; Malcom et al., 1976; Ong et al., 2011). It denotes “the exclusion of women of color in STEM and the undermining of their career pursuits because of both racism and sexism” (Ireland et al., 2018, p. 228). The overarching concept dates (at least) as far back as the late 1970s where it was used in a report concerning the Conference of Minority Women Scientists, produced by the American Association for the Advancement of Science (AAAS) Office of Opportunities in Science (OOS) (Malcom et al., 1976). While AAAS is the world’s largest general scientific society with a mission to advance science, engineering, and innovation, the OOS focuses on projects to enhance the participation and advancement of underrepresented groups in science (women, racially marginalized groups, people with disabilities, etc.). The impetus of the conference was the OOS’ observation that its efforts toward broadening opportunities for women were not adequately addressing the unique concerns and experiences of women from racially marginalized groups. Moreover, similar concerns existed about the degree to which efforts targeting “minorities” advanced the concerns of women within that demographic category. As a result, the Conference of Minority Women Scientists was orchestrated to explore the “special problems peculiar to minority women scientists” which were not being addressed because these women were “falling somewhere in between the funded efforts to improve science opportunities for minorities and efforts to advance women in science” (Malcom et al., 1976, p. vii). The convening brought together women within this demographic category in order to better understand their unique experiences and to develop recommendations for addressing prolonged issues within precollegiate, collegiate, career, and professional domains. Solidifying the double-bind concept within STEM lexicon, the report concerning the outcomes of this convening begins by noting that “minority women” represent a disturbingly small proportion of the scientific workforce and their needs are unaddressed by existing programs for “minorities” or women. The authors then note that these women have “traditionally been excluded because of biases related to both their race or ethnicity and gender, constituting a double bind” (Malcom et al., 1976, p. 1). Interestingly, this discussion within AAAS occurred during a point in history where broader discourse concerning historical social agendas related to feminism and gender (in)equality was being critiqued for failing to adequately represent the needs of non-White women (Collins & Bilge, 2020; Pruitt, 2022). Nonetheless, the broader concept of experiencing a double bind related to race-based and gender-based exclusion in STEM and the need to address these issues has provided grounding for work that specifically examines the experiences of Black women in STEM.

Critical Race Feminism: An Anti-Essentialist Critique of Feminism

Critical Race Feminism is also used in studies regarding the experiences of Black women in STEM within various facets of higher education (Charleston et al., 2014b; Decuir-Gunby et al., 2009). Similar to the concept of double bind, this theory emerged out of an interest in better understanding racialized and gendered oppression of non-White women. While Maria Stewart—a Black abolitionist and feminist—is sometimes (though rarely) acknowledged as one of the first women to speak publicly on gender inequality, especially as it relates to Black women (Richardson, 1987), the US feminist movement is often linked to the late 1800s and the Seneca Falls Convention which emphasized women's social and political rights, along with women's suffrage (McMillen, 2008; Tetrault, 2014). While this convention was attended by a number of people (men and women) who previously supported abolition, a politically driven chasm in the movement later emerged related to the extension of voting rights to formerly enslaved Black men before White women—a chasm that ultimately disregarded the extension of rights and (in)equality issues afflicting Black women (Hancock, 2022). This historic omission of Black women's rights in larger feminist discourse provides a framework for understanding critiques of feminism from racially marginalized women and the emergence of concepts such as Critical Race Feminism (Wing, 2003).

Adrien Katherine Wing (2003) provides a useful context for understanding the history, significance, and current utility of Critical Race Feminism (CRF). Wing (2003) describes how CRF is an outgrowth of other critical legal philosophies, including critical legal studies and critical race theory (CRT)—another framework whose usage is often advocated for in research concerning Black women in higher education (Howard-Hamilton, 2003). Moreover, CRF engages critiques of gender oppression common to feminist thought, although it makes a clear departure from feminism by emphasizing the unique marginalization of non-White women. Like critical legal scholars, CRF critiques liberal legalism and conservative doctrine, challenging the “notion of law as neutral, objective, and determinate” (Wing, 2003, p. 4). Similar to CRT, CRF situates itself in the larger discourse concerning the subordination of certain racial groups via white supremacy, with specific attention to the nature of race as a social construct (i.e., the social construction thesis); racism as an ordinary part of US society; a rejection of colorblindness in the legal system in favor of color consciousness and identity politics aimed at rectifying racists legal legacies; and the methodological benefits of storytelling (Wing, 2003). Also, CRF embraces critical race praxis as a means to move beyond theoretical formulations and instead emphasizes the need to involve those who are marginalized in developing solutions to the problems that they face (Wing, 2003).

As it relates to feminist theory, CRF also critiques systems of patriarchy and gender oppression; however, it does so with a more dedicated emphasis on the interest and experiences of women from racially marginalized groups. In doing so, CRF advances the notion of anti-essentialism, noting that feminist traditions position the realities and voices of White middle- and upper-class women as representative of all women (Wing, 2003). Moreover, CRF advances the concept of multiplicative

identity to note that “women of color are not merely white women plus color or men of color plus gender” further explaining that “their identities must be multiplied together to create a holistic One when analyzing the nature of the discrimination against them” (Wing, 2003, p. 7). While not a theoretical lens that is specific to the experiences of Black women, CRF’s focus on multiplicative gender-based and race-based biases have been used to explain Black women’s experiences with combined race and gendered oppression as they pursue STEM degrees.

Black Feminist Thought: A Critical Lens Focused on the Unique Experiences of Black Women

While CRF focuses on anti-essentialism and an equitable analysis of the experiences of various non-White women, Black Feminist Thought (BFT) (Collins, 1990, 2000) provides a more detailed theoretical analysis of Black women’s specific experiences with racism and sexism. Accordingly, BFT is also cited in literature concerning the experiences of Black women in STEM (Allen et al., 2022; Borum & Walker, 2012; Bryson & Kowalske, 2022; Charleston et al., 2014b; Dickens et al., 2021). In some studies, this framework is combined with others such as CRF to further elucidate narrative concerning Black women in these fields (Charleston et al., 2014b).

BFT builds upon various theoretical traditions including Afrocentric philosophy, feminist theory, Marxist social thought, critical thought, and postmodernism (Collins, 1990). It starts with the premise that “African-American women have created an independent, viable, yet subjugated knowledge concerning our own subordination” (Collins, 1990, p. 13). Furthermore, it “consists of specialized knowledge created by African-American women which clarifies a standpoint of and for Black women,” and it “encompasses theoretical interpretations of Black women’s reality by those who live it” (Collins, 1990, p. 22). BFT deliberately centers the voices of Black women, and it does so in a manner that is intentionally accessible to this group given the desire to speak to their lived experiences (Collins, 1990). Moreover, it acknowledges the need to include the works of a range of Black women thinkers to avoid treating this group monolithically and to counter the tendency of mainstream scholarship to canonize specific group spokespersons and then ignore any but those chosen few (Collins, 1990).

Within the USA, the politics of BFT are rooted in the tension between suppressing African American women’s ideas and their intellectual activism in response to that oppression. Collins (2000) suggests that this oppression manifests within three dimensions to keep Black women in an assigned place of subordination: the economic dimension which notes the historic and contemporary exploitation of Black women’s labor as an essential part of US capitalism; the political dimension which denies Black women the rights and privileges routinely granted to White male citizens; and the ideological dimension which represents Black women in degrading and stereotypical ways as mammies, jezebels, welfare mothers, etc. As a critical social theory, BFT not only embodies knowledge and practices that “grapple with central questions facing US Black women as a group” (Collins, 2000, p. 31); it also

seeks to empower Black women and advance social justice concerns as a counter to oppression and subjugation. BFT also acknowledges the power of intersecting oppressions based on race, gender, class, sexuality, national origin, and other factors (Collins, 2000). Hence, BFT's critical nature lies in its objective to advance justice for US Black women, as well as others from similarly oppressed groups (Collins, 2000).

In addition to being informed by multiple theoretical traditions, BFT is largely shaped by various forces that have relegated Black women's voices to the margins—especially in the US social context. One such dynamic involves African American history, and African American women's push for gender equality within Black social and political organizations that: (1) were largely run by African American men, and (2) did not stress Black women's issues (Collins, 1990, 2000). Hence, BFT is informed by Black women's fight to include their issues on the larger social and political agendas concerning Black communities. A similar fight emerged in terms of Black women and the larger framing of gender equity issues. As previously noted, various aspects of feminism and the overall gender rights movement have been critiqued for ignoring the experiences of women from racially marginalized groups (Hancock, 2022). Consequently, BFT emerged out of a need to counter the historical suppression of Black women's ideas in feminist theory which primarily focused on White, middle-class women's issues (Collins, 1990, 2000). Collectively, BFT seeks to disrupt the “masculinist bias in Black social and political thought and the racist bias in feminist theory” (Collins, 1990, p. 9). Collins (2000) notes that Black Feminism and BFT remain important because US Black women remain oppressed, with subordination existing within intersecting oppressions. Nonetheless, Collins (2000) acknowledges that BFT is dynamic and must change as social conditions evolve to ensure its continued relevance.

Intersectionality: Compounding Systems of Oppression

Stemming from traditions similar to BFT, intersectionality is also frequently used in higher education literature concerning Black women in STEM. In fact, these two theoretical positions have often been combined in studies given their similarities (Sanchez et al., 2019). While BFT is positioned as an epistemological standpoint, intersectionality has been described as a paradigm or interpretive framework that can be used to explain social phenomena (Collins, 2000). This framework is common in higher education literature concerning Black women (Charleston et al., 2014a; Harris & Patton, 2019; Haynes et al., 2020; Ireland et al., 2018; Museus & Griffin, 2011; Patton & Ward, 2016). Intersectionality can be employed to examine how various systems of oppression interact to shape the unique experiences of marginalized groups (e.g., racism, sexism, classism, etc.); however, within STEM contexts, it has been primarily used to better understand the race and gendered experiences of Black women in fields where they often encounter a double bind from reinforcing oppressions due to race and gender, specifically (Malcom et al., 1976).

There are various perspectives about the history of intersectionality as a concept, with some scholars suggesting that there is no single legitimate origin story (Collins & Bilge, 2016, 2020). While intersectional thought, advocacy, and social justice work pre-date intersectionality's manifestation in academic settings (Collins & Bilge, 2016, 2020), Kimberlé Crenshaw (1989, 1991) is often credited for coining the term and indoctrinating it within the academy—specifically within legal scholarship. Crenshaw's (1989, 1991) work is noted as an important “marker that shows not only intersectionality's growing acceptance in the academy, but also how this acceptance subsequently reconfigured intersectionality as a form of critical inquiry and praxis” (Collins & Bilge, 2016, p. 81).

As articulated by Crenshaw (1989, 1991), intersectionality offers a Black feminist criticism about the treatment of race and gender as “mutually exclusive categories of experience and analysis” (Crenshaw, 1989, p. 139). Moreover, it situates Black women, and by extension women from other racially marginalized groups, as knowledge-creators whose voices are obscured because of their social locations (Collins & Bilge, 2016; Crenshaw, 1989, 1991). In doing so, intersectionality disrupts the use of single-axis frameworks which dominate antidiscrimination law, feminist theory, and antiracist politics, noting how these frameworks distort the experience of racially marginalized women, and theoretically erases them by focusing on the most privileged of the oppressed whose experiences represent only a subset of the larger group (Crenshaw, 1989). Similar to BFT, intersectionality problematizes feminist theory for focusing primarily on the experiences of White women—especially those with greater financial resources. Crenshaw (1991) specifically notes instances where the experiences of poor and Black women have been objectified only to garner support and bolster protection for White women and not to “disrupt the patterns of neglect” that permitted problems to continue as long as it was imagined to be a “minority problem” (p. 1260). Moreover, in terms of Black people and antiracist politics, Crenshaw (1989) criticizes Black liberatory spaces for a failure to critique patriarchy. She notes that Black women often must set aside their concerns about gendered intraracial oppression in order to present a form of solidarity among the Black community. The struggle against racism results in the “subordination of certain aspects of the Black female experience in order to ensure the security of the larger Black community” (Crenshaw, 1989, p. 163). Crenshaw (1989) suggests that this largely results from the racial otherness that Black women experience along with Black men the prevents “Black feminist consciousness from patterning the development of white feminism” (1989, p. 162) given that White women do not have to battle subordination due to color and culture. Hence, the context of racism in which Black women operate makes the development of a political consciousness that is oppositional to Black men a challenge. Crenshaw (1991) suggests that this is also true for other women who experience intersecting race and gender marginalization. Moreover, Crenshaw (1989) indicates that “. . . the intersectional experience is greater than the sum of racism and sexism” (p. 140); hence the entire framework of feminist theory and antiracist policy discourse must be restructured analytically.

There are several commonalities among the various concepts and frameworks previously outlined. The most noticeable common feature is their attention to the ways that racial oppression and gender oppression combine to create a unique space of discriminatory practice. Accordingly, a number of scholars have used either one of these lenses or a combination thereof to explore the racialized and gendered experience of Black women collegians pursuing STEM disciplines. The following section examines this literature in more detail.

A Thematic Review of Existing Research

A number of themes emerge from extant literature concerning Black women collegians and their experiences pursuing STEM degrees. Some literature emphasizes the challenges that these students encounter during their academic pursuits, especially with regard to their raced and gendered experiences; the various ways in which marginalization manifests for Black women in these fields; and how STEM environments on many college campuses can be spaces of isolation and subordination—particularly at predominantly white institutions (PWIs). Other literature discusses the resolve of Black women pursuing STEM degrees, noting how supports from key individuals such as family and peers can help to foster positive outcomes; however, some research also cautions that resilience comes at a price. Another aspect of the literature examines Black college environments—specifically the experiences of Black women pursuing STEM degrees at HBCUs, along with the strengths and challenges that manifest within these institutions that influence Black women’s STEM academic success. The following sections examine each of these themes, outlining the tapestry of higher education literature concerning this topic. The vast majority of literature in this area is qualitative and centers the actual voices of Black women to provide a deeper understanding of their unique experiences traversing collegiate STEM environments. Accordingly, specific text from existing studies is incorporated in the discussion as appropriate to offer the reader intimate insights into the literature and the data that the authors drew upon to shape their analyses and findings. While each of the studies mentioned includes an analysis of multiple pieces of data, quotes from current research are highlighted in the text that follows to provide specific insights about how the various themes discussed emerged within the literature.

Race, Gender, and the Complexities of Intersectional Marginalization

I get to [location name] and the first question someone asked was if I was someone’s secretary...because I’m Black? A woman? I can’t tease those things apart. (Charleston et al., 2014b, p. 171)

As previously discussed, a number of studies regarding the experiences of Black women in STEM employ intersectionality as a framework to explore the race-

gendered biases that they encounter which can hinder their academic and professional trajectories in these fields (e.g., Charleston et al., 2014a; Dickens et al., 2021; Ireland et al., 2018; McGee & Bentley, 2017; Sanchez et al., 2019). It is also worth noting that many of these studies provide a glimpse into the complexities of negotiating intersecting forms of oppression due to race and gender, with a number of instances emerging where it was often hard to disentangle or differentiate if Black women's experiences resulted from their race, gender, or race and gender combined (Charleston et al., 2014a, b; McGee & Bentley, 2017). These complexities manifest at different points along Black women's academic trajectories in higher education. The opening quote illustrates this point, in which Charleston et al. (2014b) highlight the complexities of intersecting racial and gender identities in their qualitative study of Black women in computing. Moreover, the authors indicate that context is important in order to understand the most salient identifier for many Black women in STEM, noting that a greater emphasis may be placed on their race, gender, or both based upon the educational environment or social space. This finding echoes that of similar research (Charleston et al., 2014a).

While pinpointing the source of marginalization was challenging in some studies (i.e., race, gender, or both), in other instances Black women identified race as a primary source of their mistreatment within STEM departments and their general experiences with discrimination (Charleston et al., 2014a, b; Dortch & Patel, 2017; McGee & Bentley, 2017). At times race and racism were more often identified as sources of marginalization than gender discrimination (Dortch & Patel, 2017). While discussing their encounters with racism, many Black women connected their experiences with broader issues related to bigotry and questions concerning Black intellect (Charleston et al., 2014a, b; Dortch & Patel, 2017; McGee & Bentley, 2017). This is illustrated in the following example by McGee and Bentley (2017) in their qualitative study of high-achieving Black undergraduate and graduate women in STEM. In this example, a doctoral student is explaining her unsupportive interactions with a faculty member and feeling left out because of her racial background.

I'm dissertation stage. He didn't even know that I wanted to be faculty. How is that possible? How. . .you've been with me now for years. How do you not know what I want to do when I leave here? But because we have this cultural difference. . .and he em—and sometimes it does feel funny when he embraces the other cultures and. . .and leaves me out. (p. 279)

Other research provides similar examples of racial discrimination. The following quote from Charleston et al. (2014a) offers insights about how some faculty in STEM departments subscribe to discriminatory ideas which circumscribes Black women's potential and contributions in STEM. This statement reflects a comment that a faculty member made to an Asian student concerning a Black woman in his program:

I don't think she has talent. I think White professors gave her grades because of her race and they felt bad about slavery. I don't think there are any real computer scientists who are Black, and maybe she can be the first. (p. 283)

Both quotes from existing research illustrate how racism limits Black women's STEM educational experiences, specifically. They also illustrate how racism is often top-of-mind in the ways that Black women describe their experiences and how key institutional actors (i.e., faculty members) (mis)construe these students' potential. Some scholars have framed these experiences as reflections of anti-Blackness' global entrenchment in STEM areas which situates Black people as "unsuitable to the demands of STEM education and employment" (McGee & Bentley, 2017, p. 279). Various studies indicate the racism that exists within STEM fields and the toxicity for individuals in those fields that are from racially marginalized groups (Charleston et al., 2014a; McGee, 2020, 2021; Park et al., 2022).

While much of the literature highlights how discriminatory mindsets concerning Black women's race and gender identities can present unique risks, drawing from the work of bell hooks (1989), one author suggests that "the margin can be a site of resistance and empowerment rather than simply a place of deprivation and domination" (Morton, 2021a, p. 314). From this vantage point, one study in particular explores how Black women's racial and gender identities can be positive and empowering, thereby operating as a protective factor (Morton & Parsons, 2018). In a strength-based phenomenological study of undergraduate women's STEM identity development and how it is shaped by race and gender, Morton and Parson (2018) found that although their study participants were aware of the historical and contemporary racial struggles afflicting Black people (e.g., stereotypes, discrimination, etc.), they also found "solace, pride and support in their Black racial identity" (p. 1384) which served as a protective mechanism contributing to their STEM persistence. Hence, this study offers initial insights and a complementary perspective about how facets of Black women's identity can operate in both positive and negative ways.

Stereotypes as Mechanisms of Marginalization: Gender-Normed, Mammified, Jezebelled, and Misidentified

One of our professors [from a] different culture, he said, 'You could learn a lot from the women in my culture.' Because [he's] telling me to do something, I'm saying, 'Okay, well, that sounds good, but in my class I learned this procedure. You don't think that this would be a better procedure?' He just looked at me. 'You could learn a lot from women in my culture.' So basically you're telling me to shut the hell up, is what you're saying to me. (McGee & Bentley, 2017, p. 281)

An overwhelming body of literature discusses the marginalizing experiences of Black women in STEM, with a particular emphasis on the various stereotypes that they encounter. Often noted are the gender norms to which Black women are expected to subscribe (Charleston et al., 2014b; McGee & Bentley, 2017; Rosa & Mensah, 2016) as well as their being misidentified as incapable because of assumptions concerning their intellect or lack thereof (Allen et al., 2022; Charleston et al., 2014a, b; Joseph, 2012; Morton, 2021a, b). The opening quote from a study by

McGee and Bentley (2017) illustrates this as Sonya, a Black women doctoral student in Computer Engineering, describes her interaction with a professor and how his comments suggested African-American culture was deficient. Furthermore, this example illustrates attempts to employ gender norms in a manner that subordinates Black women and silences them in academic spaces, thereby misidentifying them as lacking intellect and rendering their potential contributions invisible. While the quote illustrates such treatment from faculty, other research suggests that students were also culprits, as some male colleagues would question why their Black women peers were not taking care of their husbands and children (Rosa & Mensah, 2016). The following discussion outlines some of the common themes in existing literature concerning how Black women collegians in STEM are marginalized by gender norms—particularly race-gendered norms that position them as “mammies” and “jezebels” (McGee & Bentley, 2017)—as well as cases of mistaken identity with regard to their “place” in STEM academic contexts.

Gender Norms and Black Women’s Race-Gendered Marginalization in STEM Areas

Research notes the ways in which STEM fields are often viewed as masculine (Bejerano & Bartosh, 2015). Accordingly, the literature suggests that many Black women must disrupt stereotypes related to their identity as women in largely male-dominated fields; however, from a gendered and raced perspective, they also must wrestle with stereotypes resulting from their unique identity as Black women. Some of these stereotypes are related to their behavior and the way Black women are expected to present themselves. As noted by a participant in one seminal study on successful Black women in computing, “There are often assumptions that I am supposed to act a certain way because I am a Black woman” (Charleston et al., 2014b, p. 171). The authors discuss how this student’s reflection relates to assumptions that Black women would be defiant and get upset when faced with unfavorable circumstances. Other research also discusses how many Black women in STEM environments at PWIs monitor aspects of their appearance in response to assumptions about what it means to look professional or smart (Joseph, 2012).

While some of these stereotypes related to behavioral assumptions concerning Black women’s attitudes, other authors highlight stereotypes aligned with common tropes regarding Black women, their sexuality, and a social location of subordination deemed appropriate. Such treatment came from men from various racial/ethnic backgrounds, including Black men. The following data highlighted by McGee and Bentley (2017) illustrates this phenomenon:

You need to become comfortable with sexual advances, which is cumbersome. Um, it really is. Because how do you prove it? You know, who do you. . . who do you confide in, how do you combat it? You just don’t. You just suck it up and say, ‘I’ve got 1, 2 more years left. I can’t wait to get the hell out of here,’ you know. And it’s not just here, because it is here, make no mistake. Um, but even when I go to conferences. . . I’ve had a number of men ask to be on my committee, and then solicit me for sex. And so, uh, it sucks. . . . Some days I feel very powerless. Um, I feel like they make me their work wife. So, any time someone needs

to take notes or run and get an errand and grab something to eat—flunky stuff—it’s typically me who gets those directives. (p. 280)

The authors note how this data does not only reflect stereotypical gender norms that may afflict any woman but are specific to the stereotype of Black women as Mammies (i.e., caretakers, especially of White people) by subjecting them to menial task such as running errands and “flunky stuff.” Moreover, the authors suggest that the example shared situates Black women as Jezebels (i.e., women deemed sexually promiscuous and acquiescent) by creating an environment where sexual harassment is so prevalent that it is deemed a common occurrence. Ultimately, McGee and Bentley (2017) note how such mistreatment positions Black women as a commodity instead of scholars and colleagues in STEM.

Marginalized and Misidentified

Another prevalent finding within the literature is related to the ultimate misidentification of Black women in STEM. Such a phenomenon often took one of two forms—misidentification as questioning Black women’s legitimate physical presence in STEM spaces and misidentification as questioning Black women’s intellectual aptitude. Each of these can serve as a form of microaggression which devalues Black women’s roles as students in STEM. While the former ultimately forces Black women to answer questions (such as Are you supposed to be here?), the latter poses questions such as Are you smart enough to be here? It is worth noting that the term “misidentification” is not meant to suggest an innocent mistake on behalf of various individuals in academic settings. Instead, it is meant to convey the contours of mistaken identity that underestimate the potential of Black women to compete in highly competitive STEM fields. In this way, misidentification is used to describe the ways that bigotry, ignorance, and discrimination blind the ability of students, faculty, and other institutional actors to see who these Black women really were, as pointed out in existing literature (Allen et al., 2022; Charleston et al., 2014a, b; Joseph, 2012; Morton, 2021a, b).

Research conducted by Allen et al. (2022) illustrates aspects of the misidentification related to Black women’s legitimate physical presence. In this study, the authors conducted a longitudinal qualitative analysis of Black women who enrolled at a community college and expressed an interest in transferring to a 4-year institution to major in a STEM field. The findings include the experiences of a computer science student named Kamala who shares how her physical presence was ignored and questioned by a professor at her 4-year institution after he suggested that she come to his office for assistance. The following text is included in the authors findings:

When she arrived there, he ‘thought I was the wrong person. Like said, “are you sure you are in the right department and not nursing?”’ When faced with a Black woman, this professor thought that she did not belong in computer science and was looking for help in the wrong department, thereby communicating to Kamala his opinion that people who looked like her had no place in computer science. Kamala noted that this interaction was discouraging and made her ‘not even want to ask the question anymore.’ (p. 14)

In addition to faculty, research notes how questions about Black women's legitimate presence in academic spaces also manifested from on-campus staff members. Such microaggressions sometimes emerged in passive aggressive, debilitating ways that depicted differential treatment between Black women and other individuals viewed as legitimate STEM students (e.g., White men). As an illustration, the following data was shared by Dortch and Patel (2017) in their phenomenological study of Black undergraduate women and their sense of belonging in STEM at PWIs. This quote was provided by Brittney who studied physics:

The standout things are being carded to go in doors when you see White men going past you who didn't tap in or anything. That's so frustrating. Like, stuff like that just rattled me. . . Being asked if I was lost when walking the physics halls. . . Me and my friends have also experienced like, situations where students are like, to our face, 'You're only here [in college] because you're Black.' (p. 210)

While discussing this data, the authors detail how Brittney experienced harassment from campus security by being carded when entering buildings, while White men who were also students were assumed to be in the right location. This and the previous example illustrate misidentification tied to questioning Black women's legitimate presence in STEM academic spaces.

A large bulk of research concerning Black women in STEM also notes forms of mistreatment which misidentify them as academically and intellectually inept. This can manifest in various ways including being ignored, being inappropriately interrupted while speaking, having their competence questioned, or generally receiving verbal or nonverbal signals that they do not belong (Allen et al., 2022; Charleston et al., 2014a, b; Joseph, 2012; Morton, 2021a, b; Rosa & Mensah, 2016). In their study, Charleston et al. (2014a) note that "identifying as a Black woman conjured a wealth of misperceptions and stereotypes regarding their academic identity as well as their intellectual capacity" (p. 282). The authors continued by sharing the following reflection from a Black woman whose is described as having a White male classmate who questioned her academic competence during a team assignment, made unilateral decisions on group work, and submitted assignments without her input—"Maybe there was the perception that I was female, I was Black, and I was incompetent. His perception was I was going to pull him down" (Charleston et al., 2014a, p. 282). Research from Allen et al., 2022, also reflected a similar phenomenon in the following quote where Serena, a former biology major at a PWI, describes being "talked over, having her competence questioned" (p. 14) and overall messages that she did not belong in her STEM subject.

The final shock for me was, I had a lab and it was like me and two White guys and a White woman and one of the guys. . . didn't talk very much. The other White guy was older and. . . would talk over me and the other young lady in our lab group. . . It was literally just me and him contributing ideas. We were cutting things and examining stuff and if I made a point and said, 'this is this, I am identifying the body part or whatever,' and he would always challenge it and call over the TA to settle a dispute. I happened to be right and he would just be, 'okay, let's move on,' but if it was him being right, he would be like, 'I knew I was right'

and making a big deal out of it and it was like he would challenge me in ways that he did not challenge anyone else in the group even though he spoke over the other young lady and she was adamant but he wouldn't call the TA over to ask a question. (p. 14)

The authors discuss how Serena's negative experiences made her lose her confidence and excitement about STEM. This ultimately caused her to decide to leave the field and switch majors to social science. In explaining this decision, Serena shared, "being a person of color it was going to be 10 times harder for me. It made me think how passionate I am about this? To put up with this. I decided I wasn't. I love it but not that much" (Allen et al., 2022, p. 9). The insight offered by Serena illustrates how many Black women in STEM fields, even those with great academic potential, can have their value and belonging questioned in ways that not only misidentifies them but also pushes them away from continuing in their initial majors. Furthermore, this example illustrates how Black women can often be treated differently from other women in these fields. Other studies note how Black women in STEM can have difficulty finding support or allyship with other non-Black women students in their field (Charleston et al., 2014a, b; Dortch & Patel, 2017).

Isolation and Subordination: Unwelcoming Environments and the Loneliness of Onliness for Black Women Studying STEM

It took a good six weeks before people were finally opening up to me. (Charleston et al., 2014a, p. 282)

Various studies within higher education note the critical influence of academic environments on students' experiences and outcomes (Museus, 2013; Williams & Taylor, 2022; Taylor & Williams, 2022). An overwhelming finding in literature concerning Black women in STEM illustrates the ways in which these students find these fields and, by extension, STEM academic settings, unwelcoming. As a result of these characteristics, research suggests that Black women often feel isolated and, in many instances, subordinated as one of a few, if not the only Black women represented within the academic settings of these fields—a phenomenon representing the loneliness of onliness. The opening quote from the work of Charleston et al. (2014a, b) illustrates this point, as they describe the experiences of Black women in computing as inundated with isolation that is "precipitated by the lack of support from faculty and their respective institution alike. . ." (p. 282). The text that follows provides further insights into this phenomenon as evidenced by existing literature.

A common theme across the literature on Black women in STEM suggests various unwelcoming aspects of these disciplines. Many studies situate STEM environments as toxic, noting issues such as structural racism, sexism, race-gendered biases, problematic institutional culture, and problematic disciplinary practices designed to weed out students (Allen et al., 2022; Borum & Walker, 2012; Charleston et al., 2014a; Joseph, 2012; McGee & Bentley, 2017). For instance, the work of

Charleston et al. (2014a) discusses the unwelcoming nature of the computing landscape in particular and problematic institutional culture—especially at PWIs. The study generally notes the “enduring presence of racism and sexism throughout the STEM and computing science educational trajectory” (p. 285), while emphasizing Black women’s progression from undergraduate to graduate study and highlighting power relations that manifest at the intersections of race and gender. Similarly, other research on Black women in STEM has described the departmental climate at PWIs as chilly (Allen et al., 2022; Joseph, 2012) and culturally insensitive (Dortch & Patel, 2017). Dortch and Patel (2017) shared the following quote in their study on Black women doctoral students reflecting upon their undergraduate experiences in STEM. In this excerpt, a Black woman in their study discusses experiences with racial microaggressions during her nursing program.

I had some racial experiences based on patients. One encounter was, they kept asking if I was Hispanic because I look racially ambiguous. Then they went on this tangent on how Mexicans shouldn’t be in this [country]. This is before I had told them that I was Black and White and they assumed that I was Mexican. They said that Mexicans should just go back over the border, just said some horrible racial things about Mexican people and that was like, I was just like, you just like assume that I was Mexican and then you said all this nasty stuff! It was completely inappropriate and I remember going to my professor and clinical instructor and she was like, ‘Oh, that’s horrible.’ Period. That’s it. And so this was outrageous. I remember reading that some of the nursing books that said when you press down your skin, you should turn pink; my skin doesn’t turn pink, so I was pissed like from the literature that we were reading, from my clinical and interactions with patients who didn’t wanna work with me because I was like brown. And you’re not gonna address this? You’re not gonna say nothing, I was told about cultural competence and I was like, I was very upset. . . (p. 209)

The authors note the faculty member’s complacency in responding to the student’s concern about the racist remarks made by a patient. They also discuss the systematic lack of cultural competence in her field as reflected in the learning materials used during coursework, framing these collective issues as microinsults against Black women that are “promoted and reinforced in STEM cultures and environments” (p. 212).

Other research has captured the negative influence of structural institutional and departmental challenges by examining Black women who were enthusiastic about pursuing STEM degrees initially and how their interests subsided as they transitioned from supportive collegiate environments to those where support was nonexistent. Allen et al. (2022) conducted a longitudinal qualitative study of Black women in STEM, their transition from a community college to 4-year institutions, and how their experiences differed according to institutional context. While in community college, the students were excited about the opportunities ahead of them and confident about their potential in these fields, although they knew they would be underrepresented. They indicated positive experiences with instructors who were described as helpful, passionate about teaching, and willing to put in extra effort to build relationships with students. Moreover, students indicated overwhelmingly supportive and positive relationships with peers—connections that often remained

even after transferring. Despite a promising start in the community college environment, when interviewed 3 years later, each of the Black women in the study had either left STEM, were planning to leave, or regretted staying. Many of the students who left STEM cited climate issues as their motivation, reporting transfer shock resulting from an unsupportive institutional environment; instructors that were dismissive and uncommitted to teaching; and peers that did not want to work with them and/or questioned what they knew. Collectively, the authors described these incidents as reflective of a chilly climate in STEM. Moreover, the authors explained how these experiences resulted in systematic discouragements related to Black women's race and gender, along with their social class at times. Other work notes how the trauma of unsupportive STEM environments has damaged Black women's self-esteem and resulted in their leaving programs without the intended degree, second guessing their degree ambitions or enrolling a different institution (Borum & Walker, 2012). Also, complimentary research notes how perceptions about the degree to which particular STEM fields are (un)welcoming shape Black women's STEM career choices and their related academic decisions (Jackson, 2013).

Problematic STEM cultures and environments are closely connected to negative interpersonal experiences that are also quite common in the literature on Black women in STEM. Given the limited number of Black women in many STEM areas, unwelcoming STEM environments often create facets of onliness which ultimately leave many Black women feeling alone, out-of-place, and without sufficient opportunities to develop race and gender peer social networks (Allen et al., 2022; Charleston et al., 2014a; McGee & Bentley, 2017; Sanchez et al., 2019). To be sure, not all Black women in STEM express concerns about isolation from peers, faculty, etc. due to their race or gender (Borum & Walker, 2012), and other work notes the need to attend to variations that may also manifest within this demographic (Winkle-Wagner et al., 2019). Nonetheless, the ark of the literature notes common acts of isolation against Black women in many STEM fields, including limited social interactions with peers, exclusion from peers during group-related activities (Charleston et al., 2014a, b; Dortch & Patel, 2017; McGee & Bentley, 2017), and (as noted earlier) general mistreatment from faculty who were sometimes described as the central contributors to Black women's isolating experiences (Allen et al., 2022; Borum & Walker, 2012; Charleston et al., 2014b). As a result, many Black women felt the need to deal with various problems alone and/or the need to overcompensate as the only Black women in their programs in order to serve as a positive example of their abilities (McGee & Bentley, 2017; Morton, 2021a; Sanchez et al., 2019). In some instances, Black women also felt obligated to function as cultural brokers with their non-Black peers, being responsible for exposing them to aspects of Black culture given that they were the only Black students in their departments (Joseph, 2012). Literature suggests that the presence of other non-Black women did not help to alleviate isolation, with these women often being unable to relate to the experiences of their Black women colleagues and their need to find community with students of a similar background (Charleston et al., 2014a, b; Dortch & Patel, 2017; Rosa & Mensah, 2016). Also, the role of Black male colleagues in helping to assuage isolation is mixed. While some research

discusses how Black males were resources to Black women in dealing with some aspects of mistreatment—especially matters related to sexual harassment (McGee & Bentley, 2017)—other studies note the ways in which some Black men “othered” their Black female colleagues in STEM academic settings. The “othering” process was sometimes related to perceptions of relative (un)importance. Recognizing that White males are viewed more favorably in STEM—particularly from professors—some research suggests that Black men were more inclined to try to develop relationships with their White male counterparts than their Black women peers (Charleston et al., 2014a, b). Other work documents intra-racial and gender micro-invalidations that Black women experienced from Black men based upon their physical attributes (Dortch & Patel, 2017). Hence, the literature suggests that, in some instances, Black men were not reliable sources of camaraderie or social support and instead helped to perpetuate the loneliness of onliness for Black women who were underrepresented because of both their race and gender. This phenomenon appears to manifest despite the shared racial identity between these two groups of students.

Resolve Re-examined: Resilience and Its Unanticipated Negative Consequences

Given the social and academic isolation that many Black women experience while pursuing STEM degrees, literature notes the various strategies they employed in attempts to traverse challenging STEM environment successfully. This included things such as having a strong commitment to their goals (Joseph, 2012); actively working to demonstrate their academic competence in attempts to prove themselves (Morton, 2021a); trying to establish relationships with others in STEM, with a particular emphasis on networks of students from underrepresented groups (Morton, 2021a; Rosa & Mensah, 2016); and becoming heavily involved in various activities in their department to try to feel more included, albeit often without the anticipated outcome (Joseph, 2012; Rosa & Mensah, 2016). The literature also underscores the importance of faith and religious beliefs in helping Black women to get through challenging situations as students in STEM fields (Ferguson & Martin-Dunlop, 2021; McGee & Bentley, 2017), and how their STEM commitments were often sustained by their desire to increase Black women’s representation in STEM and ultimately change the field for future generations (Dortch & Patel, 2017; Lane & Id-Deen, 2023; McGee & Bentley, 2017). Another common thread across the literature points toward the role of family in not only helping to cultivate Black women’s interest in STEM but also sustaining their persistence (Allen et al., 2022; Charleston et al., 2014a; Ferguson & Martin-Dunlop, 2021; Jackson, 2013; Lane & Id-Deen, 2023; Morton & Parsons, 2018; Morton, 2021a). While many studies note the utility of these factors in helping to foster successful outcomes, often framing them as sources of resilience, other research also emphasizes the unanticipated negative consequences of such resolve. The following sections discuss these aspects of existing research in more depth.

Family and Family Redefined

A number of studies emphasize the important role of family in shaping Black women's STEM trajectories. Family influence is discussed from two vantage points throughout the literature. One aspect focuses on family via blood relatives—a common definition. Another aspect focuses on the critical role of parakin or fictive kin family (i.e., individuals who do not share blood connections, but are treated as family) and the role that these individuals play in providing necessary supports (Williams, 2014a). Regardless of how family is defined, the overwhelming bend of the literature suggests that familial connections are instrumental to Black women's success in STEM.

From a pathway perspective, research underscores the important role of blood relatives on Black women's early STEM academic trajectories, emphasizing how these individuals help to cultivate their initial STEM aspirations and encourage them to pursue STEM degrees in college (Allen et al., 2022; Ferguson & Martin-Dunlop, 2021; Lane & Id-Deen, 2023). Moreover, a study by Ferguson and Martin-Dunlop (2021) provides useful insights about stories of resilience among Black women in STEM areas. The authors discuss how Black women's motivation to engage in STEM often resulted from spending time with family members who shared similar interests. They note that parents play an important role by helping Black girls and women to become more efficacious about their ability to achieve their STEM goals. They also emphasize the benefits of high levels of parental involvement and encouragement within grade school and beyond—even if the parents had no prior collegiate experiences to help inform their guidance. Moreover, the authors frame high parental expectations as a source of resilience—expectations that encouraged Black women to remain steadfast despite challenges such as racism and bullying.

In addition to a general discussion about parents, the role of mothers in particular has been noted in research (Lane & Id-Deen, 2023; Jackson, 2013; Morton & Parsons, 2018). The following quote from a study conducted by Lane and Id-Deen (2023) illustrates how mothers nurtured Black women's STEM interest and helped them to develop the capital necessary to achieve in these fields.

It was just my mom trying to keep us active. 'Here, try something new out. You don't have to just go do basketball or something like that. Let's do something to stimulate your mind.' I remember every Saturday; I would spend my entire Saturday learn[ing] Javascript. Of course, I wasn't too excited about 13 years old, going, yeah. Missing my Saturday. But... I'm glad my mom made me do it cuz it just opened up my eyes and now I'm here [in college]. (p. 17)

This quote illustrates mothers' commitment to enhancing Black girls' STEM exposure and investments. The authors continue by discussing mothers' dedication to ensuring that their Black daughters had access to STEM programming during early points in their academic trajectories and to helping facilitate their daughters' participation (Lane & Id-Deen, 2023).

In other studies, mothers are cited as sources of support and inspiration for Black women to persist in STEM fields despite challenging circumstances (Morton &

Parsons, 2018). In some instances, mothers also traversed challenging STEM environments during their academic training, and their professional outcomes and success helped to facilitate positive STEM identity development for their Black daughters (Jackson, 2013). Drawing from their blood relative support systems, research notes how many Black women were proud of the pride their families had about their accomplishments, which ultimately helped to further fuel their desires to succeed (Lane & Id-Deen, 2023). Moreover, some Black women felt that their success was not only important for them individually but also to the family unit. One motivation to succeed was rooted in a desire to serve as a positive example for other family members, and another was rooted in their desire to financially support their families after graduation (Lane & Id-Deen, 2023).

In addition to blood relatives, studies note the ways in which chosen family (i.e., parakin relatives) were also important sources of support for Black women in STEM areas, serving as an extension of individuals with biological connections. In some instance, these familial relationships manifested within the context of programs specifically designed to provide academic resources to Black women in STEM. For instance, using Yosso's (2005) community cultural wealth framework, Lane and Id-Deen (2023) situated supportive interactions with program staff in STEM summer programs as sources of familial capital which supported Black women's and girls' academic, socio-emotional, and professional needs; helped to develop a sense of purpose, self-awareness, belonging, and responsibility; provided spaces for students to be themselves with care and support from staff to cultivate academic outcomes and personal well-being; and helped to foster critical consciousness that prioritized community well-being and group success over individual achievement. Along with structured support from administrators within programs, studies also note the importance of Black women's relationships with each other to help sustain their STEM commitments (Charleston et al., 2014a; Morton, 2021a). Some work discusses the importance of sister circles for Black women's resilience and persistence in STEM fields, situating these as sites of "fellowship, friendship, support, and community" (Morton, 2021a, p. 307). Literature notes how such communities can provide opportunities for Black women in STEM to discuss, assess, and validate aspects of their race-gendered experiences—particularly their experiences with microaggressions. Furthermore, such intragroup interactions provided emotional social support and safe avenue for members' personal expressions (Morton, 2021a). Beyond the specific context of sister circles, literature notes the unique value that Black women bring to each other in collectively disrupting racist and sexist stereotypes about them (Charleston et al., 2014a).

At What Cost?: The Trauma of Resilience

As a parallel to research concerning Black women's resilience in STEM and the factors that enhanced their persistence, another branch of research explores the various sacrifices that Black women make while pursuing STEM fields and the challenges that can often accompany such resolve (McGee & Bentley, 2017; Morton & Nkrumah, 2021; Rosa & Mensah, 2021). While this research does not devalue Black women's steadfastness and how it has helped them to actualize success, it

critiques an over emphasis on resilience at the expense of discourse that (1) critically examines the toxicity of STEM disciplinary and academic environments and (2) disrupts problematic systems of oppression which necessitate resilience. Some of this research discusses the physiological toil of resilience on Black women's health. For instance, in a study concerning the troubled success of high-achieving Black women in STEM fields, McGee and Bentley (2017) discuss the stress that some Black women experience in racially charged STEM environments where they feel the need to prove themselves and how that can ultimately result in negative physical consequences. The following insights are provided from a student in their study who developed a neurological condition because of the stress she experienced as a STEM student.

Again, it was so difficult studying in an environment that seemed to loathe your very presence. So, as I was gearing up to take the qualifier the spring of 2010, I studied so hard and I stressed so hard I ended up getting sick, really sick. I don't know if you know what Bell's palsy is. Bell's palsy is when a part of you may be paralyzed and one of the causes is stress. And so, I ended up, the right side of my face was paralyzed. And it ended up going away, but from then on, I was like, 'I gotta take care of myself.' But...that's how hard I studied. I took the qualifying exam; 14 people took it at that time I believe. And I ended up failing; I failed that time.

The authors continued by describing how the hostile racial climate and race-related stress that the student experienced resulted in racial battle fatigue—"the psychological and physiological stress that racially marginalized individuals experience in response to specific race-related interactions between them and the surrounding dominant environment" (Smith et al., 2020, p. 86). Other research on Black women in STEM also highlights connections between stressful environments, physical health issues, and racial battle fatigue (Morton, 2021a).

In addition to physiological challenges, research discusses the negative psychological consequences of STEM environments that are laden with racial biases, and how Black women's resistance and persistence in oppressive environments can be described as unhealthy coping (Morton, 2021b; Morton & Nkrumah, 2021). In doing so, this work notes how a focus on coping promotes individual reform instead of a focus on larger structural issues in STEM disciplines (Morton & Nkrumah, 2021). As an alternative, a number of scholars argue a need to examine Black women's experiences in STEM fields using a critical assessment of the environments that these students traverse (McGee & Bentley, 2017; Morton & Nkrumah, 2021; Rosa & Mensah, 2021) and radically transform STEM spaces so that high levels of resilience—especially around race and gender issues—are not necessary for Black women's success (Morton, 2021b; Morton & Nkrumah, 2021; Rosa & Mensah, 2021). Furthermore, some authors suggest redefining what success looks like in STEM to employ a more communal lens focused on service to others (Rosa & Mensah, 2021). Collectively, this body of work points toward the possible trauma of resilience and a need to change STEM spaces to help facilitate Black women's success therein—not to change Black women to better fit into the toxicity found in many of these fields.

HBCUs and Black Women in STEM Fields: The Nuances of Racial Identity Spaces

Similar to Black women (and the Black communities from which they come), HBCUs often experience organizational challenges and deficit framing that is rooted in anti-Blackness sentiments which position them as inferior to PWIs in STEM disciplines and other domains (McGee & Bentley, 2017; Williams et al., 2019a). However, prevailing research consistently underscores these institutions' important contributions to the production of Black STEM professionals (Williams & Taylor, 2022; Anderson et al., 2018; Dillon et al., 2021a, b). In addition to research concerning the role of these institutions in producing Black STEM professionals, some studies specifically note the experiences of Black women in STEM at HBCUs. As a contrast to the literature focusing largely on the negative experiences of Black women in STEM at PWIs, a substantial portion of the literature concerning their experiences at HBCUs emphasizes the ways in which these institutions can be culturally affirming and creates supportive environments for Black women's academic and professional development. However, some studies also suggest limited levels of support for Black women at some HBCUs as the faculty and student demographics on these campuses shift such that these *institutions* may be primarily Black but certain *STEM departments* are not. The following sections discuss these attributes of HBCUs, and the nuances of Black women's STEM experiences within the context of these academic spaces of racial identity.

Faculty, Administration, and Institutional Commitments to Black Women's STEM Success

The overall thrust of literature suggests that many Black women have positive STEM experiences at HBCUs, thereby underscoring these institutions' unique ability to create spaces of affirmation for many of these students. The following quote from an analysis by Jackson (2013) of Black women who transferred from a community college to an HBCU illustrates this point:

Developing a STEM identity was not challenging for me at all. I heard many people say oh STEM oh STEM it is so hard and you really have to work at it and it is challenging for certain groups. Well it definitely helped that at [SPU] my peers looked like me and had many of the same goals and values so that was an easy transition and took away some of my fears. Now that that is out of the way, I can focus on being a STEM student. When I think about it, I guess I can see the challenges if I was to go to a school that was all white. Ok yeah then I would have to find people who looks like me and that I get along with and then on top of that find people who look like me in my area [STEM]. So yeah, I would definitely have to say that. (p. 264)

As indicated in this quote, HBCUs provide an environment where many Black women can focus on developing their STEM identity without the challenges of racial biases.

Literature notes that these affirming spaces are often the result of institutional characteristics that emphasize support over weed-out dispositions and the attentive

work of faculty and administrators to help Black women in STEM to achieve their academic goals. For example, in a case study of Spelman College—an all-women’s HBCU—Perna et al. (2009) examined how institutional policies and practices mitigate barriers to Black women’s attainment in STEM, such as inadequate STEM preparation before college and financial barriers therein. The findings suggest that faculty at Spelman were intentional about the following for these students: reinforcing their aspirations; finding ways to help lower-performing students in difficult core courses; and fostering their self-esteem even when students encounter academic setbacks. Like other research concerning the detrimental impact of students’ financial strain on STEM outcomes (Rosa & Mensah, 2016; Williams, 2014a), this study notes how financial difficulties related to college costs were sometimes a barrier to educational attainment. In response, faculty helped to alleviate some of these issues by recommending students for paid undergraduate research opportunities. Unlike other studies which note the hands-off nature of faculty in terms of establishing study groups at PWIs and how that disadvantages Black women (Morton, 2021a), Perna et al. (2009) suggest that faculty at Spelman promoted student participation in these groups, sometimes helping to craft them in a way that mixed students who were doing well with those who were not so that they could learn from each other. This ultimately reflects a faculty disposition toward collective achievement instead of exclusion. At an institutional level, the Black women in the study indicated that it was apparent that the institution invested a lot of resources in STEM research and creating an environment to nurture their development. This included having small class sizes and locating faculty offices in areas that students can easily access. Other research on HBCUs and Black women in STEM also notes the benefits of small class sizes on their academic development (Borum & Walker, 2012). Perna et al. (2009) note that many students chose to attend Spelman because of its reputation of producing successful Black women in STEM and faculty commitments to students’ success. Similarly, other research discusses the positive experiences of Black women in STEM at Spelman and how attending that institution enhanced their confidence in their ability to make substantial contributions to STEM fields (Morton, 2021a; Jackson & Winfield, 2014).

In addition to studies that are specific to Black women’s colleges, research also examines how senior administrators on various HBCU campuses have been instrumental in helping Black women to succeed in STEM. Lockett et al. (2018) conducted a multi-site case study of 71 Black women STEM students and 6 HBCU presidents across 10 HBCU campuses to explore how these institutions shape Black women’s STEM degree ambitions. The study generally underscores the positive impacts of engagement between senior-level administrators (i.e., deans, provosts, vice presidents, and presidents) and Black women in STEM, noting how these interactions help these students to feel supported and motivated which contributed to their success. This often included encouragement and motivating words of affirmation. Moreover, the authors suggest that senior administrators helped to shape an overall supportive organizational ethos reflective of the familial culture of care at HBCUs and their historical commitments to community uplift that is often noted in other literature (Winkle-Wagner & McCoy, 2018; Williams et al., 2022,

2021). From this vantage point, the research suggests that senior-level administrators were purposeful about putting institutional supports into place to help matriculating students and implementing organizational changes to be responsive to students' feedback—particularly as it relates to feelings concerning their treatment on campus. Specifically, the authors noted that “students believe that their opinions are valued by senior administrators and woven into an institutional culture of community” which helps them to be successful (Lockett et al., 2018, p. 9). Ultimately, this research suggests that many HBCU senior-level administrators (including presidents) saw student support via direct engagement with students as a priority in addition to their general administrative duties—a form of practice that is not always apparent within many higher education institutions.

While the previous studies focus squarely on the experiences of Black women in STEM on HBCU campuses, other studies have taken a different approach by comparing the experiences of Black women in STEM at HBCUs and PWIs (Borum & Walker, 2012; Johnson et al., 2019; Joseph, 2012; Morton, 2021a). Relative to PWIs, this body of literature generally highlights that HBCU environments are more supportive because of positive experiences that Black women in STEM have with faculty, staff, and their peers (Borum & Walker, 2012; Joseph, 2012; Morton, 2021a; Rosa & Mensah, 2016); affirm Black women's potential by instilling a strong self-belief in their abilities (Joseph, 2012); encourage advanced educational pursuits in STEM (Joseph, 2012); offer co-curricular activities that help to facilitate Black women's success in STEM (Borum & Walker, 2012); and provide positive exposure to potential role models (Johnson et al., 2019; Joseph, 2012). Literature also notes how these environments instill a sense of social responsibility (Joseph, 2012), an important attribute given other research which notes the value of Black women being able to connect their STEM pursuits to helping their communities (Dillon & Williams, 2020a, b). Authors also note how, relative to Black women in STEM at PWIs, Black women at HBCUs often experience a higher sense of belonging within the institution and within STEM (Johnson et al., 2019). This finding is likely related to broader educational logics that undergird many of these institutions and that can manifest within some HBCU STEM departments (Williams & Taylor, 2022).

Black But Limiting: Negative Implications of Black STEM Spaces that Reflect Anti-Blackness and Male-Domination

While many studies note the positive experiences of Black women in STEM at HBCUs, some literature also points toward the complexities of their race and/or gendered experiences on some HBCU campuses, suggesting that there can be some variations in how Black women experience these environments (Morton, 2021a, b; McGee & Bentley, 2017). This smaller body of work illustrates the downfalls of Black educational spaces where Black women's gender, race, or race-gendered identities are not centered, thereby making these institutional environments Black but also limiting. For instance, Morton (2021b) illustrates the gender-related challenges of underrepresentation for Black women at a Black institution. In a study of Black women in an undergraduate research experience (URE) at an HBCU, Morton

(2021b) outlines how the institution's racial makeup facilitated support by validating students' racial identity. Also, the STEM URE incorporated aspects of students' personal interests within the learning environment which created a space of affirmation. However, the author discusses how the limited number of Black women faculty at the HBCU that could serve as STEM mentors (an aspect of the department that reflects larger representation issues in the field) had detrimental impacts on Black women participants by reifying STEM culture as White and male-dominated. The author then discussed how this can ultimately result in alienation, isolation, and minoritization even within the context of a Black institution.

Other work takes a critical look at HBCU environments for Black women in STEM and how they can evolve from supportive to isolating due to shifts in student and faculty demographics or institutional policies. As an example, McGee and Bentley (2017) provide insights about a Black woman in their study who had drastically different experiences at her HBCU as an undergraduate and graduate student in STEM. This individual discussed having positive undergraduate experiences at her HBCU, where faculty supported students' development and helped to prepared them for various opportunities postgraduation. Later, that same environment was different when this person returned for graduate training. After completing her undergraduate degree, the STEM department at this institution experienced student and faculty demographic changes that privileged non-Black individuals. These changes were described as related to broader structural issues, including defunding scholarships for Black students and racist ideologies that favored the hiring of Middle Eastern and Asian faculty who were generally thought to be smarter than Black candidates. The authors note how these non-Black faculty members mistreated Black students by being unsupportive and disengaged, exhibiting a lack of commitment to these students' success without being held accountable. They situate this type of treatment within an HBCU as indicative of the "pervasiveness of anti-Black racism in STEM" (McGee & Bentley, 2017, p. 280) and discuss how "global anti-Blackness is playing out at HBCUs and against the recent mantra of diversifying STEM fields" (McGee & Bentley, 2017, p. 279). Similarly, other studies document how policy shifts and related politics rooted in structural racism have transformed STEM spaces on some HBCU campuses from supportive and inclusive of Black students to isolating, particularly when Black students evolve from the majority to an minoritize minority (Darnell, 2015). To be sure, research notes the ways in which non-Black faculty who position themselves as allies can support Black women in STEM despite racial/ethnic differences (Johnson et al., 2019; Rosa & Mensah, 2016). However, these findings illustrate instances in which Black women in STEM can feel racially marginalized in HBCU spaces that are no longer Black-centered and underscore the need for research to attend to the current demographics and commitments of institutions in addition to their traditional or historic missions. This is especially important given the increased levels of diversity prevalent in STEM departments at many historically Black institutions (Mobley et al., 2017).

Making Conceptual Connections Across the Literature: A Role Strain and Adaptation Model for Black Women's Student Development in STEM Fields

As previously discussed, many of the current studies on Black undergraduate women in STEM employ lenses such as CRF (Wing, 2003), BFT (Collins, 1990, 2000), and intersectionality (Collins & Bilge, 2016, 2020; Crenshaw, 1989, 1991) to articulate the race and gendered experiences of Black undergraduate women in STEM. What is missing is a holistic framework which illustrates how various important elements shape these experiences, guided by these conceptual underpinnings. Building upon the literature previously reviewed, this section offers a framework concerning the experiences of Black women in many STEM fields which synthesizes two largely disparate bodies of work in this area—one which focuses on Black women colleagues' challenges and another which focuses on their sources of resilience. In doing so, the framework that follows brings together these bodies of literature, making conceptual connections between them in a dialogic fashion.

The proposed conceptual model is informed by a number of theoretical traditions, including BFT (Collins, 1990, 2000) and intersectionality (Collins & Bilge, 2016, 2020; Crenshaw, 1989, 1991) previously detailed. Both lenses underscore the unique experiences of Black women from an epistemological standpoint and the importance of theoretical considerations that reflect their specific realities. Additionally, given the nature of the current canon of research which discusses Black women colleagues' challenges and resilience in STEM, the model draws upon social psychological theories concerning role strain and adaptation (Bowman, 2006). Such lenses discuss the interplay between strain (i.e., challenges) that individuals may have in a highly valued life role (i.e., being a student), as well as strengths they may pull from in attempts to overcome those challenges (e.g., resilience). These parallel facets of Black women's experience in STEM emerged from the thematic discussion of extant literature previously outlined.

Role strain and adaptation framing has been used in various studies concerning marginalized students and their experiences in STEM (Burt et al., 2018, 2019; Williams, 2014a, b, 2020; Williams & Davis, 2021; Williams et al., 2016, 2019b). One prominent framework often discussed in this body of research is the Bowman role strain and adaptation model (BRSAM) which describes how strain and adaptation combine to influence successful outcomes. A central aspect of the BRSAM is its utilization of role strain theory which has been used in fields such as sociology (Goode, 1960), psychology (Bowman, 2006, 2012), and more recently, education (Williams, 2020; Williams & Davis, 2021; Williams et al., 2019b). Role strain theory suggests that individuals can encounter various life difficulties (i.e., strains) that have the potential to hinder successful outcomes in a particular life role (Goode, 1960). Building upon role strain theory, the BRSAM acknowledges the strains that individuals can encounter within a life role (e.g., as a student) but situates strain within a confluence of other important factors that ultimately impact these challenging experiences. These factors include structural social inequalities and stratification related to individual's background characteristics; life course and biological factors

such as age and parental status; and social psychological (i.e., psychosocial) risk factors that manifest at personal, social, and ecological levels (i.e., multilevel psychosocial risks) which can encourage risky behaviors in response to role difficulties. Although the BRSAM centers upon the concept of role strain, as a strength-based model, it also centers the concept of role adaptation. Role adaptation represents the ways in which resilient individuals (e.g., resilient students) mobilize multilevel strengths in response to role difficulties, thereby promoting successful outcomes (e.g., academic advancement) (Bowman, 2006). The model suggests that role adaptation and related coping strategies can be shaped by multilevel psychosocial strengths which operate as protective factors at the personal, social, and ecological levels as well.

The role strain and adaptation model for Black women's STEM success in college presented below (Fig. 2) combines the epistemological underpinnings of BFT and intersectionality, with the conceptual insights from the BRSAM to offer a specific framework for understanding the experiences of Black women collegians in STEM in a manner informed by existing research in this area. In doing so, I adapt and extend the BRSAM to more explicitly articulate: the structured inequities that many Black woman collegians encounter in STEM as a result of their intersectional identities; how those inequities shape the overall STEM academic opportunity structure of Black women in these fields; and important components of Black woman collegians' multilevel psychosocial strengths and risks—particularly factors related to STEM departments, overall institutional environments, and disciplinary logics noted in existing research. As the model is discussed, relevant connections to existing research are noted as useful contextual information. Given the various outcomes that were considered in the literature, as well as studies that examined Black women's experiences generally, this model focuses on Black women's overall success in STEM fields as a broad concept which includes outcomes such as future academic plans and other metrics related to successful progression toward STEM

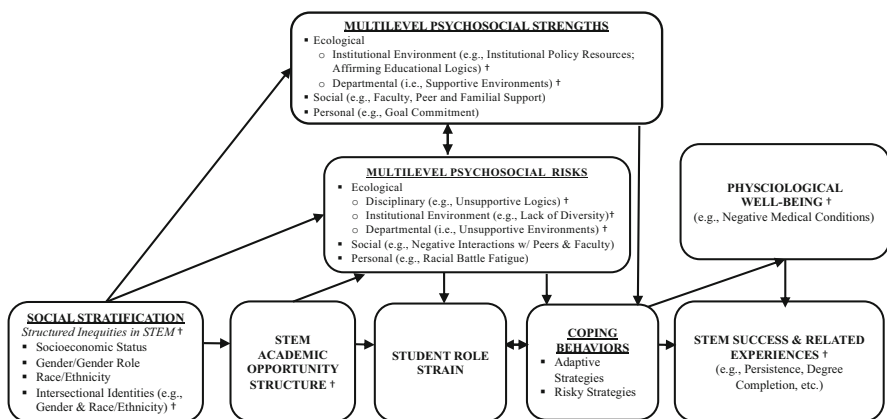


Fig. 2 Role strain and adaptation model for Black women's STEM Success in College. († Denotes extensions of the Bowman Role Strain and Adaptation Model)

degrees and careers. Specific notations are included in Fig. 1 to highlight how the model extends and builds upon the BRSAM.

Like the BRSAM, the model in Fig. 2 first situates social stratification as an important point of entry, acknowledging various ways that structural inequities in STEM can influence Black women's ultimate student development in these fields. Considering social stratification in this manner builds upon research about Black women's intersectional identity and the theoretical contributions of BFT to understanding important aspects of their overarching experiences (Collins, 1990, 2000; Collins & Bilge, 2016; Crenshaw, 1989, 1991). As noted in the previous discussion of literature, important structured inequities include biases due to Black women's race/ethnicity, gender/gender role (i.e., societal behavioral and attitudinal expectations associated with a particular assigned sex; Lindsey, 2020), and the intersections thereof. The literature discussed generally does not distinguish Black women's gender identity (i.e., the internal sense of one's gender), gender expression (i.e., expression of this internal sense of self), and sex (i.e., a label assigned at birth based on biological characteristics)—often using terms such as female and woman interchangeably. Nonetheless, the author acknowledges distinctions between these concepts and that there may be role expectations associated with an individual's assigned sex that create structured inequities in STEM regardless of a person's gender identity or gender expression.

In addition to race/ethnicity, gender/gender role, and their intersection, some studies indicated that finances and family background were important considerations that ultimately shaped the behaviors of Black undergraduate women in STEM (e.g., major choice, leaving STEM, or desires to be in a future financial position to support family; e.g., Allen et al., 2022; Lane & Id-Deen, 2023; Rosa & Mensah, 2016), as well as faculty who work closely with those students (e.g., sharing information about paid research opportunities to alleviate possible financial barriers; e.g., Perna et al., 2009). Hence, stratification that may manifest due to Black women's socioeconomic status is also included in the model. While not specifically illustrated in Fig. 2, it should be noted that intersectional identity may involve race/ethnicity, gender/gender role, and socioeconomic status as described by intersectionality theory (Collins & Bilge, 2016, 2020; Crenshaw, 1989, 1991).

Figure 2 suggests structured inequities in STEM influence Black women's STEM academic opportunity structure (i.e., the general opportunities in STEM to which they have access). While beyond the scope of this review, complementary research concerning the K-12 experiences of Black girls in STEM underscores the limited early academic opportunities that they often encounter which ultimately has lasting impacts on their trajectories into STEM majors within higher education contexts (Butler-Barnes et al., 2021; Davis, 2020; Morton et al., 2020). Both social stratification and the STEM academic opportunity structure influence the multilevel social psychological (i.e., psychosocial) risks that Black women encounter in STEM environments. Moreover, key aspects of Black women's identities also shape their multilevel psychosocial strengths.

Psychosocial risks and strengths manifest at multiple levels— ecological (e.g., important aspects of the environment), social (e.g., relational), and personal (e.g.,

individual). At the ecological level, the model suggests that risks and strengths can exist within: STEM departments (i.e., unsupportive or supportive departmental environments; e.g., Allen et al., 2022; Joseph, 2012; Perna et al., 2009) and institutions (i.e., a lack of diversity which can diminish sense of belonging or affirming educational logics; e.g., Charleston et al., 2014a; Williams & Taylor, 2022). Furthermore, the model indicates how ecological risks can manifest at a broader discipline level in STEM with regard to unsupportive logics discussed in existing literature (e.g., a culture of weeding out and competition; Borum & Walker, 2012).

In addition to ecological risks and strengths, the model also includes these elements at the social level. Such factors were often reflected in research concerning interactions between Black women and peers or faculty, with negative interactions resulting in these women generally having negative experiences in STEM (e.g., isolation or stereotypes; Charleston et al., 2014b; McGee & Bentley, 2017), while positive interactions helped to increase their persistence (e.g., sister circles; Morton, 2021a). At the personal level, the model indicates how psychological experiences such as racial battle fatigue (Smith et al., 2020) can hinder Black women's STEM development as students (McGee & Bentley, 2017; Morton, 2021a) and motivation such as goal commitments may enhance such development (Ferguson & Martin-Dunlop, 2021; Joseph, 2012). In addition to outlining aspects of multilevel psychosocial risks and strengths, the model also illustrates a possible interplay between these factors as discussed in the literature. For example, because some non-Black peers isolated them (i.e., a social risk), and because of a general lack of diversity at many PWIs (i.e., an ecological risk), research indicated that Black women looked to spaces of community such as sister circles for support (i.e., a social strength) (Morton, 2021a). Moreover, the model suggests that Black women's multilevel psychosocial risks can influence the level of strain that they experience in their student role (i.e., student role strain). Other literature connects psychosocial risks with the concept of strain in a similar fashion (McGee & Bentley, 2017).

Risks and strengths can influence Black women's coping behaviors and such behaviors can be either adaptive or risky. Adaptive strategies noted in the literature include things such as advocating for oneself or engaging faith traditions to facilitate resilience which can help to foster Black women's STEM development via outcomes like persistence (Ferguson & Martin-Dunlop, 2021). Risky strategies may include things such as dropout ideation (Allen et al., 2022). Nonetheless, research suggests that coping can be accompanied with unanticipated negative physiological consequences which can ultimately reduce Black women's STEM success (e.g., developing a negative medical condition; McGee & Bentley, 2017; Morton, 2021a).

A Path Forward: Recommendations for Future Research

This chapter closes with a number of recommendations regarding fruitful areas for future research. While a lot of useful information has been amassed from the growing body of literature on Black women studying STEM fields in college, the suggestions that follow are informed by gaps in existing literature which create

opportunities to expand what has been studied presently. Below is a list of key research questions worthy of further investigation regarding this topic.

How do Black women's challenges and strengths combine to impact their overall STEM experiences and outcomes in college?

As previously discussed, a number of studies highlight the challenges that Black women encounter pursuing STEM degrees. This literature often critiques prevalent issues regarding biases these students experience because of their race, gender, and a combination thereof. Other research highlights the various factors that help to foster success, including things such as support from family and other Black women. While each of these bodies of work provide important information about Black women's overall STEM experiences during college, what is missing is a discussion of how the challenges and factors that promote success interplay or combine to ultimately influence Black women's STEM outcomes. The role strain and adaptation model for Black women's STEM success in college provides a useful conceptual lens to help inform future research in this area. Such an analysis could provide some insights about how (or to what degree) those success-promoting factors assist Black women with overcoming the challenges that they may also encounter simultaneously. Moreover, suggested by role strain and adaptation model for Black women's STEM success in college, this analysis should seek to explore the interplay of strengths and strains within multiple domains (i.e., personal, social, and ecological).

Are current policy-related initiatives regarding diversity equity and inclusion in STEM helping to address the unique needs of Black women who are students in these fields?

Conversations regarding diversity issues and underrepresentation in STEM fields are long-standing as previously noted. Relatedly, a number of policy-related initiatives have been put into place to help develop a more diverse pool of future STEM professionals. While some initiatives provide resources directly to students who pursue STEM disciplines (e.g., financial assistance), more recent initiatives critically examine STEM institutional environments and a need for more structured changes to promote successful outcomes. Future research might explore the efficacy of each of these approaches and the degree to which they ultimately move the needle concerning the representation and inclusion of Black women in various STEM disciplines. As suggested by the role strain and adaptation model for Black women's STEM success in college, future studies might explore the degree to which policy serves as an effective lever for change with regard to the following:

- Disrupting structured inequities in STEM related to Black women's (and other students') background characteristics.
- Expanding the academic opportunity structure to be inclusive of a more diverse group of students.

- Dismantling multilevel risk outlined within the model—particularly negative departmental and institutional cultures, and larger unsupportive disciplinary logics which can ultimately result in personal risks such as racial battle fatigue (Smith et al., 2020).
- Building upon the things shown to be effective such as creating supporting and affirming institutional and departmental environments.

To accomplish these changes, ultimately it will be critical to connect funding priorities with initiatives that focus on these outlined issues. Moreover, other research and related work has begun to emphasize the need for policy-shift that focus on changing environments (Williams et al., 2022; AAAS, n.d.)

Are Black women's experiences different based upon the STEM degree that they are pursuing?

As discussed in the previous section, there are variations in Black women's level of (under)representation within a number of STEM fields. Hence, it is feasible that Black women's experiences in these fields may differ based upon the number of other Black women who are also pursuing degrees in a particular STEM discipline. Nevertheless, very few studies examined Black women's experiences within a specific STEM field (Charleston et al., 2014b; Dillon & Williams, 2020a, b; Rosa & Mensah, 2016). Instead, many studies employed the STEM acronym in a manner that positions these disciplines as a collective. While in some instances, it may be helpful to frame and talk across all of the fields included within the STEM umbrella, future research should consider Black women's experiences within specific STEM areas given the varying degree of representational challenges they may encounter based upon their field of study.

What were the experiences of Black women who are no longer pursuing STEM degrees? Why did they leave?

Much of the existing literature focuses on the experiences of Black women who are currently pursuing STEM degrees or who have successfully traversed these fields. What is missing is a detail examination of the Black women who left these fields and what their experiences were. Such an examination would enrich what is currently discussed in the literature and could shed light on additional barriers or challenges that ultimately led to these women no longer pursuing their interests in these fields.

Are there differences in Black women's experiences base upon their ethnicity?

Within higher education research, there is often a tendency to conflate race and ethnicity and to refer to Black students in monolithic ways that fails to appreciate within group differences. Such framing can ultimately essentialize the experiences of all Black individuals without proper attention to possible ethnic differences within

this racial category. Some research has started to explicate how Black students' collegiate experiences in STEM may differ based upon their ethnic backgrounds (George Mwangi et al., 2016), yet additional research in this area is sorely needed. Furthermore, analyses that attend to differences between Black women in STEM from various ethnic backgrounds could be a compelling addition to the current body of research.

Are there differences in Black women's experiences base upon institutional type?

Some of the research discussed previously examined Black women's experiences within PWIs vs HBCUs (Borum & Walker, 2012; Joseph, 2012; Morton, 2021a). Additional studies that examine these issues across various institutions could also be helpful. Moreover, it would be interesting to explore Black women's experiences within the context of different HBCUs. For example, are there differences in Black women's experiences within HBCUs that are women's colleges (i.e., Bennett College and Spelman College) versus HBCUs that serve women and men? Literature notes the importance of Black education logics at HBCUs and how that can help students to be successful in STEM (Williams & Taylor, 2022). While there are studies to support this phenomenon, it is plausible that such logic can vary by institution and/or the specific STEM discipline. This is especially important to consider as the faculty composition at some Black institutions continues to evolve in ways where the representation of Black faculty may be diminishing—especially in some STEM areas. Furthermore, a logic that affirms Black students may not operate the same for Black women and Black men given their gendered differences. In general, these gaps in existing literature highlight possible areas for further exploration.

Are there ways in which quantitative data might be employed to complement the important insights gained from qualitative studies?

The overwhelming majority of the literature concerning the experiences of Black women in STEM utilizes qualitative research methods—the most common of which are phenomenology (e.g., Charleston et al., 2014b; Dortch & Patel, 2017; McGee & Bentley, 2017) and case-study approaches (e.g., Joseph, 2012; Lockett et al., 2018; Perna et al., 2009). This largely qualitative body of work centers the voices of Black women in very important ways to provide a deep and rich description of the challenges that they encounter pursuing STEM degrees, as well as various assets that help them to overcome those challenges. Building upon this seminal body of research, future scholarship might employ complementary quantitative methods. This might include a large-scale national survey of Black women collegians in STEM which explores relationships between the various elements outline in Fig. 2 (i.e., the role strain and adaptation model for Black women's STEM success in college) and their association with outcomes often explored within higher education literature (e.g., persistence, degree completion, work-force outcomes, etc.). Future research might also combine qualitative and quantitative methods (i.e., utilize mixed methods or multiple methods) to tap into the strengths of various methodological traditions by using qualitative insights to further explicate

quantitative findings or quantitative data to explore the degree to which associations discussed in qualitative research also manifest on a greater scale. Identifying ways in which quantitative insights might help to complement the current qualitative canon will help to extend the methodological reach of the existing corpus of work.

The listed questions provide a number of paths forward, as scholars continue to explore Black women's experiences in STEM, and the things that hinder or enhance their success. Such questions will remain relevant as the USA continues to grapple with concerns about the future STEM workforce, and broadening participation for groups that have a history of underrepresentation and isolation in STEM academic environments, accentuating the need to re-examine the efficacy of many STEM diversity, equity, and inclusion efforts. This list is not meant to be exhaustive; however, it provides some initial, high-level guidance concerning the research areas that future scholars may explore as they expand this area of research.

Conclusion

The preceding discussion of existing literature provides an overview of the current body of research regarding the experiences of Black women as they traverse collegiate environments in pursuit of STEM undergraduate degrees. This thematic review is contextualized by insights about the evolution of STEM as a concept; the larger policy discourse regarding STEM equity issues and rationales for an increased emphasis on opportunities in this area; and the STEM representational terrain with a focus on differences within particular STEM disciplines. The literature review highlights the complexities of Black women's intersectional marginalization in STEM due to their race and gender, combined; how stereotypes operate as tools of marginalization; the unwelcoming institutional environments that Black woman STEM collegians often encounter which make many of them feel isolated, and often subordinated; the ways in which family (i.e., blood relatives and "chosen family") can be sources of resilience in the face of challenge; and how trauma can sometimes be an unanticipated consequence of resilience, particularly in terms of damages to Black women's physiological well-being. Drawing upon this body of work, along with related research concerning racially marginalized groups in STEM (Burt et al., 2018, 2019; Williams, 2014a, b, 2020; Williams & Davis, 2021; Williams et al., 2016, 2019b) and critical lenses concerning these groups in general (Bowman, 2006, 2012) as well as Black women in particular (Collins, 1990, 2000; Collins & Bilge, 2016, 2020; Crenshaw, 1989, 1991), this chapter offers the role strain and adaptation model for Black women's STEM success in college as a framework for understanding how the challenges that many Black women encounter while pursuing STEM degrees, their strengths, and their coping strategies coalesce to ultimately shape their success in these fields. Moreover, recommendations for future research are offered to help inform work that hopes to shape policy and practice in ways that expand opportunities for these groups.

As reflected in the literature discussed, there has been a growing emphasis on examining the unique experiences of Black women in STEM. Unfortunately, this discussion is not novel. While advances have been made in certain areas, extreme

opportunities for growth remain in others—especially as it relates to disrupting the social, disciplinary, institutional, and departmental environments that create barriers to Black women’s STEM success. As the push for change continues, it will be especially important to understand the ways in which Black women’s STEM experiences may not be solely raced, but simultaneously gendered. Theories like CRF (Wing, 2003), BFT (Collins, 1990, 2000), and intersectionality (Collins & Bilge, 2016, 2020; Crenshaw, 1989, 1991) guide us to better appreciate Black women’s intersectional experiences in STEM, particularly the double bind (Malcom et al., 1976) that often manifests due to racism and sexism. Accordingly, efforts to expand opportunities to Black women in these fields should reflect this important detail.

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