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"It is what it is": Using Storied-Identity and intersectionality lenses to understand the trajectory of a young Black woman's science and math identities

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Abstract

Science, technology, engineering, and mathematics (STEM) identity has become a popular lens in science education research. However, few studies have looked at how using the interpersonal, structural, cultural, and disciplinary domains of power sheds light on how women of color differently navigate the various cultures of formal and informal schooling as well as college science and math departments. This paper uses narrative inquiry methodology to examine how a young Black woman constructs science and math identities through stories about her previous experiences becoming a science and math person. By also framing it within intersectionality and employing a storied-identity lens, this study provides insight into how stories that shape identities inform her science and math identities. Specifically, this study looked at how she navigated the emotions and social experiences that fostered an interwoven storied science, math, and racial identity across different times, spaces, and settings. It highlights how a strong sense of belonging in her science and math trajectories was positively influenced through various sources and moments of recognition from community influences (e.g., family, peers, and faculty) and structural disruptions (e.g., the HBCU

she attended and STEM camp). Despite negative emotions of self-doubt and frustration were present when her science, math, racial, and smart student identities came into conflict, she leveraged the positive emotions of joy and pride in her interwoven science and math storylines, which strengthened not only her science and math identities but also her racial identity. The study underscores the importance of leveraging counter-narratives of resilience as a resilience strategy but also practicing acceptance and self-compassion when navigating tensions between racial, science, math, and smart-student identities for women of color in STEM. The study's conclusions add to the call for structural changes within K-12 and higher education that are crucial for equity goals within STEM education.

KEYWORDS

black women in STEM, emotions, intersectionality, recognition, science and math identities, storied-identities

1 | INTRODUCTION

Research in the science, technology, engineering, and mathematics (STEM) fields results in innovations that impact society by improving our quality of life as well as our understanding of the world around us. However, women in Europe (European Institute for Gender Equality, 2017) are underrepresented in these fields, and in the United States (where this study takes place) women of color are notably underrepresented (National Science Foundation [NSF], 2019). Black women in the United States make up 7.1% of the undergraduate age population (United States Census, 2019), but their representation in STEM can vary from 5.5% in biology to as low as 2% in mathematics and 1% in engineering (NSF, 2019). Prior research has shown the reasons for this underrepresentation are a lack of relevant, hands-on STEM experiences in K-12 (e.g., Calabrese Barton et al., 2013; McCreedy & Dierking, 2013), a lack of role models or connections to authentic STEM research for K-12 and college students (Eccles, 2007; Ong, 2005), and the culture within certain STEM disciplines that encourages the attrition and exclusion of systemically excluded groups (Johnson, 2020; Ong, 2005). This culture can vary across STEM disciplines, with some (e.g., physics) being more focused on "innate" intelligence and dominated by men than others (e.g., biology) (Eaton et al., 2020; Leslie et al., 2015). But there are common barriers across STEM disciplines cited in the research such as sexual and gender harassment, racial discrimination, and gatekeeper courses where the goal is to fail a large portion of students and demonstrate the difficulty of STEM (Clancy et al., 2017; National Academies of Sciences, Engineering, and Mathematics [NASEM], 2017; NASEM, 2018). These complex and multifaceted causes for the underrepresentation and systemic exclusion of Black

women are historical, cultural, and linked to power differentials inherent to society (Collins & Bilge, 2016).

STEM identity has become a popular lens in science education research in understanding how programs and institutions can improve the representation of historically underrepresented and systemically excluded populations. Kim, Sinatra, and Seyranian (2018) define STEM identity as the way "individuals [recognize] themselves and are accepted as a member of a STEM discipline or field" (p. 591). These authors highlight the importance of a sense of belonging based on both internal and external recognition. Building on the seminal work of Carlone and Johnson (2007), in this study we draw from this definition to understand how women of color (specifically Black women) recognize themselves as belonging in the science and math fields. Just as Hazari et al. (2020) mentioned, we agree that a sense of belonging and recognition are related but distinguishable theoretically in that an individual can recognize themselves as a "science person" but not necessarily feel like they belong due to other identities they hold that makes them feel like they do not belong (e.g., gender, race/ethnicity; see Strayhorn, 2012). Current scholars advocate for more research into Black women's STEM identity trajectories from an asset-based (as opposed to deficit-based) perspective (Ireland et al., 2018; Joseph et al., 2016). For this study, we focus on the science and math identities of Marie, a young Black woman who started in the sciences and ended up in the math field. We explore how she recognizes herself and is recognized by others as a science and math person and how these moments and sources of recognition provide her with a sense of belonging in STEM despite interpersonal, structural, cultural, and disciplinary domains of power that influenced her experiences in the fields of science and math.

As a result of the double bind of gender and race (Malcom & Malcom, 2011; Williams et al., 2014), Black women are often forced to hide certain identities in science and math realms so that they are seen as competent (Johnson, 2020; Ong, 2005). Consequently, intersectionality has become an important lens to study science and math identities for Black girls and women in STEM (Collins & Bilge, 2016; Johnson, 2020; Kim et al., 2018). Intersectionality comes into play when a person's various identities (such as racial, ethnic, or gender) are reinforced or erased in certain contexts where dominant cultural and structural norms marginalize non-dominant identities (Collins & Bilge, 2016). A better understanding of the development of the science and math identities for Black women can improve diversity within these relevant fields and careers, which can, in turn, improve innovations created in STEM (Dou et al., 2019; Joseph et al., 2017).

1.1 | Theoretical underpinnings

In the following section, we describe the various constructs we drew upon to frame our study of Marie's salient identities as a smart person, a science person, a math person, and a Black woman. The first construct is science identity, specifically the role that moments and sources of recognition play in Black women's sense of belonging in science and math (Avraamidou, 2021; Hazari et al., 2020; Ong et al., 2018). The second theoretical frame we drew from is intersectionality, namely how Marie's identities were influenced by interpersonal, structural, cultural, and disciplinary domains of power (Collins & Bilge, 2016). By including the influence of domains of power on Marie's science and math identities, we were able to see how systemic racism and sexism within STEM fields and the broader US culture shaped her trajectory in science and math. Lastly, we use the construct of emotions because of how emotionality is intrinsically tied to identity and lived experiences.

1.2 | Science identity

Carlone and Johnson's (2007) seminal work highlights the components of science identity for women of color,[1] consisting of three dimensions: (1) *competence*: knowledge and understanding of science content; (2) *performance*: social performances of relevant scientific practices; (3) *recognition*: recognizing oneself and being recognized by perceived experts as a science person. Avraamidou (2020b) goes even further to define recognition as "an ineradicable part of our social world, bound within sociopolitical and historical contexts, and hence, tied to specific cultural norms, values, beliefs, and stereotypes." (p. 332) We use this lens of science identity to identify moments and sources of recognition (Avraamidou, 2021) in science and math over the course of Marie's schooling—both when she recognizes herself as a science or math person and when she perceives others recognizing her—and how they influence her sense of belonging within a future science or math career (particularly during her college years as she develops competence yet encounters stereotypes in science and math disciplines) (Hazari et al., 2020). Women of color's sense of belonging in STEM is made even more difficult because of their underrepresentation and systemic exclusion in STEM fields (Good et al., 2012; Johnson, 2012; NSF, 2019; Ong, 2005; Smith et al., 2013; Strayhorn, 2012) as well as the structural, cultural, and disciplinary domains of power that promote stereotypes keeping Black women from fully feeling like they belong (Corbett & Hill, 2015; Dweck, 2006; Hill et al., 2010). Researchers have found that *recognition* is an understudied construct of STEM identity tied to one's sense of belonging, particularly in fields where women are severely underrepresented and systemically excluded like engineering and physics (Godwin et al., 2016; Hazari et al., 2017; Wang & Hazari, 2018). Research has focused on the role of recognition at the high school and college level (Hazari et al., 2017; Lock & Hazari, 2016; Wang & Hazari, 2018), highlighting the influential role of external and explicit recognition (when teachers make direct comments about students' abilities). In addition, Rodriguez, Cunningham, and Jordan (2017) found that recognition within the disciplinary community [was] especially important because it was connected to how peers and faculty members "invited them into or pushed them away from a STEM community" (p. 267). These studies highlight how experiences of recognition in STEM can support or hinder identity trajectories at crucial development stages for women of color.

1.3 | Intersectionality's role in science and math identities

1.3.1 | Intersectionality as a theoretical concept

To better understand the science and math identity development of Black women across contexts and over time, an intersectionality lens is crucial. Avraamidou (2020b) stresses the importance of using an intersectionality lens to understand the science and math identities because it allows researchers to examine the relationality and plurality of other identities along with science and math identities. Research that uses an intersectionality lens to study STEM identity has relied on the foundation built in the work of Patricia Hill Collins (Avraamidou, 2020a, 2020b; Collins, 2019; Collins & Bilge, 2016; Johnson, 2020; Ong, 2005). Collins argues that to understand how power is organized in a setting (e.g., who belongs and who has access to resources and opportunities in STEM disciplines and settings), researchers need to focus on four domains: the interpersonal, the cultural, the structural, and the disciplinary (Collins, 2009; Collins & Bilge, 2016).

The interpersonal domain is the power expressed between individuals in the form of inclusion versus exclusion to STEM spaces or concepts among peers (e.g., who is invited to participate or acknowledged in study groups or the role of gatekeepers and how teachers position their students for performance and consequently recognition in STEM) (Collins & Bilge, 2016; Johnson, 2020). The cultural domain is the power expressed in how a group's values are conveyed or contested. The dominant culture within STEM is a White and Western culture that portrays scientists as White, rational, and infallible making it difficult for those who do not fit this dominant group to be recognized as STEM people or feel like they belong (Collins & Bilge, 2016; Johnson, 2020). The structural domain is how power is allocated within large social structures. The structural impacts of racism and sexism influence the science and math identity trajectory of Black girls beginning as early as elementary school. Black youth disproportionately attend low-income and under-resourced schools, preventing them from accessing the necessary STEM courses to major in these disciplines. In addition, teachers' own stereotypes and biases affect their ability to treat and see Black girls as potential STEM people (Johnson, 2020). Black women in college who are not yet deterred from STEM then encounter "weed-out" classes that make them question their preparation and belonging. They also encounter peers who refuse to study with them and faculty who treat them differently because of racial and gender stereotypes (Johnson, 2020). Finally, the disciplinary domain refers to how rules and regulations get enforced for and by whom. Research on K-12 has shown that Black girls are disciplined more severely for behaviors than their peers resulting in a lack of access to learning through suspension, expulsion, and even imprisonment (King & Pringle, 2019; Love, 2019). In college, Black women may be "disciplined" by those in power (e.g., faculty) based on implicit rules such as dress codes (Johnson, 2020; Ong, 2005).

1.3.2 | Intersectionality in research

Some studies have referenced intersectionality without focusing on these domains of power explicitly. For instance, Ong (2005) interviewed undergraduate and graduate women of color in physics to determine how they performed their various salient identities, which she referred to as the realms of gender, race, and physics for her participants. The women in her study engaged in two forms of body projects wherein they would fragment their gender or racial identities from their physics world to be seen as competent. Some would engage in multiplicity, which she defined as the performance of all identities at the risk of being labeled as not belonging. Ong found that none of the women could fully hide their female and/or racial identities, which left them feeling excluded from physics. Ong's study helps us to see how the matrix of oppression (Collins, 2009) that women of color experience in physics, but it does not explain how power differentials influence that. Power relations and structures exist at the intersections of racism and sexism, which historically underrepresented and systemically excluded groups experience as they try to negotiate their STEM identities and are confronted with an unwelcoming environment.

Johnson (2020) used the domains of power when conducting an anthropological study to better understand how women of color negotiated their physics identities in one university physics department. She attended at least one class session of every physics class and lab during the semester she was conducting the study and interviewed 6 out of the 8 women undergraduate physics majors (including all three women of color), asking for their life stories in physics. This physics department used research-based strategies to help students persist, so the women

in the study saw physics differently than the prototypical physics department (i.e., the women saw physics as collaborative and full of curious and engaged critical thinkers). Johnson did not see any differences between the women of color and the White women in the study; however, like other researchers, she advocates for more research using the domains of power to study Black women's STEM identity trajectories.

1.4 | Emotions

We also draw from the construct of emotions in science identity (Avraamidou, 2020b) and use it to highlight the important role emotions play in the formation of science and math identities across time and place. According to Keltner and Gross (1999), emotions are "relatively short-term, biologically-based patterns of perception, experience, physiology, action, and communication that occur in response to specific physical and social challenges and opportunities" (p. 468). Emotions such as joy, pride, or frustration are part of people's stories and lived experiences. As Solomon (2007) said, "we live through our emotions" (p. 10), and how we navigate and make sense of our emotions shapes our lived experiences, which in turn shapes our identities. For example, as Rivera Maulucci (8) found in her study of one Black preservice teacher learning to teach social justice as a chemistry teacher, emotions such as hope can serve as a resource one leverages to make sense of one's experiences and enact changes. How she navigated her emotions was crucial in how she positioned herself as a social justice teacher since "emotions are fully implicated in teachers' evaluations of their physical well-being, teaching practices, or relationships with others" (Rivera Maulucci, 2013, p. 473). Therefore, by acknowledging the important role of emotions in shaping one's identity, we also recognize that becoming a science or math person is a humanizing experience (Avraamidou, 2020b) shaped by our sensemaking of these emotions and how we act toward them.

Bringing together the three constructs of science identity, recognition, and emotions offers a framework for how we define and describe science and math identities in this study. We examine how a young Black woman recognizes herself as a member of the science and/or math fields across different settings and over time (Kim, et al., 2018), which changes with her perceptions and how she emotionally navigates her experiences and the domains of power within science and math. We use Marie's storied science and math identities to illustrate not only how she moves through both science and math disciplines, but also how she emotionally navigates the oppressive aspects of STEM within these domains of power.

1.5 | Literature review of black women and Girls' experiences in STEM

In this section, we review studies about the unique experiences of Black women and girls in STEM to illustrate the oppressive nature of these disciplines, specifically in the science and math fields and during their K-12 schooling as well as university experiences.[2] Because Black girls and women are historically underrepresented and systemically excluded in science and math fields, they are often ignored by the research and the science and math communities, rendering them "hidden figures" (Ireland et al., 2018, p. 226). The narratives and experiences of Black girls and women in mathematics are largely invisible in scholarly studies (Gholson, 2016), with quantitative studies lumping all women of color together and ignoring their

intersectional experiences as part of the aggregate. Other studies treat gender and race as two mutually exclusive groups which ignore the ways in which gender and race intersect and create different outcomes for women of color in science and math compared to White women and men of color (Ireland et al., 2018). Multiple researchers have called for the use of an intersectionality lens to study Black women and girls' trajectories in science and math (Bullock, 2017; Ireland et al., 2018; McGee & Bentley, 2017; Morton & Parsons, 2018).

To address the issue of "figure hiding" (Bullock, 2017) and the exclusion and suppression of research on Black women in mathematics, Bullock (2018) conducted a literature review of critical mathematics education studies and found that there were different models used for intersectionality analysis. These included identity models, which examine different life experiences; conflict models, which examine how individuals negotiate conflict; institutional models, which focus on how various *isms* operate through institutions; and discourse models, which look at structures in place to perpetuate and maintain dominations. Bullock (2018) suggested that these models can be used to shed light on the social and political challenges Black women may encounter pursuing careers in mathematics. Our literature review highlights why using an intersectionality lens is needed to study Black women's science and math identities.

1.6 | K-12 schooling experiences

Studies of Black girls' science and math interest and identities at the K-12 level highlight the importance of role models and interventions that connect girls to hands-on and relevant STEM activities (Gholson & Martin, 2014; Ireland et al., 2018; King & Pringle, 2019). Gholson and Martin (2014) attempted to study the complexity of mathematics learning for Black girls at the elementary grade level. Their analysis of the interviews of the girls showed that social settings and networks are important in developing the learning and racial identity of girls. King and Pringle (2019) utilized a Critical Race Feminism lens to give voice to six Black middle school girls who participated in a community-based informal STEM program (I AM STEM) that included hands-on programming with role models. The researchers were participant observers during the camp and collected interview and document artifact data to create narrative stories for each of the girls. These stories were then developed into counter-narratives—stories that challenge the dominant ideology and reject the deficit-based normative discourse regarding Black girls and women in order to open new possibilities for those who are marginalized or isolated in society (Joseph et al., 2016). The authors found that the girls' counter-narratives gave them resources to craft positive STEM identities that they could draw upon when returning to their K-12 science classes.

Reflective studies that have asked Black women to reflect on their K-12 experiences have provided information on the role that sexism and racism play. Black women begin to see the stereotypes related to who belongs in STEM—White men—as early as an elementary school in both their formal and informal STEM experiences (Morton, 2021). The reasons for this perception include the lack of STEM or education role models, isolation if they attend predominantly White K-12 schools, and lack of support from socializers (e.g., parents, guidance counselors, family members, or mentors) regarding their interest in STEM (King & Pringle, 2019; Morton & Parsons, 2018). Morton and Parsons' (2018) study of 10 undergraduate Black women in science, engineering, and math fields found that all participants shared stories of isolation and discrimination from their K-12 experiences. But they all had positive counter stories to support their STEM identity through supportive family members and teachers. Later, Morton (2021)

conducted a study that included five undergraduate Black women in physics, engineering, math, and chemistry who referenced their motivation to pursue STEM because they never met a Black teacher in their K-12 experiences, and they wanted to be a role model for Black girls.

1.7 | College and graduate school

There are several studies that have focused on Black women in STEM at the college and graduate level. Ireland et al. (2018) reviewed 60 articles on Black women and girls' experiences in STEM and found that Black women experience racial microaggressions, sexist stereotypes, alienation and discrimination, and feelings of isolation. These experiences can be compounded when Black women are not given academic and research opportunities that help them to develop independence and research skills. One of the positive interventions for STEM students is undergraduate research experiences, which are opportunities for undergraduate students to work with a faculty member on a research project. Yet, Black women can still experience isolation as the only Black woman in these programs (Ireland et al., 2018).

Nicole Joseph et al., 2017 also conducted a literature review that included 62 articles focusing on asset-based studies of Black girls' and women's success in mathematics. The authors used a combined framework of Critical Race Theory, Critical Race Feminism, and Black feminist thought to put Black girls' and women's lived experiences at the forefront and to advocate for counter-narratives. The authors identified three themes that were common across the studies for Black women and girls' persistence in mathematics: structural disruptions, community influences, and resilience strategies. Structural disruptions can range from short-lived to permanent opportunities, including physical resources like books, human capital like culturally responsive educators, and social justice-based programs and policies. This latter category included Historically Black Colleges or Universities (HBCUs),[3] particularly Spelman College as an all-women's HBCU. Nguyen et al. (2021) note that HBCUs act as affirming counterspaces that challenge deficit notions and support Black women students' strengths and recognize their background as an asset. Research has demonstrated that Spelman serves as an institutional structure that fosters a sense of collaboration and cooperation among peers that promotes academic achievement and success for Black women (Borum & Walker, 2012; Joseph et al., 2017; Perna et al., 2009; White et al., 2019).

The second theme of community influences examines how Black women and girls can develop a sense of belonging in mathematics to combat social stereotypes related to who can be successful. The articles Joseph et al. (2017) reviewed highlight that role models, mentors, and encouraging teachers played a significant role in developing a strong math identity in Black girls and women. However, parental math influence outweighed that of teachers, counselors, and peers in terms of career selection, and this influence mattered most during middle school and the first half of high school. Finally, the third theme of resilience strategies emerged when studies found that Black girls have higher math career aspirations compared to their female peers but over time structural hindrances limit their access to higher level math courses—combined with teachers' low expectations hindering their opportunity to learn (Riegle-Crumb et al., 2011; Rist, 2000). Safe and orderly learning environments, positive teacher-student relationships, and quality mentoring have all been credited as contributing to resilience.

These three themes can be seen in other studies published after Joseph et al., 2017 review. For example, Morton and Parsons' (2018) focused on 10 undergraduate Black women in STEM, five of whom attended a HBCU, which for some had positive community influences and served

as a structural disruption. Of the five who attended predominantly white institutions (PWIs), all experienced stereotypes associated with being a Black woman (e.g., having their competence or even whether they belonged in the department questioned, White peers and faculty being surprised by their competence) and developed resilience strategies in response. They referenced both internalized oppression and pride as Black women, with the latter positive-protective identity described by the authors as #BlackGirlMagic. The women focused on historical and current family stories and community influences regarding the resilience of Black women and engaged as active agents in reimagining what it means to be a Black woman in opposition to historical and cultural systems of oppression.

Another study by Morton (2021) highlighted that not all HBCUs provide the structural disruption and community influences that Black women need to succeed in STEM. Morton found that the five undergraduate women in his study had their STEM identities influenced by the "antagonistic, oppressive STEM culture" within their departments. All five women attended an HBCU and yet even in this space they still experienced isolation since they saw few Black women faculty. They were internally motivated to persist in STEM because there were so few Black women, and all five discussed that their identity as a Black woman meant that there was no room for failure. Morton found that the women's sense that as Black women they had to exhibit resilience to be successful highlights how the system of oppression creates stereotypes of what it means to be a Black (super)woman that prevents them from being their authentic selves (Morton, 2021), underscoring the personal cost to Black women and girls in order to overcome the norms of Whiteness in STEM (Joseph et al., 2016).

Another study that highlights the emotional and physical cost for Black women who persist in STEM was conducted by McGee and Bentley (2017). In their study, they interviewed three high achieving Black women in STEM (Nia = undergraduate in computer science and math, Maya = PhD graduate in mechanical engineering, Sonya = 4th year PhD student in computer engineering) to better understand the resilience strategies that Black women engage in to persist in STEM. They found that the three women in their study developed "functional resilience" and coping strategies such as perseverance and optimism in the face of oppression, discrimination, and stereotypes, but that the need to do so exacted a significant toll on their mental and physical health.

This literature review highlights the unique experiences of Black women and girls in STEM, especially in science and math, which include negative experiences based on racism and sexism as well as the coping strategies utilized by Black women that lead to their resilience. These authors call for more research on Black women's STEM trajectories, especially through an intersectionality lens, to understand their experiences and develop interventions and strategies to help them succeed without risking their mental and physical health. Ireland et al. (2018) advocated for the use of an intersectionality lens because it focuses researchers on the structural inequalities and systemic oppressions that affect Black women's educational experience (e.g., stereotypes, overt gender and racial discrimination, educational access). Intersectionality points to "factors such as power, privilege, and institutional barriers, which affect the mental processes and educational choices of Black women and girls in STEM education, beyond their individual characteristics" (p. 245). By using an intersectional analysis lens, Mensah (2019) was able to highlight how the science, racial, and gender identities of an African American female elementary science teacher played out in her science teacher educational experiences as well as in her early career as an elementary science teacher, highlighting how she felt marginalized as a woman of color at the intersection of Blackness and smartness and thus pointing to the value of using intersectionality as a lens to shed light on the experience of single individuals.

Responding to these calls, we chose to focus on one Black woman's life story as a science and math person to highlight the intersection between her various salient identities. Marie's trajectory within science and math highlights how she was able to negotiate various and sometimes incongruent identities as a Black woman in science and math from middle school through college. We focused on how her recognition within these disciplines was affected by the various power domains that impacted her as a Black woman through her own reflections. Our study seeks to add to the paucity of research on the trajectory in the science and math identities of Black women through storied-identity (Ibourk, 2021) and intersectionality lenses (Ireland et al., 2018). We are particularly interested in how Marie's stories shape her science and math identities, the factors, emotions, and domains of power that supported or hindered these identities, and the implications this may have for understanding the ongoing underrepresentation and systemic exclusion of Black women in science and math. This study delved into the following research questions: (1) What are the storied-identities that shaped the trajectory of a young Black woman's science and math identities? (2) What emotions and domains of power shaped her storied science and math identities?

2 | METHODOLOGY

This study uses a narrative inquiry methodology as a form of qualitative research to understand how Marie authored the various narratives or stories she told that shaped her science and math identity trajectory. Connelly and Clandinin (1990) argued that "humans are storytelling organisms who, individually and socially, lead storied lives" (p. 2). Stories are important in that they help members make meaning of their culture, make sense of their lives at different stages, as well as explain their actions. As Sfard and Prusak (2005) stated, "[narratives] that constitute one's identity, being an important factor in shaping [a] person's actions, will be useful in research even if they communicate one's experiences only as well as human words can tell" (p. 14). Therefore, stories are powerful in that they tell the "specifics" behind the history of the lives of people and what shaped their journey.

Specifically, we utilized a storied-identity approach (Drake et al., 2001; Ibourk, 2021), or exploring stories that shape one's identity, to highlight how moments of recognition in Marie's stories about becoming a science and math person shaped her identity trajectories. Storied-identities are fluid, dynamic, and tentative (Drake et al., 2001; Ibourk, 2021) since they are based on narratives and lived experiences that develop across time, space, and different settings. Storied-identities are also a process of becoming with no final product or outcome (Avraamidou, 2020b). Therefore, we viewed her science and math identities as shaped by her experiences moving iteratively across different settings, times, and spaces that were affected by the interpersonal, cultural, structural, and disciplinary nature of these landscapes. Using a storied-identity approach allowed us to explore critical events and stories that shaped Marie's science and math identities and how they intersected with other salient identities such as race and gender.

2.1 | Participant and setting

Marie (a pseudonym) became the focus of this study as part of a larger study focused on the STEM identity trajectories of women of color who participated in a middle school summer STEM camp (STEM Girls) between 2006 and 2014. Initially, we contacted women of color

within the college-age range and conducted interviews with multiple alumnae. For this study, we chose to focus on Marie since her stories were rich and her ability to reflect on her experiences made her stand out, particularly her ability to see and describe how her racial identity both empowered and constrained her storied science and math identities. Marie began college as a biology major but switched to a math major. She was enrolled in Spelman College (not a pseudonym—as Marie gave us permission to use it), an all-women's HBCU in the US.

2.2 | Data collection and analysis

We used qualitative methods for our study. Data sources included open-ended responses on Marie's applications and pre- and post-survey data from her participation in multiple years of the summer STEM camp, a life story interview, and a follow-up interview. Both interviews (about an hour long and conducted by the second author) were instrumental in giving us insight into the stories that shaped her science and math identity trajectory (Drake et al., 2001; Ibourk, 2021). To get at Marie's storied science and math identities in our first round of analysis, we used open and closed coding (Corbin & Strauss, 2008; Strauss & Corbin, 1994), which was event-guided and focused on critical events from her lived experiences that she named (such as a peak experience, a low experience, and a turning point in her science and math identity trajectory). We used narrative coding (Clandinin & Connelly, 2000) to pinpoint the people she named in her stories of becoming a science and math person, the interwoven storylines, and the places that surfaced. We used NVivo and line-by-line coding techniques to develop a codebook to further guide our analysis. Some of these first-order codes were influential people, supportive experiences, tensions among identities, lack of support, interwoven storylines, or moments of time travel where she repeatedly referenced experiences from the past, memorable events, moments of uncertainty, and productive struggle. Using a storied-identity lens, her science, math, racial and "smart person" identities emerged as the salient identities that were shaped by the stories of her becoming a science and math person. In our second round of analysis, we drew from Carlone and Johnson's (2007) model of science identity, particularly the role of recognition, and coded for moments and sources of recognition (Avraamidou, 2021) in her stories of becoming a science and math person. Influential people (parents, high school teachers, math college professors) in her stories were coded as sources of recognition while supportive experiences and positive memorable events were coded as moments of recognition. We also used this recognition lens to examine how external and self-recognition and the emotions that Marie connected to these moments shaped her science and math identity trajectory. See Table 1 for examples of Level 2 Analysis.

Our third level of analysis focused on how moments and sources of recognition (Avraamidou, 2021) in her becoming a science and math person tied to her sense of belonging as it related to her racial and smart student identities (Strayhorn, 2012). These moments of recognition also include her positive experiences in her story of becoming a science and math person as well moments that made her feel supported, heard, and seen and hence positively influenced her sense of belonging. We coded these sources as community influences (Joseph et al., 2017) and the settings where these community influences were as structural disruptions (Joseph et al., 2017). We used an intersectionality lens (Collins & Bilge, 2016) to better understand how her salient identities (science, math, racial, and smart student) came into tension and where and how they showed up in the interpersonal, cultural, structural, and disciplinary domains of power (Collins, 2000, 2009; Collins & Bilge, 2016). We coded tensions among her identities when we saw she had moments of self-doubt

TABLE 1 Level 2 analysis

Narrative code	Description	Category (sources or moments of recognition)	Sub-category-(emotions)
Influential people	Individuals Marie referenced as having a positive impact on her becoming a science and math person story.	Influential people (parents, family members, peers, high school teachers, math college professors) in her stories also were sources of recognition.	Emotions that surfaced here with influential people were joy and pride.
Supportive experiences/ Positive memorable events	Experiences that Marie mentioned which have helped her in her becoming a science and math person. This includes both her turning point and a peak experience in her story of becoming a science and math person.	These were coded in her stories as moments of recognition positively influencing her science and math trajectory.	Emotions that surfaced in her supportive experiences were joy and pride.

and conflict among one or more of her identities (e.g., science and math identities or conflicts with racial and/or smart identities). These moments included moments when she experienced impostor syndrome or thought she could not be successful or experiences where she felt unsupported, ignored, unheard, silenced, or rejected. We also applied the intersectionality framework to note the emotions that surfaced in her stories in each of the interpersonal, cultural, structural, and disciplinary domains and what they can tell us about how she acted upon those emotions (her individual agency of practicing the resilience strategies of acceptance and self-compassion) and how they either constrained or enabled her own self-recognition and informed the development of her science and math identities. The emotions that surfaced were joy, pride, self-doubt, and frustration. Table 2 shows the questions that drove our analysis at this phase. We included both the questions relevant to the intersectionality lens as well as the emotional context.

The three main themes of (1) interwoven storylines strengthening racial, science, and math identities, (2) interwoven storylines helping negotiate identity uncertainty, and (3) how domains of power created tensions between her racial, science, and math identities were the final products of our three-level analysis. In each of these three themes, we noted that moments of recognition were positively influenced by community influences such as family members, peers, teachers, and professors and showed up in structural disruptions such as in Marie's HBCU as well as the resilience strategies of acceptance and self-compassion. The three themes interwoven around Marie's storylines spoke to her interpersonal stories of resilience.

2.2.1 | Trustworthiness

Maxwell (2005) provided a checklist of eight strategies that helped test the validity of our conclusions. Out of the eight strategies, we used triangulation, searching for discrepant evidence and negative cases, member checking, and rich data. We triangulated multiple sources of data, which included interviews, applications, and surveys. We repeatedly compared and cross-examined these data to help us reach our results to search for discrepant evidence. As a team of three

TABLE 2 Domains of power questions for the third level of analysis

Domain	Intersectionality questions	Emotion questions
Interpersonal Domain (power expressed between individuals)	What influence did Marie's interactions with family, peers, teachers, and faculty have on her science and math identities?	What emotions did Marie express when describing these social interactions?
Cultural Domain (how a group's values are conveyed or contested)	What were the values expressed by Marie and her family? What were the values expressed by teachers, peers, and later faculty? How do these values align with the larger cultural beliefs about race and gender?	What emotions did Marie express when describing values? What emotions did Marie express when describing her salient identities (e.g., racial, gender, science/math identities)?
Structural Domain (how power is allocated within large social structures such as in K-16 school settings)	What were the policies (written and unwritten) that Marie described in her story? How did these policies/rules affect her science and math identities?	What emotions did Marie express when describing the role policies had on her experience?
Disciplinary Domain (how rules and regulations get enforced for and by whom)	What behaviors were praised in Marie's story of becoming a math and science person? What, if any, behaviors were corrected in Marie's story of becoming a math and science person?	What emotions did Marie express around praise and criticism?

authors, we periodically solicited feedback on our analyses and findings from each other. We used a comparative analysis method Corbin & Strauss (2008) that enabled us to compare the multiple sources of narrative data. By doing so, we were able to address any negative and disconfirming evidence against our working hypothesis. After our final round of analysis, we asked Marie for her views and thoughts about our analysis to validate our interpretations further. The life history interviews and the unstructured interviews provided rich data, excerpts of which are provided in the findings section.

2.2.2 | Positionality

The first author is a female immigrant from a North African background and not a native English language speaker. Her racial identity is a mixture of Arab and Amazigh, which is an indigenous group of North Africa. She comes in with knowledge and works in storied-identities and science identity and how leveraging one's storied-identities and reflecting about them can be a powerful tool toward continuously reauthoring one's identity. The second author is a White middle-class woman, who is the director of the center that houses summer STEM camp. She has known Marie as a middle school student in the camp and as a volunteer for programs over the years. Although she never taught Marie at the camp, she has kept a good rapport with her over the years, which led to Marie's comfort in volunteering for the two life-history interviews and providing feedback on the findings section. Because she holds some bias as to the

STEM camp program as a director and views it as influential in girls' science and math identities, the other two authors were active in checking for discrepant evidence in Marie's stories. The third author is an African American male with a doctorate in science education who attended an HBCU as an undergraduate. Outside of race and attending an HBCU as an undergraduate, he does not have any shared commonalities with Marie. Like Marie, he has experienced moments in life that impacted his STEM identity trajectory that gave him a unique perspective when analyzing her stories.

3 | FINDINGS

In this section, we present Marie's science and math-related stories from her childhood to her third year at the university, focusing on the pieces that shaped her storied science and math identities, and what structures and factors influenced her storied-identities over time. We present the outcomes of our analysis in a narrative chronological format to stay true to the narrative inquiry methodology and the storied-identity approach. However, because part of storytelling involves reflecting on the stories one tells, we incorporated aspects of Marie's reflections in this format as well.

3.1 | Elementary and middle school

Marie's first memory of science was in elementary school. She described sitting in her third-grade class and her teacher telling the class that they would be learning about the rainforest. "And I was like, 'Oh yes! This is the place for me!'" During her childhood, Marie also recalled watching science shows on channels such as *The Animal Planet* and *Discovery Channel* and described her parents as influential in piquing her interest in science, enrolling her in science camps throughout her childhood. As a 5th grader, Marie described how she participated in a competition for "science night" where students presented their school science projects. Marie placed 2nd in the competition and because of her success was selected for the regional science fair.

It was also during elementary school that Marie was exposed to the limited presence of African Americans as teachers. During her first interview, she remembered that the only Black teacher she had was in 4th grade. She said, "it was really cool that she taught math; like in retrospect it was really cool...[that] I had that exposure as a child." Marie also noted the presence of her uncle who was an aeronautics graduate and her science mentor while growing up.

Marie's parents both attended an HBCU. They saw the importance of safe and majority Black spaces for her beginning at a young age and sent Marie to an environmental science camp in the summer before 5th grade at a local HBCU. When asked how the summer camp changed her outlook on science, Marie shared:

> It introduced me to actual jobs in science and just working with other students on a science project but still having fun. So, I think it made science a more concrete thing to me because before that I was just like watching *Discovery Channel*, *MythBusters*, and *Animal Planet* and just like, "oh wow, it's cool that these people do these things." And then I got to summer camp and I was like, 'Oh, *I* can do these things!'

In addition, Marie explained the influence of the camp on her racial, science, and math identities: "I definitely felt a sense of belonging because that was the first time I had, I think Black science teachers. That was my first experience [with] real Black scientists."

As she continued through middle school, Marie's love for science grew. During 6th grade, Marie described doing another project where she worked on solar panels and researched how different colors of light conducted solar energy. Maire's love for science was also evident through her continued participation in STEM summer camps. After her successful engineering project in 6th grade, she expressed interest in learning more about engineering on her application for a STEM summer camp:

> I love to learn new things about science and how things work. Science is also my favorite subject in school, and I have earned straight A's in that class. I think this camp will benefit me because I am interested in earth/space science and electronics.

Marie enjoyed her experience so much that she applied again at the end of her 7th grade year. On her application, she mentioned her uncle and her 7th grade teacher as being influential in her pursuit of science—specifically her interest in engineering and microbiology, respectively. She noted how her teacher assigned an instructional unit examining DNA where Marie learned about its structure, how it is copied and translated to make proteins, and how it replicates. During the last activity in the unit, students isolated their own DNA. In her camp application, she noted how the instructional unit on DNA played a factor in her changing career focus from being an electronics engineer to a biologist.

In her interviews, Marie highlighted the activities she engaged in at the STEM camp as particularly important in cementing her love and enjoyment of doing science: "I think [those science camps] were more focused on science exposures... we did projects and then had fun with those, but also explaining the science behind them." She also referenced the value of presentation skills, remembering one scientist who presented during her camp experience: "Now I really think about presenting to different audiences. I often challenge myself like, 'Hey, can I understand this on a level where I can explain it to my non-STEM mom.'" She specifically cited when women scientists would come and talk as influential in her pursuing science as a career:

> I have a very clear memory of sitting at one of the lunch panels that we had where women scientists [came] to talk to us...I do not remember what they did or who they were, but I remember sitting in there and being like, "Oh, this is really cool!"

Marie's stories from her elementary and middle school experiences were filled with critical moments that shaped her science identity. These stories pinpointed parental engagement and support from teachers, excitement and love of science, and involvement in science summer camps as important in shaping her storied science identity.

3.2 | High school

Marie continued to build her science and math identities during high school. She discussed the support of science teachers but also her own inner drive to succeed. Her first memory was her freshman year Advanced Placement (AP) environmental science course and the impact the teacher had on her:

> He was the first high school teacher that I really bonded with, and he would tell me about his college and graduate school experiences. Basically, he just made me feel more comfortable about entering college. He made me feel more confident.

Marie knew she would go to college as that was an expectation from her parents. However, the support from another adult made her feel more confident about this path, especially since she knew she was interested in science as a potential major.

Marie's algebra teacher during her first year in high school also strengthened her confidence by recognizing her as a strong student and encouraging her to tutor math during the summer. She also saw herself as competent in math because students often asked her for help in her math courses, which is where we see what initially shaped her storied math identity.

> That [was] like a common occurrence for me, just having the kids sitting around me ask me questions. Thinking back, I suppose that whole thing of being asked for help in math, [made me think] like I can do this, but at the time I do not think it felt any different cause I just felt kind of like the smart kid...

But this identity of being "the smart kid" caused her anxiety as well. This was best articulated when Marie told a story from her second year in high school:

> I got sick like with the flu, and I missed school for like a week and a half and I was super worried cause I was one of those kids who's just super stressed about missing class. I remember waking up from a fever dream and then just like doing math on the couch and then eating some soup and then going back to sleep. And when I got back to school, we had a test, and I got an A on it. So, I was so happy! My mom was like, "You know, you didn't have to kill yourself while being sick to work on math."

This sense of things coming naturally with hard work and her sense of herself as the "smart kid" led to self-doubt and frustration in her senior year when she took AP Calculus. She was one of three seniors in a class with mainly juniors who she felt knew more than she did. Tellingly, she describes the difference in racial and gendered terms, highlighting the role that race and gender played in being the only Black girl in the class:

> I remember just thinking for like a while that I do not understand how all these White boys are getting it so easily. Why am I struggling?... I would stay after school sometimes to get help from my calculus teacher. I would try to work on it with him and it was just kind of like "I wish it came easier" because before then I had never really struggled with any math concepts. I got to calculus, and I was like, "Ahh, I don't like this." I do not like... feeling like I cannot do it just like everybody else can. So that definitely took some work.

As a "smart" person, Marie believed that she was "supposed to be like an A student, like I should get it." The sense of others "getting it" before she did frustrated her in AP Calculus, impacting her sense of competence and her identity as a "smart student" who does not "struggle" with any math concepts and who "can do it just like everybody else."

Marie did have a positive experience in her senior year physics class which helped her to see potential success in science. She credited her physics teacher with instilling confidence in her science abilities:

> He was really great and just made me feel super great about all the science that I was interested in, and I would regularly ask him questions that he could not really answer, and we would learn. [When I would ask more advanced questions] he was like, that's a good question, that's a really good question. I wish I could answer that, and I hope you find out one day.

Marie also mentioned a positive experience of inclusion and peer collaboration based on her participation in a year-long science research experience in a local HBCU. During this internship, she was partnered with another Black young woman who she had originally met during the STEM camp in middle school:

> We did externship together and we both worked in the lab at the school of pharmaceutical sciences.... just having that experience where both of us were working in a real lab and we were together in that and together on our learning and our experience. And it was just really nice to have each other in that experience... It's a personal sense of motivation to see each other succeed and continue moving throughout our trajectories and reaching our goals.

Marie felt joy and pride as a result of being in this externship with another Black female peer and being part of the HBCU community that made her feel included.

Marie's stories from her high school experiences were also filled with critical moments that shaped her science and math identities. These stories described moments of recognition in her high school classes and sources of recognition from her science teachers as well as her algebra teacher and further strengthened her sense of belonging in these fields and her science and math identities.

3.3 | College

Marie focused her college search on science and math programs. Her parents encouraged her to look at HBCUs because "the experience you get and the feeling you have from going to an HBCU, it's just kind of invaluable. Like you can't put a price tag on that. And... once you miss it, you can't, there's no other way you can recreate that experience." After visiting Spelman College, a women-only HBCU, she "trusted her gut" and knew that was the place for her. She referenced the positive impact of having professors and mainly Black women peers:

> Being at Spelman, it's its own universe, a bubble within everywhere else. So, the thing at Spelman, like you are with [other majority Black people], like, in my major, my professors are Black women, my peers are Black women, the administrators, everybody else. Black women are everywhere.

Marie entered college as a biology major based on her interest in DNA and biology beginning in middle school. She saw herself as a good student but had "trepidation about college" in

light of her "smart" identity: "I was like, I can't fail. I was really hyper focused on passing all my classes and doing everything well." Initially, she felt supported and recognized for her work in her biology major. During her freshman year, Marie studied the effects of the sickle cell at the University's School of Medicine. She enjoyed this experience, partly because her supervisor allowed her to be creative and work independently. Marie did various lab activities such as analyzing information on cells, reviewing manuscripts, and helping write summaries that contributed to the research goals of the lab. At the end of her freshman year, Marie presented a poster on the work she did in her lab at the Medical School's annual research day. During this event, all of Marie's friends, professors, and family saw her present. Not only did this moment increase her confidence as a science person, but she also became more comfortable doing public presentations. Marie also was the only freshman to present at this conference and won second place in the biology category. She was recognized by not only her peers, her professors, and her family, but the award she received was also a source of recognition of her competence as a science researcher. This experience was formative for her:

> I think that this experience has made me more confident of my place as a person in STEM. So, now I can say I've had the full experience. Like I worked in a lab, I made my own poster, I wrote my abstract, I submitted it, got accepted and presented my research and won an award... I think it just cemented my confidence as a student researcher. It definitely made me want to go farther.

However, Marie also referenced some negative experiences where she struggled to deal with changes. For example, in the summer before her freshman year, she worked on a science research project and had prepared the poster when her faculty mentor told her and the group that there were no results so they would have to start over:

> He basically just gave us some old data that had been created in the lab about completely different proteins. So... I had two days to memorize the function of the new proteins, chlamydia infection pathway, and everything. And it also was just like, personally, the hardest hit I think I've ever taken because I was very proud. [Whenever] I make a project or anything that I did, I'm very proud of it, and I'm very personal about it. He was like, okay, I think your project is good and it's nice that you finished it, but we are not going to do that. And then I cried in the bathroom for like 10 minutes.

Her way of dealing with disappointment (including mentors who took on too many students and could not be readily available and classes that were tough) was to reach out to her peers:

> Last semester there was one really hard professor. So definitely just talking to [my peers], making study groups and we all had a group chat where we would talk about hard homework problems or say, "Does anybody want to meet up on Saturday before the test or anything?" That really helps. And then just having their encouragement like: "You'll be fine. It's okay. We have one hard test, but we'll get an extra credit at the end of the semester, so it'll be all good."

By repeatedly seeing that her strategies for overcoming challenges were working, Marie gained confidence and a sense of belonging. "Since I've gone through those challenges, I know

that I can overcome more challenges. So, a big thing I say to myself, it's like, 'okay, if you can get through this, you can get through anything.'" Marie also indicated that she had relaxed more in her frustration with not getting things right away: "Sometimes it doesn't come on the first or second try and you just have to kinda like move on or just, you know, stick with it and... do what you have to do to understand it." She realized that she did not have to completely understand every new concept right away, but rather she became confident that she had the skills (whether pausing to gain perspective or seeking out additional help) to overcome challenges.

During Marie's junior year she became less interested in biology and decided to switch her major:

> I felt like I did not want to memorize the whole biology textbook if I wasn't going to medical school. It's kind of, what am I doing this for? It's just rote memorization and I'm not really feeling challenged in these courses. So, I switched to something that would challenge me, and math is definitely doing that.

She referenced the period before the switch as the lowest point in her science and math trajectory because biology had been so important to her science and math identity. During her initial interview soon after switching to math, she indicated that math was not a salient part of her science and math identity up to this point:

> I never thought of math as anything significant throughout my schooling and upbringing. My whole life I was just on the life science track. I think animals are cool. I think plants are cool and living in [my home town] is like, you can go to the beach, you can go to the forest, and you can see all kinds of different life. So, my thinking about math is different because I have to think a little deeper as far as like significant memories because it wasn't what I was expecting to end up in.

However, a year later, she had begun to see math as a salient identity because of the applications math can provide:

> I like the problem-solving aspect; I think math gives me a sense of satisfaction that I did not get from a lot of other subjects. Like you can write an essay in English and then you get feedback and that's it. But for math it feels like, it feels more personal. I find myself much more interested in how math can be applied.

She even saw how math can be applied in areas like biology and education, two fields she was interested in for graduate school. "I'm just looking at anything that's applied math or math and biology or the intersection of math and some other life science field. If there is a teaching element, I'd like to go for that because I really do enjoy my math tutoring."

Marie described the decision to leave biology as a low point because she did not know what she wanted to major in if it was not biology:

> [My advisors] were pretty receptive of that, but they were kind of like, "Okay, well figure it out, kid, good luck." They did not offer a lot of like, direction and guidance. So, I cannot say I expected that of them, but I did a little bit. And basically, after that meeting, I just ended up feeling really sick and like, okay, "Dang, what

> am I doing here? What do I want to do? Where do I want to go?" Grad school is approaching so quickly, and I do not know what I'm going to do.

When asked how she got through this turmoil, she referenced two supportive people: her mom and her calculus professor. She called her mom a lot for support and felt confident because of what her mom said:

> "You don't have to figure it all out right now at this very moment. Like your life is going to be really long and you have a lot of life ahead of you. So, it doesn't matter if you don't know this week what you want to do for the next 30 years."

Her calculus professor ultimately influenced her to become a math major:

> I also went to a professor I'm close to who is also the head of the Math department here. She was the person that actually convinced me to be a math major because she was like: "You did extremely well in my class and usually I'm a pretty good judge of who would be good as a math major. So, I think you should definitely consider it because with math you can do whatever you want to. Like, it's really just a tool for all the other fields of science. So, if you want to stick with biology and research, you can do that with math. If you want to go into plant biology, you can do that with math."

Marie transitioned to being a math major because her math professor recognized her as a strong math student and her many past moments of recognition and support.

3.4 | Race and science/math

Marie's bubble at Spelman was made even more apparent when she participated in science research experiences at a PWI. During her first research experience outside of Spelman during the summer of her sophomore year, she was struck by the visual cues related to race. This was when she first experienced impostor syndrome:

> I was looking at the display board in the building of all of their graduate students and faculty. And there are no Black women in the faculty and no Black women, undergraduate students, they are all on the staff and secretaries and such. ...Like I knew that we were not represented, but just seeing it firsthand here at a school that's like right down the street from Spelman has been pretty eye-opening and kind of like lit a fire in me to continue on this track and go as far as I can.

At the same research experience, Marie saw very few Black students in her cohort:

> There are not a lot of Black women in STEM in the first place and then especially within math and STEM. There are three more of us out of 22 students in the whole program and no Black men as far as I know. I've seen others [Black students] like in the physics, biology, chemistry program, but not specifically here in the math program. So, it is important to me to be a face that's not

> commonly represented in this field and be a positive representation for others who want to enter this field.

Marie saw her "only one" status as a source of motivation to persist because she wanted to be a role model for other Black women. In a follow-up interview, Marie expounded more on why she feels "significant" as a Black woman in STEM.

> Being the first to do something is usually seen as a significant thing. And I suppose for people within the Black community, like you are either, you can be like a first-generation student or maybe the first one in your family to go into a STEM field or something and you are kind of like upheld within the community because of that.

Marie went on to describe these experiences in vivid terms:

> In the sense [you are] like being a pioneer. There are of course negative aspects, but I would not say negative is the right term. It's just kind of like the realness of it or I suppose the reality somewhere that's not exactly negative but it's just kinda like *it is what it is* [emphasis added]. Because you know, when you are the pioneer or the first one in the situation, that's a lot of weight for you to carry in terms of representing everybody who's similar to you in the eyes of everyone else. You have to balance microaggressions and like feeling tired and just kind of worn down because you should not have to represent the whole and yet you kind of have no other choice... But overall, the significance is definitely a positive thing because...I would not want to do anything else... it's not a responsibility that I would shirk.

Marie saw the value of being a Black woman in math. She recognized the pressure that she would be under but also believed it was something she could and should do.

3.5 | Reflections on being a Black woman

Marie's reference to herself as a pioneer is based on her sense that as a Black woman, she would be among the few but also a trailblazer in STEM. She saw that at her first research experience and continued to see it in the racial makeup of graduate departments she was looking at. She credits Spelman with instilling her with the knowledge of impostor syndrome and microaggressions that helped her to persevere in programs at PWIs. In her first research experience at a PWI, she described moments of exclusion that she was able to overcome by revisiting past stories of success that strengthen her confidence:

> Spelman is a liberal arts college, and they focus on teaching us so many things outside of just our majors. There are other kids whose schools are hardcore tech that they just take maybe one freshman [prerequisite] and then it's just math, math, math for the next four years. So, there were definitely other students who had had a lot more math classes than I had and were already so far ahead in material that I'd never even heard of. They would just like name drop theorems and then laugh and make inside jokes. And I'd be like, what are you guys talking about? So, I felt excluded, but since I knew what the situation was, I did not feel bad about it,

> cause I was like, it's not on me. I just have not taken those classes yet. I have not been taught that material. So, it's not, it's not even necessarily a bad thing. *It is what it is.*

Marie's response shows her development from high school as well. There she was in a similar position relative to her high school AP Calculus experience where she did not know what students were talking about. But in college, she practiced the resilience strategies of acceptance and self-compassion and knew she would eventually take the classes and learn the material. She also did not see this as a lack of preparation as she saw value in the liberal arts courses she took at Spelman, most notably her Black Diaspora class, which helped her to realize her own strength as a Black woman in math.

She described another research experience during her junior year at a PWI where she was joining a faculty member who researched bumblebees. The faculty member, Dr. K, was a White woman. When Marie and Dr. K spoke, Dr. K explained that she wanted to bring on a physics major (a White male senior) to help with the physics aspects of the project:

> And so, on the outside, I was like, "cool, great. The more the merrier." And then on the inside I was kinda like, "Ah, is it going to be another time when a White boy comes in with his advanced computer science skills and kind of like takes over a little bit?"... I really did not want that to happen, and I was nervous about our first meeting about appearing, you know, professional and like I could do it. I had a talk with my mom about it and I came to the conclusion that kind of like my life motto: *It is what it is*... I came to the conclusion that I just had to not even think about it 'cause I have a habit of overthinking a lot of things. And I really had to just say, you know, how they see you is how they will see you. All you can do is cover your own bases and... present yourself as best you can. Do the best work that you can and just continue to do all the things that you know you are supposed to do.

In saying that she has no control over how "they"—the White faculty member and student—"see her," Marie alludes to the historical and cultural racism that results in stereotypes and students' fears about being stereotyped for not performing well because of their race, gender, or background (Spencer et al., 2016; Steele & Aronson, 1995). Her phrase of "*it is what is"* shows her practicing acceptance and self-compassion of the moments where she experiences negative emotions, which enhances her motivation to persevere.

However, Marie saw a way forward in combining her identity as a Black woman who is heard and recognized as a science and math person.

> I had to recognize the differences between how we operate at Spelman in a professional setting and how they operate like at [the PWI] in a professional setting, which is much more relaxed [e.g. calling professors by first names rather than Dr.]. Changing according to what the situation called for and making sure that I still spoke out when I had thoughts, ideas, and questions. I think a big thing for me is not silencing myself when I'm in a space that I'm uncomfortable in, 'cause... that's what I naturally do. I like to become an observer rather than like a presenter or a talker with questions or anything. I just like to...observe in my own safe bubble, but I told myself, No. Talk about this, point that out'.

Marie references the tools she used to continue to be herself and make herself heard, and in so doing reveals the double bind for Black women as they navigate their racial, gender, and science and math identities (Malcom & Malcom, 2011; Ong, 2005).

4 | DISCUSSION

Overall, the salient themes that emerged from the analysis of Marie's stories were (1) the ways that her racial, science, and math interwoven storylines allowed her to make sense of the present and strengthen her science and math identities as a Black woman, (2) how this interweaving of storylines helped her negotiate moments of identity uncertainty that often occurred at the intersections of race, science, and math, and (3) how domains of power create tensions between racial, science and math identities. In what follows, we will unpack these themes and describe how they showed up in Marie's storied science and math identities using an intersectionality lens.

4.1 | Interwoven storylines strengthening racial, science, and math identities

Research has demonstrated that as Black women move and advance within science and math disciplines, they experience more isolation as well as interpersonal, cultural, and structural racism that impacts their sense of belonging, requiring them to code-switch or fragment their racial identity from their science identities (Collins & Bilge, 2016; Ong, 2005). Research on Black women in science and math has highlighted the emotional toll that the antagonistic and oppressive culture of science and math can take (McGee & Bentley, 2017; Morton, 2021). Yet, these studies have also shown that Black girls and women can develop counter-narratives based on their experiences in science and math through community influences and structural disruptions that lead to self-resilience and motivation (Joseph et al., 2017; King & Pringle, 2019; McGee & Bentley, 2017; Morton & Parsons, 2018). Like the women in these studies, Marie developed an asset-based sense of purpose and commitment to her math major because of her racial identity and her goal to be a pioneering Black woman. Her strong sense of belonging in her science and math trajectories was positively influenced through various sources of recognition, or community influences, from family, teachers, faculty, and peers, as well as during moments of recognition at structural disruption spaces such as HBCUs and STEM camps she attended. These sources and moments of recognition strengthened her sense of belonging in science and math.

Marie's primary and secondary school experiences included stories of support in science and math, particularly as a Black girl. She referenced the positive emotions of joy and pride in her stories of attending a science camp at the local HBCU, her science fair project work, and her high school internship experience with another Black girl peer at an HBCU. These experiences where she was surrounded by Black peers and role models and encouraged to participate by her family were akin to the counter-narratives expressed by the Black girls in King and Pringle's (2019) study. Black family members and faculty/teachers in these HBCU science programs recognized her salient science identity, which helped her see how both her science and racial identities could weave together and make her feel like she belonged. This sense of belonging was influenced by the structural disruptions, i.e., STEM camps held at HBCUs, and community

influences, i.e., support from her family and Black teachers (Joseph et al., 2017). She would refer to these stories as resources and leverage the emotions in these stories, which would motivate her during moments of self-doubt in her STEM courses where she might be the only Black girl. It was not until high school and college that negative emotions started to become more present for Marie. But despite these experiences, she was able to associate positive emotions with interpersonal experiences related to science and her race. These social supports and stories of social recognition strengthened her developing science identity. Marie left high school with a goal to major in biology, but she was cognizant of her racial and gender identities and how those could be marginalized in science (Morton & Parsons, 2018).

Marie chose to go to Spelman after she visited the college and saw the cultural and social support the school created for Black women that her parents had championed. It was during college that she collected more counter-narratives of recognition that added to her resilience as she was accepted into research groups and was able to present and win awards for her work on science research projects. The experience of being in classrooms with Black women peers and Black faculty strengthened her racial identity as a Black woman in science. It was during college that we began to see the role that a woman-only HBCU can have in creating a supportive structure and culture for women of color in STEM (Joseph et al., 2017; Ong et al., 2018; Perna et al., 2009). Marie's stories at Spelman had mainly positive sources of recognition, unlike other studies that highlight negative experiences for Black women even at HBCUs (McGee & Bentley, 2017; Morton, 2021). They highlighted the role that emotions played during these moments of importance in her science story, especially in her ability to remember these moments so vividly. A big part of her strengthened science and math identity stories was her sense of belonging as a Black woman that she developed through multiple moments of joy, pride, and recognition related to her competence and performance in science and math at Spelman. Marie was also able to tell stories where both her racial identity and her science and math identities mutually supported each other (e.g., her uncle helping her with science fair projects as a child, camps and internships at a local HBCU in middle school and high school, attending an HBCU where she learned racial pride and belonging in science and math). Figure 1 provides a timeline of Marie's moments of recognition in her storied science and math identities trajectory, as well as the various intersections of her salient identities (science, math, racial, and being a smart student) that occurred across different times and settings.

4.2 | Interwoven storylines helping negotiate identity uncertainty

Despite these positive moments wherein Marie's racial and science identities wove together to create a positive science and math identity trajectory, there were moments in Marie's story where she had to negotiate between identities and/or recognize that there were conflicts due to power domains in the US stemming from racism and sexism. Using an intersectionality lens allowed us to further understand how her salient identities—racial, science, math, and "being smart" identities—played out in her storied science and math identities. These negotiations were evident in the moments where Marie experienced the emotions of self-doubt and frustration with her science identity. The three key identity tensions that we observed in her stories were: (1) negotiating the changing perception of what "being a smart person" meant; (2) negotiating from a biology major to a math major and (3) negotiating between her racial, science and math identities. We will unpack each of these below.

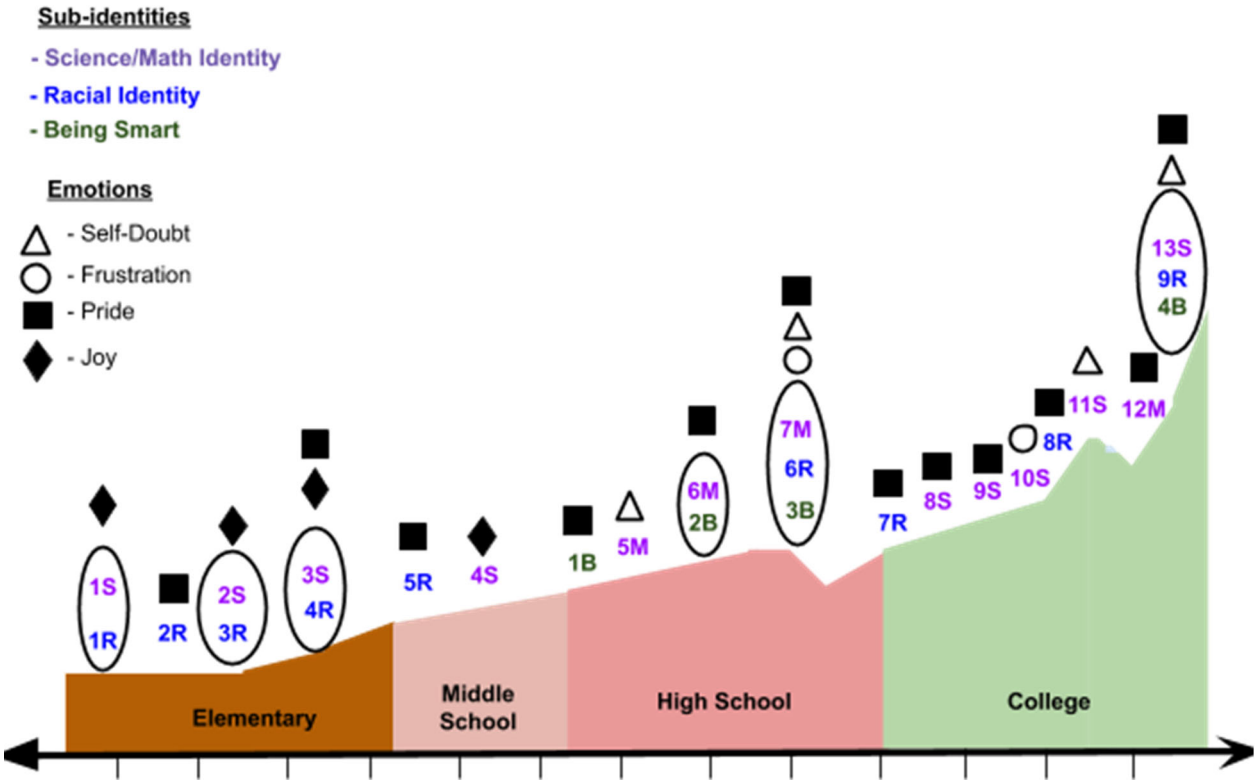

FIGURE 1 A timeline of Marie's STEM storied- identity trajectory and the emotions that surfaced. Sub-identities are categorized by color (Science/Math Identity - purple; Racial Identity - blue; Being Smart - green). Emotions are categorized by shape (Self-Doubt - triangle; Frustration - circle; Pride - square; Joy-Diamond. Moments of recognition where sub-identities wove and interlocked together are denoted with an oval. Below is the key (table) for the list of moments of recognition as a STEM person for each sub-identity in chronological order

4.2.1 | Being a smart person

Beginning in middle school, Marie came to see herself as a smart person not just in science and math. This "being smart" identity was because she easily understood math and science content. Throughout elementary, middle school, and into high school, she received positive recognition in terms of encouragement from teachers and the grades she received. It was not until AP Calculus that she found herself struggling to understand the math concepts, making her question her "being smart" identity. This experience in AP Calculus was also related to her concepts of cultural power domains and inherent Whiteness and anti-Blackness that impact who we as a culture perceive to belong in STEM. As Marie moved through her schooling, she saw that she could still be a smart science and math student and need in some cases more time than her peers to learn the concepts. She leveraged these stories of positive results from taking time to ask for help and learn the concepts, which strengthened her science and math identities as well.

Tensions arose for Marie because she saw being smart as an interpersonal trait that made her worthy of praise and future success within her school. When calculus did not come easily, she questioned her sense of identity as a science and math person. Marie had a supportive mother who told her she could succeed if she worked at it, and this led her to go for extra help with her teacher. This allowed Marie to see how being smart does not mean understanding things easily but knowing that learning can take time and smart people know the steps to learn. In this tension, we do not see much evidence of the other domains of power for Marie, but other studies have highlighted how the structural domains of schools and school science can frame Black girls as less scientific because of racist and sexist cultural domains (Calabrese Barton et al., 2013; Ireland et al., 2018). Because Marie sought help, she was able to see that she could learn calculus. However, we wonder how many Black girls choose not to seek help because they fall prey to racist and sexist stereotypes of who belongs in science and/or math, or they are denied help because of educators' stereotypes related to who belongs in science and /or math.

4.2.2 | Switching majors

When we first interviewed Marie, the lowest point in her science and math trajectory was when she was trying to decide on a major other than biology. She expressed self-doubt about not knowing where she belonged in STEM because she had spent so many years being certain of her biology focus. During our first interview after this switch, she could not think of any math stories to add to her storied science and math identities. However, by the second interview, she could remember more math stories that supported her new identity as a math (and science) person. She was even able to combine both interests since she was planning to go to graduate school for quantitative biology or applied math, which would connect her love of biology and math thereby creating a career trajectory that included her passions.

Unlike other studies that have highlighted lack of support, recognition, and preparation as causes of switching majors (Russell & Russell, 2015), Marie had support and felt prepared for her major. She simply realized she did not want to be a doctor. However, at the time of the switch, Marie identified so much as a biology person that her switch was a low point for her because she had created a story around that identity. It took six months for her to remember her math experiences and support her new math major with past experiences of competence and performance in math. This tension highlighted her fear that she was not satisfied with biology despite this being a huge part of her science and math identities. She was going through a

shift in her identity from biology (not wanting to do medicine as a career) to something that could engage other interests (math and education). It was interesting to see how quickly she could fall back on her positive math stories to create a strong math identity by the second interview. This highlights how the disappointment surrounding Black women's decisions to switch majors can be overcome through positive science and math stories of competence, performance, and recognition, leading to a more resilient STEM identity (Joseph et al., 2017).

4.3 | How domains of power create tensions between racial, science, and math identities

Marie mentioned three moments where she questioned her science and math identities based on her race—AP Calculus class and two separate research experiences at PWIs. These moments were influenced by the ever-present domains of power (Collins & Bilge, 2016). The domains of power intersectional lens allowed us to better understand her negotiations during these moments of tension. Most of Marie's interpersonal experiences in science resulted in her being positively recognized as a science and math person by peers and those in authority roles. These interpersonal stories were influenced by the values expressed through community influences by her family (e.g., supporting her in her STEM endeavors, particularly in racially supportive environments) so that she could see that she belonged (Joseph et al., 2017). Her teachers in high school supported her as a smart student who should attend college and was such a skilled math student that they asked her to tutor her peers. She leveraged these counter-narratives of support, recognition, competence, performance, and positive results, or counter-narratives of resilience, as a resilience strategy that she could return to in her mind, to motivate her to persist during times when she questioned her belonging (Joseph et al., 2017).

The moments when she questioned her belonging were related to the cultural, structural, and disciplinary domains of power within the US and the various institutions with which she engaged (e.g., K-12, higher education, STEM disciplines). In high school, Marie had a perception that science and math people naturally get it and that those people tended to be White. This was expressed in her frustration when she thought the "White boys" were understanding the math faster than her. This frustration and tension were related to the cultural domain of power in the US that portrays scientists as White men who are geniuses. This cultural domain of power made her question her sense of belonging since she was neither White, male, nor easily grasping the concepts. In addition, we witnessed the disciplinary domain for Marie in while that working hard to understand concepts was rewarded in her AP Calculus class, this growth mindset (Dweck, 2006) is not always the common culture in public high schools or STEM departments (Johnson, 2020).

In her first Research Experience for Undergraduates (REU) experience, she initially worried that she did not belong because she felt like she did not have the same STEM background as her White peers. Her questioning her belonging was related to the disciplinary power domain in that she felt ostracized from the group who appeared to be "getting it" and compounded by the cultural power domain that often made her question whether she belonged in these STEM opportunities as a Black woman. She found a counterspace within this majority White space by turning to a Black student peer in the program and realized that they just had not had the courses yet because they went to a liberal arts school. Marie saw the value in getting a liberal arts education, even if she did not have as many science and math courses as her White peers. Again, she was able to find interpersonal evidence to disconfirm the stereotype threat of being Black in the science and math fields. She realized that she was not lesser as a Black woman and

remembered that she could learn the material and still benefit from her current experience in the REU (McGee & Bentley, 2017; Ong et al., 2018).

She returned to these affirming counter-narratives of resilience when she began working on a second research project at another PWI. She worried that when the White male physics undergraduate student was invited onto the project, she would become less relevant. But she again remembered her counter-narratives of resilience that she was able to shine in her previous REU and AP Calculus stories and would continue to be recognized as a science and math person if she stayed true to herself (Joseph et al., 2017; King & Pringle, 2019). There could be tension as Marie continues into graduate school as she herself knew that there would be fewer women of color in her graduate program as she described herself as a pioneer—which carries its own sense of isolation. However, Marie has developed excellent resilience strategies of leveraging counter-narratives of resilience and practicing acceptance and self-compassion along with strong community influences to deal with moments of impostor syndrome (Joseph et al., 2017).

One of the key experiences that helped Marie develop her strong sense of belonging as a Black woman in biology initially and later math was her college experience. Our research, like other studies that have focused on Black women's STEM identity and/or persistence, has highlighted the positive impact of counterspaces, structural disruptions, community influences, and resilience strategies (Joseph et al., 2017; Ong et al., 2018). One of the ways that Marie was able to maintain strong and positive science, math, and racial identities was because she attended Spelman University. She always felt a sense of belonging in her science and math classes and the faculty were supportive of her efforts. Spelman faculty also encouraged collaboration and working through problems which she developed over time in college when she realized that being smart did not mean being innately gifted (Joseph et al., 2017; Perna et al., 2009). The culture at Spelman created a space where Marie was able to envision a more expansive perspective of science and math as a space where she belonged, like the women in Johnson's (2020) study. This strengthening of her sense of belonging from her first year to her final year of college was made possible through the supportive and central counterspace of Spelman (Hazari et al., 2020; Ong et al., 2018). She never felt marginalized or ostracized at Spelman which is not always the case for Black women at HBCUs (McGee & Bentley, 2017).

Spelman College itself is a structural disruption to the structural power domain within higher education that privileges Whiteness and maleness (Joseph et al., 2017). Spelman is structurally different from other HBCUs and PWIs as Marie herself explained when she called it a protective "bubble" dominated by Black women that instills in them not just an understanding of specific disciplines/majors but also an understanding of the power differentials that continue to inform racism and White supremacy in the US. Marie's sense of racial identity was strengthened through her enrollment at Spelman, and this allowed her to see herself as a Black woman in science and math without many moments of doubt.

Marie's stories around her racial, science, and math identities created a positive storyline of resilience. Her courses at Spelman and the faculty there recognized her efforts and supported her so that she felt like she belonged in her chosen major. This sense of resilience and belonging even carried over into her research experience at PWIs and gave her a storyline to fall back on in moments of self-doubt (Joseph et al., 2017; King & Pringle, 2019). Marie was also motivated to persist because she wanted to be a role model for other Black girls, like Black women interviewed in previous studies (McGee & Bentley, 2017; Morton, 2021). Marie did not experience the emotional toll of developing her resilience like other studies have highlighted (McGee & Bentley, 2017), and most of this was due to her supportive network at Spelman and her family, but also how she leveraged the resilience strategies of acceptance and self-compassion when

TABLE 3 Moments of identity tensions due to domains of powers

	Cultural domain	Structural domain	Disciplinary domain
Perception	Perception that science and math fields are dominated by White men who are naturally gifted.	In most higher education spaces, particularly STEM departments, are dominated by White men and have historically prevented women and people of color from thriving.	Typically, in STEM competition and natural giftedness is rewarded, whereas collaboration and asking for help is disciplined.
Outcome	In each situation, Marie initially succumbed to this cultural belief, however, she turned to past interpersonal experiences where she had been recognized as a science or math person to help her overcome self-doubt.	In high school, Marie relied on the support of her family who reminded her that she could study more and get extra help. Then Spelman College served as a structural disruption, a protective bubble that is different from the world because it is a space dominated by Black women that instills in them not just an understanding of specific disciplines/majors but also teaches resilience strategies.	In both high school and college, Marie had educators who encouraged her to ask for help and supported her in these endeavors. She realized asking for help was important to being a science or math person. In addition, Spelman created a collaborative environment which also helped her to see science and math as a supportive space.

navigating the negative emotions of frustration and self-doubt and persevering. Table 3 summarizes where and how the cultural, structural, and disciplinary domains of power came into play in Marie's storied science and math identities.

4.4 | Limitations

Although this is a study of one young Black woman and its findings may not apply to other women of color, it provides an in-depth understanding of her experience. In particular, her experience at Spelman is unique and very different from Black women's experiences at PWIs. However, the purpose was not to form generalizations but to illustrate the characteristics of this unique case (i.e., a young Black woman pursuing a STEM field) and to investigate the role recognition and the interplay of emotions, sub-identities, and four domains of power in her storied science and math identity development.

4.5 | Implications

Our findings have implications for theory, research and practice. First, our use of intersectionality along with science and math identity lenses allowed us to uncover the power domains inherent in

science and math disciplines that affected Marie's sense of belonging (Ireland et al., 2018; McGee & Bentley, 2017; Morton, 2021; Morton & Parsons, 2018; Russell & Russell, 2015). By using an intersectionality lens, Mensah (2019) showed how power and race converge and operate in teacher education programs leading to teachers of color experiencing microaggressions, "onlyness," and marginalization. In our study, an intersectionality lens allowed for critically analyzing the cultural, institutional, disciplinary, and interpersonal domains of power in Marie's science and math identity trajectories. We could see how these domains influenced her sense of belonging, her developing competence, her performances, and the recognition she received. Marie experienced many positive sources of recognition (e.g., supportive White teachers, family, and then Black women faculty at Spelman), which strengthened her confidence in her abilities despite the broader cultural and institutional racism that exists. These moments of support and confidence provided her with positive stories to strengthen her resolve during moments where she doubted her sense of belonging (e.g., her research experiences at PWIs).

Marie's stories provide evidence for the value of our research methodology. By focusing on one woman and her storied-identity experiences, we were able to see how the positive emotions of joy and pride Marie associated with her multiple moments of recognition allowed her to revisit these stories in her memory. These moments of recognition are vivid memories that she could revisit repeatedly in times of doubt to remain confident in her science and math identities and were part of her counter-narratives of resilience. This research adds to the call for a stronger understanding of recognition and its role in science and math identity development (Godwin et al., 2016; Hazari et al., 2017; Wang & Hazari, 2018). Studying science and math identities through a storied-based approach allowed for a deeper examination of the stories that shaped Marie's transition from science to math. There is potential in future research studying the development of women of color's science and math identities through a 'story-based' approach given the potential value of gaining an understanding of the stories that women of color carry with them and how these stories are nested in larger stories, especially since individuals derive a sense of identity (racial, math, science) from the stories they leverage and/or relinquish and how they choose to author and reauthor them.

From a practice standpoint, this study also highlights the importance of institutional structures in acting as bridges or barriers in Black women and girls' persistence in science and math fields. Marie referenced race and gender as part of her high school story when she wondered why the "White boys" were understanding math sooner than her. Had she not talked to the people in her life who had served as important external recognizers (her mom and her teacher) she might have assumed she did not belong in math in 12th grade and had a very different trajectory in college. In addition, Marie's unique experience as a student at Spelman allowed us to highlight the importance of looking at institutional structures as either supporting or not supporting Black women in science and math fields. Johnson (2020) described the prototypical PWI physics department in her study. Marie's experience at Spelman was a counter to this, and she was able to notice the difference between Spelman and other college STEM programs through her participation in research projects at PWIs. Because she had stories of moments of recognition and successful learning to fall back on that were characterized by the emotions of joy and pride, she was able to persevere during moments of self-doubt.

More importantly, because she attended an all-women's HBCU, she was able to see multiple examples of Black women who were successful science and math people, providing examples of her future. Parents and teachers play an important role in strengthening Black girls' sense of belonging and future success in STEM (Ireland et al., 2018). College STEM departments are often the locations where the domains of power begin to chip away at the confidence Black

women have developed (McGee & Bentley, 2017; Morton, 2021; Morton & Parsons, 2018; Russell & Russell, 2015). Even HBCUs can have this deleterious effect (McGee & Bentley, 2017; Morton, 2021). However, at Spelman, Marie learned about the African diaspora which allowed her to see the power domains of racism clearly. She was also taught coping mechanisms for dealing with racism that strengthened her resolve and confidence to overcome racism. STEM departments can add examples of the role that racism and sexism have had in STEM to their courses, thereby confronting the colorblind and rational myth of STEM that ignores and consequently dismisses Black women's experiences historically and personally. These STEM departments can support Black women in their departments through networks with other Black women nationally so that they can find strength and a sense of belonging even if there are no other Black women in the department.

5 | CONCLUSION

As a Black woman who is not just surviving but seemingly thriving in STEM, Marie is a success story in many ways. To do this, she had several sources of support that worked as bridges to create moments where her racial, science, and math identities could weave together. Marie's moments of recognition can give insight for scholars into how recognition (both external and self) is negotiated to strengthen science and math identity. If we are serious about supporting Black girls and women and keeping them in the science and math pipeline, it is important for researchers and educators to consider the complex cultural, social, and institutional factors that prevent them from thriving in STEM. Science educators and STEM faculty need to discuss the role that stereotypes and biases have played both historically and today. Parents, teachers, and faculty can promote or create in-person and virtual counterspaces for Black girls and women to develop and strengthen their science and math identities (Ong et al., 2018). This study adds to the call to strengthen science and math identity for Black girls and women through research into the role that intersectionality and recognition plays.

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ENDNOTES

[1] We use the author's term for participants when we describe their studies. Even though we are focused on Black women in our study, previous research still instrumental to our current understanding may have used the broader term and included Black women but did not solely focus on Black women.

[2] When referencing K-12 STEM experiences, we focus on science and math because these are the dominant disciplines. We will use the term STEM when participants represent all STEM fields or if the authors use that term.

[3] The Higher Education Act of 1965, as amended, defines an HBCU as: "...any historically black college or university that was established prior to 1964, whose principal mission was, and is, the education of black

Americans, and that is accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education] to be a reliable authority as to the quality of training offered or is, according to such an agency or association, making reasonable progress toward accreditation." HBCUs offer all students, regardless of race, an opportunity to develop their skills and talents. These institutions train young people who go on to serve domestically and internationally in the professions as entrepreneurs and the public and private sectors." Retrieved from https://sites.ed.gov/whhbcu/one-hundred-and-five-historically-black-colleges-and-universities/ on December 16, 2020.

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