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"I WANT TO MAKE AN IMPACT": THE SCIENCE IDENTITY AND CAREER GOALS OF BLACK AND LATINX SCIENCE AND ENGINEERING POSTDOCTORAL SCHOLARS

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This instrumental case study examines the science identity and career goals of 16 Black and Latinx science and engineering postdoctoral scholars. Interviews were conducted and grounded by the model of science identity to understand the ways in which science identity develops over time and the influence of race/ethnicity and gender on career goals. Through deductive data analysis techniques, four themes emerged: (1) science competency is built at an early age and solidified in high school; (2) science performance is actualized but questioned in college; (3) science recognition is fostered through professional development and success; and (4) racism and sexism shape the desire to make an impact through a STEM career. Understanding how Black and Latinx postdoctoral scholars' science identity and STEM career goals are nurtured and thwarted within educational systems can be illuminating to those training the next generation of advanced STEM professionals. If the individuals next in line to enter the professoriate are deterred, greater consideration must be given to their experiences.

KEY WORDS: *Black and Latinx postdoctoral scholars, science competence, science performance, science recognition, STEM diversification*

1. INTRODUCTION

This instrumental case study (Stake, 1995) explores the ways in which science identity is cultivated for Black and Latinx science and engineering postdoctoral scholars and the influence of race/ethnicity and gender on career goals. Interviews grounded by the model of science identity (Carlone and Johnson, 2007) offer an in-depth understanding of science identity development over time. Science, technology, engineering, and mathematics (STEM) academia and the academy at large may benefit from a greater understanding of the construction of science identity and STEM career goals of Black and Latinx postdoctoral scholars if STEM workforce diversification is indeed a goal. Diversifying STEM is crucial to strengthening the U.S. economy and boosting creative

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and innovative STEM research (Allen-Ramdial and Campbell, 2014; National Science Board & National Science Foundation [NSB & NSF], 2020). This research is sponsored by the National Science Foundation (NSF) Alliances for Graduate Education and the Professoriate (AGEP; Award No. 1821008).

2. LITERATURE REVIEW

The diversification of STEM fields is of paramount importance to the scientific and educational communities. The nation must inspire all citizens' diverse talents and capacities to be competitive internationally in the 21st century. One promising STEM diversification research area involves understanding ways to measure, develop, and leverage science identity. Researchers tend to define "science identity" in similar ways; Rodriguez et al. (2019) noted it "is a reflection of how one understands and positions oneself within the STEM culture and the recognition one receives from others in that community" (p. 2). Much of the research is built on the science identity model of Carlone and Johnson (2007), which purports science identity encompasses three overlapping dimensions of competence, performance, and recognition and rests on racial/ethnic and gender identities. Generally, science identity is premised on the understanding that "all individuals have the potential to develop a science identity . . . science identity is a developmental process that unfolds over time . . . [and] the environment informs the identity the individual develops" (Kim and Sinatra, 2018, p. 4).

While much science identity research has been devoted to students of color, a growing body of inquiry has focused on postdoctoral scholars of color. These scholars report their science identity is compromised due to feelings of racial/ethnic isolation within STEM and a desire for a greater sense of belonging, social identity, and professional growth (Brockman et al., 2022; Chakraverty, 2020; Eaton et al., 2020; Hudson et al., 2018; Jaeger et al., 2019; McGee and Bentley, 2017b; Mendez et al., 2022; Pyhältö, 2018; Van Benthem et al., 2020; Yadav et al., 2020). Black and Latinx postdoctoral scholars indicate a lack of access to socialization opportunities, as well as experiences of invisibility, marginalization, microaggressions, and blatant bias in the academy from their time as undergraduate students to their postdoctoral positions (Brockman et al., 2022; Eaton et al., 2020; Karalis Noel et al., 2022; Malone and Barabino, 2009; Mendez et al., 2022; Yadav et al., 2020; Yost et al., 2013). Racism and sexism at the individual, departmental, and institutional levels are highly concerning, as race/ethnicity and gender are two of the most significant contributors to identity formation. Often, they shape in- and out-group statuses and are used to understand different power systems in STEM, which consist primarily of White men (Carlone and Johnson, 2007; Eaton et al., 2020). The severity of racism and sexism is compounded for Black and Latinx women, as they frequently observe the STEM workplace to be unwelcoming to two major cornerstones of their identity (Eaton et al., 2020; McGee et al., 2020; Miles et al., 2020; Scott and Elliott, 2019).

These types of antagonistic experiences diminish Black and Latinx postdoctoral scholar science identity and lead them to question their STEM career goals (Castellanos,

2018; McGee et al., 2019). The unwelcoming environment leads to social devaluing; the impostor syndrome; decreased productivity; and feelings of anxiety, trauma, and depression (Brockman et al., 2022; Chakraverty, 2020; Eaton et al., 2020; Kim et al., 2018; McGee and Bentley, 2017b; Mendez et al., 2022; Miles et al., 2020; Scott and Elliott, 2019; Yadav et al., 2020). While some use these adverse experiences as motivation to continue their STEM career goals, others abandon their plans, particularly among those preparing to enter the tenure-track faculty job market (Castellanos, 2018; Robinson et al., 2016; Yadav et al., 2020).

Hostility in the academy reinforces beliefs that STEM fields are designed for White men, an attitude significantly more pervasive in the academy than in industry (McGee et al., 2019; Yost et al., 2013). Therefore, Black and Latinx individuals in STEM are more likely to assume jobs in research labs or the private sector than in academia, and Black and Latinx women tend to self-select out of academia due to their inability to advance up the ladder, unsupportive family policies, and the double bind of racism and sexism (Castellanos, 2018; Chakraverty, 2020; Eaton et al., 2020; McGee et al., 2019; Winterrowd et al., 2021; Yost et al., 2013). In fact, Eaton et al. (2020) indicated STEM academia shows a natural bias for hiring men and prefers White and Asian people over those from Black and Latinx backgrounds, with Black and Latinx women perceived to be least hirable. Researchers also have found Black and Latinx scholarly interests, which tend to center on social justice–oriented topics, conflict with the individualistic, competitive nature of STEM. This conflict results in a disproportionate number of Black and Latinx scholars seeking employment in industry (Castellanos, 2018; McGee and Bentley, 2017a; Scott and Elliott, 2019).

Research also has revealed the conditions that encourage Black and Latinx science identity creation and persistence in pursuing an academic STEM career. Supportive mentorship is essential, as it has been found to aid in career and professional identity development (Allen-Ramdial and Campbell, 2014; Alston et al., 2017; Brockman et al., 2022; Karalis Noel et al., 2022; Mendez et al., 2022; Pyhältö, 2018; Rybarczyk et al., 2016; Santa-Ramirez, 2022; Yadav et al., 2020). In addition, mentorship is beneficial in combating the feelings of "onlyness" and isolation cited by many Black students and postdoctoral scholars, which is essential when considering Black individuals have the highest attrition rate from STEM compared to other races/ethnicities (Alston et al., 2017; Fisher et al., 2019; Karalis Noel et al., 2022; McGee and Bentley, 2017b; McGee et al., 2019). As fewer faculty of color exist in STEM to act as mentors, enlisting White mentors willing to examine systems of power and oppression is essential in supporting Black and Latinx postdoctoral scholars as they navigate the academy (Alston et al., 2017; Karalis Noel et al., 2022; Miles et al., 2020).

Colleges and universities that invest time and effort in building postdoctoral networking opportunities provide a sense of belonging (Aguado and Porras, 2020; Allen-Ramdial and Campbell, 2014; Belli, 2021; Mendez et al., 2022; Yadav et al., 2020). Moreover, institutions and postdoctoral advisors who purposely leverage Black and Latinx interests in equity, social justice, and helping others have been shown to increase the self-efficacy of postdoctoral scholars as researchers (McGee and Bentley,

2017a; Yadav et al., 2020). A recent study by Brockman et al. (2022) noted recognizing the achievements and identities of postdoctoral scholars of color helps mitigate the discrimination that challenges their science identity. Finally, reducing racial and gender discrimination in STEM aids Black and Latinx postdoctoral scholars in developing stronger leadership skills, self-efficacy, and science identity (Yadav et al., 2020).

A postdoctoral position is a vital steppingstone to faculty tenure-track positions in academia. As some researchers have labeled it, the postdoctoral appointment is a "queue" for those waiting for a job as a faculty member (Andalib et al., 2018). Therefore, this career stage is quite significant due to its echoing effect on the number of Black and Latinx individuals who pursue the professoriate as a career because the candidate pool remains predominantly White and foreign born (Allen-Ramdial and Campbell, 2014; Andalib et al., 2018; Yang and Webber, 2015). Although industry positions have become more attractive due to their propensity to offer higher pay, better benefits, and more advancement opportunities, higher education institutions must continue to diversify their STEM faculty, as it increases creativity, innovation, and economic productivity and further promotes inclusivity (McGee et al., 2019; Scott and Elliott, 2019). Additionally, postdoctoral opportunities are crucial for continuing to develop the science identity of postdoctoral scholars and solidifying their STEM career goals, particularly related to entering the professoriate ranks (Mendez et al., 2022). During an appointment, postdoctoral scholars hone their research expertise and identity, publish and write grants, and develop their teaching pedagogy while receiving vital mentorship for entering the next phase of their careers (Andalib et al., 2018; Karalis Noel et al., 2022; Pyhältö, 2018; Rybarczyk et al., 2016; Van Benthem et al., 2020).

Although Black and Latinx PhD recipients secure postdoctoral positions at a similar frequency as their White counterparts, their transition to faculty positions is lower (Meyers et al., 2018). Approximately 17% of all STEM postdoctoral scholars become tenure-track faculty members (Andalib et al., 2018), and less than 10% of STEM faculty identify as Black or Latinx (Yadav et a1., 2020). The top three predictive factors for a successful transition to faculty status include the intended career track, a candidate's number of publications, and the number of first-author scientific publications produced during graduate and postdoctoral training (Rybarczyk et al., 2016). The last two factors are concerning, as Black graduate students and postdoctoral scholars publish at lower rates than their peers (Fisher et al., 2019).

Despite the growing importance and number of studies regarding the diversification of the STEM professoriate, further research is needed to understand the experiences of Black and Latinx postdoctoral scholars, as these individuals are in an advantaged position to assume tenure-track faculty roles due to the refined expertise and skills developed while in these positions. A better understanding of the Black and Latinx postdoctoral experience specifically may identify ways to prevent their disproportionate attrition from STEM academia. While Black and Latinx PhD recipients are in high demand for tenure-track positions (Allen-Ramdial and Campbell, 2014; Kamimura-Jimenez and Gonzalez, 2018), little is known about the cultivation of their science identity or the influence of race/ethnicity and gender on STEM career goals.

3. CONCEPTUAL FRAMEWORK

The Carlone and Johnson (2007) model of science identity is utilized as the conceptual framework for this study. The model contains three components: competence, which considers the meaningful scientific knowledge used by individuals to understand and view the world; performance, which posits the individual can demonstrate the skills of a scientist; and recognition, in which the individual and others purport to be a "science person" (Carlone and Johnson, 2007, p. 1190). These components overlap and are considered interconnected, emergent, and enduring as individuals craft their science identity (Carlone and Johnson, 2007). An important and relevant aspect of this model is acknowledging one's racial/ethnic and gender identities influence science identity, promoting intersectional thinking around identity development. Carlone and Johnson (2007) found that while many Black and Latinx scholars display competence and perform well in STEM, few receive recognition, which reduces their perceived self-efficacy for STEM work. Indeed, Vongkulluksn et al. (2018) noted higher perceived self-efficacy is related to stronger disciplinary identity formation.

The science identity model can aid researchers in understanding the ways in which individuals make meaning of their science experiences and identities and how others shape and alter those meanings and identities (Carlone and Johnson, 2007). An individual's constraints, resources, and experiences influence the development of science identity, and these experiences are influenced by systems of oppression and prejudice (Carlone and Johnson, 2007). It should be noted Carlone and Johnson (2007) indicated their model would continue to evolve as this research line expands. Recent work has noted the model fails to address the importance of environmental influences on science identity, including access to STEM classes, peer group effects, and school and family values (Kim and Sinatra, 2018; Kim et al., 2018; Vincent-Ruz and Schunn, 2018). In this study, the model supports the exploration of the way in which science identity morphs over time from childhood to the postdoctoral stage to uncover how these individuals make sense of their science identity as meaningful decisions are made about their future careers. The model serves as a conceptual lens to understand science identity development, thus serving as foundational to the interview and deductive coding protocols and a channel to consider the implications of this qualitative inquiry.

4. METHOD

4.1 Research Design

An instrumental case study design (Stake, 1995) was employed to explore the ways in which science identity is cultivated for Black and Latinx science and engineering postdoctoral scholars and the influence of race/ethnicity and gender on STEM career goals. Instrumental case studies allow a researcher to uncover a specific problem or concern from participants' perceptions that may be interpreted as unimportant to others (Stake, 1995). Interviews, grounded by the science identity model of Carlone and Johnson (2007), provided insight into the descriptions of 16 Black and Latinx science and

engineering postdoctoral scholars on the construction of their science identity and career goals. The research questions that guided this study were:

1. What are the ways in which science identity is cultivated for Black and Latinx science and engineering postdoctoral scholars?
2. How do Black and Latinx postdoctoral race/ethnicity and gender influence STEM career goals?

4.2 Participants

This research study analyzed the interviews of 16 Black and Latinx science and engineering postdoctoral scholars who were part of a larger project that included 50 STEM postdoctoral scholar interviews. Participants from the larger project who did not identify as Black or Latinx and were not in a science or engineering discipline were excluded from this study. All individuals were recruited from the National Postdoctoral Association (NPA) through an email alert and given a $25 e-gift card for their contributions. Before the interviews commenced, participants completed an online demographic profile in which they were asked to self-identify race/ethnicity, gender, and other demographic indicators through open text boxes. Table 1 includes the ways in which the participants self-identified, as well as their general fields of study. The researchers categorized the racial/ethnic identities of the participants as Black- and Latinx-identifying participants.

TABLE 1: Postdoctoral scholar demographics

Pseudonym	Race/ethnicity	Gender	General field of study
Abeo	Black	Male	Engineering
Angela	Columbian	Woman	Engineering
Armando	Columbian	Male	Engineering
Chris	African American	Male	Atmospheric Science
Eugene	Columbian	Male	Engineering
Eya	Black	Woman	Chemistry
Jaime	Black/Latino	Man	Engineering
Kaia	African American	Woman	Environmental Science
Kelsey	Puerto Rican	Woman	Neuroscience
Kinsley	Black	Woman	Biology
Melanie	Dominican/Polish	Woman	Biology
Milo	African American	Male	Neuroscience
Scarlett	African American	Woman	Engineering
Sophia	Latina	Woman	Biology
Suzanne	Latina	Woman	Biology
Sylvie	Brazilian/White	Woman	Medicine

4.3 Protection of Vulnerable Populations

Following Institutional Review Board approval, participants were provided with a consent form detailing the purpose of the study, interview procedures, and safeguards in place to protect privacy and confidentiality. All were given pseudonyms, and only deidentified interview transcripts were stored on a secured server accessible only to the research team. Additionally, the researchers were hyperconscious of the possibility that the participants could be identified if their specific disciplinary area or institution name or type were known, since there are so few Black and Latinx STEM postdoctoral scholars in the US. Not only was masking their identity critical, but also being vigilant about empathetically and ethically elevating the triumphs and struggles shared by the participants. In that vein, the interviewers were mindful and aware of the potential stress that could result when probing for deeper understanding during the interviews. Also, the research team was forthright in sharing that the interview could be stopped at any time, and/or a completed interview or a portion of an interview would be excluded from the analysis upon request. None of the participants made such a request.

4.4 Data Collection

Interviews averaged 60 minutes in length and were conducted one-on-one via telephone or web conferencing. The model of science identity (Carlone and Johnson, 2007) was embedded in a semistructured interview protocol, with direct attention to concepts of science competence, performance, recognition, and career goals, as well as other factors that influence the postdoctoral experience and career trajectories of postdoctoral scholars in STEM. Appendix A includes the interview protocol. The protocol allowed for rich data collection through the predeveloped questions, and the interviews were conducted in an unstructured manner to allow for a comfortable, genuine dialogue in which the interviewers could seek clarification and meaning as needed (Patton, 2015). During data collection, the interviewers worked to build trust and rapport with the participants through active listening, fostered a supportive and validating interview atmosphere, and shared gratitude for participant candor and transparency.

4.5 Reflexivity and Author Positionality

Throughout the study the research team engaged in reflexivity (Patton, 2015), both individually and collectively. This was accomplished by reflecting upon, bracketing out, and dialoguing about experiences, values, beliefs, and assumptions on the nature and construction of science identity and the influence of race/ethnicity and gender on science identity and STEM career goals. The researchers acknowledge their own experiences of racial and gender bias in academia influenced the way in which they engaged in reflexivity, which led to discussions on systems of power, privilege, and oppression that operate in higher education spaces. In qualitative research, reflexivity is a crucial component

of inquiry. It positions researchers to consider their bias and its potential impact on meaning-making and interpretations during the data collection and analysis.

Lincoln and Guba (1985) contended researchers must disclose their positionality so readers are aware of the unique perspectives they bring to the study. In this case the research team comprises social science academics trained in qualitative research methods within educational settings in which participants are considered the experts and researchers are mere conduits for participant voices and experiences. This type of training affects how data decisions are made and implemented, as research participation is considered a gift, and researcher humility is integral to the data collection and analysis process. The research team members hold professorship, administrative, and graduate student roles and actively engage in research, teaching, and service efforts to diversify higher education. All researchers identify as women; one identifies as multiracial and the other three as White.

Undoubtedly, the researchers' backgrounds affected the interpretation of the data. As women, all have experienced sexism in the academy, and the researcher of color has been subjected to racial microaggressions on countless occasions—these shared experiences with the participants created a closeness that must be acknowledged. The research team discussed this closeness and viewed it as a strength that promoted participants to feel more comfortable and secure in sharing their academic, emotional, and social highs and lows. Moreover, while the research team worked diligently to elevate the racist and sexist realities experienced by the participants, the predominantly White, all-woman research team may have missed some of the complexity that was shared. However, as all members of the research team experienced marginalization and microaggressions in academia, the team is aware of the psychological and emotional challenges created by these experiences; therefore, the researchers were intentional in honoring and respecting what was shared during the interviews.

4.6 Data Analysis

The interview data were analyzed using Stake's (1995) four-step deductive analysis process of direct interpretation, categorical aggregation, pattern recognition, and naturalistic generalizations. The Carlone and Johnson (2007) model of science identity was used to develop a deductive coding protocol directing attention to the ways in which science identity is cultivated concerning competence, performance, and recognition, as well as the influence of race/ethnicity and gender on career goals. The researchers first used the coding protocol to independently make direct interpretations of the interview data by identifying how science identity was developed and career goals were fostered. In the second step categorical aggregation was accomplished by collectively reviewing the nuanced codes identified in step one and categorizing the codes into preliminary themes.

Using Stake's (1995) third step of pattern recognition, the researchers established more precise codes by refining the grouping of associated data, developing fuse codes that blended existing codes to create new meanings and understanding of the data, and reconceptualizing the preliminary themes. This allowed the team to determine daily

experiences among the Black and Latinx postdoctoral scholars that influenced their science identity and STEM career goals. After further dialogue and consideration, four themes emerged: (1) science competency is built at an early age and solidified in high school; (2) science performance is actualized but questioned in college; (3) science recognition is fostered through professional development and success; and (4) racism and sexism shape the desire to make an impact through a STEM career. In the last step, the themes were evaluated to assess their naturalistic generalization, meaning the way in which readers could connect with and transfer the themes to their own experiences (Stake, 1995). This step was critical to ensuring the final themes represented the totality of the data and could be applied broadly to similar situations outside the context of the study at hand.

4.7 Trustworthiness

Multiple verification strategies were employed to ensure the findings were trustworthy by attending to credibility, transferability, dependability, and confirmability (Lincoln and Guba, 1985). The researchers utilized cross-case synthesis to address credibility, assessing whether themes were similar or different among the participants' perspectives (Patton, 2015). Thick, rich descriptions with participant quotes were included as evidence to aid in transferability and the ability of readers to apply the findings to other contexts, situations, and populations (Lincoln and Guba, 1985). The researchers' reflexivity and bracketing, examination of their preconceived notions and biases, bolstered the findings' dependability. Confirmability of the findings and conclusions was possible by striving to validate the themes in the early and late stages of the data analysis process (Patton, 2015). Both dependability and confirmability were achieved through the involvement of multiple researchers in the data analysis process and by providing several feedback loops in which the research team examined the themes and interpretations until a consensual agreement was met on the final themes. The research team also engaged in a peer review of the final themes with Black and Latinx engineering faculty who had postdoctoral appointments to aid in the overall trustworthiness of the findings (Patton, 2015).

4.8 Limitations

As in all research inquiries, this study has several limitations. First, due to the difficulty in both scheduling and conducting the interviews because of the participants' demanding schedules, the research team did not conduct member checks to solicit participant feedback on the final themes. Member checking may have provided more complex and nuanced depictions of the participants' experiences, allowing for a more in-depth understanding of the Black and Latinx postdoctoral experience regarding their science identity and career goals. While the study attended to exposing researcher bias through reflexivity and positionality, its potential to influence the findings and interpretations cannot be ensured. Last, while none of the researchers possess a STEM academic background,

they are engaged in STEM education research focused on the experiences of Black and Latinx postdoctoral scholars and faculty. Nonetheless, the data were approached mainly from an outsider's perspective, which the researchers viewed as both a weakness and a strength.

5. FINDINGS

5.1 Science Competency Is Built at an Early Age and Solidified in High School

The notion of science identity was rampant throughout the postdoctoral interviews, as participants shared fond memories about their first forays into STEM. Many received encouragement from teachers to participate in elementary and secondary school STEM activities, which built their early competence in science. Melanie shared:

> *I became interested in biology when I was in fourth grade . . . my biology teacher, she encouraged me to participate in some biology competitions, and I started going from one to the other and then learning more, and that's how I got excited about molecular biology.*

Similar to other participants, Melanie's STEM competency was developed early on, and through these positive experiences, she found her calling in STEM. Additionally, Chris warmly shared he "was certainly bitten by the weather bug and was really passionate about all things of science. I liked disasters, if you will, natural disasters." This initial passion carried into high school when "the science club put a weather station on the roof," which he considered a unique opportunity that helped him develop his formative STEM career interests.

Attending science-focused elementary and secondary schools also influenced participants' science identity. Sophia chose to attend a science magnet high school due to its hands-on learning opportunities; she noted the field trips were pivotal in her development as a scientist. Kaia also discussed memorable experiences that altered the trajectory of her life:

> *In high school, I had the chance through our school's eco-club to take a summer trip to the Teton mountain range. And there, we got to explore the outdoors through a scientific framework that I hadn't had the opportunity to do before. And I learned that was something I could do.*

These experiential academic opportunities led the postdoctoral scholars to find science and mathematics exciting and enjoyable.

The participants frequently pointed to teachers as critical in influencing their interest in science and desire to attend college. Jaime stated:

> *In high school, I was on a high-I.Q. competition team. The teachers that were in charge of it kind of were there to try to keep me going, keep me engaged. If it wasn't for them, who knows where I would be right now . . . I wasn't supposed to go to college . . . but one of my teachers in high school said that I should. So, she had a connection with the local college . . . and she said, 'Apply there,' and they got me in.*

Jaime's experience reflects the essential support of teachers in helping students develop their capacity and confidence for science and interest in attending college and pursuing a STEM degree.

In addition to teachers, parental support in developing postdoctoral scholars' formative interest in science was cited as pivotal. Suzanne noted:

> *Pretty early on, school was really important. And I guess my involvement in research started in elementary school with science fair projects. And then, my interest in science really was shaped in high school. I always found science very interesting. My parents aren't scientists, but they definitely valued finding joy in school.*

Similarly, Scarlett shared her parents, who are in the medical field, were science champions for her and her siblings: "Very early on, they put us in STEM camps, robotics, sports, all of those various things to keep us engaged." Eya noted, "Everybody wanted their child to be a doctor" in her home country, and her father "decreed that I was going to medical school." This encouragement led to her early interest in STEM, and while she was initially on the path to becoming a medical doctor, she found her passion in research. Similarly, Milo received support from his mother in exploring his scientific interests:

> *My mom sort of always was like, science is a cool thing that you should be interested in, and so I watched a lot of TV shows like ER and stuff when I was a kid and thought that would be a really good career path.*

The science reinforcement from parents at home, coupled with initial academic experiences at school and with teachers, prompted a genuine passion for science which participants carried into college. Without these positive STEM experiences, many indicated they would not have entered college with a love for science or be in a STEM career field today.

5.2 STEM Performance Is Actualized but Questioned in College

The postdoctoral scholars cited confidence in their ability to perform as a scientist or engineer in college; however, they often questioned whether they belonged in STEM. Many found it challenging to self-classify as a scientist or engineer because they had

few to no faculty with whom to identify with regarding race/ethnicity and/or gender. Some even wondered whether they were "worthy" of attaining a STEM degree, as they had no role models to emulate or to serve as examples. This was a particularly pertinent issue among the Black and Latinx women participants. As indicated by Sophia, a few questioned whether they "could be a scientist":

> *I was trying to get as much experience as possible, even though it wasn't clear cut that I could be a scientist at that point, just because I had never met anyone to either tell me that I could be a scientist or that looks like myself.*

All the participants began college as STEM majors, but these experiences and a lack of belonging led them to struggle. This inability of participants to find examples of successful scientists or engineers who looked like them is an example of environmental microaggressions that can reduce feelings of belonging and productivity for STEM postdoctoral scholars of color.

Furthermore, undergraduate institutional type played a role in participants' beliefs about their status within STEM. Those who attended historically Black colleges and universities (HBCUs) felt as though they were insiders, and those who attended predominantly White institutions (PWIs) felt as though they were outsiders. Kinsley, who attended a PWI during her undergraduate education, stated, "I knew that I didn't see a lot of people who looked like me in those research environments," which caused her to speculate whether a research career was the correct path. The lack of diversity in STEM academia also hindered participants from connecting with their faculty because of a lack of shared background. The absence of connection manifested in the postdoctoral scholars being less vulnerable to their professors when they struggled. When Abeo's advisor questioned his productivity, he was ready to give up:

> *[My advisor] didn't think I would cut it . . . he set it to a graph with the pace of the progress of the ideal grad student and then my pace. I was like, 'Yeah, I don't think this is going to work out.'*

While his pace of work did not match those of his peers, Abeo ultimately succeeded in graduate school when another faculty member offered to advise him. However, he remained unclear whether the lack of support from his original advisor stemmed from his racial identity and reflected racist microaggressions or was truly centered on his work output. While many had similar experiences, all noted they persisted because of their passion for science and engineering.

While the postdoctoral scholars questioned their place in STEM and their stamina for the productivity required, they continued to develop their STEM abilities while learning more about the particular aspects that excited them. Jaime found a passion for mentoring when his advisor suddenly took a leave of absence, and he was the most senior on the team:

> *I became the surrogate advisor for students, and we stuck together, we fought through, completed projects, tried to get stuff done, tried to be productive . . . it was that experience that I was like, wow, I can't believe we did it.*

Other postdoctoral scholars shared excitement related to the promotion of their work, the expansion of their networks, and the honing of their research interests as their skills developed. Abeo noted his enthusiasm during a stretch when "we had a paper accepted, a conference presentation, an oral presentation at a conference, a big international conference . . . and it was great to be able to present the work."

The postdoctoral scholars discussed hands-on learning and application opportunities as the most critical contributors to performing well in science. Scarlett worked with startup companies and a professor in her lab, which allowed time to "test out what do I like, what do I not love as much." Milo discussed his epiphany that graduate school rather than medical school would give him the education needed to fulfill his career goal of becoming an academic researcher: "When I was ready to graduate, my boss was like, 'I think you should go to graduate school instead of medical school' . . . I didn't realize growing up that you could get a PhD or sort of what that meant." Chris stated during his undergraduate years he had "a great internship . . . that really opened my eyes to the world of research and beyond . . . then I was adamant about looking at graduate programs." Finally, Eya noted, "I felt most successful when I got an Outstanding Graduate Teaching Assistant Award." This recognition helped to increase her self-efficacy as a teacher and made her realize she is most passionate about STEM education.

5.3 STEM Recognition Is Fostered through Professional Development and Success

The postdoctoral scholars were proud to share their professional development and successes throughout the interviews, particularly in gaining technical and research recognition. This acknowledgment came from learning a new technique in their lab, presenting an innovative methodological procedure at a conference, and publishing their work. Growing one's expertise in research helped the postdoctoral scholars to mold their science identity. All participants pursued a postdoctoral position because bolstering their research skills was seen as key to being competitive in the tenure-track job market. According to Armando, "I believe that a postdoctoral position is a great experience to become, or to be part of, in academia because you get to work with scientists, companies, collaborate with other organizations." Sylvie shared a postdoctoral position was integral in receiving the advanced research mentorship she could not experience in her home country. She remarked, "There is a big difference to do research here in the US and in my country. I have always wanted to have an experience here."

Regardless of their technical skills entering their postdoctoral appointment, participants viewed postdoctoral work as a necessary step to future success as a scientist or engineer, whether in academia, industry, or government. Jaime shared he accepted a postdoctoral position after attending a job fair and was advised to "apply for a fellowship with

funding . . . and that's how I got here." His desire to learn more through a postdoctoral appointment reflected the expected progression in many STEM fields from PhD acquisition to a postdoctoral position before entering academia. Kinsley expanded on the desire to accrue new skills and the excitement that accompanied her success at learning:

> *A lot of these skill sets that I'm learning are new to me, so they're frustrating at first. But typically, what I do is take a moment to step back, recollect, and then try again. So, when it works . . . I was super excited, and it felt good.*

Similarly, Milo expressed a desire to learn new skills and obtain new tools during his postdoctoral position:

> *[My position is] half academia, half industry. So, we do a lot of clinical trials, we do a lot of preclinical trials, and then my lab is a basic science lab, but I get to do a little bit of both. So, it's sort of the perfect blend of getting able to do the basic and translational research.*

The eagerness to acquire new knowledge and skills and to gain more experience helped the participants firm and narrow their STEM career interests.

The participants also perceived themselves as successful when describing their efficacy in teaching and mentoring students. They experienced both personal and professional fulfillment when nurturing the next generation of scientists and engineers, as indicated by Milo: "I take pride in the fact that my research has led to two senior design winners, and I take pride in working with the students and getting them to do some really good research. It gets recognized here." Many felt the most recognized when they successfully integrated research and teaching and worked closely with students. Participants repeatedly discussed that students were the primary reason for pursuing a tenure-track faculty position. The opportunity to work with Black and Latinx students was considered a rewarding career perk of academia.

Last, the postdoctoral scholars indicated recognition came by being afforded more research independence and flexibility during their postdoctoral positions. The participants believed they had moved to a new level of recognition and were no longer seen as "apprentices" when their doctoral advisor or postdoctoral supervisor encouraged them to conduct an experiment they had designed or attempted a novel method in their lab. Abeo noted the importance of being recognized as a professional: "It's also been very different having supervisors that kind of treat me like I have some expertise from the get-go . . . [and] getting the sense of being more independent." Furthermore, Chris felt successful when he first joined his postdoctoral lab:

> *My P.I. was like, 'Oh, I think we should write this F32. I know you're super new, and this is going to be big, like, you know, it's going to be kind of crazy for you to write it. You've been here three months, but I think you should just go for it' . . . And I actually got awarded my F32.*

Chris' experience bolstered his confidence as an independent researcher. Jaime expanded on the importance of his postdoctoral position: "I think any postdoc should have that intellectual freedom as part of it just so that you're starting to develop as an independent researcher." These sentiments emphasized the importance of postdoctoral appointments promoting research independence and preparing postdoctoral scholars for their future careers.

5.4 Racism and Sexism Shape the Desire to Make an Impact through a STEM Career

All postdoctoral scholars expressed a desire to "make an impact" in their careers. Many spoke of their desire to be on the front line of scientific discovery to benefit society and communities of color; they viewed this aspect of their work as essential and symbiotic. Scarlett noted a responsibility to use her scientific knowledge and skills to engage the children in her community in STEM activities: "I want to give back and to share different experiences to young children about the different STEM opportunities that are out there for them." She is well aware of her unique position as a woman of color in STEM and seeks to remove barriers to make these fields more accessible to people of color and those from underserved communities, which reflects an acute understanding of how role models and the environment shape science identity and career goals. Furthermore, the participants felt research questions from scholars from diverse backgrounds are more poignant and applicable to improving the human condition and benefiting communities of color that far too long have been on the margins of science and engineering breakthroughs.

The postdoctoral scholars also spoke in unison regarding their intent to diversify the broad STEM workforce and academia. Most aspire to be faculty members, but others aim to serve in support and policy development roles in higher education institutions. The participants are keenly aware they could not individually diversify the STEM workforce. Nevertheless, they desire to be part of the cultural transformation they believe is needed in the training and socialization of scientists and engineers. Suzanne noted, "I think I would just change that culture to drive the understanding that [faculty] may not be mentoring someone who is going to follow their path into an assistant professor position." Participants feel they would be considered "failures" if they do not follow the professoriate career paths of their advisors and supervisors. And yet, they feel STEM fields are plagued with discrimination and systemic barriers that limit their career advancement and those of other Black and Latinx scholars. This responsibility and drive to diversify the STEM workforce is a product of the racist and sexist experiences they have endured, which they suggest White men (and often White women) do not even consider because systems of oppression, marginalization, and discrimination do not mark their STEM experience.

While all participants desire to facilitate further diversity in STEM, each intimate future challenges and stress are expected. Jaime stated he was recruited to this postdoctoral position to increase diversity in his specialty area: "It's a lot more monolithic,

and it's not as diverse, and I definitely am cognizant of my interactions in trying not to disappoint or leave a bad impression. It's a great deal of responsibility to hold." Many postdoctoral scholars share this same belief and affirm the notion that representing everyone with their racial/ethnic background is a tall order. While all feel they are up to the challenge, they also know it will take an emotional toll on them and already has, particularly when they were students.

Additionally, several participants feel a need to temper disclosing their intent to focus on their communities' scientific and engineering needs, as they fear their ideas would be "shot down or berated." Angela wondered:

> *Is my idea crappy, or are they just saying that because they don't get it? You know, if nobody else who looks like me has made it, does that mean I can't make it either? Will they accept my ideas? Do I have to pretend to be someone I'm not? All those things, they start weighing really heavily.*

Angela's thoughts reflect internalized microaggressions resulting from sexism and racism. These experiences made her question her work and contributions to the engineering field. She wondered if she was not accepted because of the quality of her work or because no one else looked like her in the department. Kinsley also shared, "I think me wanting to get a PhD solely came from people thinking that I couldn't." She stated through conferences, education programs, and networking, she realized "men are more represented with PhDs in social and hard sciences . . . it was five to one . . . so that also further pushed me into wanted to go into academia." The prevalence of men in STEM fields also was noted by Melanie, who expressed frustration with microaggressions from colleagues: "I look different than the rest of the population in the department. And if I hear the word *cute*, I just roll my eyes. This is not a description of a scientist." The postdoctoral scholars are uniquely aware of how racism and sexism shape "their place" in STEM and purposely lean into dismantling it.

6. DISCUSSION

This instrumental case study (Stake, 1995) sought to explore the science identity of Black and Latinx science and engineering postdoctoral scholars and the influence of race/ethnicity and gender on STEM career goals. As participants are still traversing their career pathways, they confidently shared their ultimate career goal is to "make an impact" and contribute to bettering communities of color through their disciplinary choice. The four themes reveal science competency is built at an early age and solidified in high school, science performance is actualized but questioned in college, science recognition is fostered through professional development and success, and racism and sexism shape the desire to make an impact through a STEM career.

Throughout this study the science identity model of Carlone and Johnson (2007) was integral to considering the way in which science competence, performance, and recognition occurred for the participants and provided a deeper understanding of how they

made meaning of their STEM experiences as postdoctoral scholars of color. Moreover, the findings support the work of Kim et al. (2018) and Vincent-Ruz and Schunn (2018) by highlighting the importance of environmental impacts on science identity formation. These STEM experiences included early science exposure, the decision to pursue a doctoral degree, and the continued morphing of their science identity well into their postdoctoral appointment. The model guided the interview protocol, the deductive data analysis process of Stake (1995), and the interpretation of findings, which provide critical insight into how science identity development continues to be refined and reassessed at various stages of STEM pursuits.

The findings of this study contribute to the existing literature regarding the experiences of Black and Latinx science and engineering postdoctoral scholars and provide evidence that STEM journeys are laden with questions regarding the potential for success in a career field that can be highly dependent upon perceived science competence, performance, and recognition, as well as racism and sexism (Carlone and Johnson, 2007). Each participant's science competence was built at an early age when their love of science was developed in school by teachers and reinforced at home by parents. While their science identity was emergent at that point, their confidence was built to enter college as a STEM major due to these formative hands-on experiences. Their science identity was actualized in college and beyond, but their belongingness was questioned when they observed a lack of racial/ethnic and gender representation in their chosen field. This lack of belonging resulted in feelings of isolation and of being an outsider, which is mirrored in the literature (Chakraverty, 2020; Fisher et al., 2019; Scott and Elliott, 2019; Yadav et al., 2020). As noted by other researchers, participants shared supportive mentoring and research recognition, and awards mediated these experiences and feelings (Alston et al., 2017; Brockman et al., 2022; Karalis Noel et al., 2022; McGee et al., 2020; Mendez et al., 2022; Miles et al., 2020; Pyhältö, 2018; Santa-Ramirez, 2022; Yadav et al., 2020).

During participants' postdoctoral appointments, nearly all described instances of their technical skills and research independence being recognized, which they pointed to as pivotal to their science identity development, a finding supported in the work of others (Carlone and Johnson, 2007; Hudson et al., 2018; McGee and Bentley, 2017b; Mendez et al., 2022; Miles et al., 2020; Van Benthem et al., 2020; Yadav et al., 2020). Recognition created a shift in the participants as they began to view themselves more fully as insiders who are scientists and engineers making a difference in their disciplines and the lives of others. However, to attain this sense of recognition, many traversed through microaggressions, marginalization, and bias, a topic all too common in the literature (Brockman et al., 2022; Eaton et al., 2020; Malone and Barabino, 2009; McGee et al., 2019, 2020; Miles et al., 2020; Robinson et al., 2016; Santa-Ramirez, 2022; Yadav et al., 2020).

As anticipated, racism and sexism played a prominent role in cultivating the participants' science identity and career goals. These experiences led them to wonder whether others saw them as credible when their research ideas were demeaned

and diminished, as found by other researchers (Brockman et al., 2022; Chakraverty, 2020; Malone and Barabino, 2009; McGee et al., 2020; Mendez et al., 2022; Miles et al., 2020; Robinson et al., 2016; Yadav et al., 2020). Thus, this study reiterates the environment's crucial role in science identity development (Kim et al., 2018; Mendez et al., 2022; Vincent-Ruz and Schunn, 2018). The participants not only considered how their environment influenced their science identity, but they also shared a deep desire to create more inclusive STEM environments within academia and their home communities.

6.1 Implications for Practice

Participants spoke at length about the challenges experienced in STEM due to racism and sexism. Greater awareness is needed of the ways in which race/ethnicity and gender are essentialized in educational settings, including how implicit bias works against the creation of equitable practices, policies, and environments (Kim et al., 2018; McGee et al., 2020; Mendez et al., 2022; Miles et al., 2020). While nearly all higher education institutions espouse equity, diversity, and inclusiveness goals, the lack of action must be questioned, as little increase has occurred in the representation of Black and Latinx faculty in STEM or the broader academy over the last few decades (NSB & NSF, 2020). Additionally, a concerted effort must be made to employ culturally relevant mentorship practices with students, postdoctoral scholars, and faculty. The lack of self-awareness and cultural humility displayed by some supervisors resulted in participants feeling they did not belong in their academic spaces. This must be disrupted if equity, diversity, and inclusiveness goals are to be achieved.

These types of environmental changes would not only ease the barriers Black and Latinx individuals face in STEM but also bolster their science competence, performance, and recognition (Karalis Noel et al., 2022; Kim et al., 2018). For example, Black postdoctoral scholars at Yale University formed the Yale Black Postdoctoral Association to provide visibility and support for Black scholars in the School of Medicine, which has received positive accolades within the community (Belli, 2021). Another program that exists to unite Latinx scientists and engineers is LatinXinBME, which focuses on reducing feelings of isolation and increasing community connections (Aguado and Porras, 2020). Additionally, higher education institutions must prioritize research endeavors that impact communities of color, as participants spoke at length about their desire to conduct meaningful and relevant research. This shift may foster greater retention of Black and Latinx postdoctoral scholars moving into the professoriate and improve community-based research endeavors. Finally, the academy and broader STEM community must consider science identity as continuously in flux rather than static at an early age. The participants reframed and reexamined their science identity well into their postdoctoral appointments. Science identity was strongest when the postdoctoral scholars received recognition and were encouraged to operate as independent researchers.

6.2 Future Research

An important area for future research and exploration is to examine the way in which science identity continues to morph over time for Black and Latinx science and engineering postdoctoral scholars. How might science identity development look different for those who enter the professoriate versus those who enter industry or government? Examining the potential fragility of science identity (Elmesky and Seiler, 2007) may be a fruitful line of inquiry as academia continues to wrestle with broadening participation in STEM. Additionally, a better understanding is needed of the efficacious policies and practices that strengthen Black and Latinx science identity for replication and scalability across higher education institutions to promote science competence, performance, and recognition. Future research also is warranted on ways to leverage the desires of Black and Latinx STEM postdoctoral scholars to make an impact in their careers, be on the front line of scientific discovery, and give back to communities of color. Understanding the educational environments that nurture these desires and intentions would benefit the academy (Karalis Noel et al., 2022; Kim et al., 2018; McGee et al., 2020). Moreover, more research is needed to understand how racism and sexism undermine science identity. Studying the way in which science identity is impeded is imperative, as far too many Black and Latinx individuals leave STEM fields due to discrimination, racism, and sexism, which must be confronted and deconstructed.

7. CONCLUSION

This instrumental case study (Stake, 1995) sought to explore the ways in which science identity is cultivated for Black and Latinx science and engineering postdoctoral scholars and the influence of race/ethnicity and gender on STEM career goals. The findings align with and extend prior research in this area (Brockman et al., 2022; Chakraverty, 2020; Eaton et al., 2020; Hudson et al., 2018; Karalis Noel et al., 2022; McGee et al., 2020; Mendez et al., 2022; Yadav et al., 2020; Yost et al., 2013). Participants shared how their science identity was strengthened and challenged in STEM settings, suggesting identity is not static but, instead, is dynamic and continually reconceptualized. An important finding from this research is the need for the STEM community to leverage that knowledge and consider science identity to be a lifelong learning objective. The findings also reveal the participants' desire to make an impact through a STEM career. All participants desire to give back to communities of color through their technical expertise and to change the cultural landscape of STEM by diversifying the STEM workforce. Understanding the ways in which Black and Latinx postdoctoral scholars' science identity and STEM career goals are nurtured and thwarted within educational systems can be illuminating to those training the next generation of STEM professionals. Not only will this benefit Black and Latinx postdoctoral scholars, but it will also promote greater creativity, innovation, and economic advancement of all involved in the STEM ecosystem.

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APPENDIX A. NPA INTERVIEW PROTOCOL

1. Talk to me about your childhood, including your family structure and early experiences, that led you toward pursuing your PhD.
2. What experiences defined your undergraduate experience and your choice to continue on to graduate school?
3. What experiences defined your graduate experience and your choice to pursue a postdoctoral opportunity?
4. Who in your life has been influential in your pursuit of a PhD, and share why they were influential?
5. What factors directed you toward a postdoc position? Were you given any incentives to accept your position?
6. Talk to me about your postdoc work. What are some of your favorite and least favorite experiences so far? Why?
7. Are you satisfied with your postdoc appointment? What factors would improve your experience?
8. Within your postdoc appointment, when have you felt the most successful? When have you felt the least successful? What exactly made you feel that way?

9. Outside of your postdoc experience, tell me about a time when you felt the most and least successful. What exactly made you feel that way?
10. What professional development activities have you engaged in during your postdoc experience to help prepare you for your next career step? Who hosted these activities? What activities have been most helpful and why?
11. What experiences occurred to make you feel as though you belonged in a STEM career?
    a. What experiences made you feel you could succeed in a STEM career?
    b. What experiences made you want to succeed in a STEM career?
    c. What experiences helped you to understand what it would take to succeed in a STEM career?
    d. Were there any personal relationships with family members, friends, faculty members, or others that served to bolster your desire to be in a STEM career? If so, please describe.
    e. How has your gender interacted with your desire to be in a STEM career? Success in a STEM career?
    f. How has your racial/ethnic background interacted with your desire to be in a STEM career? Success in a STEM career?
12. What are your long-term career goals?
    a. Which components of your postdoc work make a career in the professoriate look appealing, and why?
    b. Which components of your postdoc work make a career in the professoriate look the least appealing, and why?
    c. Are you considering positions in academia outside of the professoriate? If yes, what are you considering, and why?
    d. Are you considering positions in industry or government? If yes, what are you considering, and why?
13. Describe your process in identifying your career and life goals. Elaborate on how those goals are connected. What experiences or people shaped your career/life goals and why?
14. What are the most important factors in determining your career path moving forward? Why is this so important?
15. What would you do if you had a magic wand to improve postdoctoral experiences?