Drawing on Internal Strengths and Creating Spaces for Growth: How Black Science Majors Navigate the Racial Climate at a Predominantly White Institution to Succeed

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ABSTRACT

To support Black students in earning undergraduate science degrees, faculty need to understand the mechanisms that Black students use to succeed. Following an anti-deficit achievement approach, we used the community cultural wealth framework to investigate the strengths that Black undergraduates bring to their science majors. Community cultural wealth consists of capital or "knowledge, skills, abilities, and contacts" that students of color can use in their education. Through participatory action research, we studied academically successful Black science majors in the final year of their undergraduate degrees at a research-intensive predominantly white institution (PWI; *n* = 34). We collected data using a demographic survey and two semistructured interviews. Three themes emerged from content and thematic analysis. First, Black science majors use their capital to navigate the racial climate at a PWI. Second, Black students use internal strengths as capital to succeed in their science majors at a PWI. Third, Black science majors create virtual and physical spaces where they can share their capital and thrive at a PWI. We use our results to offer suggestions for researchers and instructors who want to take action to support the success of Black science majors.

INTRODUCTION

Black[1] scientists have achieved excellence in their fields because they were able to persist in earning undergraduate science degrees despite many barriers. Researchers have described several ways that societal systems have failed to serve Black students. Black students must disproportionately cope with inequitable policies, practices, opportunities, and funding in K-12 and higher education (e.g., Ladson-Billings and Tate, 1995; Harper *et al.*, 2009; Riegle-Crumb and King, 2010; Museus *et al.*, 2011). Additionally, Black students must navigate feelings of isolation, racial stereotypes, and subtle and overt racism, which can hinder their persistence in undergraduate science, technology, engineering and math (STEM) programs (e.g., Brown *et al.*, 2005; Russell and Atwater, 2005; Strayhorn, 2015; Dortch and Patel, 2017). To support Black students' persistence in science majors, we need to understand how they succeed in the face of systemic challenges. One way to do this is to investigate the strengths and assets that academically successful Black science majors possess and the contexts in which they are succeeding. Then, we can use the knowledge we gain to inform actions that build on the strengths and assets of Black science majors

[1]We use "Black" to describe individuals from the African diaspora, which also includes individuals who identify as African American.

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and improve science learning environments for Black students.

We used an anti-deficit achievement approach to study the experiences of academically successful Black science majors at a research-intensive predominantly white institution (PWI; Harper, 2012). This approach invites researchers to reverse deficit-oriented questions such as "Why do so many Black students leave science majors?" and reframe them as achievement-oriented questions such as "Why do Black students persist in science majors despite all the known barriers?" (Harper, 2010). In this study, we took an anti-deficit achievement approach for understanding the strengths and assets that 34 Black science majors used to succeed in their science majors despite the racial climate at a research-intensive PWI. In the following sections, we provide an overview of the external and internal factors known to contribute to Black undergraduates' success in science. Then, we outline our theoretical framework, community cultural wealth, and our research approach, participatory action research (PAR). Finally, we provide context about the contributions of the present study.

External Factors That Support Black Students' Persistence in STEM

Historically Black colleges and universities (HBCUs) have supported an increasing number of Black students in earning science degrees (National Science Foundation, 2013). Studies of Black students at HBCUs have revealed several important factors that contribute to their persistence in science. HBCUs provide Black science majors with ample opportunity to engage with faculty members and access supportive peer groups (Fries-Britt and Turner, 2002; Kim and Conrad, 2006; Palmer and Gasman, 2008; Fries-Britt, 2017). For example, Black women in undergraduate STEM programs at one HBCU faced academic challenges; however, they found that faculty encouragement and the cooperative environment supported their persistence in earning a STEM degree (Perna *et al.*, 2010). Compared with Black students at PWIs, students at HBCUs report fewer feelings of loneliness and fewer experiences with negative racial climate (e.g., Fries-Britt and Turner, 2002). HBCUs allow Black students to achieve academic success and develop their racial, intellectual, and leadership identities while also helping to cultivate their values (Arroyo and Gasman, 2014). Dr. Claudia Rankins described the contribution of HBCUs to Black students' success in STEM as follows: "HBCUs let Black students live their best and authentic lives" (Rankins, 2019, p. 2).

Factors that positively affect Black students' persistence have also been investigated in the context of PWIs. Black students at PWIs use support and encouragement from their family, faculty, and peers to succeed in science (e.g., Russell and Atwater, 2005). Science-related organizations, mentoring programs, and undergraduate research opportunities also contribute to Black students' persistence in STEM (Chang *et al.*, 2014; Wilson *et al.*, 2012; Lane, 2016). For example, engagement in pre-health clubs and clinical shadowing programs are important for reinforcing Black students' decision to pursue a science degree (Palmer *et al.*, 2011). Instructional methods in science courses can positively impact Black students' success at a PWI. For example, Black students performed significantly better and perceived a biology course to be more useful when active-learning methods were used (Eddy and Hogan, 2014). Combining active-learning methods with mindset interventions in an introductory biology course also resulted in greater achievement for Black students compared with a lecture-based course (Bauer *et al.*, 2020).

Internal Factors That Support Black Students' Persistence in STEM

Psychological factors that contribute to Black students' success have also been identified. For example, self-confidence, science identity, a sense of community, and self-concept play a role STEM persistence (e.g., Griffin *et al.*, 2010; Strayhorn, 2015). Black men pursuing STEM degrees who had confidence in their academic ability and a sense of belonging in STEM were able to persist in their degree programs (Strayhorn, 2015). The development of a science identity through a prestigious STEM scholar program helped Black students resist discrimination they faced in their science majors (Oseguera *et al.*, 2019). Similarly, Black students in the Meyerhoff Scholars Program gained a sense of community in addition to a science identity from their engagement in the program (Maton *et al.*, 2017). Self-concept (perception of one's self) is also positively associated with persistence in STEM (Museus *et al.*, 2011). Some studies have pointed to resilience as a factor that supports the success of Black women in STEM (Ferguson and Martin-Dunlop, 2021), but caution should be exercised before promoting resilience of individuals in the face of systems of oppression, as opposed to focusing on their resistance to oppressive systems (Morton and Nkrumah, 2021).

Theoretical Framework: Community Cultural Wealth

In this study, we use the community cultural wealth framework as a lens to examine the strengths and assets of Black science majors at a PWI. Dr. Tara Yosso developed this framework to challenge the notion of cultural capital, which has been used to explain unequal educational achievement of youth based on social class (DiMaggio, 1982; Bourdieu, 1986). Cultural capital is seen as a nonfinancial asset that affects social mobility, because it is valued by the predominant culture (Bourdieu, 1986). Others have argued that this view of cultural capital often positions wealthy, white students and their families as having access to cultural capital and students and families of color as lacking cultural capital (Moll *et al.*, 1992; Yosso, 2005). Yosso asserts that such "deficit thinking takes the position that minority students and families are at fault for poor academic performance because: (a) students enter school without the normative cultural knowledge and skills; and (b) parents neither value nor support their child's education" (Yosso, 2005, p. 75). Thus, cultural capital often fails to recognize the wealth that students and families of color possess that can contribute to successful educational outcomes.

Yosso used critical race theory to counter deficit thinking by proposing a model of community cultural wealth. Critical race theory acknowledges that racism is pervasive and shapes and impacts every social institution, including schools, colleges, and universities (Ladson-Billings and Tate, 1995; Delgado and Stefancic, 2001). Critical race theorists have discussed how the histories and experiences of students of color and their families are often silenced and devalued in the U.S. education system, leading to inequities in education (Ladson-Billings and Tate, 1995; Bernal, 2002; Yosso, 2005). To challenge racism in education, critical race theory focuses on centering the

TABLE 1. Forms of capital incommunity cultural wealth[a]

Form	Description
Aspirational capital	"Ability to maintain hopes and dreams for the future, even in the face of real and perceived barriers" (Yosso, 2005, p. 77)
Navigational capital	Skills for navigating through higher education and other social institutions, including in the face of subtle and overt racism
Resistant capital	Abilities gained from using agency to challenge inequality or oppressive messages
Linguistic capital	Skills gained from experiencing more than one language or communication style
Familial capital	Ability to expand family boundaries to include extended family and friends and a "commitment to community well being" (Yosso, 2005, p. 79)
Social capital	Ability to use networks of people that provide emotional support, including peers and other social contacts

[a]Community cultural wealth includes six forms of capital possessed by students of color (Yosso, 2005).

experiences and stories of students of color and identifying and addressing the pervasiveness of racism in policies, practices, and curricula (Ladson-Billings and Tate, 1995; Yosso, 2005).

Community cultural wealth recognizes "an array of knowledge, skills, abilities and contacts possessed and utilized by Communities of Color to survive and resist macro and micro-forms of oppression" (Yosso, 2005, p. 77). Community cultural wealth includes six forms of capital: 1) aspirational capital, 2) navigational capital, 3) resistant capital, 4) linguistic capital, 5) familial capital, and 6) social capital (Table 1). For example, navigational capital includes the ability to find and use resources to maneuver through institutions "not created with Communities of Color in mind" (Yosso, 2005, p. 80). These forms of capital are not discrete categories; they are likely to interact and overlap (Yosso and García, 2007). The community cultural wealth of students from minoritized groups could offer important insights into improving education outcomes, yet the strengths and assets of students from minoritized groups may be overlooked in educational settings.

Researchers have used a community cultural wealth framework to explore the experiences of students from minoritized groups (Jayakumar *et al.*, 2013; Liou *et al.*, 2016; Samuelson and Litzler, 2016; Holland, 2017; Murillo *et al.*, 2017; Pérez, 2017), but few published studies focus on these forms of capital in Black undergraduate science majors. Jayakumar and colleagues (2013) found that Black high school students' involvement in a community-based organization supported students' "development of aspirational and social capital as they came to envision themselves as college students" (pp. 568–569). Samuelson and Litzler (2016) used community cultural wealth for secondary analysis of existing interview data from Black and Latino undergraduate engineering students. They found that navigational and aspirational capital were most commonly mentioned. Ortiz and colleagues (2019) also used community cultural wealth for secondary analysis on interview and journal entry data from Black STEM majors at an HBCU and a PWI. They identified examples of each type of capital from the framework. In this study, we used community cultural wealth in our research design for investigating the success of undergraduate Black science majors within the racial climate of a PWI.

Participatory Action Research

Individuals who are part of underrepresented or underserved populations hold "critical expertise" that must be acknowledged to address pressing social issues (Appadurai, 2006; Fine, 2009). PAR partners these individuals with researchers to form a community of scholars. Together, they study social issues by collaborating on all aspects of research, including study design, data collection, and data analysis (Fine *et al.*, 2004; Cammarota and Fine, 2008; Powers and Allaman, 2012). The community of scholars uses their results as inspiration for creating evidence-based products that address issues of equity and promote social change. For example, PAR products can include developing a workshop, giving recommendations to school administrators, or hosting an art exhibit featuring work that confronts issues of inequality (McIntyre, 2008). A PAR approach requires researchers to rethink who holds knowledge and power throughout the study (Fine *et al.*, 2004; Cammarota and Fine, 2008; Ayala, 2009). PAR has been successfully used in areas such as community development and public health, but it is a more novel approach in STEM education research at the undergraduate level.

We used a PAR approach to closely collaborate with Black science majors in foundational research that has led to the development of research-based products (Kindon *et al.*, 2007). In PAR, undergraduate researchers are not simply research assistants, they are *co-researchers* who are critical in constructing knowledge and building theory. These same co-researchers then lead the translation of the research into programs that apply the knowledge for a wider audience, with the goal of promoting equity. Our partnership with undergraduate co-researchers on this project was essential, because it increased the likelihood that our results reflect the experiences of Black undergraduate science majors. The partnership also helped ensure that our products are relevant for informing actions that build on the strengths and assets of Black science majors.

Present Study

In this study, we sought to expand on the knowledge of factors that contribute to Black undergraduates' success in science using an anti-deficit achievement approach. Specifically, we aimed to address a gap in the literature regarding the ways that racial climate affects the community cultural wealth that Black undergraduate science majors use for success at a research-intensive PWI. We chose to focus on science majors rather than STEM majors in general, because of known differences between science and other STEM disciplines such as engineering. Our rationale for engaging in this work is so that faculty at research-intensive PWIs better understand how racial climates can impact the success of Black science majors, while building on strengths and assets that support Black undergraduate students' success in science. We used an in-depth qualitative approach to answer two major research questions: 1) What is the racial climate experienced by Black science majors at a research-intensive PWI? 2) What forms of community cultural wealth do Black undergraduate students use to succeed in their

science majors despite the racial climate at a research-intensive PWI?

METHODS

Positionality

The research team of four student co-researchers and two faculty members used a shared leadership model for this PAR project. There were three undergraduate co-researchers who majored in biology or biological sciences, one who identifies as African American (O.B.), and two who identify as Nigerian-American (O.O. and C.O.), as well as one graduate co-researcher who identifies as African American and majored in biology as an undergraduate (B.M.). The faculty members included a Filipino-American faculty member in cell biology (J.D.S) and a Black faculty member in education (D.R.M). All aspects of the study, including data collection and data analysis, were informed by the lived experiences of the four co-researchers. Although co-researchers deeply connected with the participants' stories, none of the co-researchers were participants in this study.

Context and Participant Recruitment

This study took place at the University of Georgia, which is a public, land-grant university with high research activity. We used a nomination process to identify potential participants for our study (Harper, 2010). We asked science faculty and undergraduate presidents of student organizations to nominate academically successful Black science majors who met our selection criteria. All participants identified as Black and met the first criterion of persisting to the final year of an undergraduate science major (Table 2). All participants also met at least one additional criterion: 1) a cumulative grade point average of 3.0, 2) an "A" in a science course, 3) membership in a science-related organization, or 4) participation in undergraduate research. This definition of success allowed for the inclusion of successful Black science majors with a variety of community cultural wealth to share, which would not have been possible if academic performance was the sole criterion. Thirty-four nominated students consented to participate in our study. The study consisted of two interviews: one in the Fall semester and one in the Spring semester. Students were compensated for their participation with $20 and $30, respectively. The University of Georgia Institutional Review Board reviewed this study and granted it exempt status (STUDY00004426).

Data Collection

Interview Protocol Development and Testing. We developed interview questions that would help provide insights into forms of community cultural wealth that Black students use to succeed in their science majors. To examine the utility of our interview questions, we conducted "cognitive" interviews (Willis and Artino, 2013). In a cognitive interview, participants read the questions, explain their interpretations of the questions verbally, and then answer the questions as they would if they were being interviewed for the study. We conducted four cognitive interviews with academically successful Black science majors to test the efficacy of our interview protocol (Supplemental Material, Appendix D). This process allowed us to understand the data our questions elicited and helped us add and remove questions from the protocol. We also used preliminary data to clarify the wording of our questions.

Fall Interview. Data on participants' academic success were collected using a semistructured interview and a demographic survey. Before the Fall interview, participants were given a demographic survey about their backgrounds as well as their past and current involvement in science and non-science organizations (Supplemental Material, Appendix A). The Fall interview protocol consisted of 26 open-ended questions aimed at investigating the forms of capital in the community cultural wealth framework that participants used to succeed in their science majors (Supplemental Material, Appendix B). Each section of the interview corresponded to one or more forms of capital (see section headers in Appendix B). All interviews were conducted by student co-researchers, who were also Black science majors. Fall interviews lasted on average from 45 minutes to an hour and were audio-recorded.

Spring Interview. Data on participants' community cultural wealth were collected using a semi-structured interview that included a card-elicitation activity and a photo-elicitation project. The Spring interview protocol consisted of 15 open-ended questions designed to further investigate participants' community cultural wealth and their success in science (Supplemental Material, Appendix C). Whereas the goal of the Fall interview was to learn about the forms of capital Black students use to succeed in science majors, the goal of the Spring interview was to explore these forms of capital in greater depth using two elicitation methods described below (Supplemental Material, Appendix D). The Spring interview also took place at a time when many participants knew their postgraduation plans, which allowed them to reflect on their success in the context of their continued career paths.

Card-elicitation is a data-collection method from anthropology that invites participants to respond to ideas shared by other participants (Trotter and Potter, 1993). This method was important to our study, because the forms of capital in community cultural wealth are not recognized in predominant culture, and they often go unrecognized by Black students themselves. During the card-elicitation activity, participants were presented with five stacks of cards that represented different forms of capital from the community cultural wealth framework: 1) navigational, 2) familial and social, 3) resistant, 4) linguistic, and 5) aspirational (Table 1). Each stack contained five or six cards with ideas directly related to the form of capital. For example, the aspirational capital stack included cards with the following five ideas: "My ambitions and dreams," "Being self-motivated," "Being focused when I need to be focused," "Helping other minorities succeed," "Surpassing my parents' success," and "Seeing a need for more minorities in science." These ideas were derived from collective Fall interview data; the cards were not specific to each participant. The interviewers gave the participants one stack of cards at a time and asked the participants to select the cards containing ideas that resonated with them. The interviewer then asked the participants to provide an example of how the idea they selected related to their success in science. After going through the five stacks, the interviewer asked if any ideas were missing and invited participants to write those ideas on new cards. Finally, interviewers asked participants to select and explain the top five ideas that were the most important for their success as science majors.

TABLE 2. Demographic survey results

Pseudonym	Major[a]	Gender	Self-reported ethnicity
Alexandra	Biology-related major	Woman	Black
Amy	Biology-related major	Woman	Nigerian
Andrew	Biology	Man	Black
Angela	Biology-related major	Woman	African American
Annie	Biology	Woman	African American
David	Biology-related major	Man	Nigerian
Heather	Biochemistry and molecular biology	Woman	African American
Helen	Biology-related major	Woman	Black
Jackie	Biochemistry and molecular biology	Woman	Haitian American
Jasmine	Biochemistry and molecular biology	Woman	Black
Jason	Biology	Man	Afro-Caribbean and Hispanic
Jennifer	Biology-related major	Woman	African American
Jessica	Biology	Woman	African American
Joan	Biology	Woman	African American
John	Biology	Man	Black/African American
Linda	Biology	Woman	African American
Mark	Biology-related major	Man	African American
McKenzie	Physical sciences major	Woman	Black
Megan	Biology-related major	Woman	Nigerian
Melvin	Biology-related major	Man	Black
Meredith	Biology	Woman	African American
Michelle	Physical sciences major	Woman	African American
Mia	Biology-related major	Woman	Italian and Nigerian
Mike	Biology	Man	African American
Monique	Biochemistry and molecular biology	Woman	Black/Latina
Morgan	Biology-related major	Woman	Black/African American
Pamela	Biochemistry and molecular biology	Woman	Gambian/American
Rachel	Biology	Woman	Nigerian
Ralph	Biochemistry and molecular biology	Man	Nigerian/African American
Robert	Biochemistry and molecular biology	Man	Black
Sarah	Biology-related major	Woman	Black
Stacy	Biology-related major	Woman	African American
Susan	Biology	Woman	African
Vanessa	Biochemistry and molecular biology	Woman	Black

[a]For biology-related majors represented by just one or two Black students (e.g., genetics) we use the category "biology-related major" to help protect participants' confidentiality. We also use "physical sciences majors" for chemistry and physics, which were represented by one Black student each.

The second part of the interview centered on the *photo-elicitation* project. In photo-elicitation, photographs serve as points of discussion during in-depth interviews with the goal of evoking information that interview questions alone cannot (Harper, 2002; Van Auken *et al.*, 2010). Before the second interview, participants were asked to submit five to 10 photographs or a short video that reflected the factors that contributed to their success in a science major. During the interview, interviewers showed participants their submitted photographs and asked them to select the top two or three photographs for discussion. Participants were then asked questions about each of the selected photographs to gain a deeper understanding of what their submissions meant to them. Spring interviews lasted about an hour and were audio-recorded. Of the 34 participants who were interviewed in the Fall, 27 (approximately 80%) participated in the Spring interview.

Data Analysis

Content Analysis. All transcripts were transcribed professionally and checked for accuracy. The participants' discussions of their photographs or videos were included in the interview transcripts. Thus, the photographs were analyzed with the transcript so that the context and meaning of each photograph was not lost (McGowan, 2016). First, our research team used open coding to gain an understanding of the range of the data (Saldaña, 2013). We then met to discuss the data and identify new codes that could be added to an existing codebook (D. Means, J. Stanton, B. Mekonnen, O. Oni, R. Breeden, O. Babatola, C. Osondu, M. Beckham, and B. Marshall, unpublished data). This codebook was initially developed as part of a larger study that our team is conducting. Approximately 70 codes were used to label examples of: 1) participants' community cultural wealth, 2) other factors that contributed to their success in science, and 3) the nature of the racial climate at their institution. We used this codebook for content analysis in a qualitative analysis software program called MAXQDA (VERBI Software, Berlin, Germany). For example, the code "proving people wrong" captured a specific form of resistant capital found in our data. Portions of the transcript in which participants explained that they were motivated to succeed in science

after someone doubted their ability were labeled with the "proving people wrong" code. Transcripts were randomly assigned to team members so that each participant's data were analyzed by a minimum of two researchers. Each participant's Fall and Spring transcripts were analyzed together to gain a holistic understanding of the participant's data (Josselson, 2011). We engaged in an iterative coding process, with team members analyzing the data individually in approximately 20% increments before meeting to discuss that increment as a group. The researchers coded to consensus as opposed to coding for interrater reliability to ensure rigor and put emphasis on details that could easily be overlooked.

Thematic Analysis. After all transcripts were coded with the revised codebook, four co-researchers and two faculty members engaged in thematic analysis, which was done using a modified version of the "sort and sift: think and shift" approach (Supplemental Material, Appendix E; Maietta, 2006). This process involved steps done as a team and steps done individually. To begin thematic analysis, each researcher selected 10 quotes that represented each participant whose transcripts they coded. The goal was to identify powerful quotes that answered our research questions and told the stories of our participants. Representative quotes from each researcher were shared using a spreadsheet, and after reading them independently, the team met to discuss the quotes. Then each researcher selected the 15 most compelling quotes to exemplify the entire data set. Exemplary quotes from each researcher were shared using a spreadsheet, and many of the selected quotes overlapped.

The team read and discussed the exemplary quotes during a half-day data analysis retreat. Following the discussion, each researcher wrote three sentences to summarize three possible themes from all of the team's exemplary quotes. For example, one co-researcher wrote: "Black students are effective at finding/creating a space for themselves, where they can uplift one another, even in impossible environments." We discussed our sentences and mapped possible themes on a dry-erase board. Through continued discussion and mapping, we finalized our themes. For example, one theme that evolved was "Black science majors create spaces where they can share their capital and thrive at a PWI." In this paper, we examine three of the major themes selected by co-researchers as the most important to our participants' success in science majors.

To verify themes identified through analysis of quote data, one faculty member and two co-researchers identified 10–15 codes in our codebook that could provide evidence for each theme. For example, codes for the creating spaces theme included, but were not limited to, "peer capital of Black students," "non-science organizations for student of color," and "wanting to see other Black students succeed." Each researcher was assigned a theme to explore individually, which involved gathering the data labeled with each of the 10–15 identified codes (using MAXQDA's coded segment function) to ensure that the theme was supported in the data. The other two researchers then reviewed the summary of the gathered data. All names are pseudonyms, and participant quotes have been edited for clarity (e.g., replacing a pronoun with a specific noun in brackets).

RESULTS

We interviewed 34 Black undergraduates in the final year of their science majors to understand the forms of community cultural wealth they used to succeed at a doctoral research university with highest research activity that is also a PWI. We aimed to answer two research questions 1) What is the racial climate experienced by Black science majors at a research-intensive PWI? 2) What forms of community cultural wealth do Black undergraduate students use to succeed in their science majors despite the racial climate at a research-intensive PWI?

This paper centers on three major themes: 1) Black science majors use their capital to navigate the racial climate at a PWI, 2) Black science majors use internal strengths as capital to succeed at a PWI, 3) Black science majors create spaces where they can share their capital and thrive at a PWI. The relationships between these themes and the forms of community cultural wealth are summarized in Table 3.

Major Theme 1: Black Science Majors Use Their Capital to Navigate the Racial Climate at a PWI

In this section, we characterize our participants' experience as Black students at a PWI and the forms of capital from the community cultural wealth framework that they use to navigate the racial climate at a PWI. We describe three main experiences that participants faced: 1) a lack of Black classmates, 2) frequent racial microaggressions, 3) less frequent overt racism. By investigating racial climate, we also learned about participants' resistant capital, or abilities gained from exercising agency to challenge inequality or oppressive messages (Yosso, 2005; Table 1). We then explore a form of linguistic capital, code-switching, that participants used to in response to anti-black racism. We end this section with descriptions of several forms of resistant capital used by participants to challenge racial microaggressions and racism.

Black Science Majors Experience a Lack of Black Classmates at a PWI. One of the major experiences our participants described was a lack of Black classmates in their science courses. Being one of the few Black students in the classroom made many participants, including Rachel, feel uneasy.

> You can walk into one of your classes and be the only Black person in your class. I don't think anyone who is not Black will ever be able to understand that feeling. It's almost as if you come into a new space every time or you are dealing with a new environment every time. It takes a while to get comfortable, even if I would say comfortable, because you never really get comfortable with it, [it's just] something that you just have to accept that you are the only one who looks like you in most of your classes.—Rachel

Other participants wondered whether their instructors and classmates could understand the amount of pressure they felt as a result of being one of a few Black students. Jason described his experience as being one of five Black students in his 200-person general chemistry course, explaining that it is intimidating when "you stand out." He described a feeling of isolation, saying, "Sometimes [the other students] don't interact with you."

All of the Black students in our study were successful in persisting to the final year of their science majors. Many

TABLE 3. Themes in the data and their connection to community cultural wealth

Major themes[a]	Subthemes	Majors forms of capital represented in the data
Black science majors use their capital to navigate the racial climate at a PWI.	The racial climate at a PWI Navigating the racial climate at a PWI through code-switching, a form of linguistic capital Challenging the racial climate at a PWI through resistant capital	Navigational capital Linguistic capital Resistant capital
Black science majors use their internal strengths as capital to succeed at a PWI.	Succeeding through self-motivation Succeeding by persisting in the moment Succeeding through long-term persistence Succeeding by asking for help	Navigational capital Resistant capital Aspirational capital
Black science majors create spaces where they can share their capital to thrive at a PWI.	Creating virtual spaces and informal communities Creating formal communities within science Creating formal communities outside of science	Navigational capital Social capital

[a]This paper explores three major themes, which are divided into relevant subthemes. For each theme, we list the major forms of capital found from the community cultural wealth framework. The forms of capital within the subthemes often overlapped and intersected (Yosso and Garcia, 2007).

participants were proud of their academic achievements, but some described mixed feelings about persisting to the point that there were few Black students in their classes.

> There's not many Black people on campus. Everyone starts off as pre-med, so in the beginning, you would see a lot more Black people in your classes. But then, everyone starts to switch and it starts to dwindle down … I literally can count on one hand how many Black people are in my classes now. So, that's definitely a struggle, because you don't see people like you in your majors … you only see other people. So, it kinda keeps you motivated 'cause it's like, "At least I'm still here. I can still do it." But at the same time, it is a little discouraging because it's like, "No one else is here with me."—Monique

Monique described a feeling of accomplishment from being able to stay in her science major, but it is coupled with a feeling of disappointment knowing that many of her Black peers did not persist in science with her.

Other participants explained that a major consequence of a lack of Black classmates is the sense that they have to represent their race in the classroom. Mark described how he felt the first time he was the only Black student in a science course. He said he felt pressure, because "whatever I do is gonna have a reflection on all Black people." Similar to Mark, Rachel explained, "It's very exhausting, because while you are trying to focus on schoolwork, you are also trying to best represent your race as you can."

Black Science Majors Frequently Experience Racial Microaggressions at a PWI. Racial microaggressions are subtle forms of racism that can sometimes go undetected. The term "microaggression" was first used by Dr. Chester Pierce (Pierce, 1970), a Black educator and professor of psychiatry at Harvard University. He described microaggressions as "subtle, stunning, often automatic" exchanges that can be verbal or nonverbal with the purpose of being "put-downs" (Pierce *et al.*, 1977, p. 78). Since Dr. Pierce's initial work, other scholars have also characterized microaggressions (Solorzano *et al.*, 2000; Pérez Huber and Solorzano, 2015), which may be aimed at any group of marginalized individuals. Microaggressions are often "disguised and covert" (Sue, 2010). In this subsection, we characterize our participants experiences with racial microaggressions.

Participants in our study reported frequent encounters with racial microaggressions at the PWI they attend. In many cases, participants described the stress they experience over their uncertainty about whether or not someone's actions were meant to have a negative impact or not.

> Microaggressions, they're just a weird middle ground because it's like you never know whether the person says something because they mean harm or because they just genuinely do not know how to ask the questions that they're asking or if they're just making assumptions that they don't realize they don't need to be making. So, just dealing with microaggressions in general has been a big thing that I've just learned how to do throughout college.—Sarah

Other participants told specific stories of their experiences with racial microaggressions, which caused them to question whether racism was in play or not.

> In my new lab, I kind of suspect, not necessarily racism, but I just feel like there's a little bit of a bias where one of the grad students, she always asks me to do the busy work in the lab, like let's say my experiment is running on the PCR machine and it's going to take like an hour or something and the other girl is not doing anything either. I could be working on my homework, the other girl can be working on her homework but yet, [the grad student will] ask me to refill all the pipette tips for the lab and do this and do that … and I'm just trying to figure out, why is it always me? But it's like, I don't want to blame it on race, but the other girl is a white girl.—Susan

One form of microaggression occurred when people made assumptions about participants based on racial stereotypes. Participants described how others assumed they were from low-income families or first-generation college students.

> I notice a lot of times when I go to certain places, some people just assume I have to be a first-generation college student. My grandparents went to college.—Helen

As Helen notes, perpetuating stereotypes about Black people is another type of racial microaggression. Other participants talked about racial microaggressions that may be due to cultural insensitivity. For example, a few participants talked about how some classmates commented on and touched their hair without permission. Sarah pointed out that touching a Black person's hair without permission is not innocuous, and she warned her classmate that this could result in a very negative reaction from someone else.

Participants also described their experiences with racial microaggressions in the classroom. One common experience was difficulty finding lab partners or people to work with for small group projects. One undergraduate student co-researcher explained that many of the white science majors know each other and will immediately form groups with other white students, but Black students often do not have that luxury, because they may be the only Black student in a lab course. This can lead to a sense of anxiety about whether they will have someone to work with or not in a lab course. Michelle described this experience:

> You know, like the small kid in gym class. Nobody wants to be their partner, or like pick them on a team? You have stuff like that. Nobody wants to be in your group.—Michelle

Later in her interview, Michelle explained that she had to prove herself to be smart before other students wanted to be in her group. Similarly, Mike had group members tell him that they were surprised by his contributions, because they did not expect him to do much of the work because he is Black.

Black Science Majors Sometimes Experience Overt Racism at a PWI (But Not as Commonly as Racial Microaggressions). For this study, racism is defined as a "set of institutional, cultural, and interpersonal patterns and practices that create advantages for people legally defined and socially constructed as 'White' and the corollary disadvantages for people defined as 'non-White' in the United States" (Bell *et al*., 2010, p. 60). Some participants described experiences with obvious racism on and around campus, but with less frequency than racial microaggressions. Similar to findings from other studies, the racism Black science majors in our study experienced on campus was more covert than the overt racism they experienced off campus (Solorzano *et al.*, 2000). For example, Michelle described a time when her answers on a homework assignment were marked wrong, even though she had the same correct answers as her classmates. Her classmates noticed this, and they pointed out that this seemed racist, because Michelle was the only one to lose points for correct answers.

> [My classmates] said it before I could [say] it. It was like, a little racist right? I'm like hey, I didn't even say it first, but they saw it. When other people see it before you see it, then it's probably true.—Michelle

Experiences with overt racism happened in the downtown area that is just across the street from the university campus. As Robert explained: "[Racism is] mostly downtown more than anything like in an academic setting," and he went on to describe some of the many encounters he has had downtown. Similarly, David shared a few experiences that took place downtown. For example, he said,

> I had someone cheat off of me in one of my (science) classes. I saw him cheating. I, honestly, I didn't care … and then I saw him downtown and he called me the "N" word, walking past. It wasn't him specifically, it was the group that he was with and he was sitting there laughing with them. People are definitely fake. They'll use you when they need you, and other than that it's you are who you are, they are who they are and they don't really wanna interact with you.—David

Although this incident and ones like it took place off campus, the proximity to campus and the involvement of other people from the university affected the racial climate participants experienced at this PWI.

Black Science Majors Use Code-switching to Navigate Racial Climates. Due to participants' experiences with and knowledge of anti-black racism, they described the ability to codeswitch as a skill to succeed in academic and professional settings that were sometimes hostile to Black people. Code-switching is a form of *linguistic capital* that includes abilities students of color possess from using more than one speaking style. Code-switching can also be considered a form of *navigational capital* that includes skills for moving through systems of higher education, which were not designed with students of color in mind (Yosso, 2005). Black science majors in our study defined code-switching as an automatic, innate change in speaking style that they use for the purpose of presenting a particular image to certain groups of people. Jackie explained her definition of code-switching while discussing the "sense of comradery and a sense of security and safety" that she has with her Black professors.

> [With my white professors] I'm gonna enunciate my words, speak as clearly and concisely and knowledgeably as I can about the subject that I'm asking you or speaking to you about. With my Black professor I'll allow myself to be a little bit more me so they can see the type of person that I am, see my person rather than just me being another student asking a question about the course.—Jackie

Jackie described her ability to change her speaking style as linguistic capital that allowed her to be understood by white professors and form connections with Black professors.

Participants had diverse opinions about the role of code-switching in their lives. Two major participant views from the data are 1) code-switching is a form of assimilation that is required for survival, and 2) code-switching is a form of professionalism that is used to thrive in predominantly white spaces. As an example of code-switching as assimilation, Mike said he codeswitches when he is around white people. He explained that he changes the way he speaks without even thinking about it.

> [Code-switching is] not even something I think about doing, it's just something that happens … and it's something I've been doing for years, since probably middle school … just because that's the time that I started being in the [gifted], honors, and AP classes which had more white people. [Black people] have

> a different vernacular, they use different words, they have a different pace of speaking … So I just feel like that's a survival thing. And I don't necessarily feel like there's anything wrong with that.—Mike

Mike went on to explain how code-switching allows you to "be understood by multiple groups" and "widen your opportunity." Although Mike saw benefits to code-switching, it is important to note that Mike referred to code-switching as a *survival* mechanism and not one he uses by conscious choice. Thus, code-switching acts a form of navigational capital that allows Mike to succeed in his academics in the face of any subtle or overt racism he may experience. Andrew also explained the reasons he feels he must change the way he speaks with people who are not Black.

> I recognize that I am a Black man and being Black, there are so many things that are tied with it, like our dialect, our language, the way we communicate with each other, our humor, the stereotypes about our food—everything like that is something that I just love about being Black. But I know that if I were to go and speak to someone who wasn't Black with that same flavor that the Black community has, it would definitely be frowned upon.—Andrew

Andrew explained that his regular communication style would not be accepted by people who are not Black. Similarly, Rachel acknowledged that changing her appearance is also a form of code-switching in response to potential racism, which she uses when she feels she might not be accepted by white people.

> I had an interview last month and it was right after I came back from Nigeria. In Nigeria, braids are just a thing. We love braids … So I had these long black and blonde twists that I knew would not be acceptable going into an interview with primarily old, white men. So I had to take my braids out. This was by choice. Of course they didn't tell me I had to, but I just knew if I wanted them to perceive me as what's on the inside rather than what's on the outside, I knew I had to present myself in a way where my exterior wouldn't overshadow my interior.—Rachel

While some participants viewed code-switching as a way to survive spaces that were sometimes racially hostile to Black people, other participants viewed code-switching as a form of professionalism. Annie said, "I know how to kill interviews, I know how to be professional … I know how to switch on and off when it's necessary." In Jessica's view, everyone codeswitches to some extent in professional settings.

> Being able to code switch, I think this is very important because I think that if you're going into a professional field you have to know how to talk professionally. And some people will say like, "Oh, that's not being yourself." But everybody has a codeswitch and it's just more so even in interviews you have to be able to talk professionally, but be yourself at the same time.—Jessica

Here Jessica pushes back the notion that she is not being authentic when she changes her speaking style. Instead, she uses code-switching as a form of navigational capital to be successful in professional settings. Similar to Jessica, Amy freely codeswitches depending on the context. Amy explained the goal of her code-switching.

> When I'm around my friends I'm not thinking of how this person can benefit me … I think that's why I change my voice to fit whoever I'm talking to because I want [something]. Usually if it's a higher-up I want them to help me in some way or another. I'm trying to convince them that I'm like them and I want them to help me so that's why I change my voice.—Amy

Other participants also talked about using code-switching to thrive in predominantly white spaces. Michelle said, "I love code-switching," when describing her ability to reach scientific audiences by bringing a mix of her own natural enthusiasm and her deep knowledge of chemistry while giving talks at scientific conferences. She described how her linguistic capital of code-switching allowed her to connect with scientists. Michelle views code-switching as something that has allows her to go far in chemistry. Thus, participants use code-switching not only as a form of linguistic capital, but also as navigational capital for succeeding in fields where Black scientists are not well represented.

Black Science Majors Use Their Resistant Capital to Challenge Racial Microaggressions and Racism. Within the community cultural wealth framework, *resistant capital* consists of the abilities individuals gain from exercising agency to challenge inequality and oppressive messages (Yosso, 2005). In this section, we present abilities that participants developed through their experiences with racial microaggressions and racism. It is important to note that we do not view resistant capital as a "silver lining," nor do we see these abilities as accidental benefits of racism. We instead see resistant capital as part of the reality of our participants' experiences. We found that they were able to use resistant capital as a means of dealing with negative experiences of racism. It is also important to note that the Black science majors in our study are different people who deal with these experiences in different ways. While some are able to confront racism, others find it so overwhelming that they need to exercise their ability to ignore racism to preserve their peace of mind. Throughout this section, we bold examples of the resistant capital our participants shared.

Several participants talked about how, over time, they gained **the ability to educate people** who said and did things that were racist. Many students in our study were open to conversations about racism, which allowed them to practice this skill. Sarah explained how discussion could be beneficial for both parties.

> I feel like having conversations about [racism] opens the door to people being more willing to hear about it and maybe see where they went wrong, or see the flaws in what they might be thinking. Or to even, not necessarily change their mind about different ideals that they may have, but make them take a second look at how they might view things.—Sarah

Similar to Sarah, McKenzie saw the value in having conversations about racism. She noted that "if you want more [Black] people [in science], you need to make them comfortable as

well, not just make the [white people] feel comfortable." McKenzie explained that, in order to add diversity, a field like science must work to integrate Black people by confronting issues of racism through open discussion.

Annie also learned to educate others, which she referred to as **"checking people."** She explained: "Some people are just ignorant, they don't know they said something ignorant, so you just have to let them know." She reiterated that some people don't mean to be racist, and yet someone needs to point it out to them. She further explained that "if you have to get a little sassy and let people know their mistakes then you have to," but she said it was important to "tell people off" in a collected and intelligent way. Andrew also saw the need to sometimes check people, but he noted that he tries several other approaches first, because "checking someone can be viewed as me being violent and more generally, my community being violent."

Other participants talked about the importance of **being assertive** when someone says something racist. Megan explained why it is critical to stand up for herself in certain situations so that people know what they are saying to her is not acceptable.

> They'll say something slick [racist] and I'll just be like, "Okay, that's why…" Just because I feel like if you don't respond they won't respect you and stuff like that because they think it's okay to continue doing that. So I don't really respond passively, I sort of say it straight up. That's what I've come to learn getting older. When I was younger I would just laugh it off and let it be, pretend like it was okay because I didn't want to cause issues (because) I was a minority.—Megan

Like Megan, Amy discussed how being assertive is something she's learned from dealing with racism, and she explained that she applies this resistant capital to other settings. Amy said, "I think making sure people can't walk all over you is important, especially when you are a minority." Andrew said that regardless of whether he confronts racist statements or not, "one thing I will not do is not be myself." He will show his true personality regardless of the situation.

Mark is willing to stand up for himself and educate others about racism, yet he has learned to limit his engagement in conversations about racism so as not to give racism more attention than he feels it deserves. Similarly, after describing his experiences with racism on a study abroad trip, John said he's learned you need to "**pick your battles**." Here, Mark describes his approach to determining how much energy to devote to a racist event.

> Things like racism, it's just my mindset, it's how much attention I give to racism. I mean, yes, if it comes to my attention I will correct you, I will educate you but I'm not going to let that get to me. I'm not going to let somebody say racist things, make me feel less confident or competent about what I'm doing. So, I mean yeah, I will educate you and I'll move on … having that mindset has helped me be able to navigate through college.—Mark

Similar to Mark, Mike also described that he gauges how successful a conversation about racism will be so he can determine how much effort to put in. Some participants talked about the importance of picking your battles, because there can be significant risks when you confront someone about racism in white spaces. For example, Melvin explained that you have to consider whether challenging a person might jeopardize some aspect of your college education.

The way participants in our study dealt with racism changed over time. For example, Rachel said when she first started at the university, she worried a lot about racism and what other people thought of her, but over time she learned to **focus on what really matters**.

> Unless you are stopping me from pursuing what I want to do, why do I care so much about your opinion? That's something that I had to understand … I felt so uncomfortable in my classes at first. I was just like, "I don't want to be here. Let me try to do this, act like this, talk like this." I'm like, "Why am I spending more time focusing on other people that I don't even talk to than getting out of this class or not having to repeat it?" I just stopped caring so much … Now I have so much free space in my head because I stopped thinking about things that didn't even matter.—Rachel

Rachel went on to explain how she uses that free space in her head to focus on learning in her science courses. She holds the opinions of close friends and family members in high regard, but she doesn't let what others might think bother her.

Some participants saw the significance of succeeding in college as a way to defy racism, demonstrating another form of resistant capital. Linda shared a time when a student she met on a bus told her she would eventually change her science major. She explained that although her passion for science prevented her from changing majors, for a time she stayed in her major because she wanted to prove that person wrong. Similarly, Michelle talked about how negative stereotypes about Black students served as motivation to continue in her chemistry major. She said, "I love proving people wrong" and then explained how she excelled in General Chemistry I and II, earning "A" grades both semesters despite the courses' reputation as "weed-out" classes. In a different way, Jackie explained how she was able to focus in the face of racist experiences, because her persistence in science serves as a **challenge to the status quo**.

> I just try to make the fact that I'm here, make it count, because we weren't given this opportunity … 50 years ago, to be present. I'm here now, so I just want to make sure while I'm here I leave my mark and I do the best that I can and I'm just educated, because education is power … so I'm just gonna do everything that I can to ensure that I have the little smidge, the power that I can get from here, here, here.—Jasmine

Remembering that there was a time Black students were not allowed at the university helped Jasmine persist in her science major. She saw her success as subversive, and she went on to explain how graduating with a science degree would allow her to gain power for herself and for the Black community.

Major Theme 2: Black Science Majors Use Internal Strengths as Navigational Capital in Order to Succeed at a PWI

Studies of community cultural wealth often reveal the importance of capital that involves people other than the students themselves (for a review, see Denton *et al.*, 2020). Social and

familial capital are known to be important sources of strength for Black students. Although we saw these important forms of capital in our data, another theme emerged regarding the skills and abilities that are inherent to the participants themselves. In this section, we characterize four internal strengths Black science majors use for succeeding within the racial climate of their PWI: 1) internal motivation, 2) persistence in the moment, 3) long-term persistence, and 4) willingness to ask for help. Some of these strengths are also described in our other work (D. Means, J. Stanton, B. Mekonnen, O. Oni, R. Breeden, O. Babatola, C. Osondu, M. Beckham, and B. Marshall, unpublished data), which used aspirational capital as the main lens for analysis, whereas here we focus on how these strengths are used by participants as navigational capital and resistant capital.

At first glance, some of the strengths we describe may seem similar to strengths possessed by students who are not Black. Yet we caution readers about overgeneralizing or overidentifying with these results. Instead, we invite readers to carefully consider the unique nature of these skills and abilities for Black science majors. In our analysis, we found that the *level* at which our participants use these strengths and the *reasons* they rely on these strengths are fundamentally different than for non-Black students. In particular, participants felt like the field of science was not always inclusive to Black students, and they used navigational and resistant capital to persist despite a context that often feels unwelcoming.

Self-Motivation: "The Key to Enduring Adversity". Internal motivation was a common strength for success possessed by many participants. We define internal motivation as being self-driven to achieve one's goals. Several participants explained that motivation cannot be solely external, but rather it must originate from within oneself to sustain success. For example, Jasmine explained that motivation "starts within yourself," otherwise you are not able to push yourself to do all the things you need to do to be successful in a science major. Similarly, Andrew said that you cannot be successful if you are not self-motivated. Given the challenges of being a Black student in science, he went on to describe self-motivation not only as the key to being happy, but also "the key to enduring adversity," which points to the way Andrew uses self-motivation as resistant capital that allows him to succeed despite inequality.

Other participants also explained why their motivation cannot be derived from outside sources. For example, one reason is because they are Black science majors at a PWI.

> I feel like I have to be self-motivated because there's so many things to put me down or hinder my success … people might not be direct with it, like going to a PWI, but at the same time in their head they'll be like, "Oh, she's probably not as smart as me," or something like that. So, I know I can't get my motivation from outside sources, so it has to come [from] within.—Monique

For Monique, it is essential to be internally motivated in an environment where her ability to succeed is doubted because of her race. She explains that when most everyone around you is white, they may not *say* you are unqualified to be at the university, but they may *think* you are unqualified. She went on to explain that in this environment, trying to derive her motivation from the few people who do support her would not be enough if she didn't already believe in herself. Thus, Monique's self-motivation acts as resistant capital to challenge the notion that she does not belong at the university. Similarly, McKenzie described the importance of self-motivation for her success in physics.

> I wouldn't have gotten this far if I didn't motivate myself. There were several times when I felt like I wasn't capable enough or I wasn't smart enough to handle the course load that I had or that I didn't fit in within the environment within the physics field, but I just motivated myself and reminded myself that I could make a space for myself … that is what basically has kept me going.—McKenzie

Here, McKenzie talks about resisting the feeling that she does not belong in physics by focusing on her own motivation as opposed to looking to others to give her that feeling. By making a space for herself, McKenzie is using navigational capital to succeed in her physics major.

Other participants talked about their internal motivation in connection to wanting a role model and not having one. Michelle plans to become a chemistry professor and then a university president so that she can affect real change in higher education. She explained what it is like to strive for success as a Black woman in chemistry.

> I am a very driven person. I think it's more innate. I don't really have someone I look up to and say I want to be just like them. It's more like I want to do this. This is me so I know what I need to do to be that future me.—Michelle

Michelle explains that without existing role models she has to be her own role model, and that requires her own internal motivation.

"Just Getting It Done": Persistence in the Moment. Many participants described their ability to focus on the work they need to do as a strength that allows them to succeed. This ability was described by some participants as "just getting it done," which involves focusing on the task at hand without complaining or procrastinating. Students used this persistence in the moment as a form of navigational capital that allowed them to do what needed to be done in their science majors. For example, David explained,

> Just getting it done: that's with respect to when you have a lot of stuff to do, you can complain about it, you can definitely complain, but that's not gonna get you anywhere. You have to make sure that you get it done … by any means necessary.—David

David went on to talk about how he feels pulled in many directions, but that the only way to get things done is to manage his time carefully. Similarly, Jason talked about the importance of not procrastinating in order to get things done.

> I know a lot of people have a hard time just focusing when they need to get something done, but when I have something that needs to be done, I just get it done right away. And I have to thank my parents for that, especially my dad, because he'd

> always be on top of me about getting homework done, doing your reading. And I just got fed up with that and him asking me about that stuff, so I just did it myself. And then he'd ask me, and I'd say, "Oh, I did it," and it feels good to say, "I did it," before he even asked me to do it.—Jason

Jason went on to describe the importance of being able to focus on his path to becoming a physician. He also mentions how he learned this skill from his father, indicating his ability to focus is derived from familial capital. Other participants also connected their ability to focus with dedication to their career paths. Morgan talked about the temporary nature of the stress of getting things done compared with the long-term future gain. She said that you may feel unmotivated, tired, or disillusioned in the moment as a Black student, but you have to "just get it done so that you can have something to be proud of later."

"Failure Is Not an Option": Long-Term Persistence. Complementary to "just getting it done" in the moment was the idea participants expressed that "failure is not an option" when it came to their overall science majors at a PWI. This idea explains why participants relentlessly persisted in their science majors. They defined this idea as a headstrong refusal to fail in the pursuit of their overall career goals.

> At the end of the day I feel like I have something to prove just for myself and I don't want to appear as someone who just gives up. And I think that is what helped me develop the resiliency, I guess you could say, because … if I start something, I'm gonna finish it. I don't know how long it might take me to finish it, I don't know what different paths I might have to take to finish it, but I'm gonna finish it regardless.—Sarah

Instead of viewing the inability to achieve a goal in a set time or manner as an example of failure, participants like Sarah see this as an opportunity to find a way to achieve their goal (e.g., of being a nurse practitioner) through another means. She exemplifies navigational capital through her willingness to identify other paths, which may not be commonly used by white students, in order to succeed.

Jasmine talked about not succumbing to the trials of difficult courses, which have a reputation for causing students to leave science majors.

> If God has called me to be [a doctor], I will do everything in my power to make sure that I will be this. And you know, well maybe it's me being stubborn but I said I'm not going to fail, I'm not gonna allow [this university] to take my dreams away from me.—Jasmine

Jasmine explained that she would realize her dream of becoming a nephrologist no matter what academic challenges she encountered. Later on, Jasmine said, "I don't have another option … it's just success or success." She demonstrates not only her navigational capital, but also her aspirational capital through her ability to preserve the goal of becoming a doctor regardless of any challenges she encounters. Many participants in our study did not allow themselves to consider a career goal that did not involve science. As a result, they did not see changing to a non-science major as a viable solution for coping with academic challenges.

Some participants did consider leaving their science majors, but the notion of "failure is not an option" came into play. Megan explained why she did not leave her biology major.

> I've tried to give up so many times [to quit]. My body physically won't let me. I can't … because I know what I'm capable of. When you know what you're capable of and you know your potential, you kind of know your purpose. When those two things meet, I feel like it's just a beautiful thing … I'm trying to figure out what my purpose is and I don't want to give up until I do or until I achieve it.—Megan

When considering how this internal strength is different for Black science majors compared with other students, undergraduate co-researchers explained that for some Black students failure is not an option, because they may not have generational wealth to fall back on, which adds to the pressure they feel to succeed.

"I'm Not Afraid to Ask for Help". Students in our study described their willingness to ask for help as a strength that acted as navigational and resistant capital for succeeding within the racial climate of a PWI. Some participants explained that this skill is particularly important in the sciences, because concepts build on one another, "so if you don't understand the first concept, the second and third and fourth are going to be out the window for you." The idea of asking for help presented an initial challenge for many participants, but once mastered, this skill became a key for success. Sarah explained a critical barrier to her willingness to ask for help and how she overcame it.

> Part of why I wasn't as willing to ask for help [when I was younger] is because I didn't wanna look like I didn't know how to do what I was here to do and that it could be attributed to me being Black. But then I just got away from that because, like, "Okay, well, you might be saying you don't wanna get help because you don't wanna look like you can't do it because you're Black, but you still need the help. So where does that leave you?" And then you start to see that everybody needs help so it's not like people are looking at you like, "Oh, of course she needed help 'cause she's Black."—Sarah

Sarah revealed that her hesitancy toward asking for help was fueled by the idea that others would attribute her lack of knowledge to her race. Yet Sarah was able to push past that fear and see that people of all backgrounds need help. Thus, her ability to ask for help stems from both her resistant and navigational capital. Unfortunately, other participants in our study also faced this dilemma. Susan also talked about having to put aside her concerns of what other people think, including possible racial stereotypes, when asking for help.

> If I don't understand the material or something, I'll either ask my professor or my friend or somebody in the class, even if I don't know them well … sometimes I can kind of tell that they don't like me asking them questions but I honestly, I have to pass. So, I will still ask because I need to learn the material … I'm not afraid to ask for help.—Susan

Susan explained she is not deterred when she senses that her instructors and peers do not want her to ask questions. Another participant, Sarah, challenges any notion that might exist that suggests she should keep to herself and not disturb her professor or classmates. In a different way, Annie described the need to be humble when asking for help.

> You can't get anywhere if you don't ask for help. You can't let your pride get to you. I remember … some science class, I was doing terrible. My friend was making A's left and right. I was like, girl help me. I started making A's. So you can't let your pride get to you or be scared to say that you're failing or doing bad.—Annie

Annie learned to lean on her peers for support as a way to persist in her science major. In asking her friends for help she also used her social capital to succeed.

Major Theme 3: Black Science Majors Use Social Capital to Create Spaces Where They Can Share Navigational Capital in Order to Thrive at a PWI

In addition to using their internal strengths, participants explained how they create virtual and physical spaces where they are able to succeed in their science majors in the face of racial microaggressions and racism. One major reason these spaces support Black science majors' success is because they provide them with a place to share navigational capital with one another. Jasmine explained why it is so important for Black students to be able to do this.

> Black students are not able to utilize the … conventional system …that is primarily used by white students, so we have to form a system amongst ourselves where we feel comfortable. We're able to exist and we're able to excel in that space.—Jasmine

Here Jasmine explains how Black students can succeed in an institution that was not built for Black students by establishing their own structures for succeeding (Yosso, 2005). Morgan agreed, explaining it was initially challenging to succeed in a white space, but said that over time, "[I] ended up finding myself and my space."

Black Science Majors Create Virtual Spaces and Informal Communities for Support. Black science majors in our study use virtual spaces to connect with other Black science majors so they can give and receive peer and navigational capital. Peer capital is a form of social capital that can be defined as the ability to utilize connections to peers to gain access to college and navigate other social institutions (Yosso, 2005). Rachel talked about the GroupMe (a large group text) for the African Student Union (an official organization at the institution where data collection took place).

> I'm also in the African Student Union and so there is this GroupMe that we are all in. You can use that GroupMe for … so many different things. One of them was to … ask the upperclassmen for different resources like, "Hey, who knows so and so and can get me in contact with so and so? How can I get research? How can I get shadowing? What classes should I take? Who is the best professor?"—Rachel

Rachel went on to explain the wealth of information, or navigational capital, that she and others can gain from the upper-division students who are a part of the African Student Union GroupMe, which serves as a virtual space for their community. She explained, "The answers are already there for you, why not use them?"

In addition to virtual spaces created by official organizations, participants talked about informal communities of Black students. Some participants, like John, shared their thoughts on an informal community that has been important to their success.

> BUGA, which is like Black UGA, which is an informal community. It's not an actual group—no meetings or anything, it's just a sense of knowing you're a part of [BUGA] if you're a Black student at UGA, and what comes with that is just a family bond with the people here … they give you a lot of support, the people in it keep you going if you're struggling.—John

John pointed out that informal communities like BUGA are especially important when you are far from family members or unable to talk with family regularly. For some participants, BUGA moved beyond social capital to familial capital when participants extended the definition of family to include close friends from BUGA. Melvin explained why he feels that informal communities are more valuable than formal communities.

> BUGA isn't really an entity, but it's just what you call Black people at UGA … It's not that the formal [groups] are bad, but the informal ones are more genuine. You usually find them in a means of genuine struggle or genuine desire as opposed to, we all think the same, so let's make this club. Clubs are always hit or miss, but the informal [groups], if they're not worth having, they usually don't exist.—Melvin

Melvin went on to describe the value of friendships he made through BUGA and how those friends have helped him throughout college. Along these lines, Stacy explained how BUGA helped her feel like she belonged at a PWI.

> I just feel like it's helpful to have a space where you can come together and talk to people who look like you, and share beliefs with you, and that you can just have normal conversations … maybe they're not educational … but just having that community at a predominantly white institution, makes you feel like you're less alone and that other people are going through what you're going through, who experience similar things.—Stacy

While Stacy pointed out the nonacademic benefits of BUGA that act as social capital, Jasmine explained how BUGA members help one another succeed in science by exchanging navigational capital. She explained that, through BUGA, she shares course resources, recommends professors, provides mentorship, and forms study groups. She said that she connects with other science majors through BUGA and that "we always end up studying together, and flourishing together, and prospering together."

Black Science Majors Create Spaces Within Formal Communities in Their Scientific Discipline to Access Resources. Many of our participants expressed the importance of joining

academic spaces such as science organizations. Some participants, like Megan, found that these organizations allowed her to help other racially minoritized students succeed.

> Helping other minorities succeed [resonates with my success]. So I'm the vice president of the Minority Student Science Association (MSSA). This is literally our mandate. We want to see minorities progress in the sciences because there's not really a safe space for them at a PWI, so we try to make that environment for them to grow and feel like they have the tools and resources to be as efficient and as motivated as any other student on campus.—Megan

While MSSA is a student-led organization, participants also saw value in organizations led by faculty and staff, such as the Louis Stokes Alliance for Minority Participation (LSAMP). For example, participants mentioned the importance of the knowledge, wisdom, and resources that certain science organizations gave to Black students. Jasmine describes her experience with the LSAMP as such:

> They try to compile everything and show us that, "You are here at the (university), and we're gonna show you exactly what you get from being here. So, here's somebody, here's some professors, here's some resources, let's go on a trip. Let's go present some research. Let's make you get some money. Let's go ahead and get this fellowship down. Let's do all this stuff to create the best students possible, best graduates possible, the best professionals possible." So, LSAMP has been super dope.—Jasmine

Black Science Majors Create Spaces Outside Their Scientific Disciplines to Foster Community. In the same way that Black science majors are able to find community within their science organizations, they also strive for the same sense of community outside of science. Participants described joining non-science organizations that have members who look like them.

> So, the video is of me and a couple other people on the stage for African Night, which is a huge cultural show that's thrown by the African Student Union every year … I submitted this video to highlight African Student Union and what that has done for me. I think being a science major [at a] PWI as a minority student it's good to form that bond with people who resemble you or people who have similar background from you, and I found that through the African Student Union … a close group that I can help and rely upon when times are tough.—John

Here, the African Student Union serves as social capital, which provides John with connections to other students and emotional support during college. Similarly, many participants also described their willingness to join organizations for the opportunity to form ethnic and cultural connections to certain communities.

> Organizations that uplift Black culture, so Georgia Daze, MANRRS, and even Pamoja helped me find my community and helped me stay grounded because those are where you can have the discussions when political things happen. They're outlets where you can be with people who look like you. You don't have to censor who you are or what you're saying. I feel like the formal communities help me stay grounded in who I am, but also show the greatness that other Black people are doing, which encourages me to be better.—Stacy

Here Stacy mentions Georgia Daze, which is an overnight weekend program for Black high school seniors who have been accepted to the university; MANRRS, which is an agricultural club for agriculture students from diverse backgrounds; and Pamoja, which is a dance company. Each of these organizations creates spaces outside Stacy's science major, which helps support her success.

Black science majors are able to create spaces where they can thrive, because they feel a sense of responsibility to one another. David describes a "silent code" that Black students use to help their fellow Black peers as well as to gain wisdom that is crucial to their success in science.

> Since there are so little of us, we all know each other and we have this … I wanna say **it's like a silent code**. We all understand, if you need help, come. Somebody will help you. Somebody's always willing to help you. I know, personally, I have people coming up to me asking questions about stuff. I honestly never talked to them for real before, but it's like, "Yeah, I got you. If I can help you … If I can find those notes for you for that physics class that I took I got a high A in … If I got an A, I want you to get an A, so I'll give you all the notes I got. Or all the lab stuff I have so you can succeed." It's a give and take sort of situation. Yeah, we don't have a lot of us, but people that are here are really willing to help. It's kind of hard to describe.—David

The silent code David spoke of reflects the social and navigational capital Black students share with one another.

DISCUSSION

In this study we asked: 1) What is the racial climate experienced by Black science majors at a research-intensive PWI? 2) What forms of community cultural wealth do Black undergraduate students use to succeed in their science majors despite the racial climate at a research-intensive PWI? We used qualitative methods to identify the capital that 34 Black science majors used to succeed at a PWI. In this *Discussion*, we connect our findings to forms of capital from the community cultural wealth framework. Then we share insights for researchers on using a PAR approach. We end with implications for instructors, including specific suggestions from participants and co-researchers.

Connections to Community Cultural Wealth

The strengths and assets we describe in this paper represent several forms of capital from the community cultural wealth framework. In this section, we contextualize our results with findings from other studies of community cultural wealth involving STEM undergraduate majors. Although the use of navigational capital to succeed was evident in each theme (Table 3), we focus this section on linguistic, resistant, and social capital because of the novelty of our findings in these areas. For additional connections, we also point readers to a review of published and unpublished (i.e., dissertations) community cultural wealth studies in STEM (Denton *et al.*, 2020).

Linguistic Capital: Code-switching to Survive—Code-switching to Thrive

Our data reveal ways that code-switching can serve as linguistic capital for Black science majors who must navigate environments that may be unwelcoming to Black people. Code-switching occurs when individuals change their way of speaking while in conversation with others (Woolard, 2004). Most research on linguistic capital in STEM centers on the abilities students acquire from being bilingual (Denton *et al.*, 2020). For example, students who speak Spanish and English can use their linguistic capital to learn the vast language of science (Aguilar-Valdez *et al.*, 2013) and remember scientific terminology (Peralta *et al.*, 2013). Similar to participants in our study, Deaf students use their bilingual ability to access academic resources and to connect with others (Braun *et al.*, 2017). Few published studies have considered code-switching as a type of linguistic capital. In a study of the community cultural wealth of engineering majors, Black, African-American, Hispanic, and Latino students reported that they had the ability to switch communication styles or languages (Dika *et al.*, 2018). Yet their responses did not provide insights on the nature or context of their code-switching.

Black science majors in our study view code-switching as a multifaceted skill for navigating academic and professional settings that were sometimes racially hostile to Black people. They expressed an array of views, ranging from seeing code-switching as a form of assimilation that is required for survival, to seeing code-switching as a form of professionalism that is used to thrive in predominantly white spaces. A few participants have strong feelings about their code-switching abilities, while others feel conflicted or ambivalent. Some Black science majors talked about the benefits of being able to use different communication styles to access opportunities, while other participants expressed frustration about code-switching, because they feel they cannot be accepted for their authentic selves. Our data do not indicate whether participants who use code-switching connect this practice to anti-black racism. However, most Black science majors in our study feel that code-switching is not a choice; they see it as something they must do to be successful.

Everyone, regardless of race, can codeswitch to adjust to the situations they find themselves in. Yet the reasons why and the extent to which Black science majors in our study codeswitch are different. For example, if a Black student chose to use African American Vernacular English, or AAVE, during a research presentation, that student's knowledge and expertise might not be seen as legitimate (Debose, 1992). White students are not scrutinized with the same assumptions in academic and professional settings. Several participants in our study were hypervigilant about how they were perceived by white people because of potential assumptions about Black people's intelligence and abilities. When Black students use code-switching as linguistic capital, they may do so to assimilate, to be seen as educated, and to be taken seriously in the face of anti-black racism.

Resistant Capital: Challenging Anti-Black Racism

Black science majors in our study reported using previously described and undescribed types of resistant capital. Three forms of resistance were found in our data: conformist resistance, transformative resistance, and resilient resistance (Solorzano *et al.*, 2000; Solorzano and Bernal, 2001). *Conformist resistance* occurs when students are motivated to seek social justice, but they are willing to work within existing systems rather than challenge those systems to change. Students who use conformist resistance may accept the "myth of the meritocracy" (Liu, 2011; Samuelson and Litzler, 2016). *Transformative resistance* is characterized by a willingness to critique existing systems with the motivation to change them. *Resilient resistance* occurs at the interface of conformist resistance and transformative resistance (Solorzano and Bernal, 2001). When students use resilient resistance, they navigate through systems so they can persist to help not just themselves, but other students like them.

Only a few published studies connect resistant capital to undergraduate success in STEM. In one study, Latinx engineering majors used resistant capital by serving as role models for younger students, doing outreach in their communities, and becoming active members of the Society of Hispanic Professional Engineers (Revelo and Baber, 2018). In a study of Black and Latinx engineering majors, students talked about a desire to disprove stereotypes in their field (Samuelson and Litzler, 2016). Similarly, we learned how participants dealt with racism by working to disprove stereotypes about Black students in science. This is a form of resilient resistance, because it challenges the status quo. For example, some participants were motivated to persist in their science majors because others suggested they would eventually switch majors. Taking this a step further, Jasmine viewed her persistence in science as a way to gain power through her education. She wanted to use that power to change the field of science, and having this goal is a form of transformative resistance.

We also uncovered less well-described examples of resistant capital by examining the skills our participants talked about gaining from their encounters with racial microaggressions and racism. Black science majors in our study talked about choosing to educate other students who make racist remarks. By being open to conversations about racism, these participants are able to address comments with the goal of helping the other person see why they were wrong. Another skill some participants gained was the ability to assert themselves. In some cases, participants talked about not letting others "push them around" and not changing to please others. Other participants talked about their ability to adopt a mindset that allows them to focus on what matters despite frequent experiences with racism. While Black students can use resistant capital to persist in the face of anti-Black racism, doing so costs them time, energy, and attention that their white counterparts do not have to spend.

Social Capital: Formal and Informal Counterspaces

Black science majors in our study talked about how they created virtual and physical spaces where they can thrive at their PWI. Participants explained how these spaces were formed through informal and formal communities that include other Black students. These communities gave them a safe space to share resources and support, which was important for their success in the racial climate of a PWI. Our data fit with the idea of counterspaces, which are a source of social capital. Solórzano and colleagues defined counterspaces as "sites where deficit notions of people of color can be challenged and where a positive collegiate racial climate can be established and maintained" (Solorzano *et al.*, 2000, p. 70).

Counterspaces have been also described in other studies of Black undergraduate students. For example, a place in the student center of a PWI called "The Hub" served an counterspace where Black students gathered to be affirmed for who they are (Black and Bimper, 2020). Similarly, regular meetings of the African American Student Network (AFAM) acted as a form of therapy for Black students who were able to cope with racial microaggressions and racism at a PWI (Grier-Reed, 2013). Researchers characterized AFAM as providing Black students with safety, connectedness, validation, empowerment, intellectual stimulation, and a "home base" (Grier-Reed *et al.*, 2018). Similarly, many participants in our study also talked about the ways in which formal and informal communities gave them a place to share support and grow as people. Some undergraduate research environments have also been shown to serve as counterspaces where Black students can be recognized for their scientific abilities (Lane, 2016).

Participants in our study gained a sense of belonging at a PWI through their participation in both informal and formal communities, which served as counterspaces. These communities were important in making Black undergraduates feel supported as they pursued science majors. Participants gained access to important academic resources through their communities, which is indicative of both social and navigational capital. Interestingly, virtual communities also played a valuable role in participants' success. For example, Black students shared the ways BUGA had a strong virtual presence, which was instrumental in providing students a supportive lifeline that they felt they could access at any time. Participants engaged with other virtual communities in addition to BUGA. For example, some participants were a part of a large group text for Black students in one of the life science majors on campus. These virtual communities helped participants feel like they were not alone despite being racially minoritized students on campus.

When examining the navigational, linguistic, resistant, and social capital used by Black science majors, it is evident that their strengths and abilities and the reasons they use them are not surface, but rather embedded in their identity as Black science majors. They use their community cultural wealth to succeed in predominantly white academic spaces.

Implications for Research: Using a PAR Approach

While there are multiple ways to collaborate with Black science majors, we chose to use a PAR approach in recognition of our co-researchers' critical expertise from their lived experience of being a Black science major. While many PAR studies have been done in collaboration with K–12 students, fewer studies have used this approach with undergraduate students (Elwood, 2009; Trott *et al.*, 2018, 2020).

PAR differs from traditional research experiences in several important ways. First, PAR is led or co-led by people *inside* the community being studied, rather than by people *outside* the community (McIntyre, 2008). On our research team, Black co-researchers who are science majors take the lead on all aspects of the work, including project design, data collection and analysis, and dissemination of results. They use their insider knowledge to inform and shape the project at each stage. Second, power dynamics must be constantly reconsidered in PAR (Kidd and Kral, 2005), whereas traditional research often involves a hierarchy of power dictated by disciplinary culture. For our project, we found it essential to hire an external evaluator with expertise in equitable evaluation and research inclusivity. Our evaluator observes several team meetings each year, interviews co-researchers without faculty present, and provides feedback to the team on how we can improve our approach to shared leadership.

Third, PAR focuses on awareness and disruption of inequities and injustices (Fine, 2009), while traditional research may not explore these issues. While our team shares insights about Black science majors' success, we cannot do so without acknowledging the racial climate that Black students are succeeding in. We explore the systemic challenges Black science majors face while investigating their strengths and assets. Finally, a PAR approach requires a team to use their research results to take action for social change (Kidd and Kral, 2005), whereas traditional research generally does not. For example, co-researchers on our team developed and led an implicit bias workshop for science faculty. Co-researchers use their findings on Black science majors' community cultural wealth to help shift unconscious beliefs instructors hold about Black students.

While there are significant benefits to taking a PAR approach to research, there are also significant challenges. Sharing leadership with undergraduates can be challenging for faculty who earned their degrees in science, where lab hierarchies may be culturally accepted. PAR also requires continuous consideration of how the research will affect social change. Without action to address inequities and injustices, the PAR process is not complete. We encourage interested researchers to read more about PAR before they consider using this approach (e.g., Cammarota and Fine, 2008). *PAR is a powerful way to do research, but it requires considerable commitment from the entire research team and is not an approach to be entered into lightly.*

Implications for Instructors

Recognizing Community Cultural Wealth in Students. Instructors should make deliberate and consistent effort to recognize the community cultural wealth that Black science majors bring to their classrooms. For example, science instructors can reflect on the forms of capital described in this paper and make a point to notice when Black students display these strengths and abilities. By raising their own awareness, instructors can start to shift their own implicit biases. This recognition will take intention, because the forms of capital Black science majors possess often go unrecognized by the predominant culture. The goal of recognizing Black students' community cultural wealth is not for instructors to point it out, nor is the goal to co-opt Black students' capital for their own interests (Yosso, 2005). Instead, the purpose is to allow this awareness to affect instructors' unconscious thoughts and, in turn, their actions.

Beyond Recognition: Doing Your Own Work First. After recognizing Black students' community cultural wealth, our research team has considered what instructors can do to support Black students' success. Yet the co-researchers on our team know firsthand that there is no "one-size-fits-all" approach for supporting Black science majors. Not all Black students are the same; what supports one Black student may not support all Black students. It may be tempting to ask Black students what instructors

should do to support Black science majors, but we feel it is important for faculty to do their own work first. We point to Dewsbury's deep teaching model (Dewsbury, 2020) and Dewsbury and Brame's evidence-based teaching guide on inclusive teaching as two ways to begin (Dewsbury and Brame, 2019).

Instructors should work to educate themselves on experiences of Black science majors, beginning with an understanding of the racial climate at their own institutions. They also need to work to increase their awareness of Black student achievement. Instructors can participate in professional development opportunities that will allow them to develop cultural competence. After taking the time to think deeply about the experiences of Black science majors, instructors can start to generate their own ideas for supporting Black students and share these ideas with trusted colleagues to get feedback. After doing this work, instructors may want to ask Black science majors for their advice on the ideas the instructors generated. Even after putting in thought and effort, instructors must realize that they are likely to make mistakes. Yet if instructors are thoughtful and authentic, they can also learn and recover from those mistakes.

Possible First Steps for Supporting Black Science Majors. Our data reveal the connected spaces that Black science majors create in order to thrive at a PWI. Given this result, co-researchers recommend that instructors first plug into existing formal communities that serve as rich networks for Black students. At the institution where data collection took place, an organization for science students from racially minoritized populations offers professional mixers for its members and science faculty. Instructors can take a first step toward supporting Black science majors by volunteering to participate in existing events like this. Through their participation, instructors can continue to learn about Black science majors' experiences. Then they can develop their own initiatives, such as creating additional supports for Black science majors. Examples include alumni seminars featuring Black graduates, events to connect professors offering undergraduate research opportunities with Black students, or a departmental Black student advocacy group that serves as a voice for students' concerns.

Co-researchers on our team also offers some specific examples for supporting Black science majors in the classroom. For example, some co-researchers recommend that instructors assign student groups in the classroom so that Black students are not left out or "picked last." Some co-researchers appreciated when their instructor deliberately highlighted the achievements of Black scientists. Doing this regularly can enhance classroom environments for students of color. For example, the Scientist Spotlights Initiative offers information on the stories of counter-stereotypical scientists that instructors can ask students to explore through homework assignments (Schinske *et al.*, 2016). Instructors can also explicitly discuss the value of an inclusive classroom and invite students to talk about any microaggression or racism they encounter in the classroom.

Co-researchers on our team want instructors to understand that social change does not involve a checklist, but rather an ongoing practice of awareness and action. In this sense, there must be a continual learning process. The most important aspect of any supportive attempt is that instructors are genuine in their efforts. Instructors will also be aided by a top-down commitment to supporting Black science majors. We encourage administrators to address social justice and empower faculty and departments to take the time needed to help provide a more welcoming racial climate for Black students. There should be a shared responsibility to support Black science majors from the classroom level to the institutional level.

Multiplier Effect. It may be overwhelming to think about how to do the important work of supporting Black science majors, but we urge readers to commit to making a continual and sustained effort. As participants explained, when you help one Black science major, your effort is multiplied by their community cultural wealth. Participants shared their capital with other Black science majors, because they were deeply committed to seeing other Black students succeed. Recall when David said,

> We all know each other and we have this … I wanna say **it's like a silent code**. We all understand, **if you need help, come**. Somebody will help you. Somebody's always willing to help you … I have people coming up to me asking questions about stuff. I honestly never talked to them for real before, but it's like, **"Yeah, I got you."**—David

Like David, other participants talked about having solidarity with other Black students based on race, even when they did not know other students personally. They talked about "having each other's back" and taking care of one another, because they had a desire to uphold the tradition of Black success at their institution. As explored in our other work on aspirational capital (D. Means, J. Stanton, B. Mekonnen, O. Oni, R. Breeden, O. Babatola, C. Osondu, M. Beckham, and B. Marshall, unpublished data), participants also talked about the importance of helping future generations of Black students become scientists. This includes working hard to inspire younger family members and serving as mentors to lower-division students . Finally, some participants are connected to multiple identifies through which they share their community cultural wealth. *Instructors should know that when they make a meaningful effort to help one Black science major, the student's internal strengths, created spaces, and deep connections can lead to "ripples" far beyond that one student.*

Limitations and Future Directions

We obtained rich qualitative data that allowed us to characterize the forms of capital that Black undergraduates use in their science majors. Yet there are some notable limitations to our study. First, we collected data at one research-intensive PWI, and these data may not represent the experiences of other Black science students, especially at different types of institutions. Our research team is currently analyzing data we collected at public 2-year and 4-year colleges to gain additional insights. Second, all of our data are self-reported, which can be subject to recall bias if participants have difficulty remembering their prior thoughts and actions. To address this, we compared the ideas each participant expressed in the Fall and Spring interviews, which were separated in time by 3 to 5 months. Through this process, we found that the ideas we report were stable across that time span. Third, we did not analyze the ways our participants' social identities combine, leading to additional

forms of discrimination that challenge their success in science majors. We are currently studying the experiences of Black women in science majors using the intersectionality framework (Crenshaw, 1989). Finally, our data suggest possible differences in the experiences of Black science majors who are immigrants or children of immigrants compared with those who were born in the United States. We will compare these experiences in a separate study.

CONCLUSION

Through a PAR approach we gained access to stories of Black science majors' success, which are often overlooked in support of deficit-oriented narratives. For many of our participants, success has to "come from within," and Black undergraduates already possess many of the strengths they need to persist in science majors. Yet relying only on themselves can wear students down, especially in the racial climate of a PWI. As a result, success also involves participants' deep connections to communities that allow their strengths to grow and be celebrated. Thus, academically successful Black science majors create virtual and physical spaces where they can thrive despite the contexts they find themselves in. Ultimately, our participants' success is not just for themselves; it will be shared with all the people they are connected to. Instructors should be encouraged to support Black science majors, knowing that their efforts will be multiplied by the students' community cultural wealth.

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