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Abstract: This qualitative, participatory action research study used interviews and visual data to explore the aspirations of Black undergraduate students in their final year of science degree programs at a predominantly white institution, and the assets and resources that supported persistence in pursuing their aspirations. While students experienced academic stress, including feelings of having to positively represent all Black people, they described how several influences supported their persistence: (a) aspirations to give back to their families and Black communities, (b) faith, and (c) changes in academic approaches. Findings provide insights for higher education leaders to better promote equity in the sciences.

Keywords: Participatory Action Research, Black undergraduate students, science, aspirations, Community Cultural Wealth

Black excellence in science, technology, engineering, and mathematics (STEM) is rich with Black students who persisted in undergraduate degree programs amidst overwhelming challenges, including feelings of isolation, racial stereotypes, and racism (e.g., Dortch & Patel, 2017; Fernández et al., 2021; Fries-Britt, 2017; Fries-Britt et al., 2010; McGee & Martin, 2011; Russell & Atwater, 2005; Stanton et al., 2022; Stitt & Happel-Parkins, 2019; Strayhorn, 2015). These challenges have been particularly daunting at predominantly

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white institutions (PWIs), institutions that have had continuous challenges creating supportive environments for Black students due to racism, specifically anti-black racism—a form of oppression that systemically disadvantages and disregards Black people in everyday life and social institutions (Dancy et al., 2018; Dumas, 2016; Feagin, 1991; Newton, 2017). Researchers and educators often fail to recognize the assets and resources that support Black students' success, despite their record of achievement in STEM instead favoring deficit-oriented narratives that blame Black students and their families for educational inequities (S. R. Harper, 2010). STEM education researchers have challenged these deficit-oriented narratives by highlighting resources and commitments to equity that support the aspirations and persistence of Students of Color in STEM, while examining how racism hinders their educational trajectories (e.g., Dortch & Patel, 2017; Fernández et al., 2021; McGee & Bentley, 2017; McGee & Martin, 2011; Stitt & Happel-Parkins, 2019).

We build upon previous scholarship in this article, which is a part of a larger participatory action research (PAR) study—a study designed, implemented, and disseminated in collaboration between researchers and individuals who are potential benefactors of the research to study and address social issues (Cammarota & Fine, 2008; Fine et al., 2003). Our PAR study applies a critical, asset-based lens and employs a multi-layered methodological approach that integrates visual and interview data to highlight the specific ways in which Black undergraduate students in their final year of science degree programs (biology, chemistry, physics, and related majors) used their aspirations, assets, and resources to succeed in science at a PWI. Further, this study calls attention to how anti-black racism can hinder the success of Black undergraduate students in science. For this specific article, we employed qualitative, participatory, and visual methods to explore the aspirations of Black students pursuing bachelor's degrees in science and the assets and resources that supported their persistence in pursuing their aspirations. For the theoretical framework, we used Community Cultural Wealth, which consists of "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). Our research questions are: (a) What are the aspirations of Black students in their final year of science degree programs?, (b) How do Black students use their aspirations to persist in science degree programs?, and (c) What assets and resources support the persistence of Black students in science degree programs?

Our scholarship builds upon previous scholarship in two significant ways. First, although science, computer science, engineering, and math are generally intertwined under one acronym, STEM, researchers are learning that each discipline can have differences related to culture and climate, academics and course assignments, training and preparation, and attrition

rates (Chen, 2013; Macilwain, 2010; Pfeifer et al., 2020; Su & Rounds, 2015). These differences make disaggregation of data by discipline important to gain a more nuanced understanding of science degree persistence for Black students instead of assuming all STEM experiences are the same. Furthermore, McGee and colleagues (2021) challenged the assumption that all People of Color have monolithic experiences in STEM and argued for the need to specify challenges across racial groups. Therefore, this study focuses on Black students. We used Black to describe anyone who self-identified as being from the African Diaspora. Thus, our study draws upon the narratives of an ethnically diverse sample of Black students (African American, Nigerian, Gambian, Haitian, and Nicaraguan) from multiple disciplines within science (e.g., biology, chemistry) to understand how forms of Community Cultural Wealth and other assets and resources support their success in science despite anti-black racism. By explicitly focusing on Black students in science, our findings can offer important context to educators, researchers, and administrators about the experiences of Black college students pursuing science degrees and how anti-black racism materializes in science classrooms and other science educational settings.

Second, researchers have provided important context for understanding the aspirations and persistence of Black students pursuing science degrees and careers (e.g., Archer et al., 2015; McGee & Bentley, 2017; Ortiz et al., 2019). For example, Archer and colleagues (2015) used longitudinal qualitative interview data from 10–14-year-olds and their parents to study Black children's science aspirations; they found that students' aspirations "reveal the intersection of inequalities of 'race'/ethnicity, gender, and social class, which makes science less 'thinkable' for Black students and presents additional challenges for science-aspirant students to overcome to maintain their aspirations over time" (p. 231). Additionally, McGee and Bentley's (2017) phenomenological study on Black and Latinx STEM students' values found that students, including Black students, had a strong commitment to social justice. Our study builds upon previous scholarship to study Black students' aspirations for pursuing science degrees *and* how these aspirations, combined with other assets and resources, support persistence through science degree completion despite inequities. This scholarship can be used by educators and administrators to develop and sustain more equitable academic environments that support Black students' educational trajectories through science degree programs.

For this study, we used a layered methodological approach that integrates interview data; visual data; a card-elicitation activity, a research method from anthropology to stimulate deeper discussion about a social phenomenon (Trotter & Potter, 1993); and a participatory action research (PAR) design to focus on understanding how Black students who have reached the final year

of their science degree program used multiple forms of Community Cultural Wealth and other assets to navigate the racial climate in science academic settings at a predominantly white institution. The layered methodological approach amplified our understanding of the forms of Community Cultural Wealth and other assets and resources that supported students' persistence to their final year in their science degree programs. The PAR design allowed us to form a community of scholars comprised of Faculty of Color *and* Black students in science. This community of scholars centered the experiential knowledge of Black science majors in our methods and used findings to promote equity and justice for Black students in science degree programs.

Aspirations and Persistence of Black Students in Science at PWIs: Literature Review

Only about 35% of the Black undergraduate students in one national study who begin college at bachelor-awarding institutions as STEM majors earn a STEM degree (Chen, 2013). Researchers have pointed to how Black students in science at PWIs must navigate feelings of isolation, racial stereotypes, and racial microaggressions (Dortch & Patel, 2017; Fernández et al., 2021; Russell & Atwater, 2005), which are culprits for the underrepresentation of Black students in STEM degree programs. However, Black students use various assets and resources to help lessen the negative impact of racism, including anti-black racism, at PWIs and to support their science degree persistence, including reliance on their aspirations, their social networks, psychological factors, and spirituality and religion (Ceglie, 2013; Fries-Britt, 2017; Fries-Britt et al., 2010; Russell & Atwater, 2005; Strayhorn, 2015). The literature review explores the assets and resources that support Black students in science degree programs. We build upon previous research to extend understanding about how the combination of these assets and resources supports persistence for Black students in science degree programs despite anti-black racism by using a layered methodological approach.

Aspirations

Black students have high aspirations to pursue degrees and careers in science fields. Still, they may be less likely to express their science degree and career aspirations due to several challenges, including stereotypical images of scientists, narrow views associated with science careers, and the notion of science being too difficult (Archer et al., 2015; Jordan, 2006; National Academy of Sciences, 2011). However, Black students can maintain aspirations to pursue science degrees and careers by receiving support and encouragement from family, peers, and teachers; participating in pre-college academic preparation programs; and possessing intrinsic motivation (Archer et al., 2015; Fernández et al., 2021; Fries-Britt, 2017; Russell & Atwater, 2005;

Strayhorn, 2015). Researchers have discussed how Black students' aspirations for pursuing science degrees derive from their commitment to family, the future of Black students in science, and social change (Fernández et al., 2021; McGee & Bentley, 2017; Ortiz et al., 2019; Russell & Atwater, 2005). For example, in a study on Black and Latinx students in STEM, McGee and Bentley (2017) found that students had commitments to Communities of Color, younger Students of Color in STEM, and social justice; however, they found that these commitments often conflicted with the individualism and competition emphasized in STEM environments.

Social Networks

Black students at PWIs report receiving support and encouragement to persist in undergraduate science degree programs from their social networks, including family, faculty, and peers (Fernández et al., 2021; Fries-Britt et al., 2010; Hrabowski & Maton, 2009; Russell & Atwater, 2005; Stanton et al., 2022). For example, Russell and Atwater (2005) found that some Black students in science at PWIs relied on support and encouragement from family and peers, especially peers from their same major, to support their transition into and persistence through undergraduate science degree programs. Pre-professional organizations, science clubs, structured mentoring, supplemental instruction, and research programs also support student persistence in science degree programs (Chang et al., 2011; Hrabowski & Maton, 2009).

Psychological Factors

Psychological factors such as motivation, self-confidence, intellectual curiosity, resiliency, and willingness to seek support enhance persistence for Black students in science (Fries-Britt, 2017; Hrabowski & Maton, 2009; Ortiz et al., 2019; Russell & Atwater, 2005; Strayhorn, 2015). Hrabowski and Maton (2009) found Black men in science who were willing to take advice and discuss challenges were more successful in their science degree programs. When science degree programs became difficult, participants in Russell and Atwater's (2005) study persisted by believing in themselves. Researchers have found that Students of Color and women stayed motivated when professors made learning science accessible and aligned theoretical concepts with real-world scientific problems, making coursework relevant to everyday life (Espinosa, 2011; Mayberry, 1998). Mayberry (1998) posited that Students of Color and women who can see how science can impact the global communities are more likely to continue in science-related careers.

Spirituality and Religion

Researchers have discussed the role of spirituality and religion in the academic success of Black students pursuing STEM degrees (Burt et al., 2019; Ceglie, 2013; Jett, 2019). Ceglie's (2013) findings suggested that Black and

Latina women pursuing undergraduate degrees in science found support through the experience of prayer, both as a foundation and guidance during challenging times and as an essential link between religious and cultural beliefs. Additionally, Ceglie's findings showed that religion provided universal support, stress relief, and encouragement during tough times in and out of the classroom.

Theoretical Framework: Community Cultural Wealth

Researchers and educators often fail to recognize Black student achievement in STEM by ignoring the assets and social networks of Black students, uplifting deficit-oriented narratives about Black students and their communities, and not contextualizing how forms of oppression (e.g., anti-black racism) hinder persistence in STEM (S. R. Harper, 2010). Specifically, anti-blackness disregards the humanity of Black people, and in education, anti-blackness materializes as excluding, tokenizing, and exploiting Black students (Dancy et al., 2018; Dumas, 2016; Newton, 2017). To counter these challenges, we used Community Cultural Wealth as a theoretical framework (Yosso, 2005). Community Cultural Wealth honors the knowledge and social networks of Students of Color and their families as assets that often go unrecognized or are undervalued in educational spaces while critiquing inequities in education (Yosso, 2005).

Yosso positioned Critical Race Theory (CRT) as a central theory to Community Cultural Wealth that could critique and transform the inequitable "ways race and racism impact educational structures, practices, and discourses" (Yosso, 2005, p. 74). CRT as a framework values the experiential knowledge of People of Color, seeks to be both critical of structures and practices that reproduce and reinforce racism and transformative by developing more racially equitable and just structures and practices, and challenges ideology that centers whiteness (Ladson-Billings & Tate, 1995; Patton et al., 2015; Solórzano et al., 2000; Yosso, 2005). CRT focuses on the pervasiveness of racism, anti-black racism, and other intersecting forms of oppression (e.g., sexism), which is a reflection of intersectionality, a framework that grew out of a critique of "how the experiences of women of color are frequently the product of intersecting patterns of racism and sexism" (Crenshaw, 1991, p. 1243). Researchers have discussed how students with multiple marginalized social identities experience intersecting forms of oppression that shape their educational trajectories in STEM (Charleston et al., 2014; Stitt & Happel-Parkins, 2019).

Building upon CRT to critique deficit perspectives and center the experiential knowledge of Communities of Color, Yosso (2005) proposed Community Cultural Wealth as an "array of cultural knowledge, skills, abilities and con-

tacts possessed by socially marginalized groups that often go unrecognized and unacknowledged" (p. 69). Specifically, Community Cultural Wealth consists of six forms of capital: aspirational, navigational, social, linguistic, familial, and resistant (Yosso, 2005). Aspirational capital is the willingness for people to hold onto their hopes and dreams despite any setbacks or obstacles. Aspirational capital is a recurring theme, especially within Communities of Color, who are often faced with racism, lack of belonging, social isolation, academic difficulty, and collegiate dissatisfaction (Samuelson & Litzler, 2016; Strayhorn, 2012). Navigational capital is the ability to negotiate and navigate oppressive systems and spaces (Yosso, 2005); for example, a Black student who attends a PWI and uses resources to succeed at the institution despite experiencing racism. Social capital is about creating and maintaining a social network of support, including student organizations, friends, faculty, and staff. Linguistic capital is recognizing the value of "multiple language and communication skills," including being able to communicate in more than one language and being able to use arts and performance (e.g., storytelling, poetry) to communicate with people (Yosso, 2005, p. 78). Familial capital refers to the knowledge and culture that one gains through family, including immediate, extended, or chosen family, and one's commitment to family. Resistant capital includes the concept of resisting stereotypes and actively challenging inequities and injustices. All the forms of Community Cultural Wealth can intersect and overlap (Yosso & García, 2007).

Researchers employing Community Cultural Wealth have also found evidence of spiritual capital (e.g., Farmer-Hinton et al., 2013; Means et al., 2019). For example, Farmer-Hinton and colleagues (2013) applied Community Cultural Wealth to their own K-12 experience. They found an emergent capital that was "inherent in spiritually based social networks" and that "religious institutions were central to how norms and resources were shared, leading to leadership experiences and educational programs" (p. 32).

Researchers have used Community Cultural Wealth to examine the experiences of Students of Color, including Black students, in STEM degree programs (Burt & Johnson, 2018; Dika et al., 2017; Fernández et al., 2021; Ortiz et al., 2019; Samuelson & Litzler, 2016). For example, Samuelson and Litzler (2016) used Community Cultural Wealth as a theoretical framework to examine which forms of capital African American and Latino students relied on during their engineering degree programs, finding navigational and aspirational capital were the most prevalent forms of capital. Moreover, Ortiz and colleagues (2019) employed a secondary data analysis using Community Cultural Wealth to understand sources of support for Black STEM students who attend a PWI and a historically Black university.

While previous scholars have offered important context about how Students of Color use Community Cultural Wealth to support their persistence and well-being in STEM programs (Burt & Johnson, 2018; Dika et al.,

2017; Fernández et al., 2021; Ortiz et al., 2019; Samuelson & Litzler, 2016), we provide critical contextual information by focusing specifically on science and Black students due to how anti-black racism uniquely shapes and works to hinder Black students' persistence in science degree programs. For this article, we focus on several forms of Community Cultural Wealth, including aspirational, navigational, social, familial, and spiritual capital, while acknowledging how systemic barriers can hinder the success of Black undergraduate students pursuing degrees in science. Although the primary purpose of the article was not to examine how participants' experiences varied across social identities, we noted when there was a connection between our data and research questions that reflected the intersection of social identities and/or experiences with intersecting forms of oppression.

Methodology and Methods

Participatory action research (PAR) functions as "an epistemology that assumes knowledge is rooted in social relations and most powerful when produced collaboratively through action" (Fine et al., 2003, p. 173). PAR studies share several similar characteristics. First, PAR involves a partnership between researchers and individuals who are potential benefactors of the research to study and address social issues (Cammarota & Fine, 2008; Fine et al., 2003). Second, a community of scholars (e.g., researchers and individuals who are potential benefactors of the research) collaborate on research design, data collection, and analysis (McIntyre, 2008). Third, the community of scholars commits to critical reflection during the study and to address power dynamics (e.g., power dynamics between faculty co-researchers and members of the community who are co-researchers; Guishard, 2009). Fourth, the community of scholars works together to produce research-based products that address the social issues they have studied (McIntyre, 2008). PAR's overall objective is to promote social justice, including making recommendations to elected leaders or working to change policy (McIntyre, 2008).

While PAR studies share these characteristics, they can differ in the level of participation from potential benefactors (e.g., collaborators are sometimes engaged from the beginning with the development of research questions and other times they are only involved in data collection and analysis; Kidd & Kral, 2005). Some PAR studies involve participants as co-researchers (McIntyre, 2008), while other PAR studies invite individuals who would be potential benefactors of the research as co-researchers and the community of scholars recruits participants outside of the group to participate in the study (Ayala, 2009; Tuck, 2009).

Community of Scholars for the Present PAR Study

The community of scholars for this project included two faculty researchers: a Black faculty member in education and a Filipino-American faculty member in cellular biology. The faculty member in cellular biology initially invited two Black undergraduate students in science to serve as co-researchers. Over time, through recruitment efforts of the initial two student co-researchers, the community of scholars expanded to a total of five Black undergraduate student co-researchers pursuing science degree programs and one Black graduate student in public health who began as a co-researcher during their time as an undergraduate student pursuing a degree in science. The community of scholars also included a Black graduate student in education who served as the research assistant for the study. The student co-researchers engaged in every step of the research study: development of interview protocols, recruitment of 19 students to participate in the study, data collection, and data analysis. Reflecting the characteristic of PAR to develop evidence-based products, the research team has collaborated with the Center for Teaching and Learning and the Office for Diversity at the university to design and implement a workshop on racial bias in STEM and Community Cultural Wealth. Student co-researchers used the findings in this current article to develop an online workshop for faculty and staff to improve their teaching, advising, and mentoring of Black students.

Research Site and Participants

We collected data at a public, PWI, land-grant university with very high research activity. In the state in which the study took place, approximately 30% of the population is Black, and approximately one-third of high school graduates in the state are Black; however, the university's student population is only 8% Black. During the academic terms in which we collected data, there were approximately 4,300 science majors at the institution and Black students represented approximately 14% of science majors across all academic years.

Similar to S. R. Harper (2012), the faculty and student co-researchers used a nomination process to recruit students, identifying and contacting people and student organizations that would be in a position to nominate a Black student in the final year of their undergraduate science degree program to participate in the study. In determining our criteria sampling, we built upon the work of S. R. Harper (2012), who discussed the importance of learning from Black men who have been successful in higher education to provide "insights gathered from those who somehow manage to navigate their way to and through higher education, despite all that is stacked against them…" (p. 1). Thus, we used a modified version of S. R. Harper's (2012) sampling approach, asking that participants meet one or more of the following criteria of success: (a) a cumulative GPA of 3.0, (b) an A grade in a science course, (c) participation in undergraduate research, or (d) engagement in a science-

related student organization. We focused our recruitment efforts on biology, chemistry, physics, and related majors. We contacted nominated students to invite them to participate in the study.

Nineteen students chose to participate in the study (Table 1). Seventeen participants were pursuing degrees in biology and biology-related fields or chemistry, and two participants were pursuing degrees in science-adjacent fields (i.e., exercise sports science with an emphasis in pre-medical studies and nutritional sciences with an emphasis in pre-medical studies). We assigned pseudonyms to all participants to protect their confidentiality. Each student received a total of $50 for participation in the entire study.

Data Collection

Data collection included a demographic survey, two interviews, and photo-elicitation. Prior to all interviews, the research team, including student co-researchers, formulated preliminary interview protocols, and the student co-researchers conducted preliminary interviews with Black students who were majoring in science. The student co-researchers used the information gained from the preliminary interviews to modify the interview protocols.

The student co-researchers conducted semi-structured interviews with 19 Black science majors in Fall 2017. As a research team, we decided that student participants may feel more comfortable participating in an interview conducted by a student co-researcher versus the faculty co-researchers. We noticed how student co-researchers were able to build strong rapport with student participants, likely leading to in-depth, honest responses about their experiences as Black science majors. Before the interview, participants completed a demographic survey. Aligning with our research questions and theoretical framework, our final interview protocol had 24 structured questions grouped into six sections for each form of Community Cultural Wealth to better understand the aspirations of Black science students and how the forms of capital supported their persistence in science degree programs.

At the end of the first interview, the student co-researchers provided directions to participants to engage in photo-elicitation, a form of data collection where participants take photographs that reflect their experiences related to a phenomenon (D. Harper, 2002). The method can stimulate deeper discussion and allow participants to generate data that are meaningful to their lives (Clark-Ibáñez, 2004; D. Harper, 2002). In our study, participants were asked to take 5–10 photographs that reflected assets and resources that supported their persistence in science degree programs. The photographs were discussed during the second interview.

Fifteen of the 19 participants from Fall 2017 participated in a second interview in Spring 2018. For the photo-elicitation portion of the interview, participants were asked by student co-researchers to choose two or three photographs and discuss in detail the related assets and resources that sup-

Table 1.
Student Participants, Major, and Demographic Information

Pseudonym	*Major*	*Gender*	*Self-Reported Ethnicity*	*First-Generation College Student*
Amy	Applied Biotechnology	Woman	Nigerian	No
Angela	Genetics	Woman	African American	Don't Know
Annie	Biology	Woman	African American	No
David	Exercise & Sports Science (pre-medicine emphasis)	Man	Nigerian	No
Heather	Biochemistry & Molecular Biology	Woman	African American	Yes
Helen	Applied Biotechnology-Plant Science emphasis	Woman	Black	No
Jason	Biology & Spanish	Man	Afro-Caribbean (Haitian) & Hispanic (Nicaraguan)	No
Jennifer	Nutritional Sciences (pre-medicine emphasis)	Woman	African American	No
Jessica	Biology & Psychology	Woman	African American	No
Linda	Biological Science	Woman	African American	No
Mark	Microbiology	Man	African American	Yes
Megan	Neurobiology	Woman	Nigerian	No
Meredith	Biology/Psychology	Woman	African American	Yes
Michelle	Chemistry	Woman	African American	No
Pamela	Biochemistry & Molecular Biology	Woman	Gambian/American	No
Rachel	Biology	Woman	Nigerian	No
Ralph	Biochemistry & Molecular Biology	Man	Nigerian/African American	No
Robert	Biochemistry & Molecular Biology	Man	Black	No
Susan	Biology	Woman	African	Yes

ported their success in science. Participants also took part in a card-elicitation activity, a research method from anthropology (Trotter & Potter, 1993), to better understand the forms of Community Cultural Wealth that supports students' degree persistence in science. The activity included five sets of cards developed between faculty co-researchers and student co-researchers from themes obtained from the first round of interviews. Each set represented a form of capital found in Community Cultural Wealth: aspirational, navigational, resistant, linguistic, and familial/social/spiritual (due to some overlap between familial, social, and spiritual capital, we grouped these forms of capital). Participants were given one set at a time and instructed to sort cards into two piles: cards that resonated with their success in science and others that did not. With each card that did resonate, participants were asked to explain why through a story or example. Participants were then asked to review all their chosen cards, encouraged to write in new cards with concepts they felt were missing, and look at cards newly hand-written by other participants. Finally, participants were instructed to pick five overall cards and explain why those cards resonated with them and their success in science.

Data Analysis

Audio files of the interviews were transcribed verbatim, and transcripts were checked for accuracy by research team members prior to coding. Each participant's discussions of the photographs and card-elicitation activity were embedded in the interview transcripts; thus, similar to photo-elicitation analyses by other researchers, the photographs were not analyzed separately from the transcripts so the research team could understand the context and meaning of each photograph based on the description and context provided by participants (e.g., McGowan, 2016; Means & Jaeger, 2016). Our analysis process was enhanced by perspectives of student co-researchers, given their experiences as Black science majors. For example, student co-researchers were able to provide insights into resources discussed by participants that were unfamiliar to the faculty co-researchers.

We began coding with each individual researcher completing a round of content analysis (Neuendorf, 2017) on five student transcripts from Fall 2017 to identify meaningful ideas related to participants' use of Community Cultural Wealth and persistence in science degree programs. Each researcher read through each transcript multiple times, highlighted significant statements, made notes about each transcript, and then developed an individual codebook, including proposed codes, definitions, and examples. Researchers then met to share each individual codebook, discuss similarities and differences across codebooks, and develop an agreed-upon collective codebook that included codes, definitions, and examples.

To ensure access to each other's coding process, we used MAXQDA, a qualitative analysis software program, to code our data. We applied the col-

lective codebook to all 19 Fall 2017 interview transcripts; two researchers coded each transcript, and each researcher developed a list of new proposed codes and definitions based on meaningful content not captured by the codebook. The research team then met to discuss the application of the codebook and content and ideas that were missing from the codebook, and we adjusted the codebook to include additional codes. Using the revised codebook, two members from the research team analyzed each interview transcript, including the interviews from Fall 2017 and Spring 2018; we analyzed each student's transcripts together to gain a holistic understanding of their individual experiences separate from the aggregate (Josselson, 2011). As we analyzed each student's transcripts, we used an abridged version of Maietta and colleagues' (2018) data analysis approach by identifying up to 15 significant quotations that resonated the most with us in connection to our research purpose and questions.

We met as a research team in Spring 2019 to discuss codes and significant quotations and to employ a categorical analysis approach to determine findings across participants, paying particular attention to our theoretical framework, Community Cultural Wealth, and our research questions (Josselson, 2011). While our primary focus was not to analyze how participants' experiences varied by social identities, some of the reoccurring coded data and significant quotations reflected context about students' experiences based on their ethnicity, gender, religion, first-generation college student status, and/or sexuality or intersecting forms of oppression (e.g., racism and sexism). To facilitate the categorical analysis approach (Josselson, 2011), we each wrote three sentences to describe themes across the coded data for all student participants about what supported their persistence in science degree programs. We each shared our three sentences and began to make connections across our sentences; we ended with four emergent themes. We assigned emergent themes to each team member, and we worked to identify data we had coded that could support the emergent themes. The research team discussed the data that supported (or did not support) each emergent theme and finalized the themes. In this article, we present the findings related to the theme of aspirations of Black undergraduate students in science and how their aspirations and other assets and resources supported their persistence in science degree programs.

Trustworthiness

As a PAR study on Black students' persistence in science degree programs, the faculty researchers on the team recognize the expertise that student co-researchers bring to this research project as Black science majors. With this in mind, the faculty researchers consistently discussed power dynamics in the project by having frequent meetings with each other and finding ways for student co-researchers to lead aspects of the project (e.g., facilitating

research meetings, collecting data, leading the development of a workshop based on findings) and to offer perspectives that may differ from the faculty researchers during the data collection and analysis process (Ayala, 2009; Cammarota & Fine, 2008). For example, the faculty co-researchers had planned to recruit students only through nominations from faculty and staff; however, a student co-researcher suggested we also recruit students through nominations from student leaders because students' peers may be more familiar with their academic and out-of-class engagement at the institution, which led to an increase in participants. This project was enriched by researcher triangulation (multiple researchers working together on the project to collect and analyze data; Thurmond, 2001). We also used data triangulation (collecting multiple forms of data to inform study findings) to enhance the trustworthiness of our study (Thurmond, 2001). By employing multiple data collection methods (interviews, photographs, card-elicitation activity), the research team was able to gain a more robust understanding of the participants' experiences (Thurmond, 2001).

Study Parameters

We recognize several limitations of our study. First, we believe using a nomination process to recruit student participants yielded strong interest in our study. However, by using a nomination process, some Black science students in their final year may have been overlooked by nominators. Second, we experienced some attrition between the first and second interviews, with four students not returning for the second interview. We believe the attrition may be related to the time commitment to participate in the photo-elicitation project. Third, our study took place at one institution, and, given the nature of qualitative research, we cannot generalize the study findings to all Black students at the institution and other institutions. However, our intent is to provide an in-depth analysis so educators and researchers can apply insights gained from this study to other contexts to advance racial equity in the sciences (Merriam, 2002).

Findings

We aimed to answer three research questions in this study: (a) What are the aspirations of Black students in their final year of science degree programs? (b) How do Black students use their aspirations to persist in science degree programs? and (c) What assets and resources support the persistence of Black students in science degree programs? In our first theme, "'I'm Serving a Bigger Purpose': A Deeper Calling to Science," we answer the first research question by presenting findings on students' aspirations for pursuing science degrees, which often went beyond individualistic aspirations and included aspirations to give back to their families and to serve Black communities. In

our second theme, "'Don't Give Up': Persistence in the Pursuit of a Deeper Calling," we answer our second and third research questions by providing context for the challenges experienced by student participants and how they relied on their aspirations, faith, and shifts in academic approaches to persist in science degree programs.

"I'm Serving a Bigger Purpose": A Deeper Calling to Science

Black undergraduate students in this study have aspirational capital to pursue science majors because they were deeply called to pursue careers in science or medicine. Aspirations of student participants often went beyond individualistic ambitions to serve a "bigger purpose." Student participants felt deeply called because of the aspirations of creating or maintaining a family legacy and serving Black communities.

Being Called to Create or Maintain a Family Legacy

Thirteen of the 19 participants discussed how the pursuit of their science degrees and careers in science or medicine had meaning not only to them but also to their families. Participants aspired to be the first in their family to earn a degree, to pay back their family for the sacrifices they had made, and/or to help and inspire their siblings, which reflects familial capital.

Being the First. Black science majors in our study were motivated to be the first in their family to earn a degree. For example, Heather talked about how being a first-generation college student influenced her career goal of becoming a doctor. She mentioned how her mom wanted her to earn the highest degree possible so she could "put the bar a little higher." Heather noted that her family wanted her to succeed in science and she wanted to succeed for her family. Mark described how being the first to graduate from college was a constant motivator, saying, "It's not a pressure, but it just kind of gives me that 'must', you know, that 'have to pursue.'" When school is challenging, Mark reminds himself of his role: "There are times I'm like, well, you're carrying the torch of the family, you got to keep doing it." Unlike Heather and Mark, Megan is not a first-generation college student, but she talked about the value of being the first person in her family to earn a medical degree: "My parents have gone to college, but nothing more than a bachelor's...so being a first-generation doctor, I feel like also motivates me to succeed, to be the first in my family and make my parents proud." Participants' goal of being the first to earn a bachelor's, professional, or graduate degree contributed to their aspirational capital.

Paying Family Back. Participants also discussed a desire to pay their family back for their sacrifices, which made it possible for the participants to attend college. Linda described her family as her "backbone" as she pursued a degree in science and her "reason for doing everything." Participants with parents who earned advanced degrees did not aim to surpass their parents'

success; instead, they focused on maintaining the same level of academic achievement as their parents as a way of paying back their families.

Participants with immigrant parents specifically talked about their parents' sacrifices in coming to the United States. For example, Helen mentioned that her parents' immigration from Nigeria: "helps me to stay motivated because it just reminds me of what my parents fought for." Rachel's parents also immigrated from Nigeria. She too reflected on her parents' sacrifice and described how it influenced her success in science:

My parents came over to the States for us to get a better education…My dad wanted to be a doctor when he was my age, so seeing that he gave up so much for me to have a better life is one of my really big factors.

Participants acknowledged how their families made it possible for them to earn science degrees, and they expressed a commitment to paying their families back through their success in science.

Inspiring Siblings. While many participants talked about their parents, others focused on the way their siblings and younger family members contributed to their success in science majors. For example, Heather talked about wanting to "set a good example for my sister," explaining, "I know that she's looking to me as an example of what to do, what not to do." Other participants discussed the way in which their pursuit of science careers encouraged their siblings to do the same. Susan shared how her goal of becoming a doctor affected her two younger siblings, who initially talked about wanting careers outside of science: "Now my sister says she wants to be a neurosurgeon and my little brother wants to be a pediatrician 'cause I want to be a pediatrician and he said, 'Oh, we can work in a practice together.'" Susan's comment illustrates how pursuing a career in medicine allowed her siblings to imagine careers in medicine.

Participants also talked about helping their siblings in school. For example, Mark spoke about the importance of sharing his navigational capital with his younger sister:

> My little sister, she's looking up to me. Literally, every question she asks, my dad cannot answer. I literally helped myself navigate through the college system, so she asks me that. Well, if I'm not doing anything to better myself [then] there's no point and she cannot ask my dad, who's she going to ask? She's going to come ask me.

Mark noted that by succeeding in college he would be able to provide knowledge and skills to his sister for navigating higher education.

Black Science Majors Are Called to Serve their Communities

Seventeen of the 19 participants in our study have aspirational capital to pursue science careers because they want to serve their communities. Participants talked about the desire to give back to Black communities, to

fulfill the need for more Black scientists and doctors, and/or to contribute to the representation of Black people in science careers.

Giving Back to Black Communities. Six of the participants specifically talked about succeeding in science to serve Black communities. For example, Mark wants to become a doctor to help African American communities. He explained how his hometown "is densely-populated with African American population and the immediate access to health care was not there" when he was growing up. He plans to respond to this need by earning a bachelor's degree in microbiology and then pursuing a medical degree. Similarly, Pamela is pursuing a biochemistry major to serve her community in Gambia. Pamela talked about becoming a formulator to help develop natural haircare products for Gambians. Pamela summarized her deeper calling, explaining her commitment to the community: "Helping out, just giving back, and being a value to the community, not just being a success but being a value to the community."

Responding to a Need for More Black Doctors and Scientists. Fourteen participants felt called to pursue science majors because they recognized a need for more Black doctors and scientists. For example, Jason talked about the lack of Black doctors in certain specialty areas of medicine. He explained, "I know there's not a lot of minority physicians who are psychiatrists in the community. There's a huge problem with African Americans, Latinos, minority populations not getting enough of that attention." Others spoke of the importance of having a doctor who can understand what it is like to be a part of a particular community. Robert explained that his success in science would allow him to become a doctor that can give back to both Black communities and gay communities. In addition to a need for more Black doctors, others realized the benefit of having more Black scientists. For example, Helen initially considered a career in medicine but decided to pursue a degree in applied biotechnology. After noticing she was the only Black student in her major, she explained, "I realized my perspective is needed, so I have to get into there so it can open up the doors for others." Helen took a photograph of a suit blazer and portfolio during a conference to reflect the opportunities she is taking advantage of to pursue her aspirations (see Figure 1).

Black women specifically discussed the desire to be role models for other Black women and girls. Michelle chose to major in chemistry over engineering after realizing she knew several Black engineers and having the desire to inspire Black girls to pursue chemistry:

> There [are] not too many Black chemists. There's not at all. So, I wanted to be different; I wanted to show young Black girls you can be a chemist...I don't have any Black chemists that I look up to. I don't have any Black chemistry professors. Black chemistry mentors. I don't have that, so I was like, I want to be that.

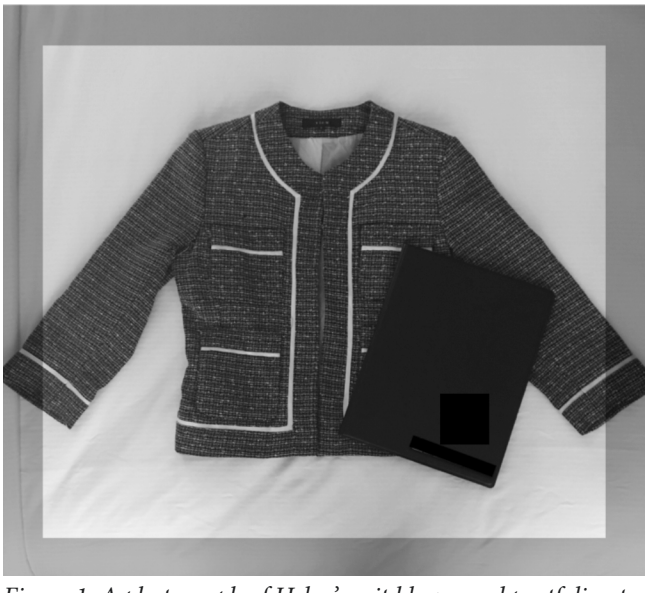

Figure 1. A photograph of Helen's suit blazer and portfolio at a conference.

Michelle noted it is important for her to succeed in science because "when we succeed, we create representation." She plans to become a chemistry professor and later move into administration to become a university president one day. In addition, Annie noted, "it's very empowering to see other Black people pursuing science careers and not just what we're known for" and going beyond "that spectrum that society has made for us." She mentioned how something as simple as seeing a bulletin board with a picture of a Black woman scientist inspired her: "I'm like, okay girl, I see you, I can do it too." Serving as a representative of Black women in science is a powerful motivator for Annie as she pursues a career in optometry.

"Don't Give Up": Persistence in the Pursuit of a Deeper Calling

During student participants' pursuit of careers in science or medicine, ten participants described experiencing enormous academic stress while in college. For example, Ralph described the academic stress of taking organic chemistry:

> It really started with the first time I took O chem actually because that was the first time I've ever just had a block like that ever in my life where I just could not do something that I needed to get done. If I needed to get something done, I will keep working and working at it and I've worked and worked at O chem and ... When I tell you it's made me give up, give up and lose hope on a lot of

> things, and yeah, I did go through periods of depression. I stopped going to classes. I just shut down, shut people out of my life.

Linda described academic stress: "You see people that are like, 'Oh, yeah. I have a 4.0 GPA,' and you're just like, 'Well, dang. I'm not there yet.'. . . You just don't feel like you're enough."

Eleven student participants described experiencing feelings of loneliness as one of the few Black students in their science courses or dealing with racial microaggressions rooted in anti-black racism in science academic settings, which may have amplified academic stress. Nine student participants described feelings of being one of few Black students in their science classes and the need to maintain a positive image for all Black people in their lives. Students described believing their successes and failures would reflect all Black people, including current Black students and future Black students at their university. Meredith described the tension of serving as a positive image for Black people and the stress associated with it:

> I would just say that we just have to work a little bit harder, because people see us a little bit differently. People just already assume oh, because they're Black, maybe they might be always underserved, that they don't always have what it takes. We have to work a little bit harder to kind of be seen in like a best, in like a better light. We can't slack, because then people are going to just attribute that to us being Black.

The tension to represent all Black people led several students to feel the constant need to prove people wrong about their academic abilities as Black students in science.

Five of the student participants specifically described experiencing racial microaggressions rooted in anti-black racism in science academic settings. These five student participants discussed non-Black classmates avoiding working with them or questioning their academic capabilities, their professors giving them lower grades for equivalent work as their peers, and their professors confusing them for another Black student. Two participants, Heather and Susan, described how microaggressions rooted in anti-black racism were present in the labs where they were working as undergraduate researchers. Heather experienced microaggressions from the lab manager about her outfits that reflected anti-black racism and sexism.

While students discussed stress as they pursued their deeper calling for a career in science or medicine and how it was made more complicated due to feelings of isolation and experiences of microaggressions, they also described several assets and resources that allowed them to persist in the face of challenges, including using their deeper calling to maintain their science identity, relying on their faith, and using navigational and social capital to shift academic approaches.

Maintaining a Science Identity by Remembering Aspirations

Sixteen of the 19 student participants described maintaining their science identity in the face of challenges by remembering their deeper calling to pursue careers in science or medicine. For example, Mark talked about how his older brother delayed going to college to help support their family. Mark explained the impact of his brother's sacrifice, saying: "If I'm not studying, I'm cheating pretty much because he's doing his part." Knowing his brother delayed his college plans helped Mark focus on studying for his science courses even when it was difficult. Michelle's desire to see more Black people in STEM was her motivation to "keep going." David took a photograph of his MCAT books (see Figure 2) to reflect his persistence:

> This is a picture of the MCAT books. I'm studying for med school 'cause that's the goal, to get to med school. Have to work hard, study hard, so I felt like that has a lot to do with my success…Knowing the road for studying is not over is sort of daunting, but that's what success is going to be built upon.

The aspirations of participants, whether they stemmed from commitment to their families, Black people, and communities, or their own goals, helped students persist in science degree programs.

Several students also stayed committed to their aspirations by persisting in the face of challenges. The students described not allowing a single course or exam to make them reconsider their commitment to science and their science identity. For example, Susan spoke about how her chemistry professor proclaimed: "50 percent of you will change your major after taking this [class]." Susan did not allow the professor to discourage her from pursuing science:

> "Oh, he is not about to kick me out of this class." I immediately knew ... And my grades in the beginning of the semester were not good, but I was like, "I'm not leaving." I already have my goals, my dreams, ambitions. I already know what I want to do…My dreams meant more to me than being scared off by a single progress check.

Pamela also discussed maintaining her science identity: "Knowing that I want to be a science student, I want to be doing something related to science in the future helped me know that I'm going to only be a science student. There's nothing else." Jennifer also described how she "wasn't going to let chemistry make me question my identity and make me question my dreams that I've had for so long." Student participants' commitment to their aspirations and careers helped them maintain their science identity even when experiencing academic challenges.

Keeping Faith

Twelve of the 19 student participants relied on their faith to maintain their persistence in science degree programs. While we did not operationally

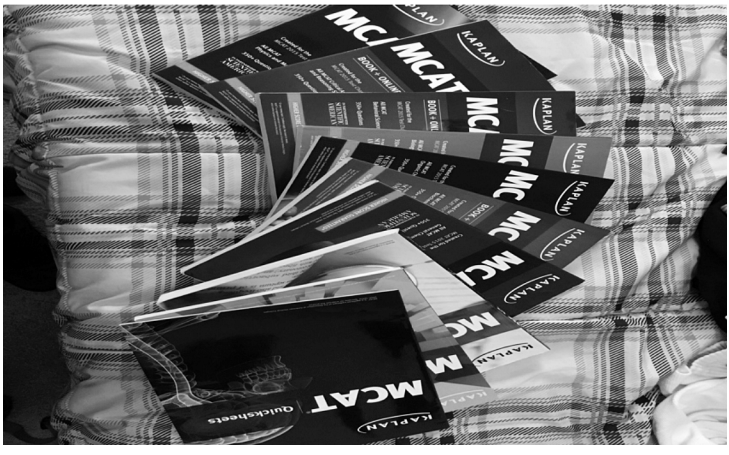

Figure 2. Photograph of David's MCAT books.

define "faith", our data show faith to be defined as a strong belief in God, in the doctrine of a religion or related to spirituality, as a means to be connected to a higher power. Participants said that faith gave them more confidence in themselves to succeed in science and a sense of direction, which is a reflection of spiritual capital. For instance, Ralph stated:

> It's God's work that I'm doing. I know there's things that I'm working on that's from God's plan, I know it. Because in the end, I'm helping people. I love helping people, and at the same time, God wants me to help people.

In Ralph's case, faith pushed him forward in life and gave him a sense of direction.

Another way participants used faith emerged in the sense of support from their spiritual beliefs. One participant, Mark, stated: "And in science, you will fail a lot and just being able to have a solid background, solid belief just keeps me strong and keeps me going." In this case, faith served as a support for Mark to stay focused on his aspirations. David and Linda used prayer to gain insight or strength on classes or professional goals; they used their faith to make sense of their academic pursuits and future aspirations.

Shifting Academic Approach

Fourteen student participants described shifting their academic approach to continue to pursue their deeper calling by asking for support and changing academic course when a previous approach no longer worked for them, which is a reflection of navigational and social capital.

Asking for Support. Student participants attributed part of their success to their willingness to ask for support from professors and peers. For

example, while Jessica did "perfectly fine" in the first level of organic chemistry, she found the second level of organic chemistry difficult. She realized that she needed more "real-life, application-based" connections with the course material, and she began going to her professor's office hours to get additional support. Megan also shared: "I couldn't find mentors for real, so I was willing to ask for help; I just didn't have the resources to ask for help. Another thing is teachers; I don't care, I'll ask questions in class all the time." Students' asking for support from their professors and peers helped them pursue their aspirations.

Changing Academic Course. Twelve of the 19 participants described adapting or changing course when their previous academic approach was no longer working for them. This change often occurred after having a setback in a class. For example, Ralph described how he learned to change his study strategies after not doing well on chemistry exams:

> My gen chem two, I think I failed the first two tests in there. But, you come back from it and you start doing more progress checks, stop going out all the time, cut down a couple things, study harder, and it always helped.

Several students used trial and error to determine the best approach for academic success in their courses. Some students relied on peer support to determine how to best approach studying when previous strategies no longer worked for them. For example, after failing a few chemistry exams, Amy received support from a peer about using different methods for studying, and the new approach helped Amy pass chemistry. The support from peers and professors helped students determine how to change course and adapt when experiencing academic challenges.

Discussion

Previous research has documented the challenges experienced by Black undergraduate students in science, including feelings of isolation, racial stereotypes, and subtle and overt racism (e.g., Dortch & Patel, 2017; Russell & Atwater, 2005; Strayhorn, 2015). Through interviews, we found that student participants experienced substantial academic stress as they navigated their science degrees; however, some of the academic stress was amplified by their racial identity, the manifestation of feelings of isolation as Black science students, and experiences with racism, specifically anti-black racism. Several students described how they felt like their successes and failures in science would reflect all Black students and people, which led to immense pressure to be academically successful for themselves and everyone who shares their racial identity.

While students experienced significant stress as they pursued their science degree programs, they also described the role of aspirations in supporting

their persistence. Previous research has documented how Black students developed aspirations to pursue science degrees and careers to honor the commitment and sacrifices of their families, to support their families, and to advance equity and social change (Fernández et al., 2021; McGee & Bentley, 2017; Ortiz et al., 2019; Russell & Atwater, 2005). Similar to these researchers, we found that students' aspirations went beyond individualistic ambitions to a deeper calling to pursue careers in medicine or science. For example, the interview and photo-elicitation data in our study reflected the varied aspirations of Black students to create or maintain a family legacy and to serve Black communities. Our research builds upon previous research by documenting Black students' aspirations beyond individualistic ambitions *and* by demonstrating how these aspirations were essential for Black students to maintain their science identity and to support their degree persistence despite academic challenges and anti-black racism.

Researchers have documented how social networks and psychological factors can support science degree persistence for students (Fernández et al., 2021; Fries-Britt, 2017; Fries-Britt et al., 2010; Russell & Atwater, 2005; Strayhorn, 2015). While our study revealed similar findings as previous research, photo-elicitation and the card-elicitation activity allowed us to better understand the forms of Community Cultural Wealth and other resources and assets that impacted students' persistence in science degree programs, reinforcing the connections between the interview and visual data. For example, similar to previous research (Burt et al., 2019; Ceglie, 2013; Farmer-Hinton et al., 2013; Jett, 2019; Means et al., 2019), we found that students relied on their faith or spiritual capital to maintain their aspirations. These compounding, intersecting forms of capital, specifically aspirational, navigational, social, familial, and spiritual capital, allowed students to build upon strengths to persist in science degree programs.

Aside from an assets-based approach, this study also extends our knowledge of Black students in science because it uses participatory action research (PAR) methodology. Typically used to amplify the voices of marginalized groups, PAR shifts power dynamics in research, transforming participants into co-researchers and providing a mechanism for them to speak back. For this study, Black undergraduate students in science served as co-researchers, defining their problems, identifying their desired remedies, and taking the lead in creating action (McIntyre, 2008). Said differently, PAR methodology is "research of the people, by the people, and for the people" (Park, 2001, p. 83). In this study, instead of serving as ingredients in our research recipe (Dillard, 2006), Black students were empowered to engage in this research process from beginning to end, contributing to the research design, data collection, and analysis processes. Co-researchers are responsible for disseminating their findings to college educators to improve the racial climate in science academic settings. This ongoing study is reciprocal work, trusting students

as co-researchers and providing them with a powerful mechanism to speak back. Thus, this study is healing, affirming, and inclusive social justice work.

Implications for Practice

We offer three major implications for practice. First, students in this study experienced an ample amount of academic stress as they navigated their science degrees, which was intensified by feelings of isolation as Black science students and experiences with anti-black racism. Higher education leaders and science faculty need to consider how to create more inclusive and equitable STEM environments. Higher education leaders, faculty, and staff should first remember the importance of acknowledging the different experiences across racial groups and within racial groups due to how different forms of racism (e.g., anti-black racism) and other intersecting forms of oppression (e.g., sexism, classism) materialize to shape students' STEM education. Higher education leaders and faculty can then use this acknowledgment to build professional development opportunities to help faculty learn how to better support Black students by recognizing forms of capital that Black students use to succeed in their science degree programs and by learning how to disrupt anti-black racism and intersecting forms of oppression in their teaching and practice. For example, our team collaborated with the Center for Teaching and Learning and the Office for Institutional Diversity to launch a faculty workshop based on our findings; we used real-life scenarios that happened at the institution to emphasize how anti-black racism is pervasive, including in STEM. At the end of the workshop, participants developed an action plan to advance racial equity for Black students.

Second, as higher education administrators and faculty consider ways to better support Black students in science, the burden should not be placed solely on Black students, student organizations designed to support racially minoritized students, or diversity-related departments on college and university campuses. Higher education administrators and faculty must integrate support for racially minoritized students throughout their institutions. For example, faculty and staff in science-related departments could develop strategies and programs that create a sense of community for racially minoritized students, including celebrations of Black student achievement. Science-related departments should also consider engaging students' familial and social networks. As an example, departments could open research symposiums, award programs, and graduation ceremonies to students' families, mentors, and friends.

Third, students in this study were deeply called to pursue careers in medicine or science. Aspirations included being able to give back to their families, using their careers to support Black people and communities, and fulfilling the need for more Black scientists and doctors. We encourage higher

education administrators and faculty to consider how they could better align science educational opportunities in higher education with the aspirations discussed in the study. For example, science departments in collaboration with development offices, career centers, study abroad offices, and service learning offices could identify funding and opportunities that could support Black students in gaining paid internship experience, scholarship-funded study abroad, and national volunteer opportunities that would allow students to make connections between science and medicine and racial equity and justice commitments.

Implications for Future Research

We offer two implications for future research. First, photo-elicitation ultimately enriched our data by presenting the opportunity to delve deeper into data collection by highlighting the cultural capital most exhibited by participants. However, we were still challenged by how to best represent the photographs in this article since most of the photographs included participants or other people; we were committed to not compromising confidentiality, yet we recognize that more photographs in the article could have provided greater insights. We also experienced some attrition in our study, and we believe it may have been related to the time commitment to participate in the photo-elicitation project. Future qualitative research should consider what forms of visual methods, if any, would provide insights into the experiences of racially minoritized students and be more convenient for student engagement.

Second, a PAR design allowed us to develop a community of scholars with students who have a personal connection to the study and to rely on their valuable knowledge to undertake a culturally relevant and meaningful study. At the same time, the design and implementation of a PAR study requires a constant commitment to rethinking power dynamics and considering how the study will have greater implications for the social issues at the center of the study. Future researchers should explore using PAR to explore how the intersection of multiple forms of oppression (e.g., racism, sexism, classism) shape science degree persistence for Black students.

While we are aware of the many reasons Black students do not persist in science, we challenge faculty, higher education administrators, science-related organizations, and industry to view Black students from an asset-based lens. Higher education institutions should also review how historical patterns of segregation, discrimination, and exclusion work to keep Black students in science perpetually marginalized. We, as co-researchers, hope that institutions explore large-scale structural changes that will work to promote racial justice and equity in science education.

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