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Racism, sexism and disconnection: contrasting experiences of Black women in STEM before and after transfer from community college

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Abstract

Background: Repeated calls to diversify the population of students earning undergraduate degrees in science, technology, engineering, and mathematics (STEM) fields have noted the greater diversity of community college students and their potential to thus have an impact on the racial/ethnic composition of 4-year degree earners. In this paper, we investigate barriers and supports to Black women's success in STEM, using longitudinal interview data with seven Black women who were enrolled at community colleges and stated an interest in majoring in STEM at 4-year institutions.

Results: Our findings highlight a contrast between community colleges and universities. At community colleges, Black women were able to form supportive relationships with professors and peers, downplayed the potential of racism and sexism to derail their STEM ambitions, and saw little to no impact of bias on their educational experiences. Those students who transferred characterized university climates very differently, as they struggled to form supportive relationships and experienced racism and sexism from professors and peers.

Conclusions: We conclude using Patricia Hill Collins' Domains of Power framework to categorize students' experiences, then end with recommendations for change that will result in less alienating experiences for Black women, among other minoritized students.

Keywords: Black, Minority, Women, STEM, Community college, Transfer, Racism, Sexism

Introduction

Current research on the status of STEM education in the United States indicates reason to be concerned with access, inclusivity and persistence, especially when it comes to the success of minoritized groups. For example, although Black women account for 11.4% of all college graduates, they make up only 2.5% of the STEM workforce and that number sharply declines when referring to the more mathematically based fields, such as physics, chemistry, engineering and math (National Science Foundation [NSF], 2019). The lack of equity necessitates that the experiences of Black women in STEM be examined to better understand and dismantle prohibitive structures and cultures to ensure that all STEM participants have equitable access to rewards, as well as to ensure that work in STEM is as robust and creative as possible.

Discussions regarding efforts to diversify the populations of students pursuing study in STEM fields repeatedly emphasize the possibility that students attending community college are a diverse group that represent an untapped resource (Bahr et al., 2017; Dowd, 2011; Wang, 2009). Research differs on whether attending a

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community college is associated with a greater or lesser probability of eventually earning a degree from a 4-year institution (Doyle, 2009; Perez-Felkner et al., 2019; Wang et al., 2019), or more specifically a STEM degree (Dinh & Zhang, 2021; Marco-Bujosa et al., 2021; Zhang, 2021). Even less clear is how Black women interested in STEM majors experience community college and potential transitions to 4-year universities. Studies that examine the experiences of Black women who have transferred from community colleges (e.g., Jackson, 2013; Reyes, 2011) typically do so only after the students have transferred to 4-year institutions, thus missing the important community college experiences that shape trajectories.

In this study, we look at two axes of identity—race and gender—and their intersections for Black women who started their pursuit of a STEM degree at a community college. Specifically, we report on a longitudinal panel of interviews with seven Black women, conducted 3 years apart, focused on understanding their STEM trajectories.

This study has several aspects that fill important gaps in understanding about the experiences of a minoritized group in STEM: Black women community college students. First, we use an intersectional approach, discussed below, to examine the STEM experiences of Black women and investigate how their positionality influences their experiences. Second, we use a longitudinal approach with interviews at two timepoints that allow investigation of the classroom and campus experiences across multiple institutions which remain largely understudied. This longitudinal perspective allows a valid examination of how STEM attitudes change from a time when students were enrolled at community college and uniformly positive about the possibility of majoring in STEM at a 4-year institution to a time 3 years later when the situation with respect to their attitudes and experiences in STEM was drastically different.

Conceptual frameworks: intersectionality and domains of power

We use an intersectional approach. Intersectionality refers to the idea that aspects of people's identity (e.g., race, gender, class, sexual orientation) interact to build identity and to condition people's lived experiences (Collins, 2015; Crenshaw, 1990). In this study we focus exclusively on the experiences of Black women. By centering Black women in our research, and thereby positioning them as knowledge producers, we illuminate the intersecting forms of oppression they experience and their unique experience as Black women, and thus seek to avoid the erasure of identity that would come with a broader examination of the experiences of women or people of color (Bowleg, 2008; Crenshaw, 1990; Haynes et al., 2020; Ireland et al., 2018).

Moreover, we draw on Collins' (2009, 2015, 2019) work on domains of power to describe the multiple ways in which Black women's identities evoke oppressive reactions from people who have traditionally held power in STEM (i.e., White men). Collins identifies four domains of power: interpersonal, structural, disciplinary, and cultural. The interpersonal domain refers to personal experiences as people relate to one another, i.e., the daily interactions between individuals. The structural domain refers to institutional and organizational arrangements, i.e., policies. The disciplinary domain refers to the rules and their enforcement that uphold social hierarchy. And finally, the cultural domain refers to institutions and practices that justify social inequalities. We use the domains of power framework to more fully illuminate the power structures at work in community college and university classrooms. As Collins describes, "The domains-of-power framework enables a more finely-tuned analysis of how unjust power relations are organized and resisted" (Collins, 2019, p. 170).

Using Collins' domains of power framework as a base, our research question focuses on how and when social processes reinforce or challenge existing intersectional inequalities during the community college-to-university STEM trajectory for Black women.

Background research

Research on Black women in STEM

Despite significant systemic structural barriers, many Black women persist and thrive in STEM. In fact, they tend to have higher levels of interest in science than White women (Hanson, 2008; Verdín, 2021). A number of studies have identified experiences that increase persistence and success for women of color in STEM (Carlone & Johnson, 2007; Espinosa, 2011; Ireland et al., 2018; Jackson et al., 2013; Ko et al., 2014; Ong et al., 2018). For example, Ko et al. (2014) identified eight strategies Black women and women of color generally employ for success in STEM, including avoiding unhelpful advisors and using peer networks to counteract isolation. Developing a solid identity as a scientist has also been effective for women of color (Carlone & Johnson, 2007), with findings echoed in Ireland et al.'s (2018) synthesis of sixty studies on Black women and girls in STEM. Navigating these strategies takes time and energy, which increases the demands on women of color to succeed.

There is a substantial body of research detailing the influence of both gender and race, and their intersections, on the experiences of STEM students (Hill et al., 2010; Madsen et al., 2013; National Academy of Sciences [NAS], 2011; Nguyen & Riegle-Crumb, 2021; Ong et al., 2011; Rainey et al., 2018, 2019; Rugheimer, 2019; Tate & Linn, 2005). The underlying historical and social contexts

that have given rise to inequity have also been detailed in the literature (Annamma et al., 2019; Gholson, 2016). In math, Gholson (2016) lays out many reasons for the absence of research on Black women—their invisibility—and the need for research that focuses on Black girls and women. These bodies of work suggest the environment and structures in STEM lead to a "chilly climate" (Flam, 1991; Hall & Sandler, 1982; Seymour & Hewitt, 1996; Seymour & Hunter, 2019) for women and students of color, resulting in diminished achievement, low satisfaction, and high attrition rates. Women of color experience multiple forms of oppression in STEM environments, exacerbating the chilly climate beyond that experienced by White women or men of color, in a phenomenon scholars refer to as a "double-bind" (McGee, 2020; Ong et al., 2011).

The climate in STEM frequently alienates Black women in multiple ways. They report feelings of isolation, invisibility and a lack of belonging (Hanson, 2008; Johnson, 2011; Ko et al., 2014) that are amplified by their low representation within many STEM fields. Black women are frequently the only women of color in these environments, simultaneously heightening their visibility and positioning them as outsiders. In addition, Black women are alienated in STEM through the sexist and racist words and actions of peers and professors, including microaggressions (Lee et al., 2020; Park et al., 2020; Robinson et al., 2016; Sue et al., 2007; Wilkins-Yel et al., 2019), harassment, and discrimination (Ong et al., 2011).

Four common categories of microaggressions women of color in STEM experience include: questioning of their skills and expertise in STEM-related topics; messages that communicate, either explicitly or implicitly, that they do not belong in STEM; having their presence and voice overlooked; and encounters that are specifically influenced by gender and race (Wilkins-Yel et al., 2019). The impact of these microaggressions is to decrease sense of belonging for women of color (Ong et al., 2011) as well as negatively impact their mental health (Nadal et al., 2014). Thomas et al. (2018b) interviewed a number of successful Black women in the computer science field who confirmed the intersectional discrimination that exists for Black women. The main barriers facing STEM, in addressing high attrition rates and low satisfaction of Black women, and women and people of color generally, are cultural and systemic. Thus, addressing the problem of underrepresentation will require cultural and systemic solutions.

Community colleges as pathways to STEM

In 2018–19, nearly, 35% of all college students in the United States were enrolled in a 2-year postsecondary institution (National Center for Educational Statistics [NCES], n.d.). In addition, community colleges enroll disproportionately higher numbers of students from racial/ethnic groups historically excluded from STEM than 4-year institutions (NCES, n.d.). When combined with a growing body of research that points to the positive environment that community colleges are able to offer, the community college pathway represents a potential systemic solution to diversifying STEM. However, there is not enough intersectional research available to determine whether Black women reap the full benefits of that positive environment.

The culture of the community college environment has demonstrated the necessary support for Black women and the success of women in general. For example, strong support systems, including interactions with faculty and advisors, are important in the academic success of Black women students in STEM and also play an important role in shaping the intent to transfer and persist (Jackson et al., 2013; Jorstad et al., 2017). Such supportive environments in community colleges do lead to student success while also increasing confidence in STEM (Starobin & Laanan, 2008; Starobin et al., 2016). While, in general, research points to the positive environments that can be provided by community colleges, it is important to note that environments likely vary by institution.

Research on the success of women, in general, has found that community colleges provide an intellectually rigorous and comfortable learning environment (Hu & Ortagus, 2019; Jackson & Laanan, 2011; Jackson et al., 2013; Jackson et al., 2013; Perez-Felkner et al., 2019; St. Rose & Hill, 2013; Starobin et al., 2016), where women are more likely to take advantage of student services than men (Miller et al., 2006) and receive more benefit from the learning and advising experience (Packard et al., 2011; Starobin & Laanan, 2008). Women also perform better than men in entry level math courses at community colleges (Wolfle & Williams, 2014). Strayhorn and Johnson (2014) found that satisfaction among Black women with their community college experience is dependent upon background traits, age, faculty engagement, family responsibility, and grades. Age was reported as a particularly important factor, with older Black women reporting higher levels of satisfaction.

Research on the success of Black students in general suggests that high attrition is related to institutional factors, such as teaching philosophy, role models, faculty and peer interaction, and campus environment (Carroll, 1998; Holmes et al., 2000; Lang, 1992; Lewis & Middleton, 2003). A larger body of research encompasses the experiences of Black men in the transfer pipeline and confirmation of such institutional factors (Bush & Bush, 2010). Several studies have looked at the transfer process for Black students or Black male students (Berhane et al.,

2020), but very little is reported in terms of the experiences of Black women.

Despite the promises offered by the community college setting, data on the success of transfer students is mixed, especially for Black women. For example, there is some question whether Black and Latinx students transfer to 4-year universities as frequently as White and Asian–American students do (Crisp & Nuñez, 2014; Malcom, 2010; Martinez-Wenzl & Marquez, 2012) and whether female students do so as frequently as male students (Dougherty & Kienzl, 2006; Surette, 2001). Nationwide data on the transfer and persistence of Black women from community colleges into 4-year university STEM programs are difficult to come by due to variances in reporting and definitions of persistence. Thus, we turn to data from administrative educational records in North Carolina, which we collected as part of our ongoing work. These numbers are based on longitudinal educational records of public school students who graduated from high school in 2004, then attended one of the sixteen public 4-year universities in North Carolina within the next 7 years. Table 1 includes the percentages of students in various categories who persisted to graduation after declaring a STEM major. Despite the suggested advantages of the community college environment, administrative records from the North Carolina high school class of 2004 show lower persistence rates from STEM major declaration to graduation for Black women transferring from community colleges than for Black women who began study at 4-year universities (40.7% vs. 64.8%). Moreover, the persistence rate for Black women transferring from community college is lower than for most other race*gender groups who make a similar transfer, with 50.0% of Latinas, 88.9% of Asian–American women, and 61.4% of White women persisting from STEM major declaration to graduation (authors' calculations from class of 2004 educational records provided in Table 1.).

When students find academic success in the community college setting it can also be difficult for them to translate that success to 4-year institutions due to a variety of institutional factors. Transfer students are very likely to feel the discrepancy between the supportive community college environment and a relative lack of support at the 4-year institution (Laanan & Jain, 2016). This experience is very common for all transfer students and is referred to as "transfer shock" (Hills, 1965; Ivins et al., 2017) and has also been studied for STEM-specific populations (Lankin & Elliott, 2016). There are limited studies as to how transfer shock may be racialized and gendered, but those that do exist suggest that, while many women of color receive the positive support needed during their time at community colleges (Reyes, 2011), their experience may have a significant negative shift after transfer. It is also possible that such transfer shock may be ameliorated by close working relationships between community college and 4-year university faculty (Jackson et al., 2013; Scott et al., 2017; Zamani, 2001), relationships that may be rarer with faculty from research-oriented predominantly White institutions.

In summary, though community colleges serve as a significant entry point for Black women in STEM, and there are numerous institutional factors that predispose the community college system to being supportive of entry, research is mixed on what role community colleges play

Table 1 Percent of students persisting from STEM major declaration to graduation by race, gender, and community college attendance: North Carolina High School Class of 2004

Students declaring STEM Major	*N*	Percent[b] of students persisting to graduation by group					
		All students	Black	Latinx	Asian–American	Other	White
Full sample[a]	3185	72.9	56.1	56.7	77.7	73.3	76.4
Women	1313	74.2	61.2	53.8	85.6	78.6	77.5
Men	1872	71.9	50.3	58.5	73.2	68.8	75.6
Transfer students	585	60.5	39.3	54.5	71.8	60.0	62.8
Women	198	59.3	40.7	50.0	88.9	80.0	61.4
Men	387	61.1	37.7	56.3	66.7	40.0	63.5
Non-transfer students	2600	76.4	59.2	57.8	78.7	80.0	80.5
Women	1115	77.7	64.8	55.0	85.3	77.8	81.5
Men	1485	75.4	52.8	60.0	74.5	81.1	79.9

The authors' calculations are from administrative educational records on the North Carolina public high school class of 2004 and the UNC System of public universities

[a] The full sample contains all students in the sample that declared a STEM major, which is then separated into students that had transferred from a community college (transfer students) and students that had originated in the university system (non-transfer students)

[b] The percentages are based on the number of students among various groups and by gender that persisted to graduation with a bachelor's degree after declaring a STEM major

in either providing or limiting access for Black women. This work aims at providing a rich qualitative accounting that highlights the community college and university experiences of seven Black women along their STEM transfer pathways.

Data and methods

Description of data set

Analysis for this paper is based on a longitudinal set of in-depth interviews with students interviewed at two time-points, 3 years apart. The subset of interviews we analyze in this paper is those with self-identified Black women who participated in the Roots of STEM–Community College interviews in the spring of 2015 and follow-up interviews in the spring of 2018. In 2015, we distributed a screening survey to students who were enrolled at one of eleven community colleges in North Carolina, chosen to represent both urban and rural portions of the state, as well as different regions. The screening survey went out via email to students who were enrolled as degree-seeking, or curriculum education, students; those who were taking continuing education classes were not recruited.

Approximately 3800 students from eleven community colleges responded to the screening survey. For interviews, we selected students who attended public school in North Carolina, were 18 years of age or older, and were planning to attend a 4-year university and considering a major in STEM. Of the respondents, about 480 qualified to be interviewed and indicated an interest in participating in the study. In selecting interviewees for the broader project, in which we investigate why there are persistent gender and racial inequalities among those who major in STEM fields, we aimed for overrepresentation of women and students of color to get information from a broad subsection of minoritized groups.

Potential interviewees were contacted via email to set up an interview (either via videoconference or phone). Interviewers were matched with interviewees by gender and race when possible. The interviews lasted between 30 min and 1 h and were audio recorded and transcribed. Students were paid $25 for participation in each interview. In total, we interviewed 120 students in 2015 who stated an interest in transferring to a 4-year university to earn a STEM degree.

The interview protocol for all students included general questions about their majors ("thinking back over the course of your life, what contributed to your becoming a _____ major?)"; their interest in science and how that interest changed throughout their lifetimes; questions concerning pedagogical experiences and interactions with teachers ("do you feel your high school math classes were taught well? Why or why not?"); science identity and confidence issues ("how have your feelings about your ability to do math/science changed over time?"); and questions concerning if/how gender and race influence STEM experiences (see Additional file 1 for examples of interview questions). All researchers had the latitude to use the interview protocol in a semi-structured fashion and to probe when an interviewee offered a particularly opaque or intriguing response to a question. At the end of the interview, respondents were asked whether they would consent to follow-up interviews in several years' time, then asked to give additional contact information if they were interested.

About 3 years later, in the spring semester of 2018, the research team contacted the original set of interviewees to facilitate an additional interview with each. In this follow-up, we used different interview protocols depending on the respondent's current educational status: out of formal education altogether; enrolled at community college; attending both community college and a 4-year institution; or enrolled (or graduated) from a 4-year university. We re-interviewed 68 of the 120 students from 2015. Once again, the semi-structured interview protocol allowed the interviewers some leeway in the order in which questions were asked. All other procedures with respect to interview recording, confidentiality, and interviewee compensation were identical to those used in the first wave of interviews. Of the 68 students that were interviewed at different times in their educational trajectory, seven identified as Black women.

Across protocols, there were some questions that were identical and some that were particular to the educational status of those being asked the questions. All respondents were asked questions about their academic experiences in community colleges, along with gendered or racialized educational experiences. For students who had left formal education, a section of the protocol focused on the reasons why they had decided not to pursue a 4-year degree in STEM. Students who were enrolled in 4-year universities or who had graduated were also asked about their academic experiences and social experiences at 4-year schools.

Analytic approach

The coding strategy we used was largely the inductive approach found in grounded theory (Glaser & Strauss, 1967). The research team worked together in an iterative process to develop a general coding scheme to be used as broad markers. The three first authors read the entirety of the set of interviews, then discussed emergent themes in those interviews, taking detailed notes during the discussion. Two overarching themes emerged that were particularly salient to the experiences of our interviewees. The first was experiences related to the classroom and

campus environment and second their specific experiences with oppression.

The research team then iteratively coded and discussed individual interviews, until reaching agreement on what items should be coded as classroom and campus experiences, as well as experiences with oppression, including what respondents named as racism, sexism, and their intersections. Within these two broad areas, we identified themes that mapped onto Collins' domains of power. Throughout, we found illustrative examples of how science is maintained as a venue that values the participation and contributions of White men above others: we call attention to these examples in the analysis.

For classroom and campus experiences we coded any mention of concepts closely related to institutional characteristics (e.g., campus size, climate), course structure (class size, format of instruction), class dynamics (e.g., interactions with teacher or students during class), personal interactions with instructors (e.g., availability, care, one on one interaction), and comparisons between the 2-year and 4-year experiences (e.g., discrepancies in teaching style, interactions, supports). Any mention of gender or racial issues or a combination thereof by the student was subsumed in the "oppression" category, to include discussions of racial composition in various majors, as well as educational experiences that the students perceived as being conditioned on their identities as Black women. Because we interviewed students before transfer, at a time when they were enthusiastic about majoring in STEM, we have greater confidence that the explanations that they give in later interviews for leaving STEM are not simply the result of attempts to emphasize positive experiences in other fields to allow themselves to maintain dignity in the face of having left STEM.

Positionality statement

The work presented here is the result of a multiyear, multigrant project spanning almost a decade of research devoted to understanding student experiences and academic trajectories in STEM majors, especially for students of minoritized groups, to inform practices that will create more equitable outcomes. All of the authors identify as middle-class women with four identifying as White and the other as Latina. Our professional experiences are largely centered in academia, teaching, and educational research. One of us is a community college chemistry instructor with a background in chemical education research, one has taught university level physics and has a background in physics education research, and the other three are university level social scientists that have extensive experience in researching STEM students' success. Throughout our respective careers, each of us has sought ways to promote equity and contribute to the body of knowledge on racism and sexism. All the authors of this paper were involved in the study design and data collection, while the first three authors completed the majority of analysis and writing for this paper. Graduate student researchers also assisted with the interviews; they included three Black women, one Black man, and one White woman, all of whom moved on to non-academic employment by the time this paper was drafted. Interviewers were matched with interviewees by gender and race when possible. Acknowledging the analysis team was White and likely had some blind spots as a result, we engaged in multiple reflective conversations about potential alternative interpretations that we may have overlooked due to our positionality. We sought out an additional perspective by working with a paid consultant who is a Black middle-class woman with a physics background. She provided feedback on an early version of this work. Throughout the process, we have worked to ensure that the participants' voices were amplified in our analysis.

Findings: student's stories

Below we present summaries of each interviewee's stories, highlighting significant impacts on their STEM trajectories. We follow with a detailed discussion of patterns in their experiences related to classroom and campus experiences and then a discussion of patterns in their experiences related to oppression.

Overview of participants

All seven of our participants started at the community college on track for a STEM major. They were all excited about their STEM futures and felt confident in their abilities to succeed. Discouragingly, by the second round of interviews 3 years later, they had all either left STEM, were planning to leave, or stated they wished they had left. There was not a woman left who was still in STEM and happy about it. These students reported many discouragements that ultimately led to their exiting the STEM trajectory. Few of these discouragements were driven by their social class, as the students represent various socioeconomic backgrounds, with several coming from families, where at least one of their parents had advanced degrees. Table 2 provides summary information about each respondent, which we elaborate on briefly below with an emphasis on the main reasons they gave for their STEM departure or desired departure.

Note that all names are pseudonyms.

Maya, Meghan and Tarana: out of STEM before transferring to a 4-year school

Of the seven students, three did not transfer to a 4-year school. Each of their stories is different. Maya, a first

Table 2 Respondents' educational goals at Interviews #1 and #2

Respondent name	Pathway at Time 1	Pathway at Time 2	Reasons for leaving/questioning STEM
Maya	Industrial engineering	Industrial design (still at community college)	Alignment with interests
Meghan	Chemical engineering	Out of school—plans to train as physical therapy assistant	Discouraging classroom experiences
Tarana	Computer science	Out of school—no plans to return	Financial difficulty
Rosa	Horticulture technology	Agriculture education	Alignment with interests
Serena	Biology	Social science—graduate	Chilly climate in STEM
Kamala	Computer programming	Computer science	Chilly climate in STEM
Michelle	Biology	Biology—graduate	Chilly climate in STEM

generation college student, talked more about art than STEM in her initial interview, wherein she expressed an interest in majoring in industrial engineering. At that point in time, she described science as "something that I am already talented at … I remember back when I was young I would just love to build stuff.… I would want to just work with my hands because I am really good with my hands." She also attributed her pursuit of STEM to a mentor who shared her faith tradition and advised her to pursue engineering. Three years later, she had switched into industrial design after her community college helped her to better align her career path to her actual interests, stating "I transferred over from associates in science to associates in arts because I spoke to my transfer advisor and I realized that I can take that pathway because in industrial design you can either do it in science or art school …. So, I just choose arts instead of science." Maya was still enrolled in community college and hoping to transfer to a 4-year institution.

Another student, Meghan, who entered confident and excited to pursue STEM, found her experiences at the community college diminished both her confidence and her interests in STEM and decided to pursue a non-STEM field. At the time of the first interview, Meghan expressed confidence in her abilities "I've been tested as academically gifted in math …. another one that comes very easy to me as well is science." She stated she wanted to pursue STEM "because there aren't many women in this field and, two, because there aren't that many minorities and because of the job security that is allowed within that field as well…(and) my mom and my grandma because they were the ones who brought it up, … since these are your strong suits, why don't you consider going into that field." Meghan was the first person in her family to attend college. Although she had intended to major in chemical engineering and start her own cosmetics company, she took chemistry twice and found that it "sucked the life out of" her, which led her to consider "is this something I really want to do?" When interviewed the second time, Meghan was out of formal education entirely, working as an administrative assistant, and hoping to go back to school to become a physical therapy assistant.

The third student, Tarana, completed her associate's degree but faced social class-related struggles in that she lacked the financial resources to continue to pursue a degree at a 4-year school. When interviewed in 2015, Tarana expressed an interest in pursuing a degree in computer science with a goal of becoming a website developer, "I want to be a web developer … and a degree in computer science will help me.… I had someone do a website for me and the girl that was doing it, she showed me a lot about building websites and I just thought it was amazing." Three years later, she had completed her community college degree, but then ran out of money and was unable to continue her education. An older student with children, Tarana did not have the financial resources to cover the cost of attending a 4-year school and had been unable to find enough scholarship money for her tuition. It is also of note that she did not report any mentors or supportive faculty at her community college who may have been able to help find scholarships or other institutionally based sources of support to lower the barriers that her social class had introduced into her educational pathway.

Rosa and Serena: out of STEM after transferring to a 4-year school

Of the four students who transferred to a 4-year school, two had earned bachelor's degrees and two were close to finishing. Three transferred into predominantly White institutions, while the fourth (Rosa) transferred to an HBCU but into a program that was dominated by White students. Two of these transfer students, Rosa and Serena, shifted their paths, earning degrees in non-STEM fields. Rosa aligned her interests and her path after learning more about her options. Serena started her pursuit of STEM confident and supported by her family and many positive childhood experiences. Yet, she reported significant discouraging experiences in STEM at the 4-year

school, which led her to pursue a non-STEM field. Serena's story is detailed in a later section due to its richness.

Rosa had initially intended to pursue a degree that would allow her to teach science, "I loved to watch The Magic School Bus and Miss Frizzle was just the coolest science teacher and she made me like science and that kind of just got me interested." However, she misunderstood what path at the community college would lead her to a teaching career, thinking the required degree program was not available when she was initially enrolling. She then enrolled in a degree program (A.A.S.) at the community college that limited her options with regard to the type of majors she could pursue at 4-year institutions, as not all majors would recognize the credits she earned at the community college. She ended up pursuing agriculture education. Rosa's family had other educated members, as at least one of her parents and a sibling had graduated from college and earned advanced degrees. Although her programs at the community college were dominated by White men, Rosa felt supported, stating "I had a lot of encouragement from my program chair" and the "hands-on work at (community college) was really rewarding and gratifying, it made me want to keep going." The support Rosa received at her institution demonstrates the opportunities and responsibilities institutions have to impact the experiences of minoritized students. This is a perspective more fully illuminated by Collins's (2009, 2015, 2019) domains of power framework, which we discuss in the analysis.

Kamala and Michelle: STILL in STEM after transferring, but with regrets

Two of the seven community college students in our original group of excited STEM pursuers were still in STEM: one had graduated and one was close to graduating. However, they both indicated they would have preferred a different path after becoming discouraged by university experiences. Only one student of the original seven, Kamala, was still planning to continue working in STEM but she spoke at length about the hostile environment for Black women. Although Michelle had graduated with a degree in biology, she was planning to leave STEM after attempting to work in the field and not feeling passionate about it.

Kamala reported pursuing computer science, because "I always had an interest in computers and I always played around computers when I was little… and there's a lot of jobs out there for it too." At the community college, she stated her interest in computer science only increased due to "meeting all my new friends that are into this program." After transferring to a regional university and majoring in computer science, Kamala became discouraged, because "I was the only Black person there. I was the only Black female… I feel like I should have just taken something else." Although she was still in computer science, Kamala expressed regret for her choice to pursue STEM and a lack of feeling of belonging. The dominance of White men in STEM and the corresponding near dearth of Black women creates a sense of isolation for students, such as Kamala. This is an example of a cultural power system in STEM, which we discuss more fully in the analysis section.

Like Kamala, Michelle had had an interest in science from an early age, stating she wanted to pursue biology, because "It's really cool… I just always had an interest in science stuff since I was little" and growing up in a family with parents who had earned at least one college degree and an advanced degree. She had a difficult time thinking of any experiences in her life prior to 4-year university that discouraged her from STEM. However, after graduating from a 4-year university with a degree in biology, she wished she had majored in something else and was not intending to continue working in biology. She attributed her diminishing interest to her experience working in the field, stating, "after I graduated I actually worked at biology-related jobs… it was okay but I didn't enjoy it that much, so I ended up leaving the lab."

Summary of participant trajectories

Two of the seven students left STEM due to stronger interests outside of STEM. Both of these students talked about these other interests in their initial interview and reported being happy with their trajectory when we last spoke to them. Neither of them recounted any significant discouraging experiences in STEM. While they did not stay in STEM, all indications are that community colleges helped them find a path that aligned more with their stated interests.

The other five students reported discouragements that likely worked toward narrowing opportunities for them and toward the maintenance of White and male dominance in STEM. The stories of these five students illuminate the dearth of Black women in STEM. None of them left, because they were not capable: rather, they encountered systemic discouragements that were related to their race and gender and were, in some cases, compounded by social class. We saw in Tarana the loss of a Black woman from STEM due to an inability to pay for college. Megan, Serena and Kamala all described classroom experiences that were largely alienating and uninspiring. Serena and Kamala additionally encountered significant sexism and racism in STEM at their 4-year colleges that left them discouraged. Michelle also discussed uninspiring classroom experiences and sexism but downplayed the significance of these experiences in her decision to leave STEM.

In listening to the stories of these Black women, two major themes emerged that offer insights into the great loss of Black women from the STEM trajectory: classroom and campus experiences that frequently eroded their passions and confidence, as well as sexism and racism that left them feeling alienated and discouraged. Below we discuss these two themes in more detail.

Findings: overarching themes

In analyzing the stories of our participants, two overarching themes related to climate and persistence emerged. The classroom environment, including connection to instructors and peers, played a significant role. In addition, participants described numerous experiences with sexism and racism in creating a hostile environment. Serena's story was particularly well captured and exemplifies many of the overall themes we discuss in our findings. Her story is presented here as an extended example, highlighting the main findings discussed in greater detail following her story.

Serena's story: driven from STEM by a hostile environment

Serena started her pursuit of biology at the community college, because she "wasn't sure what I wanted to do after graduating from high school and it seemed better to go to a community college than to a 4-year school and spend a bunch of money." She attributed her decision to pursue biology to many influences. These included: passion ("For Christmas I would ask for those little at home science kits that you could do, I had a microscope and stuff. I have always been interested in science."), confidence ("I was always good at the science classes and the math classes."), family role models and high school encouragement ("My mom, she is a computer engineer and my high school I went to was an engineering high school so I have been around STEM stuff my entire life."), and the perception of STEM being a good career choice ("I will always have a job (by majoring in biology) … I do want to go into something that I love but also can pay the bills."). Notably, in her first interview, when asked if any experiences stood out as discouraging her from majoring in STEM she replied "I honestly cannot think of any. I feel like my whole life has pushed me towards science and technology so I cannot really think of anything."

At the community college, Serena mentioned only positive experiences that supported her pursuit of biology. Serena spoke about the science courses she took at her community college, stating she enjoyed them and that she felt her teachers cared about her and her success. "I have had really good teachers in all my science classes since I have been at {community college} … I think it is just a really good place to learn your general science classes rather than having to be in a really big huge class at a university… If you don't understand something it is okay, {my teachers} make it feel like it is okay to ask questions and they make it seem like they are there for you, for you to learn and they make themselves available in that way." Serena acknowledged the potential for both gender and racial differences in her major but did not express strong concerns about how she would be impacted. When asked about gender she expressed a pro-female bias stating "it is more expected for women to do biology." In terms of race, she acknowledged there could be a negative impact stating "I guess it would be different just maybe how you interact with the other students in your class and how they interact with you and teachers just interactions within the classroom. They might view you differently because they aren't expecting to see you there." However, when asked if she felt she belonged she stated "I do" and when asked if she ever felt out of place she replied "no." Serena's experiences are consistent with our overall finding *that at the community college, most students anticipated relatively mild impacts of sexism and racism in their trajectory (finding three).*

When we spoke with Serena again 3 years later, the once confident and excited STEM student was no longer in STEM, having left to successfully obtain a degree in a social science major. Serena described an unwelcoming environment in biology at the 4-year university, where she transferred that caused her to leave STEM. When asked if her instructors enjoyed teaching she replied "No. None of them…because the school is like R1, research institute whatever the classification is. So, some of them, you know, they don't want to be teaching there." Again, Serena's story is typical. Like others, *once they arrived at university, the transfer students reported neutral to unsupportive relationships with teachers and advisors and decreasing social and academic interaction with peers. (Finding Two).*

She also noted the impacts of racism and sexism on her departure. "One of the other things I tell people is they don't prepare you for STEM being a person of color … people expect you to not know what's going on or they don't want to work with you… you don't get the benefit of the doubt, when talking to teachers, when you need some sort of help with the assignment or an extension or something." Serena went on to directly attribute her experiences to her decision to leave biology, "being a person of color it was going to be 10 times harder for me. It made me think how passionate I am about this? To put up with this. I decided I wasn't. I love it but not that much." Serena noted that her only discouraging experiences were after she transferred stating "While I was at {my community college} nothing deterred me from that path. In fact, I think I was actually encouraged… I was discouraged when I got to {my university}". Serena's increasing

experiences with racism and sexism after transferring were consistent with all interviewees. After entering 4-year institutions, participants reported dramatically greater impacts of race and gender on their educational experiences. (Finding Four).

Throughout her second interview, Serena described a teaching environment in biology that was alienating and provides numerous examples of oppression. As will be addressed in the analysis, and similar to Kamala and Michelle, these feelings of not belonging are rooted in the system of power maintained by White men in STEM. However, Serena's experiences in her social science major stand in sharp contrast. She reports that a professor in her new department told her "you as a Black woman, you would be so valuable in (social science field). Your perspective is not common and she was very encouraging with that track for me. She is an amazing teacher so it influenced me to switch over to (social science field)." And when speaking of her classes in her new major she spoke favorably saying "Once I got into (social science field), the class sizes were normal, like 20 people. Some classes were 7 or 5 people. It was really nice."

Serena's story exemplifies many of the themes we see in our interviews. She began her journey excited and confident, supported by the positive experiences of her schooling and a family that nurtured her interests. Throughout her community college enrollment she reports only positive experiences (Finding One), and does not expect to find racial and gender inequities that would disrupt her STEM pathway (Finding Three). However, upon transfer she experienced a hostile environment in biology (Finding Two). Much of that hostile environment was directly related to her race and gender (Finding Four), which caused her to abandon STEM for a major, where she felt more supported as a Black woman.

Classroom and peer experiences

In this section, we expand on Serena's account with other interviewees' experiences. Their accounts were generally in response to interview questions about how courses were taught both in terms of quality and methodology, whether instructors enjoyed teaching, and comparisons between their community college and university experiences. In this analysis, stark differences arose between students' community college and university experiences.

Community college classroom and peer experiences

Finding One—While attending community college, students generally reported positive classroom environments leading to supportive relationships with instructors and peers.

The students in our sample generally described their community college experiences very favorably. Instructors were depicted as people that were passionate, enjoyed teaching, were helpful and worked with students until they got it. Each of the students in the sample characterized multiple science, math, and/or computer science classes as positive, even for those students that did not transfer. In addition, the students indicated they studied with their peers and felt respected. They felt that relationships with peers were overwhelmingly supportive and positive.

In speaking of their relationships with instructors and advisors at the community college, the students who transferred to a 4-year school recounted how their community college professors put extra effort into relationship building and activities that made the students feel they cared. For example, Kamala said her computer science instructors "really enjoy teaching and put [in] extra activities and also bring in other, extra people like job fairs and people come and talk with us, give us advice on what we should do when we leave college." Serena also talked about the care for teaching of her professors at the community college and that she developed very supportive relationships with her math instructors that continued after transfer, "Some of them I still talk to, so I do think that they cared and do care about what is going on inside their classroom and the learning that is going on outside of their classrooms as well." Likewise, Rosa reported a strong support system in her predominantly White male community college program, "I got an outpouring of support from the program. The program was super tiny and I was one of the very few girls and one Black girl. I never felt like my professors didn't want me there or question why I was there."

The students that did not transfer also reported positive community college experiences, even if they also struggled in a class. Maya stated that community college "had a positive impact on my life and education," and her math instructors "were just positive every time they came to class and really just tried to help the students and it seemed like the class was more about learning than about grades." During the first interview, Tarana mentioned a bad experience with her biology class, but during the second interview it was apparent that Tarana had taken more science classes stating "{the classes} were tough, but I learned a lot" and her "{chemistry} teacher was helpful… a good instructor." Meghan reported the most negative experiences at the community college stating that both chemistry and pre-calculus "sucked the life out of her" and that her engineering class was not designed well. However, she said that her math teacher "was very passionate about the course material that she was teaching which made it more interesting to take the course," and her biology instructor "was very enthusiastic."

In terms of peer relationships, students that eventually transferred to a university described feeling connected to their peers at the community college. For example, Kamala "found a lot of friends in the STEM field… felt comfortable… and asked {them} questions. Or didn't have to fake or anything if {she} didn't know something." Michelle felt very connected, socially, to her peers at the community college, saying "{we} usually form a group and study together; we do stuff together outside of school and everything; we volunteer." When asked how often she socializes or studies with other students, Serena responded "Pretty often… every time I studied." Rosa did not suggest a negative experience with peers, but she was less connected. She completed an associate's program overwhelmingly dominated by White men and reported that she felt comfortable in the curriculum, but sometimes felt out of place socially. "I do sometimes feel out of place," and socializing "never [happens] off campus, but on campus, we have small talk every day."

Notably, the students that did not transfer did not report having much social interaction at the community college. Maya and Tarana felt the least connected in their community college experience due to taking online classes. For example, Tarana said "now that I am online everyone is working and doing their own thing, so nobody really has time [to socialize]." Meghan's social experience was not consistent. She reported that she was not really connected and one "semester I was able to meet a bunch of [science majors] because I was in Intro to Engineering, but, as of lately, I don't [socialize], I'm not entirely sure of how many I come into contact with." However, Meghan felt like she belonged and did not feel out of place.

As shown here, the students mentioned overwhelmingly positive community college experiences with a small number of negative experiences often attributed to one bad class or a lack of interaction in the online environment. The students in this study did not point out any additional supports for Black women beyond the supports already in place for all transfer students. However, responses were consistent with the idea that positive relationships and support systems are important to success and persistence, particularly for traditionally marginalized groups. In sum, it appears that various aspects of the community college environment were structured for a broad cross section of students to succeed, in that most students felt enthusiastic and supported throughout their STEM coursework.

University classroom and peer experiences

Finding Two—Once they arrived at university, the transfer students reported neutral to unsupportive relationships with teachers and advisors and decreasing social and academic interaction with peers.

Environments in 4-year universities were a stark contrast to the previous experiences of the students who transferred. The students were likely to cite more instances of positive class discussions and instructor interaction in the community college classroom while speaking very little to very negatively about class formats at the university. Overall, the transfer students in the sample did not describe supportive relationships with faculty or peers at their university. In addition, the larger campus and class sizes exacerbated their feelings of being disconnected.

The transfer students often described the university environment in terms of large classes taught by instructors that did not care about teaching. They recounted being viewed as part of a larger group, rather than as individuals. This prevented students from developing the supportive relationships with instructors they had when at community college. Serena compared her university experience to her community college experience by saying "So, for one they were like way bigger. I went from being in class with twenty people to four hundred people." This is consistent with Kamala's experience, she said, "at {my university}, it's like a big collection of people and they don't really try to give you one on one attention." When asked if her instructors at the university enjoyed and are interested in teaching, Serena stated,

> *"No. None of them… because the school is like R1, a research institute… So, some of them, you know, they don't want to be teaching there. They want to do their studies [but] they have to teach the class… to get their money and that's something that's openly talked about by professors sometimes during classes."*

Rosa's program was entirely online, which further hindered the development of supportive relationships as directly reflected in the statement, "I don't have a real relationship with my professors…, but when I went to community college I just talked to my professors because they were right there. We talked about stuff that had nothing to do with the classes sometime. I don't have that currently."

Michelle was the only student that reported some positive experiences at the university. She said "Professors would take a lot of their time to really help us understand challenging concepts… and I really liked that." However, she was more interested in the academic content of the course and did not elaborate on any specific relationships with instructors.

In terms of peer relationships, the findings are very similar to the lack of relationships with instructors found at the university level. Kamala's interactions with peers were very limited, as she said, "I just go straight to class and go back home. I don't really associate with a lot of

people there, pretty much with anyone there." When asked about how often she socializes with other students in her major, Serena reported, "not often at all. I have some friends [from a transfer orientation course]… some of them stayed in the biology program and some didn't even stay [at the university]… there was no socializing with bio majors." She went on to say "I thought biology at [university] would be something else than it was. It was a very huge program… There were 2500 students. Very impersonal and super competitive…it's just not an environment to thrive in." Rosa's interaction was limited due to the nature of her online program at university. When asked about her ability to make relationships with students in her classes or major, she said, "I think it's just harder because it's online, so I just kind of do my thing."

Again, Michelle's experience was a little bit different. She transferred from a smaller, more rural community college that did not offer as much student life as the university and had a different perspective on the larger size of the university and the ability to build peer relationships. She said, "student life is very, very minimal at community college. But at [university] it's very different. Obviously a bigger school… a lot of other students… more diverse… there's a place for everyone." It is also clear that study groups had a positive impact on Michelle's adjustment: "something else that really helped me out was making study groups with some of my classmates… we were all able to relate with each other… I really depended on making study groups [which increased] my confidence."

When compared to the overwhelmingly positive community college experiences, it is obvious that the students in our sample experienced varying degrees of transfer shock in finding an environment at the university that was generally not as positive. However, as highlighted by Michelle's experience, better classroom environments and supportive relationships with peers are very important to the overall view of the transition. Where the community college environment was structured for a broad cross section of students to succeed, it is clear that the university environment is not particularly designed for the success of the same broad cross section of students, especially when it comes to Black women. In addition to the stark contrast in classroom and peer experiences, these students also described very notable differences in their racialized and gendered experiences as Black women on the transfer pathway. These differences are presented in the next section.

Racialized and gendered experiences

In reading the stories of these women collectively, their experiences with sexism and racism stand out as being influential to their trajectory, particularly for those students who progressed farther down STEM pathways by transferring to 4-year universities and pursuing STEM majors there. Below, we summarize overarching themes that emerged from an analysis of their reports specific to gender and race. Typically, interviewees made statements regarding gender and race in response to a series of questions that asked them about their perceptions of racism and sexism within their majors and how/whether their own experiences had been influenced by their racial and gender identities. These findings fall into two main categories: predictions of future sexism and racism and experienced sexism and racism. Together, these examples show how these types of oppressions combined to mark science as a comfortable environment for White men and markedly less comfortable for the Black women we interviewed.

Predictions of sexism and racism

Finding Three—At the community college, most students anticipated relatively mild impacts of sexism and racism in their trajectory.

While at the community colleges, students realized that they were heading into fields, where Black women were underrepresented, but they underestimated the extent of underrepresentation and remained confident that it would not affect their trajectories. For example, Tarana was planning to major in computer science when she transferred to a 4-year program and recognized that there would not be many women in STEM, but still thought that 25% of other computer science majors would be women and 20–25% would be Black. Overall, women earn about 18% of computer science undergraduate degrees and Black people earn 8.5%, with Black women accounting for 2.2% of the undergraduate degrees earned in computer science (NSF, 2019).

Only some of the interviewees foresaw major issues with respect to underrepresentation. They were all asked whether they thought the experience of pursuing their intended majors would be different for men and for women and for people of different racial groups. While four thought the experiences would be the same by both gender and race, others saw potential differences, stemming from societal expectations and existing gender underrepresentation. For example, Kamala thought that "women may not get a lot of opportunities as men will in computer programming" and was skeptical as to whether Black or Latinx students would be given the same opportunities as White and Asian–American students. Tarana was looking forward to getting a job with her intended computer science degree, even though she did "hear that there aren't many women in STEM." And Rosa questioned whether she would feel like she "fit in", because "there might not be somebody who understands you" due

to the underrepresentation of Black people in her agricultural major.

Thus, our interviewees only vaguely noted any potential impact of identity-based oppression in their educational trajectories in the future. However, it is important to note that they were familiar with the fact that their fields of interest were predominantly White and male. Importantly, while they were still enrolled at community college, none of the students thought that any of these potential issues would be sufficient to deter them from the STEM majors they were intending to declare at 4-year universities. None of the respondents mentioned noticing any such oppression in their community college experiences or was able to give any specific examples of experiencing or witnessing any oppression.

Experiences of sexism and racism

Finding Four—After entering 4-year institutions, participants reported dramatically greater impacts of race and gender on their educational experiences.

The second iteration of the interviews offered a particularly stark contrast between students who had not transferred to a 4-year institution and those that had. All of the students who ended their formal education with community college responded in the negative when asked whether gender and race had impacted their experiences within the context of higher education. When asked whether the experience of pursuing their intended majors is different for people of different genders, the students responded with vague notions that there is sexism. Tarana mentioned that "some men tell women that we are not smart enough to do {computer science}," but none detailed specific instances of sexism or it having an impact on their lives. Likewise, Meghan said that "it could be" that there is racism," but none of the three who did not attend 4-year university offered specific instances or discussed any personal impacts. For example, when asked whether her experiences had been impacted by race, Tarana responded, "I don't think so. I try not to think about that. I just do what I do."

Meanwhile, the four students who did transfer to 4-year institutions offered specific instances of how bias played a role in their educational careers as Black women. Interviewees reported numerous instances of sexism and racism at the university. Most notably this included: assumptions they were not competent, messages they did not belong, being ignored, and being talked over. These racist and sexist acts came from both teaching staff and their fellow students. All of the instances described here decreased these students' sense of belonging within their STEM majors and contributed to their exits from STEM. It is important to note that these processes are intertwined, such that the assumptions of incompetence are sometimes manifested in a tendency of others to ignore or talk over Black women in STEM. These Black women perceived issues with respect to their gender, racial, and intersectional identities at 4-year universities for the first time: none mentioned encountering similar issues at community college.

Interviewees frequently confronted others' views that they were not competent, as did the graduate students described in Wilkins-Yel et al. (2019). Serena described how there was "overshadowing…with male counterparts." She discussed how the male teaching assistants in the lab would "invalidate…viewpoints or questions." Serena noted that these issues were especially acute in lab settings, where students are collecting data and where they are "measuring stuff or having to do calculations," and said that there were certain lab courses, where the sexism was worse than others. In these labs, Serena felt that her voice was not heard and that her expertise and skills were devalued.

Michelle had a similar experience with a teaching assistant. When asked whether anyone in biology has encountered sexism, Michelle said, "yes," and then went on to describe an experience with a lab instructor who would "treat the guys differently than the girls." She mentioned that this instructor would act in the following way:

> *"Let's say I made a mistake or read something wrong … he would be very, very hard on me and say … why don't you know this, you should know this or this is a waste of my time. But let's say if a guy does the same thing in the lab, he would be open to explaining to them what's going on and why they're wrong."*

In these interactions, Michelle experienced both a delegitimization of her skills by the lab instructor and an implicit message that communicated a lack of belonging in STEM, both of which Wilkins-Yel et al. (2019) describe as micro-aggressions that students of color experience.

Messages that they did not belong in STEM were sometimes implicit, stemming from the fact that there simply were not many other Black women in these fields. Interviewees discussed how "lonely" it was to be a distinct minority in that they were frequently the only woman of color in given fields or given classes. Serena talked about how "it was going to be 10 times harder" for her to complete a biology major and to work in the biology field "seeing that it is dominated by… White men." Kamala described the "crap [she] had to deal with" in the computer science field and how being the only Black woman was a discouraging factor that kept her from wanting to pursue a degree in computer science. She went on to say that because she didn't "look like the average person," she did not feel as if she belonged in her major and that her classmates stereotyped her as "a ghetto type Black girl",

because she was the only Black woman. Moreover, she felt like, "every single day I go into the class, I always got to prove myself," a pressure that was particularly acute, because she was the only Black woman in her classes.

Sometimes, these Black women found that they were ignored by other members of the STEM community. For instance, Kamala, a computer science major, said that her gender and race impacted her experiences because of her classmates, whom she described as being "discouraging" and "honestly not trying to listen to my view when I am trying to speak or act like I don't know what I am talking about." These microaggressions then led her to question her sense of belonging. She went on to say that in class debates "they don't really care that a Black person is speaking up or try and consider their viewpoint." In this instance, she was describing how her professors and fellow students ignored her voice. Serena said she felt "talked over and doubted," especially in the labs that she mentioned above.

Kamala further described an instance, where her physical presence was also ignored, and then questioned. She recounted an experience with a professor who had told her to come by his office for extra help. When she arrived there, he "thought I was the wrong person. Like said, 'are you sure you are in the right department and not nursing?'" When faced with a Black woman, this professor thought that she did not belong in computer science and was looking for help in the wrong department, thereby communicating to Kamala his opinion that people who looked like her had no place in computer science. Kamala noted that this interaction was discouraging and made her "not even want to ask the question anymore." Here, Kamala experienced a type of discrimination stemming from the intersection of her race and gender.

All of these micro-aggressions—being ignored or talked over, assumptions of incompetence, and messages Black women do not belong—are summed up in Serena's experience. After starting her 4-year college experience as a biology major, Serena left that major for a social science field and graduated with a degree in that social science. As she was considering switching, a professor in her social science major had told her how valuable her perspective was. In contrast, she noted the uninviting climate in biology, from both students and professors. Professors doubted her competence: Serena said that Black students would not "get the benefit of the doubt… when you need some sort of help with the assignment or an extension or something." From other students, she described a pattern of interaction, wherein students of color "can have a harder time just being approached by other students or even kind of experiencing resistance from your professor or TA, unless the TA is a person of color."

Serena described struggles with other students that conveyed messages that she did not belong and ignored her voice. These struggles included "people not wanting to work with you," and Serena characterized them as being more pronounced in interactive situations (i.e., labs) than they were in lecture sections. This example of being talked over, having her competence questioned, and conveying that she did not belong occurred in the last class that she took before dropping her biology major:

> *"The final shock for me was, I had a lab and it was like me and two White guys and a White woman and one of the guys… didn't talk very much. The other White guy was older and… would talk over me and the other young lady in our lab group… It was literally just me and him contributing ideas. We were cutting things and examining stuff and if I made a point and said, 'this is this, I am identifying the body part or whatever,' and he would always challenge it and call over the TA to settle a dispute. I happened to be right and he would just be, 'okay, let's move on,' but if it was him being right, he would be like, 'I knew I was right' and making a big deal out of it and it was like he would challenge me in ways that he did not challenge anyone else in the group even though he spoke over the other young lady and she was adamant but he wouldn't call the TA over to ask a question."*

Here, Serena experiences racialized and gendered experiences in the classroom and labs as the outcome of her intersectional identity as a Black woman. These experiences with peers and professors combined to drive her out of her STEM major, despite the enthusiasm for the field that she had prior to transferring to a 4-year university.

Our four major findings can be briefly summarized as: (1) students' experiences at the community college were generally reported to be positive and supportive; (2) after transferring to the university they experienced a generally negative and unsupportive environment; (3) while attending community college, they reported few racialized or gender experiences and anticipated few after transferring; and, (4) once at the university, they encountered substantial racist and sexist experiences that were directly related to their decisions to leave STEM.

Discussion

Summary

Our seven interviewees started on their path toward a bachelor's STEM degree in community college excited and feeling confident in their ability to succeed. Consistent with current data indicating Black women are

generally excluded from STEM (NSF, 2019), none were still in STEM without regrets 3 years later.

Two students (Rosa and Maya) described experiences and mentoring at the community college that led them to leave STEM for a field they felt was more aligned with their interests. Neither of these students felt discouraged in their STEM path; rather they simply found other fields that held more interest for them. All indications are that the mentoring they received at the community college helped them down a path that was perhaps better suited for their interests. While these students did not ultimately follow through with the interest in STEM, the nature of their departure does not raise concerns. The other two students who dropped off the STEM path during their community college experience encountered more troubling barriers. Tarana successfully completed her associate's degree, but did not transfer due to a lack of financial resources and Meghan reported discouraging experiences in her community college chemistry and math courses, academic struggles that are somewhat common for students in those entry-level STEM courses (Cohen & Kelly, 2019).

Most concerning of all were the experiences of the three women (Serena, Kamala, Michelle) who earned associate's degrees at community college and transferred to university still excited and confident in their STEM trajectory. All of these women reported a lack of supportive relationships, alienating classroom experiences and a chilly environment, related to their identities as Black women, that discouraged them to the point of either leaving STEM or staying in STEM but regretting their chosen path. The stories of these seven women align with data indicating that the environment for Black women in STEM is dismal and indicate that race, gender, and their intersections play a significant role in their departure from STEM.

Domains of power analysis

Analyzing our findings through the lens of Collins's (2009, 2015, 2019) Domains of Power perspective illuminates a multitude of ways that science, writ large, is structured in such a way as to disadvantage Black women, among others. Of note is that we find these power structures to be significantly more pronounced at the university than at the community college. We apply Collins's framework, because it provides a powerful way of reframing our inductively derived findings into a larger framework that directly points toward systemic solutions.

Below we consider findings through the lens of each of the four domains. Table 3 provides a summary.

Interpersonal domain—interactions between individuals

Our participants talked extensively about interactions with peers and instructors. Their reflections provide extensive documentation of the way power is exerted in the interpersonal domain to the detriment of Black women. When participants were at the community college, they mostly spoke positively of their interactions with both their classmates and their instructors. They reported being treated respectfully and feeling both their classmates and instructors valued them and supported their goals. They experienced few microaggressions or otherwise discouraging interpersonal interactions. In contrast, at the university, interviewees described significant negative interactions with both peers and instructors. University STEM instructors were typically characterized as not caring and discouraging. Both instructors and peers were frequently described as ignoring and talking over Black women. Our participants also recount numerous instances of instructors and peers making comments indicating they held views of these women being incompetent and unexpected in STEM. Participants indicated they were frequently socially

Table 3 Collins's domains of power identified in interviews with Black women community college and university students

Domain of power	Element of focus	Community College	University
Interpersonal	Interactions between individuals	Positive student–student interactions, caring and encouraging instructors	Social isolation, instructors distant and uncaring, numerous microaggressions (i.e., ignored, talked over)
Structural	Institutional structures	Small classes, teachers interact one-on-one encouraging and mentoring students, courses are perceived as interesting and enjoyable	Large, impersonal, lecture based courses. Few women of color in program. Course work disconnected from student's interest and unenjoyable
Disciplinary	Rules and enforcement	Not observable in the data	No consequences for students or instructors disrespecting each other. No attempt to set expectations of behavior regarding microaggressions and harassment
Cultural	Expectations and norms	Classrooms are cooperative, culture of support when not understanding, teaching valued	Black women regarded as less competent and unexpected, quality teaching not valued, competitive environment

isolated and invisible. These repeated negative interactions led our participants to be "fed up" with the environment of STEM.

Structural domain—institutional structures

Participants identified a number of structural elements in their experience that serve to maintain the White and male dominance in STEM. At the community college they spoke of small classes, where teachers knew them as individuals and made time to encourage and mentor students. At the university, in contrast, they identified large impersonal classes as problematic, where one-on-one attention was rare. They described courses as being taught without attention to students' learning needs and without care if students did not succeed or left the major. In addition, they identified the lack of other Black women in their programs as creating an uncomfortable and unwelcoming environment.

Disciplinary domain—rules and enforcement

We find little in our data to speak to the disciplinary domain at the community college other than to note that very few problems were identified at the community college to which problematic elements in the disciplinary domain would be relevant. At the university level, participants spoke of many incidents of sexist and racist behavior of peers and instructors. There were no consequences when peers or instructors engaged in disrespectful and alienating behavior. There were also no mentions of action on the part of those in authority to set expectations of interpersonal behavior. There was a pervasive disregard for any enforcement of respectful and inclusive behavior related to racial and gendered interactions.

Cultural domain—expectations and norms

If science is regarded as being primarily the province of White men in American culture, then institutions need to take actions to counter those assumptions. Instead, Black women described cultural climates at universities, where there was little, if any, challenge to that notion. Participants described a culture at the community college in which teaching was valued and students felt it was acceptable to not understand and to ask for help. They felt valued by their instructors and their peers as a presence in STEM. At the university, on the other hand, they report a highly competitive environment, where teachers did not care about students' learning. They spoke at length about a culture that does not view Black women as knowledgeable and competent in STEM. They also described not feeling they belonged in the environment at the university which was attributed in part to a sense that other students and instructors did not consider that Black women belonged in STEM.

Analysis through the lens of Collins' Domains of Power framework shows a pervasive system of power which reinforces inequity through both action and lack of action. We end with recommendations for change that are illuminated by our analysis.

Recommendations

Recommendation 1—Systemic sexism and racism in STEM is at the core of the dismal representation of Black women and must be acknowledged and addressed

Racism and sexism create a hostile environment for Black women in STEM. Fairness and equity depends on explicitly acknowledging and addressing the discrimination, harassment, and microagressions Black women encounter to achieve justice.

The women in our study entered study in STEM passionate and confident, and they demonstrated their ability to succeed as they progressed. Though they underestimated the extent of their underrepresentation and the sexism and racism they would encounter, they understood the path they were on would be more difficult for them due to their gender and race. They accepted this challenge and were willing to rise to meet it. However, the extent of the hostile climate they faced ultimately contributed to pushing them out of STEM majors and/or careers. It is also important to note the pervasiveness of this hostile climate, with racist and sexist actions and attitudes coming from peers, teaching assistants, and professors and being enacted through all four of the power domains: interpersonal, structural, disciplinary, and cultural.

The first step toward addressing racism and sexism in STEM is to acknowledge it exists. However, many of those in STEM, especially those who are the majority, i.e., White men, fail to recognize the existence of racism and sexism (Dancy et al., 2020). Furthermore, when they do recognize differential impacts they tend to attribute these to how those in the marginalized group "feel", i.e., lacking confidence, interest or sense of belonging, consistent with a deficit model of understanding inequity (Davis & Museus, 2019), rather than attributing impacts to systemic racism and sexism. It is essential to shift the dialogue to place causal responsibility more appropriately. As we saw in our interviews, these women left STEM due to hostile interactions, not because they lacked ability, confidence, or motivation.

While much attention is given to increasing persistence for various minoritized groups in STEM, efforts to address inequity tend to focus on changing those who are marginalized (i.e., tutoring, scholarships, mentoring, etc.) rather than on changing the social and cultural structure that create an inhospitable environment (Fox et al., 2009; Grunspan et al., 2016; Malcom & Malcom, 2011; Ong,

2005). While these efforts can be helpful and are well meaning, they are unlikely to result in significant change. Furthermore, they can have the detrimental impact of sending the message that marginalized groups should be more like the dominant group, that the norms of the dominant group are superior (Ong, 2005; Simon et al., 2017; Tate & Linn, 2005).

Our findings support the need for efforts to address systemic racism and sexism in STEM, particularly at the university level. We note that the students in this study generally reported positive and supportive experiences at the community college and encountered the most sexism and racism after transferring. The experiences of the women in this study highlight a need to go beyond providing structures to strengthen members of marginalized groups to actively acknowledge and work to dismantle the racist and sexist environment that undermines their success.

Recommendation 2—Behaviors of mentors and professors can significantly support or undermine the success of Black women in STEM. Until systemic sexism and racism is eliminated, it is essential that marginalized students are provided substantive opportunities to form supportive relationships with instructors and peers

Almost all of the interviewees had supportive relationships with instructors and peers at the community college. These relationships helped the students to succeed in the classroom and to maintain interest and motivation in studying STEM, even when other obstacles presented themselves. Their experiences are echoed in the copious literature on the unique role that community colleges can play in supporting students, and especially students from marginalized groups (Jackson et al., 2013; Jorstad et al., 2017; Starobin & Laanan, 2008; Starobin et al., 2016).

Yet once they transferred to 4-year universities, the students lost those supportive relationships. There did not appear to be a university mechanism to facilitate the formation of those types of relationships. Much of the university context, especially the competitiveness within the major and large class sizes with lecture-based instruction, seemed ideally situated to prevent the formation of supportive relationships between students, peers, and faculty. In addition, faculty behavior does not have to be overtly hostile to result in an unwelcoming environment. As we saw in the experiences of our participants, when faculty do not overtly attempt to connect with students, or when they give the appearance of not caring about the students or their learning, this lack of action can have a detrimental impact.

There is variability in the extent to which universities exhibit an environment that is receptive to transfer students. The difficulty in navigating the change in environment is well-established in the concept of transfer shock (Hills, 1965; Laanan, 1996, 2001). However, the experiences of the students in our study emphasize the extent to which that transfer shock can be exacerbated by racial and gender minority status in addition to an environment that is already unwelcoming due to their minoritized status.

The STEM transfer pipeline has been under more intense study for the past decade, leading to the development of programs designed to increase retention of STEM transfer students. Such university programs have implemented many of the supports found in the community college setting like intentional advising and mentoring in addition to customized orientations and undergraduate research and have been shown to be effective in improving performance and satisfaction of transfer students (Jackson & Laanan, 2011; Johnson, 2011; Ong et al., 2011; Thomas et al., 2018b; Thomas et al., 2018a). However, many of these programs focus on the overall transfer population. University STEM programs must look at the disaggregated data on Black female students and develop programs designed to build supportive relationships and foster retention and success. For example, the opportunity to make personal connections with other Black female STEM students and professionals can increase STEM confidence (Smith, 2016). Accountability practices are also a critical component of transfer programs, especially those that revolve around equity (Bensimon & Harris, 2007).

Community colleges can offer a supportive environment and viable pathway for Black women early in the STEM academic trajectory, but 4-year institutions must implement mechanisms to foster relationships and supportive structures for Black women transfer students.

Recommendation 3—Instructors should pay explicit attention to student–student interactions and disrupt sexist and racist behaviors

Our participants frequently identified interactions with their peers as being problematic, especially after transferring. Of note, they spoke of being ignored or treated in a condescending manner by peers during assigned group activities (such as lab work). And also of note, they reported very few positive and supportive interactions with peers in their STEM courses after transferring. In several cases, the large class sizes students found in university-level STEM courses exacerbated difficulties in making positive peer connections.

We are not the first to recount this pattern. Repeatedly, studies of women of color in STEM note they experience significant isolation due to being unacknowledged and ignored by peers, for example by being overlooked as lab partners or being consistently left out of study groups

(Johnson et al., 2017; Ko et al., 2014; Ong, et al., 2018). In contrast, studies indicate that having strong peer support (Chang et al., 2014; Ong et al., 2011) and being recognized as competent (Carlone & Johnson, 2007) are important factors for persistence and success.

As discussed above, active learning based pedagogies have the potential to improve outcomes for marginalized students (Beichner et al., 2007; Freeman et al., 2014; Haak et al., 2011; Prince, 2004). However, while increased student–student interactions offer the promise of improved learning and opportunities to develop positive peer supports, they can also be a source of hostility and discouragement, as our participants spoke to. It is clear from the stories of our participants, as well as others, that peer interactions are a mechanism by which the ownership of science is maintained as White and male.

If instructors do not explicitly confront and disrupt problematic behaviors in group interactions in their courses they are complacent participants in creating a hostile racist and sexist environment, which in turn reinforces STEM as a White and male space. An example of how instructors can disrupt racist and sexist peer–peer interactions is provided by Johnson (2020) in her study of a physics department, where women of color describe a positive climate. She reports that in this department with a supportive culture,

> *Faculty members expect students to work in groups, but they don't leave this process to students. … a faculty member told me about working with a student who was dominating group work during a lab. He was controlling all the materials, so she told him he had to let other people have a chance, at which point he backed up and stood far away from his group. She told him he didn't have to stand so far away and that he was either dominating the group or not participating. According to this faculty member, she said "You can't only participate when you're building, that's not OK. It can't be 'I'm either in charge or I'm out of here, guys.'"... One faculty member told me about dealing explicitly with issues of gender and group work when giving students feedback. She was dealing with a situation in which two male students were in a lab group with a woman, and they almost entirely excluded her from participation …. After the lab ended, the faculty member talked with all three of them about it. (Johnson, 2020, pp. 53-80)*

Furthermore, until racist and sexist systemic and cultural structures in STEM are dismantled, marginalized students will benefit from the availability of counterspaces (Ong et al., 2018). Counterspaces are safe spaces, where students can find support and a haven from hostile interactions. Ong offers a number of suggestions for types and ways these spaces can be nurtured.

Conclusions

The stories of the seven women we share here indicate that there are significant systemic forces that work to exclude Black women from STEM, despite their interest, passion and willingness to persevere through challenges. Using the Collins (2009, 2015, 2019) Domains of Power framework to identify structures that contribute to that underrepresentation of Black women, we are able to make specific recommendations aimed at tackling systemic racism and sexism at the college level, particularly after transfer to the university.

While both 2-year and 4-year institutions may experience similar academic challenges with preparedness and gate-keeping courses, the community college, with its smaller classes, focus on teaching, and greater student diversity, has the potential to offer a supportive environment for Black women, as our participants reported. In contrast, at the university we have highlighted structures that exclude Black women from STEM including: significant racism and sexism, lack of sufficient supportive relationships, and poor quality lecture-based teaching. We posit that each of these identified discouragements provide a mechanism for addressing inequity.

Supplementary Information

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Additional file 1: Interview Protocol—Structure and Sample Questions.

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Authors' contributions

The first three authors (DA, MD, and ES) completed the majority of analysis and writing for this paper. RM and MB contributed as members of the Roots of STEM team that contributed to the overall research design and data collection, in addition to reviewing and advising the conception of the manuscript, and MB additionally analyzed, organized and provided the data for Table 1. All authors read and approved the final manuscript.

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Availability of data and materials

The data sets generated and/or analyzed during the current study are not publicly available due to the terms of our data management plans with the National Science Foundation but are available from the corresponding author on reasonable request. They will be publicly available in the future.

Declarations

Competing interests

The authors declare that they have no competing interests.

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