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"If you aren't White, Asian or Indian, you aren't an engineer": racial microaggressions in STEM education

Meggan J. Lee¹, Jasmine D. Collins², Stacy Anne Harwood^{3*} , Ruby Mendenhall⁴ and Margaret Browne Hunt⁵

Abstract

Background: Race and gender disparities remain a challenge in science, technology, engineering, and mathematics (STEM) education. We introduce campus racial climate as a framework for conceptualizing the role of racial microaggressions (RMAs) as a contributing factor to the lack of representation of domestic students of color in STEM programs on college campuses. We analyze the experiences of students of color in STEM majors who have faced RMAs at the campus, academic, and peer levels. We draw from an online survey of more than 4800 students of color attending a large public university in the USA. The STEM major subsample is made up of 1688 students of color. The study estimates a series of Poisson regressions to examine whether one's race, gender, or class year can be used to predict the likelihood of the regular occurrence of microaggressions. We also use interview data to further understand the challenges faced by STEM students of color.

Results: The quantitative and qualitative data suggest that RMAs are not isolated incidents but are ingrained in the campus culture, including interactions with STEM instructors and advisers and with peers. Students of color experience RMAs at all three levels, but Black students in the STEM majors are more likely to experience RMAs than other students of color in the sample.

Conclusions: Our study demonstrates the need for campus officials, academic professionals, faculty members, and students to work together to address racism at the campus, academic, and peer levels. Additionally, STEM departments must address the impacts of the larger racial campus culture on their classrooms, as well as how departmental culture reinforces racial hostility in academic settings. Finally, our findings reveal the continued presence of anti-Black racism in higher education.

Keywords: Racial microaggressions, Higher education, STEM, Educational setting, Diversity concerns

Introduction

The USA is rapidly approaching the "majority-minority" tipping point. It is projected that by 2044, non-Hispanic White residents will make up less than half of the US population (Colby & Ortman, 2015). As the USA becomes increasingly diverse, the demographic makeup of the nation's postsecondary institutions is changing as well. Approximately 58% of today's college students

identify as White, which stands in stark contrast to the 84% of enrolled students in 1976 (U.S. Department of Education, National Center for Education Statistics, 2018). Despite these demographic changes, White men, in particular, remain overrepresented in engineering and many other science, technology, engineering, and mathematics (STEM) degree programs (Yoder, 2015).

Careers in STEM are one of the fastest-growing occupational clusters in the USA—falling second only to health care (Carnevale, Smith, & Melton, 2011). There were roughly 8.6 million STEM-related jobs in the USA in 2015 (Fayer, Lacey, & Watson, 2017), showing growth

* Correspondence: harwood@arch.utah.edu

³City & Metropolitan Planning Department, University of Utah, Salt Lake City, UT 84112, USA

Full list of author information is available at the end of the article

that outpaced prior projections (Carnevale et al., 2011). Additionally, studies point to the need to address the “low participation, representation, engagement, and inclusion in engineering and related STEM fields among underrepresented students” because to do so will “enrich the intellectual capacity of the U.S. STEM workforce” (Long III & Mejia, 2016, p. 216). With this growth and call for diversifying STEM, in 2015, Change the Equation—a nonprofit partnership among the Obama Administration, the Bill and Melinda Gates Foundation, the Carnegie Corporation of New York, and CEOs from some of the world’s most prominent technology companies including Intel and Xerox—called on “businesses, governments, educators, and other STEM advocates to join forces and address the massive unmet need for inspiring and educational STEM experiences” (Change the Equation, 2015, p. 3; Sabochik, 2010).

Although there has been a nationwide call for more diversity in the STEM fields for the past two decades, the results of these efforts have been slow and, in some cases, insignificant. Recruitment and retention in STEM remain pervasive at all levels of the pipeline. Nearly all STEM-related occupations in the USA require some kind of formal training beyond high school (Carnevale et al., 2011). Consequently, postsecondary institutions play a critical role in preparing the nation’s STEM workforce. According to a 2019 report by the National Science Foundation that examined graduating college students at 4-year institutions from 1996 to 2016, diversity efforts have been mixed for students of color graduating with engineering degrees. Over almost two decades, Latinx graduates have grown from 5.9 to 10.4% of graduates in this field. However, the proportion of Black students has decreased over this period from 4.7 to 3.86% (Hamrick, 2019).

Purpose

Scholars have made concerted efforts to understand the causes of race and gender disparities in STEM education and to offer solutions. Research has focused on individual-level factors, such as intrinsic interest in STEM (Bonous-Hammarth, 2000; Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkittaworn, 2007), high school GPA, and college entrance test scores (Bonous-Hammarth, 2000; Nicholls et al., 2007); institutional-level factors, including restrictive admissions policies (Long III & Mejia, 2016); and the relationship of institutional type (e.g., Historically Black Colleges and Universities, Hispanic-serving institutions) to undergraduate engineering degree completion (Chubin, May, & Babco, 2005). Sociocultural factors have also been investigated, considering implications of bias and stereotypes within engineering education environments (Long III & Mejia, 2016; Trytten, Lowe, & Walden, 2013) as well as strategies for resistance, persistence, and cultural reframing

of engineering education praxis (Samuelson & Litzler, 2016; Secules, Gupta, Elby, & Tanu, 2018; Secules, Gupta, Elby, & Turpen, 2018).

However, few studies examine the racial campus climate as contributing to representational disparities in the STEM profession. When students of color perceive a negative racial campus climate, academic persistence and retention rates fall (Chang, 1999; Reid & Radhakrishnan, 2003; Rodgers & Summers, 2008; Worthington, Navarro, Loewy, & Hart, 2008). Conversely, a positive racial environment contributes to a strong sense of belonging and is associated with higher grades and graduation rates for students of color (Booker, 2007; Brown, 2000; Goodenow, 1993; Hinderlie & Kenny, 2002; Strayhorn, 2008). The present study asserts that the racial climate, as informed by experiences with microaggressions at campus, academic, and peer levels, serves as a significant contributing factor in the low rates of students of color in STEM majors (see Fig. 1).

Literature and conceptual framing

The vast scholarship on diversity in higher education, racial campus climate, and racial microaggressions (RMAs) on college campuses demonstrates the long-standing problem of both explicit and subtle racial hostility, discrimination, and prejudice (Allen, 1992; Harper et al., 2011; Harper & Hurtado, 2007; Hurtado, 1992; Rankin & Reason, 2005; Solórzano, Ceja, & Yosso, 2000; Yosso, Smith, Ceja, & Solórzano, 2009). The racial climate of a campus may be discerned by considering “the current perceptions, attitudes, and expectations that define the institution and its members” (Hurtado, Milem, Clayton-Pedersen, & Allen, 1999, p. 5). Hurtado et al.’s (1999) campus racial climate framework denotes contexts of influence both external and internal to the campus environment.

External factors include the *government and policy context*, such as state and federal mechanisms for higher education funding as well as desegregation, diversity, and affirmative action policies that may significantly alter the postsecondary landscape at local and national levels. The *sociohistorical context*, such as the history of injustice within a society, social awareness of individuals and groups within a society, and social justice efforts at national and community levels, shapes the campus racial climate as well.

Internally, the institutional context is concerned with five dimensions (Milem, Chang, & Antonio, 2005). The first is the *institution’s legacy of inclusion and exclusion*, which examines institutional values, policies, and practices toward historically marginalized groups. For example, some of the largest bachelor’s, master’s, and doctoral degree-granting STEM programs in the USA exist at land-grant institutions (Morse & Tolis, 2013).

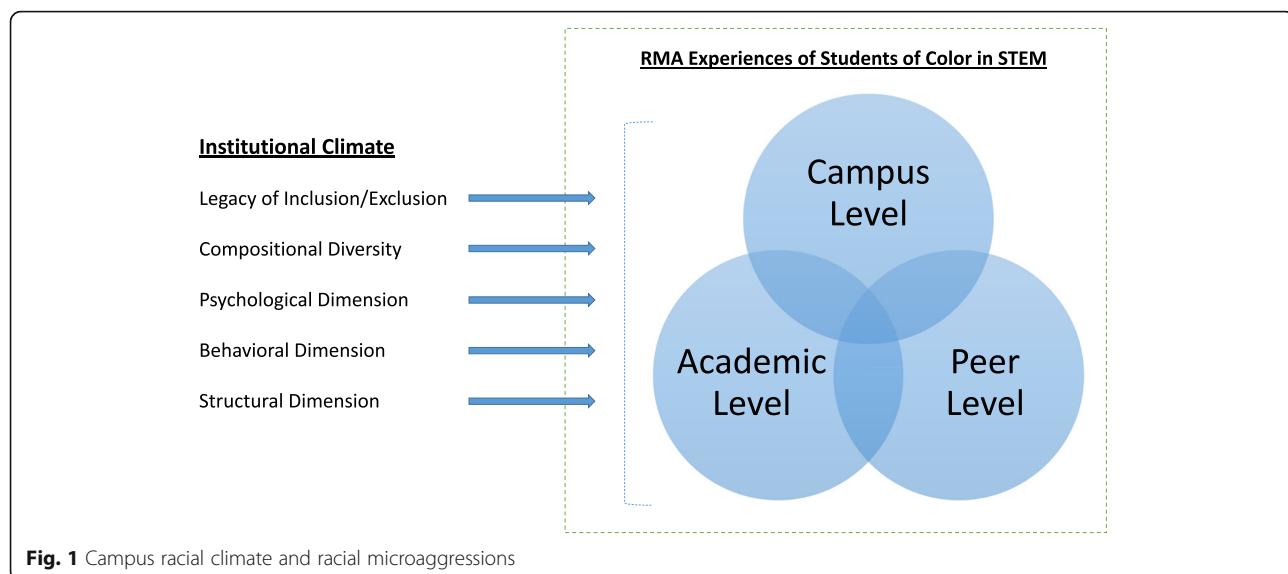


Fig. 1 Campus racial climate and racial microaggressions

Land-grant institutions were established as a result of the first Morrill Act, passed in 1862 for the express purpose of advancing applied research in agricultural, technical, mechanical, and natural sciences (Thelin, 2011). However, these same institutions denied admission based on race, gender, and/or religion. In 1890, a second Morrill Act provided funding for institutions that would later come to be known as Historically Black Colleges and Universities, effectively constituting a separate-but-equal doctrine for STEM education (Thelin, 2011).

The second component of campus racial climate is *compositional diversity*, which takes into account the numerical representation of various racial and ethnic groups on campus or within a campus environment. Racial representation of students in STEM is often attributed to pervasive stereotypes about intelligence and academic preparation based on race (McGee & Martin, 2011; McGee, Thakore, & LaBlance, 2017; Trytten et al., 2013). For Asian/Asian American students, representation in STEM is explained by such stereotypes as superior intelligence, strong work ethic, or excelling in math, all of which are a part of the model minority concept (McGee et al., 2017; Trytten et al., 2013). For Black and Latinx students, their underrepresentation is falsely attributed to personal characteristics such as inferior intelligence, weak work ethic, and deficiencies in mathematics (Long III & Mejia, 2016; Ma & Liu, 2015; Oakes, 1990).

These misconceptions may show up in the lives of students in the form of RMAs. When writing about Black-White relations in the post-civil rights era, Chester Pierce (1970, 1978) defined microaggressions as "subtle, stunning, often automatic, and nonverbal exchanges, which are 'put-downs' of Blacks by offenders" (1978, p. 66). Such exchanges in higher education establish an

atmosphere in which people of color are assumed to be inferior and are made to feel as if they do not belong. These types of exchanges make up the *behavioral dimension* of the campus racial climate framework, while the thoughts, attitudes, feelings, and beliefs regarding race, discrimination, and racial tension constitute the *psychological dimension* (Hurtado et al., 1999).

For instance, Black and Latinx students have reported feeling as though they have to prove that they belong, as they are assumed to be subpar compared with their peers, or are sometimes labeled by peers as "affirmative action" students (Camacho & Lord, 2011; McGee & Martin, 2011). Moreover, in a qualitative study with female students of color in an engineering major, Camacho and Lord (2011) found that participants had experienced racist and sexist microaggressions at both the institutional and interpersonal levels.

Since Pierce (1970, 1978), many others have documented the regularly occurring and sometimes subtle nature of racism and its effects (Coates, 2011; Dovidio, Gaertner, Kawakami, & Hodson, 2002; McConahay, 1986; Sears, 1988; Smith, 1995; Sue, Capodilupo, & Holder, 2008). Perhaps most notably, Sue (2010) has brought national attention to the concept of "racial microaggression," which refers to everyday and sometimes subtle mechanics of racism. Building upon Pierce's (1970, 1978) work, Sue et al. (2007) defined RMAs as "brief and commonplace daily verbal, behavioral, or environmental indignities, whether intentional or unintentional, that communicate hostile, derogatory, or negative racial slights and insults toward people of color" (p. 271). Sue et al. (2007) also created a typology of RMAs: microinsults, microinvalidations, and microassaults. Microinsults are "behaviors, verbal remarks or comments that convey rudeness, insensitivity, and demean a

person's racial heritage or identity" (p. 278). For example, if a bookstore employee asks to check the bags of a Black student but not a White student entering the building, this behavior, while possibly unconscious, conveys a message of criminality based on race. Microinvalidations are "verbal comments or behaviors that exclude, negate or nullify the psychological thoughts, feeling or experiential reality of a person of color" (p. 278). Like microinsults, microinvalidations may be unconscious. Examples of microinvalidations include seemingly innocuous questions such as "Where are you from?" and "Where were you born?" These questions are sometimes offensive because they assume that a person of color is foreign-born or not a US citizen.

Finally, microassaults are more overt, with purposeful discrimination at their core. Sue et al. (2007) state, "Microassaults are explicit racial derogations characterized primarily by a violent verbal or nonverbal attack meant to hurt the intended victim through name-calling, avoidant behavior or purposeful discriminatory actions" (p. 278). Unlike the "old-fashioned" racism that was public yet unchallenged, microassaults often occur anonymously or in a more private setting. An example of this is when non-Asian students speak in a pretend Asian language and laugh as an Asian student walks by the group.

Chronic exposure to such discrimination causes "racial battle fatigue" as well as harmful psychological and physiological effects such as fear, resentment, anxiety, helplessness, isolation, stress, and exhaustion (Clark, Anderson, Clark, & Williams, 1999; Smith, Hung, & Franklin, 2011). Additionally, the culmination of a lifetime of psychological, emotional, and physical exhaustion (Carroll, 1998; Smith, Allen, & Danley, 2007) "can theoretically contribute to diminished mortality, augmented morbidity, and flattened confidence" (Pierce, 1995, p. 281). Such experiences create a hostile learning environment in STEM programs and impact the attraction, persistence, and retention of students of color.

The present study advances the ever-important work of understanding and addressing disparities in STEM education, paying particular attention to the impacts of racial campus climate on students of color in STEM majors. One respondent in the present study discussed changing majors during her time at the university. She stated,

I changed my desired major from Engineering to Latin American Studies because of my race and sadly encountered others like myself within the humanities who had to change their major because of their race. If you aren't White, and you aren't Asian, and you aren't "Indian," you aren't an engineer (Latina, female, changed major from STEM to non-STEM).

If postsecondary institutions want to do their part in preparing a thriving, capable, and creative STEM workforce, they must be willing to acknowledge the role that pervasive racism plays in the weeding out of racially minoritized, underrepresented student populations.

Research questions and hypotheses

This study brings these findings and arguments together to pose the following questions: Do non-White STEM students face RMAs at the campus, academic, and/or peer levels? How do these experiences vary by race, gender, and class year? What are the specific types of RMAs experienced? How do RMAs contribute to the low numbers of underrepresented minorities in STEM majors?

Hypotheses

The study estimates a series of Poisson regressions to examine whether one's race can be used to predict the likelihood of the regular occurrence of microaggressions on the campus, academic, and peer levels. In examining racial climate on three levels for STEM students of color, we expect that those who identify as Black and Latinx will have higher rates of incidents of microaggressions (1) on the campus level, (2) in their academic interactions, and (3) from peers.

Methods

Setting and institutional climate

Data were collected at a predominantly White land-grant university in the USA. Although the institution has no written record of expressly forbidding the admission of students based on race, gender, religion, or nationality, the university did not witness its first non-White graduate until nearly 20 years after its founding. In the civil rights era, a push by student leaders and community advocates resulted in the largest-ever incoming class of African American students in the late 1960s. This degree of African American student enrollment has never been reached on the campus again. Issues of discrimination and marginalization based on race have surfaced throughout the institution's history. In recent years, predominantly White Greek organizations have hosted racially themed parties depicting stereotypical and degrading images of people of color. The campus has taken steps to create a more inclusive environment by implementing several diversity initiatives on campus, including mandatory peer-educator-led diversity training for first year students.

At the time of data collection, campus enrollment totaled over 40,000. Just over half of the student body identified as White, international students were the next-highest enrollment at 19%, Asian American students made up 11%, Latinx and African American students made up 6% and 5%, respectively, and Native

American and Hawaiian/Pacific Islander students made up less than 1% each.

Sample

During the 2011–2012 academic year, all domestic students of color were invited to complete a web-based survey. Domestic students included US citizens and permanent residents. An original list of possible respondents was gathered from enrollment and admission data that coded race, ethnicity, and citizenship information from all enrolled students at the university. Approximately 4800 students of color completed the online survey for a 45% response rate. This project followed the ethical and legal standards outlined by the Institutional Review Board for research involving human subjects. Informed consent was obtained from all individual participants in the study. As no names were collected in the survey, pseudonyms are used throughout the paper.

We restricted the data to cases with valid responses for all measures and limited the sample to students who had been identified as having a STEM major ($n = 1688$). We identified a major as STEM based on the university's categorization system. The university has 68 STEM majors, including computer science, agricultural science, animal sciences, biological sciences, engineering, mathematics, material science, physical sciences, physics, statistics, and veterinary medicine. While we wanted to focus solely on engineering, some of the cells were too small when the data were broken down by gender, race, and class level. Combining all the STEM students allowed us to create a more robust model. In our sample, 45% of the STEM students were engineering majors. Of those who identified as STEM majors, approximately 60% responded to the open-ended questions (see Table 1).

Measures and statistical analysis

The web-based survey comprised 36 Likert-scale questions, three open-ended questions, eight place-based questions, and 15 demographic questions. The survey was designed to examine racial experiences in which a student of color felt uncomfortable, insulted, or invalidated because of his or her race, and how students coped with RMAs and feelings of marginalization. The creation of the web-based survey was guided by the literature on RMAs (Sue, 2010) and campus climate assessments (Hurtado, Griffin, Arellano, & Cuellar, 2008),

Table 1 Number of respondents by major

	All Majors	STEM	Engineering
All respondents	4488	1688	755
Respondents to open-ended qualitative questions	2774	993	468

as well as previous research by the authors, including 11 focus groups prior to the survey (Harwood, Hunt, Mendenhall, & Lewis, 2012). The questions were adapted from the Schedule of Racist Events (Landrine & Klonoff, 1996), the Index of Race-related Stress (Utsey, 1999), and the Racial Life Experiences Scale (Harrell, 1997).

The survey asked questions specifically targeted to student life as members of a campus community. We separated these into three indexes to reflect three key parts of the lives of students: experiences on campus in general, experiences in academic settings (for example, exchanges with instructors or academic advisers), and peer interactions. We recognize that these levels overlap and interact. For all of the questions making up the three indices, students were prompted: "Think about your racial experiences as a student of color on this campus. Please read each item and think of how often each event has happened to you during your time here at the university."

The study estimated a series of Poisson regressions to examine whether one's race can be used to predict the likelihood of the regular occurrence of microaggressions on the campus, academic, and peer levels. Poisson regressions are used when the dependent variables are count variables that can appear to be continuous but have a range of under 100 (Liao, 1994). The dependent variables in this study were count variables. While Poisson regression measures the probability that an event will take place, in this study, it was used to predict the probability of higher incident rates of RMAs.

Dependent variable: campus level

To measure RMAs on the campus level, five variables were indexed. The campus-level questions were designed to capture general feelings about being a student of color on campus. The variables were responses to the following statements:

- (1) I have felt excluded by others on this campus because of my race.
- (2) I have felt invisible on this campus because of my race.
- (3) I have felt that the campus is informally segregated based on race.
- (4) I have felt unwelcomed on this campus because of my race.
- (5) I have experienced feelings of isolation on this campus because of my race.

From the Likert-scale responses, each of the five variables had a possible score from 0 to 5. If a student had never had the feeling, the response was coded as 0; less than once a year, coded as 1; a few times a year, coded as 2; about once a month, coded as 3; a few times a month, coded as 4; or once a week or more, coded as 5.

The reliability score of the index was .85. A count variable was then created combining the scores from the five original variables. The range of the count variable was 0 to 25 with a mean score of 5.54.

Dependent variable: academic level

To measure RMAs on the academic level, five variables were indexed. This level attempted to capture experiences in formal academic settings such as in the classroom and other academic interactions with instructors, teaching assistants, and academic advisers. The variables were responses to the following statements:

- (1) I have had my contributions minimized in the classroom because of my race.
- (2) I have been made to feel like the way I speak is inferior in the classroom because of my race.
- (3) I have had stereotypes made about me in the classroom because of my race.
- (4) I have experienced not being taken seriously in my classes because of my race.
- (5) I have experienced discouragement in pursuing my academic or educational goals because of my race.

The students were given the same possible responses as above. The reliability score of the index was .86. Again, a count variable was then created combining the scores from the five original variables. The range of the count variable was 0 to 25 with a mean score of 2.97.

Dependent variable: peer level

To measure RMAs on the peer level, six variables were indexed. These questions attempted to capture interpersonal interactions, particularly with other students. While the questions did not specifically state "with peers," the qualitative results suggest that these types of experiences often happened between students. The variables were responses to the following statements:

- (1) I have experienced negative and insulting comments because of my race.
- (2) I have experienced harassment (emotional, verbal, or physical) on campus because of my race.
- (3) I have personally experienced racism on campus.
- (4) I have experienced someone making offensive jokes to me on this campus because of my race.
- (5) People have made me feel intellectually inferior on this campus because of my race.
- (6) I feel that people treat me negatively on this campus because of my race.

The students were given the same possible responses as above. The reliability score of the index was .91. A count variable was also created here combining the scores from the six original variables. The range of the count variable was 0 to 30 with a mean score of 5.24.

Independent variable: race

The sample included only students whom the university identified as non-White. Additionally, students were asked how they identified regarding their race. Students were able to choose from a list of categories or write in a response. Dummy variables were created for five racial categories: Black/African American, Asian/Asian American, Latinx/Hispanic, Native American/Indigenous, and Other Race. The "Other Race" variable combined those who indicated that they were biracial or multiracial.

Independent variable: gender

Students were coded as male or female based on the data provided by the university. Unfortunately, our data included only male or female. Students who identified as gender nonconforming or transgender were coded as the gender that was specified at admission. Dummy variables were then created for both males and females.

Independent variable: class year

Dummy variables were created for each class year represented in the sample. This included first year students, sophomores, juniors, and seniors, as well as graduate students. See Fig. 2 for the mean of the frequency of campus, academic, and peer level RMA indices by race and gender.

Open-ended questions

The open-ended portion of the survey resulted in more than 8000 anecdotes related to racial marginalization on campus. The open-ended questions asked students to describe (a) when they felt uncomfortable, insulted, invalidated, or disrespected by a comment that had racial overtones; (b) when others subtly expressed stereotypical beliefs about race/ethnicity; and (c) when others suggested that they did not belong on campus because of their race or ethnicity.

The study drew from qualitative data to further reveal the RMAs occurring on the campus, academic, and peer levels. The qualitative data were embedded with the quantitative to provide a deeper understanding of RMAs (Creswell & Clark, 2017; Creswell & Creswell, 2017; Morse, 1991). Because RMAs are often subtle and nebulous, the student responses to the qualitative questions helped to account for the complexity of their lived experiences and served as a means to add nuance to the quantitative findings.

Analysis

Quantitative analysis

The first model in each table shows the relationship between the dependent variable and racial identity.

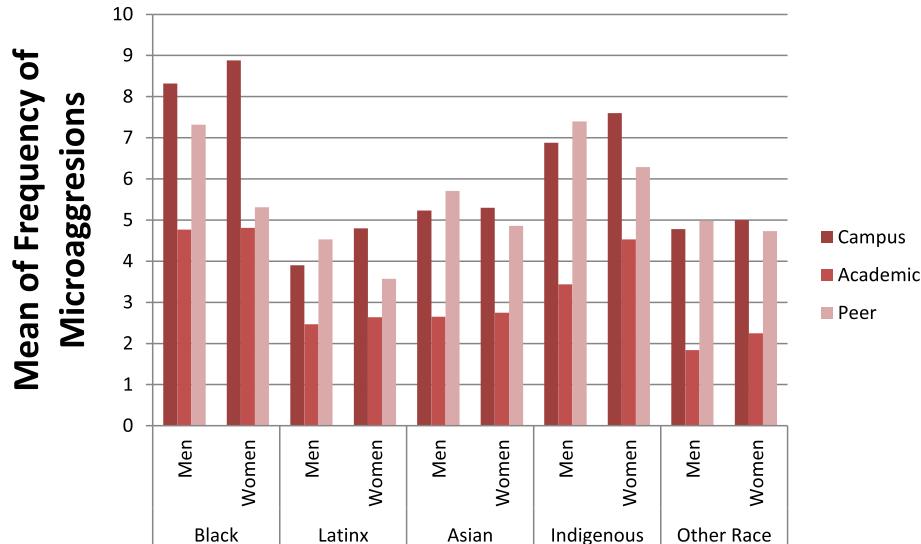


Fig. 2 Experiences of microaggressions by race and gender

Black, Latinx, Asian, Native American, and Other Race are included in the model. The second model includes gender; women are included in the model and men are the reference. The third model includes class level (e.g., sophomore, junior, etc.). See Fig. 2 for a breakdown of RMA mean scores by race and gender.

Qualitative analysis

Using our conceptual model (Fig. 1) as a guide, we employed a deductive analytical approach to identify instances of RMAs experienced by non-White STEM students on campus, in formal academic settings, and between peers. This deductive approach, also known as a template approach (Crabtree & Miller, 1999), included a series of codes developed before the analysis of the open-ended responses.

In the first step of the analysis, we used structural coding (Saldaña, 2015) to distill our initial sample of more than 8000 anecdotes down to those that were most likely to be reported by students of color in STEM. Structural coding "acts as a labeling and indexing device, allowing researchers to quickly access data likely to be relevant from a particular analysis from a larger data set" (Namey, Guest, Thairu, & Johnson, 2008, p. 141). We used 28 keywords, including *engineering*, *engineer*, *STEM*, *math*, *science*, *statistics*, *med*, *lab*, and *technology*, in addition to names of prominent STEM buildings and labs on campus, and formal and colloquial names of STEM degree programs and courses, in this sorting process. We then used nested coding (Saldaña, 2015) to simultaneously examine the types of RMAs experienced (Sue et al., 2007) and the context in which the RMAs occurred (campus, academic, or peer level).

Results

Table 2 presents the descriptive statistics of both the outcome and explanatory variables of the sample. All variables used in the models are included along with their mean, standard deviation, and range. For the dependent variables, the mean references the total score of the scaled variable. The sample of respondents included students of color in STEM majors from a large public university. Asian students made up 48% of the sample, while Black students represented 10%, Latinx

Table 2 Descriptive statistics for STEM respondents

Variables	STEM Respondents <i>n</i> = 1688		
	Mean	SD	Range
Dependent variable			
Campus level RMAs	5.54	5.18	0 to 25
Academic level RMAs	2.97	4.12	0 to 25
Peer level RMAs	5.24	5.83	0 to 30
Independent variables			
Black/African American	0.10	0.30	0 to 1
Asian/Asian American	0.48	0.50	0 to 1
Indigenous/Native American	0.03	0.15	0 to 1
Latinx/Hispanic	0.15	0.36	0 to 1
Other Race	0.09	0.29	0 to 1
Female	0.43	0.49	0 to 1
First Year	0.01	0.06	0 to 1
Sophomore	0.19	0.39	0 to 1
Junior	0.19	0.39	0 to 1
Senior	0.31	0.46	0 to 1
Grad student	0.21	0.41	0 to 1

The table reports means, ranges, and standard deviations for all variables

students 15%, and Native Americans 3%. All other students in the sample were identified as Other Race. The majority of students were in the later years of their undergraduate studies or were in graduate school when surveyed. Graduate students made up 21% of the sample, those who identified as seniors were 31% of the sample, juniors and sophomores were each 19% of the sample, and first years were 1%. We believe the latter category was so small because the survey was taken early in the school year and first years were just starting to get acclimated to their new surroundings. Additionally, many “first year” students at the university enter with enough credits to be classified as sophomores or juniors.

Campus level—quantitative

There is evidence of an effect of racial identity on experiences of microaggressions for STEM students at the campus level. Table 3 presents the results of a series of Poisson regressions that predict the incidence rate ratios (IRR) of the probability one will face frequent RMAs on campus. Each model progresses from racial identity to gender identity to class year. The results from model 1 indicate that STEM students who identify as Black have a 54% (IRR = 1.539, $p < .001$) probability of experiencing more frequent microaggressions compared with other students of color. Asian students, Latinx students, and Other Race students are less likely to experience these incidents. Asian students experience

RMAs at about a 7% rate (IRR = 0.93, $p < .01$), Latinx students at a 24% rate (IRR = 0.76, $p < .001$), and Other Race students at a 15% rate (IRR = 0.853, $p < .001$) in model 1.

Model 2 builds upon the previous model by adding gender identity. Again, Black students have a higher probability of experiencing frequent RMAs with an increase of over 20% at the same significance level (IRR = 1.802, $p < .001$). When controlling for gender, the probability is now increased for Asian students and they are more likely to experience microaggressions (IRR = 1.121, $p < .001$) by 21%. When gender is introduced as a control variable, female students of color experience microaggressions at a 7% higher probability (IRR = 1.071, $p < .01$).

Finally, model 3 builds upon the previous models by including the class year. When the class year is added, there remains a significant relationship for Black students regarding the frequency of experiencing RMAs (IRR = 1.765, $p < .001$), and Latinx students still have a decreased probability of experiencing RMAs (IRR = 0.7881, $p < .001$). Women still have an increased probability of experiencing RMAs, but the rate is slightly decreased from 7.1% to 5.9% (IRR = 1.059, $p < .05$). In addition, graduate students have a decreased probability of about 20% of experiencing frequent incidents of RMAs on the campus level (IRR = 0.798, $p < .001$). These findings allow us to better understand how often students of color may be exposed to RMAs.

Table 3 Poisson regression predicting campus level microaggressions for all STEM students surveyed

Variables	Model 1		Model 2		Model 3	
	IRR	SE	IRR	SE	IRR	SE
Race						
Black/African American	1.539***	(0.053)	1.802***	(0.1)	1.765***	(0.099)
Asian/Asian American	0.930**	(0.025)	1.121*	(0.060)	1.103	(0.06)
Indigenous/Native American	1.129	(0.072)	1.193**	(0.079)	1.217**	(0.081)
Latinx/Hispanic	0.760***	(0.028)	0.901	(0.051)	0.881*	(0.05)
Other race	0.853***	(0.033)	0.905*	(0.037)	0.928	(0.039)
Gender						
Female			1.071**	(0.026)	1.059*	(0.026)
Student status						
First year					1.249	(0.198)
Second year					1.027	(0.049)
Third year					1.045	(0.05)
Fourth year					1.014	(0.046)
Grad student					0.798***	(0.04)
Constant	5.71	(0.13)	4.59	(0.24)	4.81	(0.32)
Goodness of Fit Chi-squared	357.63***		368.34***		426.61***	

Exponentiated coefficients; standard errors in parentheses

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Campus level—qualitative

Many students of color in STEM majors experience racism at the campus level. Model 3 indicates that at a campus level, Black STEM students have a higher likelihood and greater frequency of experiencing RMAs than other students of color in STEM. Female students of color are more likely to experience RMAs than men. STEM undergraduates of color are more likely to experience more RMAs than graduate students in STEM. The student responses from the qualitative data help us understand what these campus-level microaggressions look like for all students of color.

Students in our study described feeling rejected and ignored on and off-campus. They noticed informal segregation on the campus as well. Jay said, "I feel excluded from a lot of social activities that do not include people of my race" (Asian, male, STEM). Many described eagerness to meet new people at the beginning of the school year, but experienced rejection when they tried to make friends. Marco described feeling excluded in the cafeteria:

I once tried to sit down at a random table in the cafeteria with my roommate to make friends during the first week of school last year. I felt like the people we sat down with were not open to us and weren't interested in being our friends. We sat in the next table, and then another random person sat down where we had sat, that person was of the same race as the person that we had left. My roommate and I are the same race, we felt a little discriminated for being different. I did nothing, I have made friends primarily only with people of my own race now. (Latino, male, STEM)

In both of these examples, Jay and Marco felt treated as second-class citizens. Sue et al. (2007) describe such experiences as microinsults, where behaviors and comments signal that a person is "less than" and convey the message "You don't belong."

Whether it was subtle or explicit, students of color experienced a hostile climate as soon as they arrived on campus. The respondents provided many examples of microassaults as well as explicit racial verbal assaults. These were purposeful acts, often involving name-calling. The "micro" refers to the everyday and often subtle nature of such aggressions. Amy told us about her experiences with name-calling: "Sometimes when I walk around an area with people that are a majority that are not my race, I would experience being called with derogatory words" (Asian, female, STEM). On the other hand, Jackson, who "passes" as White, did not feel "uncomfortable, insulted, invalidated or disrespected": Because "I'm lighter-skinned, people sometimes don't even

realize that I'm Black" (Black, male, STEM). Jackson's experience suggests that appearance matters.

Academic level—quantitative

There is evidence of an effect of racial identity on experiences of microaggression for STEM students at the academic level. Table 4 presents the results of a series of Poisson regressions that predict the incidence rate ratios of the probability that one will face frequent RMAs with instructors, teaching assistants, and advisers. Each model progresses from racial identity to gender identity to class year. The results from model 1 indicate that STEM students who identify as Black have a 57% (IRR = 1.566, $p < .001$) increased probability of experiencing more frequent RMAs. Asian students, Latinx students, and students who identify as Other Race have a decreased probability of these incidents. Asian students experience RMAs less, at about a 14% rate (IRR = 0.865, $p < .001$), Latinx students at a 17% rate (IRR = 0.832, $p < .001$), and those who identify as Other Race at a 37% rate (IRR = 0.631, $p < .001$) in model 1.

Model 2 builds upon the previous model by gender identity. Again, Black students have an increased probability of experiencing frequent RMAs with a slight increase at the same significance level (IRR = 1.619, $p < .001$). When controlling for gender, students in the Other Race category have a decreased probability (IRR = 0.644, $p < .001$). Of the newly introduced control variables, women experience RMAs at a 9% increased probability (IRR = 1.088, $p < .01$).

Model 3 then builds upon the previous models by including the class year. When these new variables are added, the significant relationship for Black students as well as Other Race students regarding the frequency of experiencing RMAs is unchanged. Women still have an increased probability, but the rate is slightly decreased (IRR = 1.077, $p < .05$). Of the newly introduced measures of the respondents, graduate students have a decreased probability of about 15% of experiencing frequent RMAs on the campus level (IRR = 0.856, $p < .05$), while all undergraduate students significantly have an increased probability of experiencing these microaggressions at a more frequent rate.

Academic level—qualitative

Qualitative data indicated that students of color also experienced RMAs in a variety of academic contexts, including meeting with faculty during office hours, talking with teaching assistants before or after class, and meeting with advising personnel. Students were made fun of because they did not know how to do something. Latonya told us about her humiliating experience during office hours:

Table 4 Poisson regression predicting classroom level microaggressions for all STEM students surveyed

Variables	Model 1		Model 2		Model 3	
	IRR	SE	IRR	SE	IRR	SE
Race						
Black/African American	1.566***	(0.073)	1.619***	(0.127)	1.619***	(0.129)
Asian/Asian American	0.865***	(0.034)	0.918	(0.07)	0.917	(0.071)
Indigenous/Native American	1.161	(0.101)	1.176	(0.106)	1.198*	(0.108)
Latinx/Hispanic	0.832***	(0.041)	0.879	(0.07)	0.882	(0.071)
Other race	0.631***	(0.038)	0.644***	(0.041)	0.662***	(0.042)
Gender						
Female			1.088*	(0.037)	1.077*	(0.037)
Student status						
First Year					2.262***	(0.413)
Sophomore					1.191*	(0.082)
Junior					1.353***	(0.092)
Senior					1.163*	(0.076)
Grad student					0.856*	(0.061)
Constant	3.18	(0.1)	2.89	(0.22)	2.58	(0.29)
Goodness of fit Chi-squared	265.74***		260.80***		349.44***	

Exponentiated coefficients; standard errors in parentheses

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

I was in a [STEM] class. ... I went to office hours that were being held before an exam later on in the day and I asked one of the TA's there a question regarding the material and he laughed in my face about what I was asking him. I felt highly insulted and he made me feel as though I wasn't smart enough to be in the [STEM] program. (Black, female, STEM)

It is ironic that during office hours, a time for students to ask for guidance, they are laughed at. Another STEM student mentioned an instructor who told him that if he had to go to office hours, he should change majors. Similar experiences occurred with academic advisers: "Coming in as a [STEM] student I was not given support by my [STEM] advisor. [This person] frequently discouraged my path to [STEM], and even suggested I try other majors because I may not be able to graduate with a degree in [STEM]" (Latina, female, STEM). Even at high administrative levels, students did not feel supported when reaching out for help:

I met with a dean and told him my situation, and he nonchalantly told me that I should change my major because [STEM] was too hard for me. I was completely shocked ... he didn't try to help me out, he didn't make any suggestions to help me improve my situation or my study habits, he offered NO encouragement AT ALL! ... I felt like he was looking

down on me because of my race and socioeconomic background. (Black, male, changed major from STEM to non-STEM)

Someone might suggest that these types of behavior have nothing to do with race, and that faculty say such things to all students, but that is not how students of color experienced these interactions. For the students in our study, these attitudes and comments evoked long-held beliefs about the intelligence of people of color (Aronson, Fried, & Good, 2002). Valuing raw talent and "untutored genius" over supporting and mentoring students for success works against diversifying the student body in STEM majors (Storage, Horne, Cimpian, & Leslie, 2016).

Additionally, Asian students described being humiliated by instructors when they struggled with course materials. Unlike Black and Latinx students who were stereotyped as unprepared for college, Asian students were expected to excel. John described the pressure to perform and to know all the answers: "People assume that I should understand the math and science better than the rest of the group. They may say things like 'You're Indian, tell us how to do it'" (Asian, male, STEM).

Peer level—quantitative

This study found evidence of a racial identity effect on experiences of RMAs for STEM students at the peer

level. Table 5 presents the results of a series of Poisson regressions that predict the incidence rate ratios of the probability one will face frequent microaggressions from peers. Each model progresses from racial identity to gender identity to class year. The results from model 1 indicate that STEM students who identify as Black have a 13% (IRR = 1.134, $p < .01$) increased probability of experiencing more frequent RMAs, while Latinx students and students who identify as Other Race have a decreased probability of experiencing these incidents. Latinx students experience RMAs less often, at about a 24% rate (IRR = 0.763, $p < .001$), and those who identify as Other Race at an 8% rate (IRR = 0.924, $p < .05$) in model 1.

Model 2 builds upon the previous model by gender identity. Similar to campus and academic levels, at the peer level, Black students have an increased probability of experiencing frequent RMAs (IRR = 1.344, $p < .001$). When controlling for gender, Latinx students have a decreased probability of having these experiences (IRR = 0.881, $p < .05$). Asian students now have an increased probability (IRR = 1.159, $p < .01$), by about 16%. Of the newly introduced control variables, interestingly, women experience RMAs at an 18% decreased probability (IRR = 0.822, $p < .001$).

Again here, model 3 builds upon the previous models by including the class year. When these new variables are added, the significant relationship for Black students and women regarding the frequency of experiencing

microaggressions is unchanged. Of the newly introduced measures of the respondents, graduate students have a decreased probability of about 25% of experiencing frequent RMAs on the campus level (IRR = 0.754, $p < .001$), while first year students have an increased probability, at a rate of 82% (IRR = 1.819, $p < .001$).

Peer level—qualitative

During their first year, students of color quickly experienced how race became the focal point for explicit and subtle harassment and exclusion around campus, especially in the classroom. Due to the low numbers of Latinx and Black students in the STEM majors, these students' peers assumed they did not belong. This feeling related to the psychological and compositional diversity dimensions of campus racial climate. Students reported that being the "only one" or "one of few" in STEM classrooms contributed to "feeling isolated," "discouraged," and "invalidated." Sue et al. (2007) refer to these events, signals, and spaces as "environmental microaggressions." The lack of students of color sends a message that students of color, particularly Black and Latinx students, do not belong and will not succeed in STEM majors. Interactions with peers reinforced the feeling of not belonging. Andre, a first-year student, explained how this played out for him: "A student asked me if '[I] [was] sure I was in the right class' midway through the semester of a [STEM] class I have attended regularly" (Black, male, STEM). There were so few

Table 5 Poisson regression predicting peer level microaggressions for all STEM students surveyed

Variables	Model 1		Model 2		Model 3	
	IRR	SE	IRR	SE	IRR	SE
Race						
Black/African American	1.134**	(0.044)	1.344***	(0.078)	1.336***	(0.079)
Asian/Asian American	1.007	(0.028)	1.159**	(0.063)	1.147*	(0.063)
Indigenous/Native American	1.265***	(0.084)	1.357***	(0.093)	1.388***	(0.096)
Latinx/Hispanic	0.763***	(0.029)	0.881*	(0.051)	0.872*	(0.051)
Other race	0.924*	(0.036)	0.962	(0.040)	0.992	(0.042)
Gender						
Female			0.822***	(0.021)	0.814***	(0.021)
Student status						
First year					1.819***	(0.282)
Sophomore					1.014	(0.05)
Junior					1.110*	(0.054)
Senior					1.025	(0.048)
Grad student					0.754***	(0.039)
Constant	5.36	(0.13)	4.99	(0.27)	5.15	(0.35)
Goodness of fit Chi-squared	111.57***		170.97***		291.17***	

Exponentiated coefficients; standard errors in parentheses

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

students of color in the STEM classroom that they were often rendered invisible.

Students of color majoring in STEM also describe overhearing conversations in which peers stated that Black or Latinx students get into college only because of their race, not based on intelligence. Students reported that such comments were “disheartening” and “disappointing.”

I was in a [STEM] class my freshman year sitting next to a group of Caucasian males when I overheard them say something along the lines of “This school continues to get more and more Mexican.” This was a bit offensive to me, considering that they said it not too long after I sat down. (Latino, STEM)

A lot of people automatically assume that since I’m a Black female that I should be a [non-STEM] major. Every time I walk into a lab, I always get looks. I’m not sure if it’s because I don’t “look” like a [STEM] major in general or if it’s because I’m Black. (Black, female, STEM)

Students of color reported expecting a more inclusive environment at a top public university. Racial epithets, put-downs, stares, and other forms of name-calling by their peers contributed to them feeling unwelcome and pushed out of the STEM pipeline.

Black and Latinx students wrote extensively about how White and Asian students did not want to work with them in the lab, during discussion sections, or during group projects because of negative stereotypes about their intelligence and work ethic. A Black female who changed her major from STEM to non-STEM stated, “In lab others never want to be my lab partner because they assumed that as a Black person I did not know how to perform in a lab.” We found many other examples of this dynamic in the qualitative results:

Whenever we had to pick lab partners, I would always ask a person if they wanted to be my lab partner. Most of them would look at me and say no or that they already have one and go look for someone else. (Black, female, STEM major)

It’s hard sometimes for me to contribute to a problem when I feel they don’t take my input seriously. They always ask each other for help when they get stuck. I’m never asked for help ... it makes me feel like college might not be for me. All I can do for

now is continue to contribute whether they pay attention or not. (Latino, STEM)

There have been times I’ve felt uncomfortable in my [STEM] lab sections. No one said anything disrespectful, but I felt inferior because there were only two Black people—me and another person. Somehow, we always seemed to be partners, and no one ever suggested being partners with us. I would always plan to do something about it ... but it never worked out because I didn’t feel confident in asking. (Black, male, changed major from STEM to non-STEM)

While not always explicit, such behaviors are micro-insults; embedded in the interactions are assumptions about the level of intelligence based on race. Feeling excluded, unsupported, and not valued contributed to leaving the STEM major. Students reported that they left the STEM major as a consequence of feeling marginalized and pushed out, which is consistent with other studies about the importance of a sense of belonging for women and students of color in choosing to stay or leave STEM majors (Rainey, Dancy, Mickelson, Stearns, & Moller, 2018).

Discussion

STEM students of color experience racism, both explicit and subtle, at the campus, academic, and peer levels. The study’s analysis by race, gender, and class year revealed important differences and similarities. And while we looked for other explanations, race trumped gender and class year in understanding the occurrence of RMAs for STEM students. By examining both the quantitative and qualitative data, we found that even when the occurrences of RMAs were fewer, they nonetheless made an impact on the emotions, confidence, and retention of students of color in STEM fields.

Most studies look at the racial campus environment at large and do not drill down into particular majors. In the present study, students of color who were STEM majors overheard racist jokes and comments in the classroom and racial slurs while walking to class. STEM students of color described feeling both hypervisible and invisible. Students of color felt excluded from groups or social activities. Even worse, students of color reported comments from faculty and staff in positions of authority who dismissed, discouraged, ignored, and even made fun of them. The low percentage of Black and Latinx students in STEM majors is not about academic preparation, as some argue; rather, our study suggests that the lack of diversity can be explained by a historical, demographic, behavioral, and psychological dimension of a

campus culture that is systemically hostile to students of color.

This research also reveals how much more intense that experience is for Black students. Black STEM students are at risk of experiencing RMAs more habitually due to anti-Black racism at all levels. Some Black students reported experiencing this hostility weekly. Our findings are consistent with what others have found about Black students' experiences of RMAs in higher education settings. Studies show that White individuals perceive Black students to be intellectually inferior, second-class citizens, criminals, and of inferior status (Sue et al., 2008). Black students report little interaction with faculty (Allen, 2010), and also report that constant RMAs from their instructors and peers lower their academic motivation (Solórzano et al., 2000).

Additionally, STEM students of color experience RMAs regardless of racial background. The findings for STEM students in this study mirror the findings from other studies that focus on one racial group. We see parallels between research on domestic students of color of different racial backgrounds and international students as well. Yosso et al. (2009) found that Latinx students at a predominantly White university campus reported that they were experiencing both interpersonal and institutional microaggressions. Native Americans experienced "academic and social isolation" (Clark, Spanierman, Reed, Soble, & Cabana, 2011, p. 43). Bailey (2015) found that Native students experienced having their culture laughed at and viewed as primitive. More studies are coming out on the experiences of RMAs for Asians in higher education, including studies about international Asian students. These students feel ignored, invisible, and unwelcomed by their White peers (Houshmand, Spanierman, & Tafarodi, 2014; Kwan, 2015; Sue, Bucceri, Lin, Nadal, & Torino, 2009; Trazo & Kim, 2019; Yeo, Mendenhall, Harwood, & Hunt, 2019).

Finally, the quantitative and qualitative data suggest that RMAs are not isolated incidents; rather, RMAs are systematically engrained in the campus culture (Harwood, Mendenhall, Lee, Riopelle, & Hunt, 2018). It is well documented that campuses are racially charged environments, but less is known about how racial campus climate plays out in particular majors. Our findings indicate that Black students majoring in STEM are much more likely to experience RMAs at the campus, academic, and peer levels. With so few Black and Latinx students in STEM majors, our study demonstrates the need for academic departments to address the impacts of the large campus culture on their academic programs as well as how their own departmental culture reinforces the campus level racial hostility.

STEM departments must value diversity beyond the numbers. Students of color must feel that they belong in

STEM majors and not as if they have to fit in (Feagin, Vera, & Imani, 1996; Rainey et al., 2018). Campus officials, academic professionals, faculty members, and students must work together to address discrimination at the campus, academic, and peer levels to expand the pipeline of underrepresented populations going into STEM careers. This means that academic departments cannot wait for the larger campus culture to change; they must also examine their histories, structures, and policies to create access to the STEM fields for both male and female students of color, particularly those from the most underrepresented racial identities.

Diversifying who studies in a STEM major requires intentional strategies aimed at transforming the academic culture, including a recognition that race and gender shape the perception and preference of instructional style (Rainey, Dancy, Mickelson, Stearns, & Moller, 2019), as well as the importance of mentoring (Martin-Hansen, 2018; Robnett, Nelson, Zurbriggen, Crosby, & Chemers, 2018; Rodríguez Amaya, Betancourt, Collins, Hinojosa, & Corona, 2018), and supporting faculty to move away from the traditional lecture-based pedagogy and toward instructional practices that improve student learning and help retain majors (Czajka & McConnell, 2016; Zaniewski & Reinholtz, 2016). This is possible only if the STEM curriculum also emphasizes the need to work effectively in a diverse society by demonstrating the relationship between the inclusion of diverse perspectives and talents and STEM's ability to innovate and solve society's toughest problems.

Conclusion

Through the examination of students' experiences with RMAs at the campus, academic, and peer levels, the present study considered the role of campus racial climate in contributing to representational disparities in the STEM professions. Future research can continue to build upon our findings in several ways. First, future research can examine additional dimensions of campus racial climate. Our study focused primarily on the behavioral and psychological dimensions of students' experiences and perceptions. It is worth investigating the influence of external factors, such as government funding initiatives and the national sociopolitical context, as well as additional internal factors, such as admissions and coursework policies, on students' racialized experiences in STEM programs. Second, research can more fully examine the nature of RMAs that STEM students face at the campus, academic, and peer levels using specific-group and/or intersectional approaches. Additional research on subpopulations of Asian American, Asian international, Latinx/Hispanic, Native American/Indigenous, and Caribbean American students would be particularly useful given the changing demographics of

college campuses in the USA. Moreover, studies that take into account the intersections of race with other identities such as gender, religion, ability status, national origin, and sexual orientation will illuminate student experiences and outcomes that may otherwise be overlooked. Finally, future studies should consider disaggregating the STEM discipline into specific majors or occupational clusters to more fully understand the nature and scope of racial disparities and racial discrimination to provide tailored and targeted educational interventions.

Abbreviations

RMAs: Racial microaggressions; IRR: Incidence rate ratios; STEM: Science, technology, engineering, and mathematics

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Authors' contributions

All of the authors contributed to the paper conceptualization and writing; ML developed the models and quantitative analysis; JDC and SAH did the qualitative analysis. All authors read and approved the final manuscript.

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Availability of data and materials

Due to the sensitive nature of our data, we will not publicly share the data set. However, we welcome inquiries.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Department of Sociology, University of Illinois, Urbana-Champaign, Urbana, IL 61820, USA. ²Agricultural Leadership, Education & Communications, University of Illinois, Urbana, IL 61801, USA. ³City & Metropolitan Planning Department, University of Utah, Salt Lake City, UT 84112, USA. ⁴Department of Sociology and African American Studies, Carle Illinois College of Medicine, University of Illinois, Champaign, IL 61820, USA. ⁵Cancer Center at Illinois, University of Illinois, Urbana, IL 61801, USA.

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