The Making of Future Scientists: Faculty Mentor Cultural Awareness and Inclusive Science Labs

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ABSTRACT

A compelling body of research suggests that students from racially marginalized and minoritized (RMM) backgrounds are systematically deterred from Science, Technology, Engineering, and Math (STEM) fields when teachers and scientists create ideologically colorblind STEM learning environments where cultural differences are deemed irrelevant and disregard how race/ethnicity shapes students' experiences. We examine whether and how STEM faculty can serve as important sources of information that signal racial/ethnic diversity inclusion (or exclusion) that influence RMM students' motivation to persist in STEM. Specifically, we focus on RMM students' perceptions of their faculty research mentors' cultural awareness—the extent to which students believe that their faculty research mentor acknowledges and appreciates racial/ethnic differences in STEM research. Results from a longitudinal survey of RMM students (N = 150) participating in 74 faculty-led STEM research labs demonstrated that RMM students who perceived their faculty research mentor to be more culturally aware experienced more positive *social climates* in the lab and were more *identified as scientists*. Increased science identity, in turn, predicted their motivation to pursue STEM careers 3 months later. These findings demonstrate the importance of acknowledging, welcoming, and celebrating racial/ethnic diversity within STEM learning environments to broaden inclusive and equitable participation in STEM.

INTRODUCTION

Greater scientific discoveries and more innovative solutions to important societal issues would emerge from a scientific research force that is more racially/ethnically diverse (National Science Foundation, 2022). Yet, the authentic participation of students from racially marginalized and minoritized (RMM) backgrounds in Science, Technology, Engineering, and Math (STEM) is often obstructed because of core cultural values that include colorblind and egalitarian ideologies favoring "identity-free, objective" science (Harding, 2015; Hughes *et al.*, 2022; Russo-Tait, 2022, 2023). To be sure, the idea that science is objective, culturally irrelevant, and identity-neutral is strongly ingrained in the ethos of STEM culture (Prunuske *et al.*, 2013; Cech *et al.*, 2018; McGee, 2020). When scientists and science educators create ideologically colorblind STEM learning environments, where cultural differences are deemed irrelevant and disregard how race/ethnicity shapes students' experiences in STEM, students from RMM (Black, Latinx, Indigenous) backgrounds are deterred and excluded from important STEM pathways (Carlone and Johnson, 2007; Ong *et al.*, 2011; Russo-Tait, 2022, 2023). Indeed, the decision to pursue alternative academic and career paths among RMM students is influenced by exclusionary STEM learning environments (Chang *et al.*, 2011; McGee, 2016; Thiry *et al.*, 2019).

Lisa Corwin, *Monitoring Editor*

Submitted Feb 1, 2024; Revised May 28, 2024; Accepted Jul 15, 2024

CBE Life Sci Educ September 1, 2024 23:ar36

DOI:10.1187/cbe.24-01-0032

Conflicts of interests: The authors declare no conflicts of interest.

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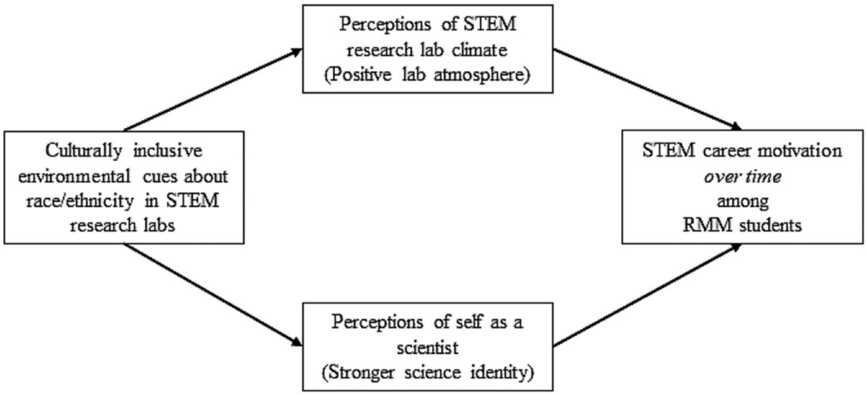

FIGURE 1. Adapted Motivational Experiences Model examining how culturally inclusive environmental cues about race/ethnicity in STEM research labs influence the motivation to pursue STEM careers of students from RMM backgrounds by shaping the way they perceive the climate of the STEM research lab and the extent to which they perceive themselves as scientists.

In STEM, faculty-led research labs are the primary context where undergraduate and graduate students receive formal research training and where they are introduced to scientific norms and values (Hurtado *et al.*, 2009; Thompson *et al.*, 2016; Thoman *et al.*, 2017; Zhang, 2022). Faculty-led research experiences are often students' first opportunity to work closely with a real scientist. In the lab, students learn the way their faculty mentor engages with science, how they interact with other members in the lab, and how they approach the research process. Research labs are the STEM learning environment where students learn what it means to become a scientist (Hunter *et al.*, 2006), to think and work like a scientist (Seymour *et al.*, 2004), and what doing science is like day-to-day (Hurtado *et al.*, 2009). Given the relatively small group context of these labs, compared with classes for example, we argue that signals of inclusion or exclusion in these environments can be powerful influences on RMM students' career decisions and persistence.

In prior work, we have identified two types of motivational processes through which inclusive (or exclusive) learning environments influence student persistence and choices (Thoman *et al.*, 2013). The first is motivation associated with one's social experiences, often described as a sense of belonging, that broadly reflects students' perceptions of the social climate and experiences with other people in the relevant social context. The second is motivation associated with one's feelings about oneself and the actual work or tasks to be done in the relevant context. Previously, this conceptual model has focused on student experiences of identity threat and has detailed how exclusionary environmental information about one's social identity affects both types of motivational processes (Thoman *et al.*, 2013). We have also detailed how broader contextual information about social roles and structural barriers influences student persistence and choices through these motivational pathways (Thoman *et al.*, 2019), but prior work has focused primarily on classrooms and taken a broad definition of the educational context. Here, we adapt the Motivational Experiences Model (Thoman *et al.*, 2013) to examine specifically whether exclusionary (inclusionary) environmental information in faculty-led STEM research labs will similarly predict students' career-related outcomes through these motivational processes.

In line with our adapted Motivational Experiences Model (Thoman *et al.*, 2013), we theorize that STEM research labs that are perceived as more culturally inclusive should influence RMM students' motivation to pursue STEM careers by shaping the way students perceive *the social climate* of the research lab and the way they perceive *themselves* in relation to the scientific work that occurs in research labs (see Figure 1 for our adapted theoretical model). As students navigate different learning environments, including STEM research labs, they attend to and draw explicit and implicit information to assess whether people similar to them are welcomed and valued in that particular context; this evaluation process influences students' decisions to persist in the relevant academic domain (Purdie-Vaughns *et al.*, 2008; Murphy and Taylor, 2012; Smith *et al.*, 2014; Cech *et al.*, 2017). Given that RMM students experience prejudice and discrimination within higher education because of their race/ethnicity, students from RMM backgrounds may be particularly vigilant to information indicating whether people from their racial/ethnic group will be welcomed and valued (Malone and Barabino, 2009; Good *et al.*, 2020; Powell *et al.*, 2021). Within STEM learning environments, including faculty-led research labs, the information about whose culture and identity are valued is often transmitted by STEM faculty and lab directors who are a primary source of social influence (Aikens *et al.*, 2016; Thompson *et al.*, 2016; Thoman *et al.*, 2019). As a result, there has been a strong effort in recent years to increase STEM faculty members' *cultural awareness*—their ability to meaningfully recognize, value, and welcome racial/ethnic diversity in STEM (Byars-Winston *et al.*, 2018, 2021, 2023; Womack *et al.*, 2020; Black *et al.*, 2022).

Culturally aware faculty recognize the cultural similarities and differences between themselves and their students, celebrate racial/ethnic diversity, and understand that students' experiences are shaped by their racial/ethnic group membership (Byars-Winston *et al.*, 2018, 2021, 2023; NASEM, 2019; Womack *et al.*, 2020). Faculty research mentors can signal cultural awareness in a number of ways. For example, we can create opportunities for our student researchers to discuss issues related to race/ethnicity (Byars-Winston *et al.*, 2018), model thoughtfulness and humanizing approaches when discussing scientific phenomena that can be negatively biased toward RMM people, discuss research articles written by RMM scholars, and even encourage our students to communicate in different culture-specific dialects or non-English languages in the lab. Faculty mentors can also guide their RMM mentees to recognize that they have unique knowledge and strengths associated with their RMM experiences that make them an asset to STEM innovation (Hernandez *et al.*, 2021; Verdín *et al.*, 2021; Silverman *et al.*, 2023). The more culturally aware that STEM faculty are, the more likely they are to signal that racial/ethnic diversity is valued and afford RMM students the opportunity to realize they can participate authentically within their labs (Haeger and Fresquez, 2016; NASEM, 2019; Black *et al.*, 2022). In these ways, culturally aware STEM faculty should cultivate equitable learning and research training environments that influence important sociopsychological processes among RMM students that affect their decisions about whether to remain in STEM (Haeger and Fresquez, 2016; NASEM, 2019; Byars-Winston *et al.*, 2023). Currently, however, more research is necessary to understand how students perceive and respond to cultural awareness in research labs and the other STEM learning environments that they navigate.

Prior research suggests that RMM students feel that racial/ethnic diversity is appreciated and invited into STEM research training environments when the STEM faculty they interact with display greater cultural awareness (Byars-Winston *et al.*, 2023; Cobian *et al.*, 2024). When individuals from RMM backgrounds feel like their identity is valued and affirmed in a particular setting, they are more likely to experience trust, comfort, and psychological safety in that environment (Purdie-Vaughns *et al.*, 2008; Jansen *et al.*, 2016; Estrada *et al.*, 2019). In other words, individuals from RMM backgrounds perceive the social climate to be more positive when racial/ethnic diversity is valued and respected (Purdie-Vaughns *et al.*, 2008; Emerson and Murphy, 2014). Indeed, signals of inclusion promote more favorable impressions of the relevant environment (Dover *et al.*, 2020; Cohen, 2022; Krivoshchekov *et al.*, 2023). Therefore, we posit that students will be more likely to perceive the social climate of their STEM research labs as warmer and more supportive when they believe their STEM faculty are more culturally aware. RMM students' perceptions of the academic climate are related to their persistence in STEM; students are less likely to persist in STEM when they perceive that the educational environmental climate is unfavorable for students from RMM backgrounds (Hurtado *et al.*, 2007; Murphy *et al.*, 2007; Chang *et al.*, 2011).

Further, a great deal of research provides evidence that RMM students are more likely to see science as an essential aspect of their identity when they feel a connection between their culture and STEM (Smith *et al.*, 2014; Jackson *et al.*, 2016; Cech *et al.*, 2019). For example, RMM students are more likely to identify as scientists and feel a greater connection to their lab's research when they perceive that STEM will allow them to fulfill culturally relevant goals (Thoman *et al.*, 2013, 2015, 2017; Jackson and Suizzo, 2015; Alkholy *et al.*, 2017; Camacho *et al.*, 2021). Additionally, recent evidence suggests that RMM students are more likely to identify as scientists when they believe that their mentor understands their cultural values (Estrada *et al.*, 2022). Collectively, prior research supports the idea that culturally inclusive STEM environments can afford RMM students the opportunity to form deep psychological connections with STEM ideas/topics and the work associated with doing science (NASEM, 2019). Therefore, we argue that students working in faculty-led research labs will be more likely to perceive themselves as scientists when they believe that their STEM faculty are more culturally aware. Science identity is an essential indicator of integration into the scientific community and a robust predictor of persistence in STEM (Carlone and Johnson, 2007; Chang *et al.*, 2011; Estrada *et al.*, 2011, 2018; Osborne and Jones, 2011; Woodcock *et al.*, 2012).

The Current Research

The current study investigated whether RMM students' perceptions of their faculty research mentors' cultural awareness—the extent to which students believe that their faculty research mentor acknowledges and appreciates racial/ethnic differences in STEM research—influenced their perceptions of the research lab climate, their perceptions of themselves as scientists and, in turn, their motivation over time to pursue careers in STEM. Specifically, we predicted that RMM students who perceived their faculty research mentor to be more culturally aware would feel more positively about their research lab's social climate and be more likely to identify as scientists, which, in turn, would increase their motivation to pursue STEM careers 3 months later.

MATERIALS AND METHODS

Participants and Procedure

Participants in the current study consisted of 150 RMM student researchers participating in faculty-led research across 74 different research labs (ranging from 1 to 8 participating students per lab; *Mean* = 2 student researchers per lab) at three universities in Southern California. These participants were part of a larger ongoing project that is studying the transmission of scientific cultural norms and values within faculty-led research labs to understand the lab experiences, interests, and persistence of emerging researchers in STEM[1]. Student researchers were recruited via their faculty mentors who were already participating in the larger investigation. In the larger study, we first recruited more than 100 STEM faculty with active research labs by randomly selecting names from complete lists of STEM faculty across three universities (additional details on the methods are available in the Supplemental Material). These participating faculty then shared recruitment materials with the students in their labs, and students chose whether or not to participate in our study (without their faculty members knowing who participated). The larger study includes a bigger and more diverse sample of participants and several measures that are not related to the current research questions[2]. To answer the current research questions, we only examined data among RMM student researchers and selected for the variables that were theoretically connected to cultural awareness and our adapted Motivational Experiences Model. We draw from extant literature which primarily has focused on the experiences of Black, Latinx, and Indigenous students in STEM—these students especially experience inequities caused by systemic racism in STEM and are the RMM students who comprise our sample in the current research (NASEM, 2019; Estrada *et al.*, 2022; Russo-Tait, 2022, 2023). We note, however, that although we include all RMM students, most participants in our sample identified as Latinx. Participant demographic information was collected in the initial Baseline survey at the time of recruitment (see Tables 1, A and B).

Student researchers working in faculty-led research labs in the life sciences, physical sciences, and engineering/computer sciences were invited via email to complete three 30-min online

[1]Please see the preregistration for the larger project here: https://aspredicted.org/blind.php?x=137_DGH.

[2]A complete list of measures included in the larger research study can be found here: https://osf.io/2hzpr.

TABLE 1. (A) Student researcher participant demographic information and (B) faculty research mentor demographic information

Variable	Student researchers
N	150
Race/Ethnicity	
Latinx	134 (89.3%)
Black/African American	11 (7.3%)
American Indian/Alaska Native/Native American	2 (1.3%)
Both Latinx and American Indian/Alaska Native/Native American	3 (2.0%)
Gender	
Men	58 (38.7%)
Women	85 (56.7%)
Nonbinary	3 (2.0%)
Prefer not to answer	4 (2.6%)
College generation status	
Continuing generation	75 (50%)
First generation	75 (50%)
Age (years)	
M (*SD*)	24.28 (4.36)
Time worked in the lab (months)	
M (*SD*)	12.38 (13.68)
STEM discipline	
Life sciences	61 (40.7%)
Engineering/Computer Science	35 (23.3%)
Physical sciences	54 (36.0%)
Variable	**Faculty mentors**
N	74
Race/Ethnicity	
White	49 (69.0%)
Asian	12 (16.9%)
RMM	10 (14.1%)
Gender	
Men	48 (64.9%)
Women	26 (35.1%)
College generation status	
Continuing generation	51 (68.9%)
First generation	23 (31.1%)
Age (years)	
M (*SD*)	46.16 (10.17)
STEM discipline	
Life sciences	29 (39.2%)
Engineering/Computer Science	19 (25.7%)
Physical sciences	26 (35.1%)

surveys (one survey every 3 months) after being introduced to the study and providing consent. Student researchers were compensated $90 for completing all three surveys. Of the 150 participants who completed the initial Baseline survey, 100 completed the first follow-up survey (i.e., Time 1) and 92 completed the second follow-up survey (i.e., Time 2). All research activities were conducted with institutional review board approval from San Diego State University.

At recruitment, all students completed an initial online Baseline survey (Time 0) that probed measures of the extent to which they felt positively about their research lab climate (i.e., research lab atmosphere), how much they self-identified as scientists (i.e., science identity), and how committed they were to pursuing a career in STEM (i.e., STEM career motivation). These baseline measures served as covariates in our primary analytic models that assessed the relationship between students' perceptions of their faculty research mentors' cultural awareness (measured at Time 1), their perceptions of the research lab climate (measured at Time 1), their perceptions of themselves as scientists (measured at Time 1) and, in turn, their motivation over time to pursue careers in STEM (measured at Time 2). The Time 1 survey was administered approximately 3 months after the Baseline survey, and the Time 2 survey was administered approximately 3 mo after the Time 1 survey (i.e., 6 mo after the Baseline survey). The primary analyses covered a 6-month time span during which student researchers were actively participating in faculty-led research labs (please see Supplemental Material for a figure summarizing the longitudinal study timeline).

Measures

Perceived Cultural Awareness of Faculty Mentor. To measure the extent to which student researchers perceived that their faculty research mentor was culturally aware, participants responded to six items (e.g., "My faculty supervisor reflected upon how the research experience might differ for students in the lab from different racial/ethnic groups"; Byars-Winston and Butz, 2021) on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). The average of all of these scale items was computed to create a mean composite score which is used for statistical analyses; the same approach is followed for all of the measures listed below.

Research Lab Atmosphere. To measure the extent to which student researchers felt positively about their research lab climate, participants received the prompt: "*Please indicate the extent to which these descriptions capture the atmosphere of your research team as a whole.*" Participants were then asked to respond to six items (e.g., "cooperative," "supportive;" Deci *et al.*, 1989) on a scale from 1 (*the atmosphere is not at all that way*) to 4 (*the atmosphere is very much that way*).

Science Identity. To measure the extent to which student researchers identified as scientists, participants responded to six items (e.g., "I have come to think of myself as a 'scientist';" Estrada *et al.*, 2011) on a scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

STEM Career Motivation. To measure the extent to which student researchers were motivated to pursue careers in STEM, participants responded to five items (e.g., "How committed are you to a career in science (or engineering);" Chemers *et al.*, 2011) on a scale from 1 (*not at all*) to 7 (*extremely*).

RESULTS

Preliminary Analyses

Before testing our primary research questions, we first examined how culturally aware student researchers perceived their

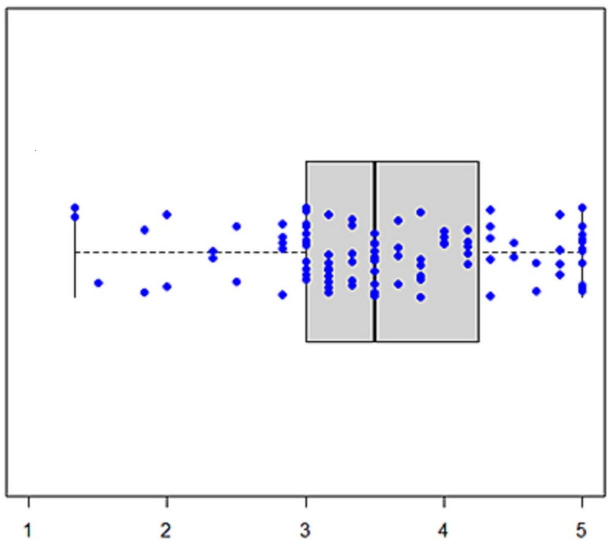

FIGURE 2. Box and whisker plot summarizing students' perceptions of their faculty research mentors' cultural awareness.

faculty mentor to be. On average, student researchers' perceptions of their faculty research mentors' cultural awareness were near the scale midpoint ($M = 3.59$ on a 1–5 scale; the midpoint of the scale was labeled "*Neither agree nor disagree*"). As illustrated in Figure 2, we observed a wide range of scores across student perceptions of their faculty research mentors' cultural awareness, including scores both at the very top and near the bottom of the scale (see Supplemental Material for figures summarizing students' perceptions of their faculty research mentors' cultural awareness across life sciences, physical sciences, and engineering/computer science disciplines, and across White, Asian, and RMM faculty). In Table 2, we provide the descriptive statistics and correlations among the primary analytic variables.

Primary Analyses

Do Students' Perceptions of their Faculty Research Mentors' Cultural Awareness Predict their Research Lab Atmosphere, Science Identity, and STEM Career Motivation? To examine whether student researchers' greater perceived faculty cultural awareness was associated with a more positive research lab atmosphere, greater science identity, and greater motivation to pursue STEM careers, we regressed students' self-reported research lab atmosphere (Time 1), science identity (Time 1), and motivation to pursue STEM careers (Time 2), separately onto their perceived cultural awareness of faculty mentor at Time 1 and the matched baseline measure for each outcome as a covariate (variables were centered and standardized). To statistically adjust for the fact that different students were nested in different labs (i.e., working with different faculty), we allowed the model to have one random effect: a random effect of faculty intercept.

Multilevel regression analyses indicate that there was a statistically significant relationship between perceived cultural awareness of faculty mentor at Time 1 and research lab atmosphere at Time 1 when we statistically control for self-reported research lab atmosphere at Baseline (Time 0), $t(91.56) = 2.56$, $p = 0.012$, $\beta = 0.19$, 95% confidence intervals (CIs) [0.04, 0.34], between perceived cultural awareness of faculty mentor at Time 1 and science identity at Time 1 when we statistically control for self-reported science identity at Baseline (Time 0), $t(97) = 11.52$, $p = 0.053$, $\beta = 0.12$, 95% CIs [0.0006, 0.25], and a marginally significant relationship between perceived cultural awareness of faculty mentor at Time 1 and STEM career motivation at Time 2 when we statistically control for self-reported STEM career motivation at Baseline (Time 0), $t(97) = 1.81$, $p = 0.073$, $\beta = 0.10$, 95% CIs [–0.008, 0.22]. In short, results confirm that the more culturally aware that RMM student researchers perceived their faculty research mentor to be, the more positively students felt about their research lab climate and the more they identified as scientists.

Do Students' Perceptions of their Faculty Research Mentors' Cultural Awareness Indirectly Influence their STEM Career Motivation via Effects on Research Lab Atmosphere and Science Identity? To test the process predictions derived from our adapted Motivational Experiences Model, we used parallel indirect effects tests via path analyses to examine whether RMM students' perceptions of their faculty research mentors' cultural awareness (predictor) indirectly influenced their STEM career motivation (outcome) through their effects on research lab atmosphere and science identity (mediators). This analytic approach aligns with recommendations suggesting that most associations between variables operate through multiple mechanisms simultaneously, and it allows us to capture two psychological processes (research lab atmosphere and science identity) at the same time and to compare the magnitude of each indirect effect while accounting for the other psychological mechanism (MacCallum *et al.*, 1996; Fabrigar *et al.*, 1999; Coutts and Hayes, 2023). We accounted for the complex sampling methods (i.e., student researchers clustered within faculty

TABLE 2. Means, SDs, ranges, reliability coefficients, and correlations for primary analytic variables

	1	2	3	4
1. Perceived cultural awareness of faculty mentor (T1)				
2. Research team atmosphere (T1)	0.31**			
3. Science identity (T1)	0.28**	0.35**		
4. STEM career motivation (T2)	0.03	0.23*	0.60**	
Mean	3.59	3.71	5.50	5.86
Standard deviation	0.89	0.42	1.01	1.11
Range	1–5	1–4	1–7	1–7
Reliability coefficient	0.92	0.89	0.88	0.87

Note. * indicates $p < 0.05$. ** indicates $p < 0.01$.

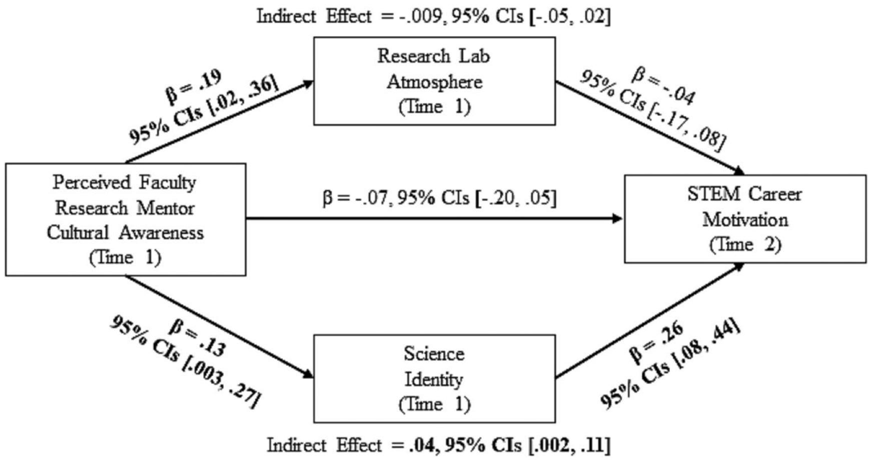

FIGURE 3. Multilevel path analysis diagram of the indirect effects of RMM student researchers' perceptions of their faculty research mentors' cultural awareness on their STEM career motivation 3 months later through their perceptions of the research lab atmosphere and science identity. Note: These analyses statistically control for auto-regressive effects of research lab atmosphere, science identity, and STEM career motivation at baseline. 95% confidence intervals (CIs) that do not contain the value 0 are considered statistically significant. Statistical significance is also indicated with bolding.

mentors) by obtaining standard errors that are weighted to account for clustering in Mplus version 8.1.2 (Asparouhov, 2005; Muthén and Muthén, 2017). Mplus uses full information maximum likelihood estimation, which adjusts for missing data that can be treated as missing at random (MAR). To evaluate this MAR assumption, we followed procedures recommended by Enders (2010) and found that none of the study variables were significantly associated with missing data patterns. We tested the significance of indirect effects using asymmetric CIs based on 1,000 bootstrapped samples asymmetric; CIs that do not contain the value 0 are considered statistically significant mediated effects. As in the earlier analyses, we again control for the matched baseline variables of each outcome as covariates, although we did not illustrate these covariates in the path model diagram in Figure 3.

The overall model fit was good, χ^2 (6) = 10.31, p = 0.112, CFI = 0.98, TLI = 0. 95, RMSEA = 0.08, SRMR = 0.06. The RMSEA and SRMR values indicate an acceptable level of model fit (Cho *et al.*, 2020). As illustrated in Figure 3, although student researchers' perceived faculty mentor cultural awareness significantly predicted students' perceptions of the research lab atmosphere, there was no statistically significant indirect effect of student researchers' perceived faculty mentor cultural awareness at Time 1 on STEM career motivation at Time 2 through research lab atmosphere at Time 1 (indirect effect = –0.009, 95% CI [–0.05, 0.02]). In contrast, the model did estimate a statistically significant indirect effect of perceived cultural awareness of faculty mentor at Time 1 on STEM career motivation at Time 2 through science identity at Time 1 (indirect effect = 0.04, 95% CI [0.002, 0.11]).

DISCUSSION

As students from RMM backgrounds navigate STEM learning environments, they are exposed to powerful environmental cues that signal inclusion or exclusion of racial/ethnic diversity. Faculty-led research labs are important STEM learning environments and microcultures where the faculty mentor is a primary source of social influence, including influence over the signals of inclusion (exclusion) that are transmitted (Archer *et al.*, 2015; Aikens *et al.*, 2016; Thompson *et al.*, 2016; Thoman *et al.*, 2017, 2019). While some research labs might be rife with signals of cultural exclusion for RMM students, other labs may be inclusive settings where RMM students are affirmed as emerging scientists who bring value to the lab's research efforts because of their race/ethnicity. In this paper, we examined whether RMM students' perceptions of their faculty research mentors' cultural awareness—the extent to which students believe that their faculty research mentor acknowledges and appreciates racial/ethnic differences in STEM—influenced their perceptions of the research lab climate, their perceptions of themselves as scientists and, in turn, their motivation to pursue careers in STEM over time.

Results suggest that the more culturally aware that RMM students perceived their faculty research mentor to be, the more positively student researchers felt about the social climate of their research lab and the more they identified as scientists. These findings indicate that RMM students' evaluations of their faculty mentors' cultural awareness shape the way they feel about the proximal environmental climate and the way they make sense of their identity as a scientist, both meaning-making motivational processes that influence students' decisions to pursue STEM long-term (Carlone and Johnson, 2007; Chang *et al.*, 2011; Osborne and Jones, 2011). Longitudinal analyses of these data, however, suggest that RMM student researchers' science identity, but not perceptions of their research lab climate, may operate as a primary mechanism through which their perceptions of their faculty research mentors' cultural awareness influence their STEM career motivation over time. In other words, the more culturally aware that RMM students perceived their faculty research mentor to be, the more that student researchers identified as scientists which, in turn, increased their motivation to pursue STEM careers 3 months later. RMM student researchers' exposure to culturally inclusive environmental information within STEM research labs may facilitate their opportunity to see themselves as a scientist, which has implications for their long-term STEM persistence (Malone and Barabino, 2009; Smith *et al.*, 2014; Cech *et al.*, 2019; Estrada *et al.*, 2022; Jackson *et al.*, 2016).

Although RMM students' perceptions of the academic climate did not act as a mechanism through which their perceptions of their faculty research mentors' cultural awareness influenced their STEM career motivation over time (when accounting for the extent to which they identified as a scientist), it is essential to note that RMM students are more likely to benefit from and thrive in supportive and positive academic environments compared with unsupportive and negative environments (e.g., Johnson *et al.*, 2014; Museus *et al.*, 2018; Brady *et al.*, 2020;

Walton *et al.*, 2023). Improving the social climate for RMM students is not only important for goals of promoting persistence, but also well-being and thriving, which were not measured in the current study. Students should be more likely to experience positive psychological well-being and perform better when they feel more positive about the academic environment that they are navigating (Browman and Destin, 2016; Birnbaum *et al.*, 2021; Koo, 2021). Indeed, when RMM students feel positive about the climate of the STEM learning environment that they are navigating, that environment serves as a resource that facilitates academic thriving and the integration of one's racial/ethnic background with their identity as a scientist (Malone and Barabino, 2009; Museus *et al.*, 2018; Good *et al.*, 2020). Our theorizing aligns with the Inclusive Science Model which posits that STEM learning environments can provide equitable opportunities for RMM students to participate and thrive authentically in STEM when the climate celebrates diversity and when RMM students have the opportunity to integrate their social identities with their science identity (Estrada *et al.*, 2016; Hurtado *et al.*, 2017; Good *et al.*, 2020; Cobian *et al.*, 2024).

The current investigation contributes to the growing body of evidence showing that STEM faculty are especially well positioned to transmit information about the culture of science that influence RMM students' motivation to persist in STEM. STEM educators have the opportunity to disrupt the ideologically colorblind culture of STEM by acknowledging students' cultural differences and emphasizing that race/ethnicity matters in scientific teaching, research, and mentorship (Aragón *et al.*, 2017; Byars-Winston *et al.*, 2018; Posselt, 2020). Indeed, *how* STEM faculty approach their mentorship with RMM students matters significantly (Reddick and Pritchett, 2015). Although many STEM faculty research mentors are motivated to create more inclusive STEM learning environments, many struggle with perceived barriers and costs, including concerns about the time required, lack of perceived norms and urgency to change, not knowing how to be effective, and a lack of institutional incentives (e.g., Brownell and Tanner, 2012; Kezar *et al.*, 2015; Thoman *et al.*, 2021; McPartlan *et al.*, 2022). Faculty mentors should receive support to be able to do so in effective and equitable ways (McCoy *et al.*, 2015; Aragón *et al.*, 2017; Russo-Tait, 2022, 2023), and they should be incentivized to do so. Fortunately, there have been broad efforts to promote evidence-based training programs that support STEM educators to develop more inclusive learning environments that benefit all students, but especially RMM students (Byars-Winston *et al.*, 2018; NASEM, 2019).

Cultural diversity awareness training programs, for example, support STEM faculty to develop culturally aware pedagogy and mentorship (Byars-Winston and Butz, 2021; Black *et al.*, 2022). These training programs that target STEM faculty's cultural awareness have been effective in increasing STEM educators' awareness of how race/ethnicity shapes RMM students' experiences in STEM and their confidence in being able to address any issues of race/ethnicity that arise (Byars-Winston *et al.*, 2018, 2023; Black *et al.*, 2022). In this way, cultural awareness training may be an important contributor to the retention of RMM students in STEM (Braun *et al.*, 2017). After STEM faculty participate in cultural diversity awareness training programs, their student mentees are more likely to rate them as having developed cultural awareness (Byars-Winston *et al.*, 2023). Social identity theory posits that people want to feel positively about the social groups they belong to, and they will gravitate toward environments that facilitate this positive identity-related experience (Tajfel and Turner, 1979; Smith, 2006; Smith *et al.*, 2007; Woodcock *et al.*, 2012; Thoman *et al.*, 2013; Hernandez *et al.*, 2023). Given that STEM faculty who display greater cultural awareness are likely to create culturally inclusive STEM learning environments that welcome and celebrate racial/ethnic diversity, RMM students will be inclined to persist in these environments where their identity is valued and affirmed and where they do not have to abandon or bifurcate their racial/ethnic identities to assimilate into the more independent colorblind environment of STEM. Proper and accurate cultural training of faculty is also important for faculty to be able to respectfully acknowledge students' cultures, as ill-informed attempts at cultural understanding might backfire and make students feel their mentors are disingenuous when it comes to their commitment to diversity.

Limitations and Future Directions

The current research provides compelling evidence that RMM students attend to and draw information from STEM faculty who transmit important information that signals inclusion or exclusion within critical and authentic STEM learning environments. Of course, this work has limitations. One limitation is that our measure of science identity is perhaps more suited to student researchers in science contexts than those in engineering disciplines for whom an engineering identity measure may be more appropriate (Godwin, 2016). Importantly, however, previous research suggests that science identity and engineering identity are strongly correlated, and that science identity is a component of engineering identity (Godwin *et al.*, 2013b; Patrick and Prybutok, 2018; Hughes *et al.*, 2019; Lockhart and Rambo-Hernandez, 2023). Indeed, among a nationally representative sample of college students, science identity significantly predicted the likelihood of students choosing engineering as a career (Godwin *et al.*, 2013a). Nonetheless, future research may benefit from examining whether RMM engineering students' perceptions of their faculty research mentors' cultural awareness shapes their engineering identity in particular, and whether their engineering identity similarly predicts their motivation to pursue STEM careers over time.

A second limitation is that the majority of our sample consisted of Latinx students. Although we draw from extant literature which centers on the experiences of Black, Latinx, and Indigenous students in STEM, our results may not be generalizable to students from all RMM backgrounds. Although we theorize that our findings extend to the experiences of Black and Indigenous students, our data primarily speak to Latinx students' perceptions of their faculty research mentors' cultural awareness. Future research should prioritize data collection among a larger and more racially/ethnically diverse sample to examine whether there are any differences in how students from diverse RMM backgrounds respond and react to their perceptions of their faculty research mentors' cultural awareness, and whether these perceptions influence their science identity, research lab atmosphere and, in turn, their intentions to pursue STEM careers. Even within the Latinx community, it is important to acknowledge this group is not homogenous and is made up of people with different life experiences and values. Data collection efforts that prioritize a larger and more diverse sample would also help us understand how different important social identities (e.g., race, gender, socioeconomic status) interact with each other to shape the experiences of students in STEM research labs as they are exposed to culturally inclusive (exclusive) environmental signals (Metcalf, 2016; Thompson *et al.*, 2020; Camacho *et al.*, 2021). Applying critical intersectional frameworks to this line of inquiry is an important direction for future scholarship in this area (hooks, 2000; Ong, 2005; Crenshaw, 1989)

Another limitation of the current study is that we cannot assess exactly how cultural awareness is transmitted within faculty-led STEM research labs. We know that students are attuned to how culturally aware their faculty mentors are (Byars-Winston *et al.*, 2023). Yet, we do not know how students come to make their assessments. For example, some faculty may explicitly communicate their ideologies about diversity. STEM faculty can convey their beliefs about diversity verbally or via teaching and learning materials (e.g., Good *et al.*, 2020; Hernandez *et al.*, 2023). There may be other artifacts in the STEM learning environment that provide information about STEM educators cultural awareness as well. For example, some faculty highlight their own cultural identities in their biographical information on their websites or items distributed across their office, classroom, or lab space (Butz *et al.*, 2019). There are also unique behaviors that faculty engage in that can transmit certain values and serve as signals of inclusion (exclusion) for students (e.g., Kroeper *et al.*, 2022). Future research would benefit from understanding how faculty transmit signals of inclusion (exclusion) and what sources of information students may be drawing from the most to make their assessments.

Another important avenue for future research is to examine how exposure to culturally inclusive environmental cues influences other student outcomes and experiences, in addition to career motivation. We already mentioned well-being and thriving experiences above, and we might also expect culturally inclusive signals to promote innovation and productivity within STEM research labs, for example. Students from a variety of historically marginalized backgrounds have unique knowledge and strengths that make them an asset to STEM (Yosso, 2005; Verdín *et al.*, 2021). Theoretically, culturally aware STEM educators should cultivate inclusive learning environments, signal that racial/ethnic diversity is valued, and afford RMM students the opportunity to feel like they can participate authentically. Consequently, RMM students exposed to culturally aware faculty should be encouraged to feel like they can bring their full authentic identity into STEM spaces. When that occurs, RMM students will be able to leverage the unique knowledge and strengths that they have acquired from their background and lived experiences to help them succeed (Hernandez *et al.*, 2021; Silverman *et al.*, 2023). In short, when STEM faculty invite RMM students to bring their full authentic identity into STEM spaces, they are inviting creativity and innovation that will contribute to important scientific innovations while contributing directly to addressing systemic inequities that exist within STEM.

CONCLUSION

Students from RMM backgrounds are more likely to see themselves as scientists and experience a more positive social climate in their research lab when they believe that their faculty research mentor acknowledges and welcomes racial/ethnic diversity in STEM, ultimately contributing to their motivation to pursue STEM careers. This line of research contributes to the growing understanding of how culturally inclusive STEM environmental information can provide equitable opportunities for RMM students to participate and thrive authentically in STEM. We hope that one takeaway from this work is that STEM faculty should be supported systemically and provided with resources and training to be able to better support the RMM students they teach and mentor.

POSITIONALITY STATEMENT(S)

Ivan A. Hernandez: As a Latinx first-generation college student from a working-class immigrant family, with access to multiple academic institutions and affiliation with both "Minority Serving Institutions" and a private "elite" research university, my experiences fundamentally affected the process of engaging with STEM faculty and their student researchers from RMM backgrounds. Indeed, my affiliation with highly intensive research universities, and my own experiences mentoring students within research labs, engendered trust among faculty research mentors. I was trusted with personal experiences that faculty felt shaped the social dynamics of their research labs. Collectively, my identities and experiences opened the door for deeper insight and clarity about steps for recruitment, data collection, and analysis. Before, during, and after speaking with faculty and recruiting students, I reflected on my experiences as a both mentor and mentee within faculty-led research labs. I, too, was affected by the reality of racial inequities that exist with STEM environments and higher-education contexts in general. I cherished the opportunity to honor the experiences of students from RMM backgrounds by producing work that has potential to advance equity and inclusion within the STEM environments that they navigate. Additionally, I am grateful for the opportunity to mentor students from RMM backgrounds in my own lab through this work, including 3 Latinx graduate student co-authors who contributed meaningfully to this manuscript.

Oliva Mota Segura: I am a Latina, Mexican American, first-generation college student who grew up in a culturally diverse community in San Diego, California. My current work as a psychology researcher investigating the sociocultural and environmental influences that STEM students face is inspired by my personal experiences and engaging in community with students who have been RMM in STEM. I was introduced to research in a traditional STEM environment where I was trained in neurobiology research techniques in a faculty led research lab. My experience as a STEM research mentee motivated my work in peer mentorship and leadership service in research programs for students from marginalized backgrounds. Throughout my academic career, I have provided social support, research training, and personal development to RMM student researchers and my research practice is shaped with the shared lived experiences of marginalized STEM students in mind. In my development as a researcher, I continue to contribute to research that is evidence based and that aims to center the voices of the student experience.

Rosalva Romero Gonzalez: As a Mexican-American, former transborder student, and first-generation college student, my personal experiences along with my community-based participatory action research with historically excluded communities, have contributed to my passion in executing research in academia that is diverse, inclusive, and culturally relevant. My research examines the scientific environments that are cultivated in faculty-led research labs and how that impacts marginalized students' (e.g., Latinx) perception of science and their likelihood of pursuing STEM careers. Additionally, I am a researcher at the National Latino Research Center, where I conduct participatory action research with Latino/a communities in areas of civic engagement, public policy, and education. My research experiences in the realm of Social Psychology and work in the Latinx/Chicanx community equip me to contribute to the field by centering the experiences of marginalized populations. Throughout my mentorship, I hope to be a source of support for students and affirm their valuable attributes and qualities that will help them excel in their academic pursuits. As a researcher, my goal is to connect the community to academia and conduct culturally relevant research to serve the community.

Lilibeth Flores: I am a first generation Mexican-American woman from an Indigenous background. My research focus and interests lie in contributing to building true equity and inclusion in STEM education for all students, particularly those who have been historically RMM. My work investigates how science identity, self-efficacy, and science values contribute to the social integration of historically underrepresented scholars into their science communities. As a graduate student, I have been working on how students' experiences in faculty-led STEM research labs can influence their perception of STEM lab environments and in turn their motivation and interest in pursuing future STEM careers. My goal is to get a PhD so I can continue to contribute to the field of STEM diversity in meaningful ways.

Miguel T. Villodas: I am a Latino clinical psychologist who studies mental health promotion among children and adolescents, especially those from Black and Latinx backgrounds, who are at risk for adversity (e.g., violence, discrimination). My research focuses on the effects of adversity on academic, social, and emotional development, as well as the dissemination and implementation of evidence-based interventions to promote well-being among underserved populations. Given my identity, I am passionate about supporting students of color in their educational and career advancement.

Christal D. Sohl: I am a White, *cis*-gender, heterosexual woman leading a biochemistry research lab at a Hispanic-Serving and First-Gen Forward Institution. I strive to use my positions of power and memberships in majority groups to facilitate access of historically excluded groups to the research enterprise, and I try to leverage my own questioning of my belonging in science to further normalize the experiences of many trainees. I am grateful to work alongside my diverse research team as we seek to understand the chemical, structural, and cellular consequences of tumor-driving enzyme mutations. I am also the Director of the Maximizing Access to Research Careers (MARC) Program which aims to provide support and resources for PhD-bound undergraduates from historically marginalized backgrounds in a meaningful effort to broaden participation in STEM.

Jessi L. Smith: I am a White, *cis*-woman-identified lesbian who is also a mother and partner. I am also a first-generation college student. My primary research specializes in social psychological aspects of gender and culture that advance the success of marginalized and minoritized people within the spaces we learn, work, and live. My positions as an academic leader and scholar-activist guide my approach to reshaping structures to positively impact motivation processes and outcomes and ensuring the highest level of integrity, inclusion, and care.

Dustin B. Thoman: I am a White, *cis*-gender, heterosexual man, and a first-generation college student. My work focuses on social influences on motivation, particularly applied to advancing equity and inclusion in STEM. As a mentor, particularly at a Hispanic Serving Institution, I strive to provide inclusive opportunities for students who have not always been included in science or research. These identities and experiences lead me to focus on social and contextual factors that create barriers or opportunities for RMM students in STEM research labs.

ACKNOWLEDGMENTS

This research was supported by grant no. 210129 from the National Science Foundation (NSF). Any opinions, findings, and conclusions or recommendations expressed in this material are our own and do not necessarily reflect the views of the NSF.

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