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## How STEM Lab Settings Influence Graduate School Socialization and Climate for Students of Color

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## **How STEM Lab Settings Influence Graduate School Socialization and Lab Climates for Students of Color**

Higher education and industry leaders have asserted that a compositionally diverse and culturally competent workforce in science, technology, engineering, and mathematics (STEM) is necessary to address the needs of a complex, global society (National Academy of Engineering, 2004; National Academies of Science, Engineering, & Medicine [NASEM], 2018; Wendler et al., 2010). While the enrollment of Students of Color (Black, Latinx, Native American, Asian American, Pacific Islander) in U.S. graduate programs has increased over time, their representation is not indicative of the compositional diversity of the U.S. and they continue to complete degrees at lower rates than their white peers (Okahana & Zhou, 2018; NASEM, 2018). In STEM fields, 44% of graduate Students of Color earned doctorates within seven years while an alarming 36% withdrew from their programs (Sowell et al., 2015). The low doctoral completion rates for Students of Color, particularly those at predominantly white institutions (PWIs) is not surprising given research that consistently highlights the hostile institutional and departmental climates students must navigate as they try to complete their degrees (Burt et al., 2018; Gildersleeve et al., 2011; Perez et al., 2019).

With this in mind, scholars have highlighted the powerful role that faculty can play in supporting or detracting from doctoral student success through mentoring and advising (Bieber & Worley, 2006; McCoy et al., 2015; Patton, 2009). Yet, faculty members are not the only actors who socialize graduate students to STEM disciplines and fields since research training primarily occurs within lab groups that may include faculty, post-doctoral fellows, lab managers, graduate peers, and undergraduate students (Borrego et al., 2017; Burt, 2017). Within laboratory settings, Students of Color may find mentors and collaborators as they develop their abilities as scientists;

conversely, they may experience isolation and hostile environments that may affect their abilities to complete their degrees (Borrego et al., 2017; Griffin et al., 2018). While several scholars have addressed laboratory dynamics between faculty, peers, and graduate Students of Color in their studies, a more focused approach is needed to understand labs as distinct context for graduate education for Students of Color. To support the success of graduate Students of Color in STEM, additional research is needed to understand their experiences in their labs and how these experiences affect them. Accordingly, our research sought to answer the following questions:

*How do graduate Students of Color in STEM disciplines and fields characterize their experiences in their labs? How do experiences within labs affect STEM graduate Students of Color?*

### **Literature Review**

To situate our research, we first examine the nature and structure of doctoral education within STEM fields with particular attention to graduate students' experiences in research labs. Subsequently, we review the literature related to the experiences of graduate Students of Color with an emphasis on doctoral students in STEM.

### **STEM Graduate Education**

Graduate education is designed to hone students' expertise and to socialize them to the norms, standards, and values of their respective disciplines and fields (Gardner & Mendoza, 2010; Golde & Dore, 2001; Golde, 2006). Furthermore, Golde (2006) asserted that doctoral education should develop "stewards of the discipline" (p. 5) who not only preserve existing knowledge but work to generate and disseminate new ideas to the benefit of their discipline or field and society more broadly. As doctoral students move towards becoming good stewards of their discipline, they learn the core knowledge that grounds their field and work towards

becoming independent researchers (Austin & McDaniels, 2006; Gardner, 2008; Gardner & Mendoza, 2010; Weidman et al., 2001). Ultimately, doctoral education is designed to train faculty members who are prepared to sustain and advance their discipline (Bieber & Worley, 2006; Gardner & Mendoza, 2010; Golde, 2006). To cultivate “stewards of the discipline” (Golde, 2006, p. 5) doctoral education is designed as an apprenticeship model of training, where students work closely with a faculty member learn the knowledge and skills to join the professoriate in their respective discipline or field (Bieber & Worley, 2006). In turn, scholars have focused heavily on understanding the roles of faculty advisors in shaping doctoral students’ understandings of their field, student retention, and students’ career interests (Bieber & Worley, 2006; Burt et al., 2018; Gardner & Mendoza, 2010; McCoy et al., 2015; Noy & Ray, 2012; Patton, 2009).

In particular, laboratory-based graduate education may be distinct from other forms of graduate education. For instance, within laboratory-based graduate education, there is often less reliance on formal courses. Graduate students are often in laboratory settings each day, attend laboratory meetings, share equipment, and engage in first-year laboratory rotations. During these activities, graduate students are socialized to the relationships and hierarchies among a variety of peers, technicians, postdoctoral fellows, senior researchers, faculty, and others in their laboratory setting.

While STEM graduate education reflects the apprentice model, the use of labs as a training site expands the expertise doctoral students learn from as they become stewards of their discipline. Specifically, STEM doctoral students develop technical and writing expertise by working with faculty, post-doctoral scholars, and graduate student peers as they generate knowledge (Burt, 2017; Gardner, 2007, 2008; Feldon et al., 2016; Holley, 2009). Working

collaboratively in labs presents opportunities for graduate students at various stages in their studies to engage in informal peer review and to support each other with challenging feedback and support (Burt, 2017). These team-based learning environments provide important spaces for students to expand their understandings of concepts introduced in courses and have been shown to increase student's self-confidence (Burt, 2017; Villa et al., 2013). Importantly, team-based learning environments have also been shown to have disparate impacts on student groups with varying levels of support (Perez et al., 2019).

Accordingly, research on STEM labs has attended to how the leadership, structure, and climate of the lab affect learning and research productivity. De Welde and Laursen (2008) asserted that "Advisors have an influential role in the way their research groups interact and communicate, and thus how the group attracts and retains students" (p. 52). They noted that advisors can be engaged in the lab or hands off, which in turn influences how lab members engage with each other. Burt (2017) also highlighted the role of faculty in setting the tone for how lab groups functioned within engineering. When faculty viewed their labs as a community designed to facilitate learning, research team meetings were meaningful opportunities for doctoral students to learn to present research, receive and respond to feedback, and troubleshoot problems. Yet, the size of labs has the potential to influence the extent to which faculty are able to create learning communities in the group. Crede and Borrego (2012) studied engineering lab groups that ranged in size from two to 23 graduate students and noted that faculty with large lab groups tended to take a managerial approach to running their lab and focused on deliverables. In contrast, faculty with smaller labs were able to work more directly with students as they engaged in research work.

Since faculty who oversee labs may not always be able to work directly with individual students, postdoctoral scholars and more advanced graduate students are pivotal to training earlier career graduate students (Crede & Borrego, 2012; Holley, 2009; Louis et al., 2007). Holley (2009) found that labs can function as a community of practice where graduate students learn both formally and informally the nature of “good science” (p. 587). Furthermore, engaging in shared research work can help graduate students become increasingly invested in their field as they matriculate and may foster a development of a collective identity within the lab. Within this socialization, graduate students often rely on student-to-student support rather than support from faculty members; in fact, many students repeatedly refer to individuals in their departments as “family” due to the frequent contact and relationships built (Gardner, 2010, p. 69). Not surprisingly, labs that are described as collaborative and supportive are more likely to retain graduate students (De Welde & Laursen, 2008; Borrego et al., 2017).

While STEM labs have the potential to create positive learning environments for graduate students as they learn the research knowledge and skills needed to advance in their field, there are also pitfalls to shared research work. Louis et al. (2007) argued there is tension between collaboration and competition in labs. People within labs need to collaborate and share information to advance the research; however, “competition among graduate students and postdocs for attention from senior researchers or the chance to work together on a shared publication” (Louis et al., 2007, p. 316) can manifest within groups. Such competition may lead to less sharing of information or resources among lab group members, more individualistic approaches to work, and decreased satisfaction with lab group experiences (Borrego et al., 2017; Crede & Borrego, 2012; Louis et al., 2007). Competition may also lead to stratification within lab groups where higher performing students get more opportunities to develop their skills and to

share their work than graduate students who are viewed as less skilled or capable by their advisor (Feldon et al., 2016). In extreme situations, competition within labs may also lead to unethical behavior such as misappropriating others' work or exploiting individuals' labor to advance the research (Löfström & Pyhältö, 2015).

### **Experiences of Graduate Students of Color**

The extant research has highlighted the numerous barriers graduate Students of Color are forced to navigate as they attempt to complete their degrees. For example, scholars have found that graduate Students of Color have consistently had less access to mentoring from faculty members than their white peers (Felder et al., 2014; Ellis, 2001; Noy & Ray, 2012; Ramirez, 2017; Turner & Thompson, 1993), which has implications for students' degree completion and pursuit of an academic career. These disparities may be exacerbated in STEM disciplines and fields since they remain predominantly white despite efforts to increase compositional diversity (NASEM, 2018).

Furthermore, graduate Students of Color are often advised by white faculty members who may be ill-equipped to mentor across race. Across the literature, graduate Students of Color consistently describe experiencing racialized and lowered expectations from white faculty (Burt et al., 2018; Ellis, 2001; Felder et al., 2014; Gildersleeve et al., 2011) which may contribute to imposter syndrome. Notably, McCoy et al. (2015) found that white faculty members often used race-neutral language when describing their work with graduate Students of Color. Although these faculty members thought they were treating graduate Students of Color fairly, they often used language that was deficit-oriented and that conveyed an expectation to conform to dominant white culture. For the Black women in STEM who participated in Joseph's (2012) study, deficit perspectives that guided white faculty member's work were consistently evident since course

instructors and advisors doubted their intelligence and abilities to succeed in graduate school. These lowered expectations graduate Students of Color may lead to them being perceived as less capable of work in labs, which in turn may give them less access to opportunities to develop their skills and to engage in the publication process (Feldon et al., 2016). Furthermore, some Students of Color in Perez et al.'s (2019) study were told explicitly by white faculty members to leave their racialized and ethnic identities out of the lab since they were not relevant to their work. In effect, the negation of students' racialized and ethnic identities amplified the negative effects of racialization for graduate Students of Color rather than delimiting it.

The hostilities that graduate Students of Color encounter in graduate school are not limited to interactions with faculty. White peers can create a chilly climate for graduate Students of Color by (un)intentionally excluding them from activities and study groups (Burt et al., 2018; Ellis, 2001; Gildersleeve et al., 2011; Joseph, 2012). Furthermore, white peers can send explicit and implicit messages that graduate Students of Color are less capable of academic success. In particular, graduate Students of Color may be told they do not belong in their program and that they were admitted based on their race rather than merit (Burt et al., 2018; Gildersleeve et al., 2011). Negative racialized messages may also be sent by academic program or lab staff (Perez et al., 2019) which cumulatively suggests that graduate Students of Color are not welcome as their whole selves in many academic departments and institutions. In turn, graduate Students of Color may feel a sense of isolation and hostility within laboratory settings which can influence completion of degrees (Borrego et al., 2017; Griffin et al., 2018).

To combat pervasively isolating and hostile environments, graduate Students of Color are often forced to seek their own support systems or to leave the academy (Burt et al., 2018; Gildersleeve et al., 2011; Patton, 2009; Perez et al., 2019; Porter et al., 2018; Truong et al.,



2016). For example, Burt et al. (2019) found that many Black male engineers leveraged their familial and faith-based communities to cope with their negative graduate school experiences. Similarly, Perez et al.'s (2019) research highlighted that graduate Students of Color found connection, solidarity, and opportunities for professional development outside of their departments, and when participants were inadequately supported, they supplemented their learning by engaging in identity-based student organizations and participating in programs sponsored by the Graduate College. In some instances, graduate Students of Color may also collectively organize to change the negative climates of their departments and institutions (Porter et al., 2018; Truong et al., 2016).

While the literature has highlighted the importance of labs within STEM graduate education and the impediments to success for graduate Students of Color, limited research has explicitly focused on the experiences of graduate Students of Color experiences within their respective labs. Understanding how STEM graduate Students of Color perceive and are affected by their experiences in their labs is imperative if educators are to better support their success.

### **Theoretical Framework**

Our research uses socialization (Tierney & Bensimon, 1996; Van Maanen & Schein, 1979; Weidman et al., 2001) as a framework to explore how individuals learn the norms, standards, bodies of knowledge, and practices that guide their disciplines and fields. Socialization has been widely used to understand how graduate students learn to become stewards of the discipline and increasingly independent researchers (e.g., Felder et al., 2014; Gardner, 2007, 2008; Holley, 2009). The concept of socialization is particularly helpful for examining the content (i.e., what), process (i.e., how), and outcomes (i.e., effects) of graduate education experiences (Perez et al., 2019).

Notably, there are multiple models of socialization that may be used to understand graduate students' entry into their academic communities. For example, Weidman et al.'s (2001) model describes four interactive stages (i.e., anticipatory, formal, informal, personal) during which graduate students acquire knowledge and become increasingly involved and ideally invested in their discipline and field. Graduate students' journeys through these stages are influenced by factors such as faculty and peer interactions and the structure of academic programs. Although socialization primarily occurs within departmental and institutional contexts, Weidman et al. (2001) acknowledged that individual characteristics, professional communities, home communities, and newer practitioners also influence how graduate students experience socialization during graduate school. Socialization models that center individuals are useful in understanding how people experience and are affected by graduate education over the course of time. Furthermore, they attend to individuals' agency during their graduate school socialization (Austin & McDaniels, 2006; Tierney & Bensimon, 1996).

In contrast to Weidman et al.'s (2001) model which attends primarily to individuals' journeys, Van Maanen and Schein's (1979) work focuses more heavily on the structure of socialization and highlights how the design of socialization processes can influence outcomes such as values acquisition and commitment to the field. Models such as Van Maanen and Schein's (1979) are useful for examining how graduate training is designed and implemented to achieved particular outcomes. However, they often frame socialization as unidirectional since they foreground the structure of entry into a group or community and give little attention to individuals' agency.

Given our interests, this research was not designed with one model of socialization in mind. Rather, it was informed by both individual and organizational perspectives on

socialization. Our study examines the role STEM labs play in the socialization of graduate Students of Color and attends to what and how people learn in this setting and the implications or effects of this learning. By drawing upon organizational and individual perspectives on socialization, we are able to more fully consider how labs function as sites of socialization in STEM and how graduate Students of Color make meaning of their experiences within labs.

### **Methodology**

This inquiry is part of a National Science Foundation (NSF) project supporting a network improvement community (NIC) of nine institutions who are working collaboratively to create more inclusive environments in STEM departments. By improving racial climate within departments, NIC institutions hope to better support Students of Color and their interest in faculty careers. To influence climate, institutions are designing and implementing interventions to cultivate faculty members, graduate students, and post-doctoral fellows' knowledge and skills related to diversity and inclusion. Although the interventions are designed to meet the needs of individual STEM departments within their institutional context, the lessons learned (i.e., challenges, successes, good practices) are shared across the NIC to enhance collective capacity to influence racial climate.

To understand how efforts to create more inclusive STEM departments affect students of color, we are engaged in longitudinal qualitative research at two NIC institutions. Our constructivist multiple case study research was designed using purposeful and maximum variation sampling (Patton, 2002). This approach allowed us greater understanding of institutional processes, transitions, and enabled us to contextualize our findings within their respective environments (Merriam, 1998). For this analysis, our approach allowed us to

illuminate the complexity of how graduate Students of Color in STEM disciplines and fields experience and are affected by their lab experiences.

### **Data Collection Sites**

From our NIC institutions, we selected two research sites based on their unique institutional contexts for graduate Students of Color in STEM as well as their differing institutional approaches to NIC interventions. We conducted research at two predominantly white universities within the NIC, Mid-Atlantic University and Northeast University (pseudonyms); each university served as a bounded case for data collection and analysis.

Mid-Atlantic university is a large, public land-grant university near a major city. The university offers a wide range of highly ranked graduate STEM degree programs and is perceived as racially and ethnically diverse. In recent years, the institution has experienced multiple challenges to climate for Students of Color as a result of racially and ethnically charged events which have taken place on and nearby campus. Within the NIC, Mid-Atlantic University has conducted interventions focused primarily on providing community-building and mentoring experiences for graduate students and postdoctoral fellows; they are currently in the process of building programming targeted at faculty advising, mentoring, and diversity.

Northeast University is a small, private, elite land-grant institution located in a rural setting. The university has a strong reputation for STEM excellence and draws graduate students and faculty internationally. In recent years, this institution has also experienced several racially or ethnically charged incidents. The university has very active graduate school STEM programming, particularly around diversity and inclusion. Within the NIC, Northeast University has conducted interventions focused on programming related to graduate school climate and career development for graduate students, post-doctoral fellows, faculty, and staff.

## Data Sources

Our primary data sources for this analysis were focus groups conducted with STEM graduate Students of Color at each research site. For the purposes of this study, our definition of STEM was in alignment with the National Science Foundation's and as such graduate students eligible to participate were enrolled in the geosciences, life sciences, mathematics and computer sciences, natural sciences, physical sciences, and selected social and behavioral sciences (e.g., psychology, economics, political science). We selected a focus group approach to gather as many perspectives as possible and allow participants to engage in shared meaning-making with each other (Glesne, 2011; Ritchie & Lewis, 2009). Working with both research site graduate colleges, we purposefully sampled (Patton, 2002) focus group participants and were attentive to compositional diversity related to social identities and disciplines/fields. We intentionally created groups where individuals would be more likely to speak freely about their experiences. When participants were no longer able to attend their scheduled focus group, we conducted an interview.

Across sites, we hosted six focus groups and one interview with 24 graduate Students of Color. With respect to race, our sample included seven Black, eight Latinx, six Asian/Asian American, and three Multiracial students. All participants were U.S. born, with the exception of one participant who identified as an international graduate student. Our participants included 15 women and nine men who were enrolled in the agricultural sciences (1), biological sciences (9), computer sciences (1), engineering (9), physical sciences (2), and social sciences (2). More detailed information about the demography at each data collection site is in Table 1.

[Insert Table 1 about here]

At Mid-Atlantic University, we conducted three focus groups and one interview with seven STEM graduate Students of Color, while at Northeast University, we conducted three focus groups with 17 participants. Of the two focus groups at Northeastern University, two were with Black and Latinx STEM graduate students and one focus group was with Asian American STEM graduate students. The variation in the structure of focus groups between campuses was reflective of the compositional diversity of the STEM departments at each institution and individuals' willingness to participate in the study.

Our focus group protocol explored topics such as experiences with peers and faculty, experiences in the lab, perceptions of climate for race in the department and lab, and ways to improve the experiences of Students of Color. Sample questions included: How would you describe experiences with peers in your lab? In what ways does your lab promote a difficult climate for underrepresented students and postdoctoral fellows? How would you describe your interactions with the primary investigator in your lab? Each focus group or interview was approximately 90 minutes long and was professionally transcribed.

### **Data Analysis**

We coded our data through a systematic, inductive approach (Bogdan & Biklen, 2003) to capture emergent themes across focus groups. Guided by the graduate education literature, we created an initial list of codes (e.g., interactions with advisor, experiences in lab). Subsequently, each author independently coded one focus group using the initial scheme to determine if additional codes were needed. We then met to discuss the initial and potential new codes and came to consensus on a revised scheme that was used to analyze the remaining transcripts. Following our initial coding, we examined excerpts relevant to experiences in labs to look for patterns among the experiences shared. From this coding, we organized the data into major

themes, first within each case, then compared across cases. The themes presented here are representative of experiences shared between the two cases.

We used several strategies to enhance the trustworthiness of our work (Jones et al., 2014). Our team met regularly to discuss the coding process and emergent themes. When our interpretations of the data varied, we collectively reviewed the data and came to consensus about our insights. Thus, we strengthened our analysis through pooled judgment and triangulation among multiple researchers who vary in positionality (Jones et al., 2014; Knafl & Breitmayer, 1989). We also explored our positionalities and assumptions about the work, acknowledging that each of us was coming from a unique individual perspective as a result of our multiple, intersecting identities and background experiences. As a team, we collectively identify as second-generation, middle class Latina cisgender woman who did not earn an undergraduate degree in STEM, but who engages in STEM education research; second-generation, middle class Asian American cisgender woman who earned an undergraduate degree in STEM and engages in graduate education research; and a working class, white, individual who identifies as nonbinary and has no formal STEM education. Our collective experiences sensitized us to the racialized and gendered experiences of STEM graduate Students of Color within lab settings, and the variation in our backgrounds helped recognize new insights from these data.

### **Findings**

Graduate Students of Color in STEM disciplines and fields characterized their socialization experiences in their labs both isolating and competitive. While students felt that their laboratory teams were like familial structures, they also described issues of dysfunction within those environments. As a result of these experiences, Graduate Students of Color in STEM created their own structures of support in order to complete degrees. This is to say that the

formal structure of the labs often informally taught graduate Students of Color other messages about working in their discipline or field, and in some instances led participants to create alternative socialization structures to support their educational pathways.

### **STEM Research Labs are Sites of Isolation & Competition**

For graduate Students of Color at both institutions, STEM research labs were often sites of isolation and competition. In both cases, isolation and competition were often linked with each other. Feelings of isolation were most pronounced at Mid-Atlantic University, despite its strong reputation as a diverse campus with high levels of representation for graduate Students of Color. Lab settings perpetuated feelings of isolation since they were formally designed to be insular; students worked long hours with the same people and had limited interaction with peers in other labs. Furthermore, the structure of many participants' labs socialized them to believe that isolation and competition were normative in STEM. Accordingly, many graduate Students of Color were discouraged from taking part in any practices that might create perceived distractions from their research or allow them to connect with others beyond the lab setting. In this regard, participants were informally socialized within their lab settings to accept isolation from other People of Color and competition among peers as a necessary structure for STEM participation, with little concern for individual agency or the potential negative effects of these norms.

For example, Jordan, a graduate Student of Color at Mid-Atlantic University said, "In chemistry, you're separated. It's almost like different factions, like you are sequestered with your group, they are sequestered with their group, and they don't really meet each other." Graduate students felt separated from peers outside of their labs. There were no formal or informal socialization structures to encourage cross-lab connections between graduate Students of Color in STEM. Their separation highlighted the divisions among labs and prevented them from



connecting with other graduate students, particularly other Students of Color. Teri, a graduate Student of Color in engineering, described this pervasive isolation:

it's the nature of there not being a lot of underrepresented minorities...when you get to graduate school in particular, everything becomes very hyper focused. One of the people [of color] I've met [at this focus group] has been here for six years. I've never seen them until today...There are other graduate students who I know who are in my program that I don't see on a daily basis and they're in the same engineering discipline. They're in the same building as me. (Mid-Atlantic University)

In Teri's experience, the insular culture of graduate studies and lab settings prevented students from knowing others in their immediate physical space or within the larger context of the discipline. Their isolation from other graduate Students of Color was further exasperated by the small number of Students of Color present within their labs, departments, and across the discipline. Both Jordan and Teri's experiences highlight the ways in which lab settings socialized graduate students, particularly graduate Students of Color, toward isolation. As a means of socialization, labs support the cultivation of disciplinary expertise and building relationships within one's most immediate workgroup, but they can also lay the foundation for more problematic socialization experiences and outcomes for graduate Students of Color over time.

For example, isolation became even more pronounced when conflict arose between graduate Students of Color and their advisor or lab colleagues. John, an African American student described feeling isolated and having negative interactions with his labmates:

When I first arrived here, I started work with an advisor who lacked confidence in my ability...she tried very hard to encourage me not to pursue a PhD, and it was my thought process that I can convince her otherwise, 'cause I'm used to having to convince people

otherwise. I don't look like what an [scientist] looks like to people, being an African American guy...[the advisor] decided to end my degree progress...and the decision was overturned, but as a result of that, it caused a lot of negativity within the department. People felt that it threatened the autonomy of the department for me to have a decision that a tenured faculty member made be overturned, as opposed to just listen to it and go with it...most of the graduate students, just became very cold and very rude towards me. Several of them were friends with my advisor and this rumor mill just kind of got started, and things became really unpleasant...it got to a point where the students had completely shut me out and they wouldn't speak to me under any circumstance. (Mid-Atlantic University)

He went on to describe his experience as both ostracizing and dehumanizing:

Nobody would speak to me. Eventually, just to make sure it wasn't all in my head, I started very obviously initiating conversation with them, and they just would not speak, would not acknowledge my presence, my existence as a fellow human being...I shut myself off from social interaction with the university.

Despite John's attempts to prove himself as a successful African American scientist, he felt marginalized first by his advisor, then by peers. Due to the isolating nature of STEM graduate studies, he perceived himself as unable to socially engage in the university environment at all. Through informal socialization practices, John's faculty advisor may have normalized John's ostracization within the lab and implicitly encouraged other graduate students to reproduce those behaviors. The faculty member also influenced the lab's norms around conflict management by discussing the situation with graduate students and depicting John in a negative light. John's advisor, whether knowingly or not, reinforced stereotypes about African American men in

STEM to their graduate students and perpetuated the marginalization and oppression that graduate Students of Color face in STEM programs.

Isolation was exacerbated when graduate students were highly discouraged from participating in activities outside of the lab, especially if those activities were considered a distraction from directly STEM-related work (e.g., diversity organizations, social connections). Students of Color described how these formal messages to solely focus on science had detrimental effects their mental health. Alex related that:

You kind of have this thing that breeds this isolation...it might not just be my lab in particular, but I would say that's the culture in the sciences is where you need to focus your energy on doing this particular aspect and furthering and advancing in that more so than worrying about extra-curriculars. It's not that they say, "Don't do them," but it feels like there's obviously a clear priority in terms of what's more important than the other...So you kind of just end up staying in your place....I think it can be detrimental...an issue comes up and that doesn't become positive anymore, it becomes stressful or you want a break...you don't really have too much to turn to outside of that.

(Mid-Atlantic University)

As they were socialized to their discipline or field, Students of Color were given the façade of agency to participate in extra-curricular activities (many of which were diversity-related), but the perceived standards of lab engagement within STEM set by leadership and faculty discouraged them from doing so. Again, participants were implicitly taught that as a graduate student in STEM, one demonstrates commitment to the discipline via lab engagement and isolation from outside groups. Graduate Students of Color perceived a need to prioritize their lab's work and, as a result, lacked outside connections to turn to in times of conflict and stress.

As a result of their isolation, paired with the lack of representation, Students of Color, like Taylor, often felt disconnected from other People of Color:

I feel like one thing about being an underrepresented student, if there's not a lot of you there, you start to forget that there's other people out there that are underrepresented doing graduate work, going through these difficulties. And it starts to just harbor that feeling of isolation. So being able to have that, you get to see, "Oh, there's other Black people doing other things outside of just my program." Just seeing people who look like you, can relate to the things that you like or don't like or things that you're seeing outside of just what you effectively go through every day. (Mid-Atlantic University)

In this example, Taylor, a Black graduate student, articulated the stress that such isolation puts on Students of Color and the benefit that interacting with fellow People of Color has on coping with graduate school experiences, particularly those that are racialized. However, these opportunities to connect with other People of Color were often difficult to create given the lack of racial diversity in many participants' labs and the perceived messages to prioritize their work as scientists over outside activities.

Coupled with isolation, lab settings also promoted a culture of competition. Graduate students in STEM were socialized to work in isolation without connections to other students, which enabled a culture of competition to flourish. These experiences, most pronounced at Northeast University, were often characterized by Students of Color as a battle ground for resources, funding, and support. In particular, Women of Color found this socialization to be problematic due to the negative effects it had on lab peer relationships and ever-changing expectations from their advisors.

Students believed that research labs often socialized graduate Students of Color in STEM to compete with their lab teammates and postdoctoral fellows for attention from their principal investigators (PIs), for opportunities to collaborate on high-profile, important projects, and for research resources. For Leslie, a Woman of Color, this culture of competition initiated by the PI encouraged her to change labs:

I was in a really, really terrible lab space that I needed to leave. That was very, very different than the space I'm working in right now... [In my old lab, my PI] would essentially pit us against each other, and say whichever one of you produces the results fastest will get to publish... The messed up thing is when I told my current advisor about it he said I had a feeling that was what was going on. So people knew it was a bad environment and nobody told me, until I navigated leaving. (Northeast University)

In contrast to her new lab, Leslie's previous lab relied on competition between students to fuel production of publications. Students who produced the most were rewarded with publications. Faculty members knowingly allow graduate Students of Color into labs with homogenous, toxic cultures where they are socialized into competition for survival of such circumstances. By emphasizing competition and productivity, many PIs may directly or indirectly, socialize graduate Students of Color to believe that their STEM contribution hinges on their ability to outpace their peers. Furthermore, as Leslie's commentary illustrates, toxic environments not only exist for graduate Students of Color but are normalized and perpetuated by departmental faculty and administrators.

Participants perceived differing expectations of production between students who were paid by PIs and students who had other sources of funding. Students who were paid by PIs generally worked more closely with PIs and were held to higher standards for production

whereas students on fellowship (many of which were fellowships designed specifically for Students of Color) were often seen as less of a priority in terms of guidance and production. The labor of graduate Students of Color was seen differently if a PI was paying for the work being completed. For Marissa, also a Woman of Color, expectations related to productivity shifted depending on her fellowship status:

Students who had fellowships had a much lower bar, because he was not paying them.

Students who he had to pay out of grant money, or whatever, he had a much higher bar because they need publications...The first two years, I was on a fellowship. I was lower bar, everything was like, "[Participant's name] is an awesome student..." The next year, he was paying me, and the bar all of a sudden was all the way up here...And, it wasn't like a conversation, it was just like all of these random things started happening, as to where he was saying these very negative things about me and my performance. Which, spilled over into my committee, and so now, it's this big question of, am I smart enough to be here? (Northeast University)

In this example, Marissa was left with self-doubt after her expected contribution to the lab was raised midway through her program as her funding source shifted. Competition for PI attention and project collaboration was vital since PIs tended to provide better mentoring experiences to students whose projects were more closely aligned with that of the PI. However, this was complicated by the constant feelings of competition and need for increased production. These experiences were not limited to the lab setting but also influenced the socialization experiences that graduate Students of Color had with other faculty members in the department, which had far-reaching effects on other aspects of the graduate training process.

### **STEM Research Lab Teams are Like Dysfunctional Families**

Graduate Students of Color in STEM often described their research lab teams as “dysfunctional” families which could, simultaneously perpetuate positive familial bonds and deeply rooted issues of control, abandonment, and rivalry. Students were simultaneously isolated from other People of Color, yet bound to faculty members who exercised high levels of control and peers who often engaged in subtle forms of racism. Students at both institutions described their labs as “family,” but characterized those families in different ways. At Mid-Atlantic University, participants attributed dysfunction to absent, preferential, or poor managing advisors. At Northeast University, participants had some positive familial lab experiences, yet, they also described subtle racism by lab peers and blatant, intentional manipulation of students by advisors.

In a positive sense, some students described lab settings as spaces for building positive familial bonds and cultivating community with fellow lab teammates. In particular, graduate Students of Color found labs that were diverse in terms of gender, race, and ethnicity to be welcoming spaces. As Troy, a Man of Color, related:

The dynamics with my lab have been phenomenal. Mostly because there are people like me. I'm the only male in my lab, everyone else is female. Coming from other under-represented minorities. It is truly family. (Northeast University)

Graduate Students of Color connected diverse lab settings to setting norms where familial bonds had positive connotation. For Troy, the sense of family in the lab was enhanced by being with people who shared his racialized identity and understood his experiences. His narrative ran counter to those of Students of Color who described their labs as places where they felt isolated and where they were made to feel as though they didn't belong in the space based on racialized

identities. However, despite his account of positive familial bonds within his lab, Troy also described negative racialized elements to his experiences:

Having said that...I feel like the fact that I came in right away with [multiple years] of funding, there was a little bit of jealousy. You could tell by the body language, that in a way, no one ever told anything, but I could feel with some people they were thinking that I was not struggling with having those fellowships. Or, I just got them because of my color, not because of my academic strength. That was something really shocking...

(Northeast University)

Troy's PI created a diverse, familial lab setting, yet his labmates were jealous of his funding opportunities and subtly questioned his abilities as a Scientist of Color. Despite the positive dynamics that he highlighted, Troy's experience suggests that graduate Students of Color in STEM face more nuanced, racialized socialization experiences, particularly with the presence of diversity-funded fellowships.

Another student, Austin, mentioned the importance of structure in determining the dynamics of the family setting: "So I think your lab is a little bit more like your family, but it depends on how your group is structured" (Mid-Atlantic University). These familial bonds were highly dependent on the size and hierarchy of the lab (i.e., PIs who primarily interacted with postdoctoral fellows or more senior graduate students), and in particular if the PI was experienced and both physically and psychologically present for those members of the lab. Students sometimes struggled with new faculty members who, at times unsuccessfully, tried to manage their lab families and socialize them to more constructive norms and supportive practices. For Ezra, the term "family" denoted both positive and negative attributes related to faculty management of their laboratories and socialization of the graduate students in STEM:



I think I use it [“family”] in the whole concept of the word which is like it can be dysfunctional at times, there couldn't be people that are with you at times, I feel like the same thing with parenting. I think people, especially with their first kids, they're on the fly. Even though they read books and stuff like that, they're really trying to figure out what's working. I think for the new professors it's the same thing. (Mid-Atlantic University)

In this case, Ezra saw the good faith effort of their PI but also recognized the challenges they faced. Tasked with managing competing priorities (e.g., funding, tenure, knowledge production), newer PIs had to be deliberate in order to maintain familial structures as a component of graduate student socialization. In turn, these PIs did not always attend to the racial diversity of their lab family and the racialized experiences of their graduate Students of Color.

Notably, the familial structure of STEM labs was often described as rife with conflict. Some PIs exercised high levels of control and power over the financial resources and future career opportunities of the students in their labs. For example, Peter, a Man of Color, described the family-like power-structures that he saw unfolding before him:

to the matter for a family, you know, it's a dysfunctional family like the dad is not there. Then the debt keeps like [accumulating], I don't know, I guess the purse strings of allowance is very close. I guess the money for labs or doesn't sign the IRB applications so you can't do anything. (Mid-Atlantic University)

Characterized as “fathers” who held “the purse strings,” PIs sometimes deliberately exploited lab members who were part of the “family.” As described above, graduate Students of Color already faced racialized experiences with isolation and hostility, and faculty members exacerbated those

feelings by exercising further control over already vulnerable students. Leslie, a Woman of Color, described how her former PI often exploited the most vulnerable students:

He almost always exclusively preyed on students that were desperate for funding and made them promises of, "I will fund you."... He also almost, exclusively has postdocs that are international and uses their visa status against them, essentially saying if you don't do what I say, I won't renew your visa status. It's a terrible lab environment. I got out of there very quickly. (Northeast University)

Within this environment, graduate Students of Color were socialized to formally rely on their PIs both procedurally and financially. Students relied on their PIs to accomplish basic tasks in order to make the labs function properly as well as to provide funding and employment support so that they could continue their studies and work towards degree completion.

Even when PIs were not overtly characterized as oppositional forces in the lives of graduate Students of Color, students could sense when their lab families were dysfunctional. As described above, graduate Students of Color believed that their lab settings often perpetuated feelings of sibling-type rivalry between graduate students. At times, their lab teammates were supportive while other times, they were competitive and cruel to each other. Feelings of rivalry were often related to the need to compete for attention from the PI and opportunities to collaborate on important projects. Graduate Students of Color suggested that such dysfunction might be the result of PI preference for students whose research interests were more aligned with theirs. Lkening PI behavior to an absent or "hands-off" father, graduate Students of Color often felt a sense of abandonment regarding the mentoring process. Students with projects that were more distant from the PI's interests and priorities experienced a lack of connection to their labs,

including less substantial feedback on their research. For example, Peyton illustrated how a graduate student's research topic could benefit or marginalize them:

So you mentioned about a family, so I feel like you sometimes get support and sometimes you don't. It depends on people's projects, it's all about timing... sometimes in a lab group, what I've figured out is my project is not very interesting to people. It's interesting to me, but it's tangential to what helps your professor. If your stuff helps your professor, then of course they'll give more critical feedback. If it's not, then it's your kind of in between places... as far as my research area, I don't have much guidance there. (Mid-Atlantic University)

Because Peyton's research topic is not in close proximity and does not "help" the PI, the PI provided less feedback and guidance, essentially leaving Peyton to conduct research in isolation. As challenges mounted, some graduate Students of Color attempted to reach out to members of their lab "families," but at times found little support. As a result, some students, like Peter, looked to their "extended family" outside of the lab for support:

I can't tell you what's different between other people's experience and mine. I can only tell you they have more support... that's why you have to find students or people who have some sort of similar aspect to you... the faculty will not consider that the minority students that are like being held back. Is it because you know you're not giving enough support to the minority students? This extended family, students from other labs, other faculty... I started to lean on my extended family for help... it's when I shared my concerns with the other grad students, they come after and say "I think, you know with your issues, it's serious enough that [the problem] should actually be brought up. We don't expect there will be a solution, but you should just make it known that you are

encountering problems and it's not one off, it's a pattern. It's universal, it's not just to you, it's to other people in your lab.” (Mid-Atlantic University)

Graduate Students of Color sensed that their socialization experiences were not equal to that of their white peers and articulated a lack of faculty awareness of the issue. While students often felt isolated within their own labs, this isolation could be remedied by seeking support beyond the lab setting. These sources of support outside of the lab encouraged graduate Students of Color to acknowledge, document, and overcome various challenges within their labs. Rather than suffering in isolation, these extended familial bonds helped normalize challenges for graduate Students of Color and provided support and encouragement that was absent in some lab “families.” Yet, as previously noted extended families were often difficult to find and to create given formal expectations placed on Students of Color to prioritize their lab work over their efforts to find and build community outside of the lab.

### **STEM Research Lab Members Create Their Own Structures of Support**

Given the climate of their labs, graduate Students of Color at both institutions often needed to create their own support structures. At Mid-Atlantic University, these efforts were focused primarily on building awareness around recruiting Students of Color while at Northeast University, these efforts were primarily concerned with building the skills and abilities of graduate Students of Color to navigate graduate educational spaces. Students at both institutions sought to connect with other graduate Students of Color both in and outside of the lab and change STEM cultures. These efforts represent labor from graduate Students of Color that faculty members, administrators, and white graduate students were not engaged with in a meaningful way. As a result, departments demonstrated to graduate students that there was little value placed on supporting Graduate Students of Color and that these commitments were not

salient to the socialization experiences within STEM labs. Graduate Students of Color attempted to raise concerns with their advisors, department heads, or heads of graduate studies, but they were often met with opposition or indifference. When concerns about the socialization experiences of graduate Students of Color were addressed, efforts were often thwarted in individual lab settings by PIs who either did not desire to change or whose changes did not go far enough to shift the negative lab climate. In turn, participants like Riley, a Woman of Color, often turned to other students for advice on how to navigate processes and handle challenges in the lab, particularly with their PI:

I think I've been fortunate enough that there have been individuals in my lab or in the program that do a good job of cluing you in to things you should know about your faculty member or certain other faculty members...my PI is a good person, but not flawless.

Instead of taking four years to figure out how to interact with him in a way that's productive, a grad student in my lab kind of pulled me aside and was like, "Well this is kind of how he thinks. This is how I deal with it. Here's how you can try." And, it's just really kind of sped up a lot through a lot of those hurdles that I would've encountered.

(Northeast University)

While at an individual level this advice allowed graduate Students of Color to successfully navigate their own, nuanced situations, they sought change not only for themselves but for other graduate Students of Color who would come after them. However, Riley also highlighted the ways in which she was frustrated by the need of graduate Students of Color to take on socialization-oriented tasks like these, rather than have faculty members, who are fully capable of creating inclusive lab environments, do the work:

I feel like that bugs me the most. Pseudo-bystander type thing....They know about this stuff. It's not an education thing. They just don't wanna do any of the labor to fix the problem...they just don't wanna do the work and they'd just rather us do it. That's what frustrates me the most. (Northeast University)

Riley's perspective suggested that while PIs are formally responsible and are capable of shifting the norms, standards, and practices of their labs, their commitment to these efforts is limited. Informally, other graduate students, particularly graduate Students of Color, attempted to reorient socialization practices to be more supportive.

Rather than come from department or lab-based leadership, the bulk of change and movement towards creating a more positive lab climate came from the graduate Students of Color (students, administrators, and faculty acknowledged this assertion). For Morgan, other graduate Students of Color worked to shift the culture of the laboratory environment:

My advisor's very hands off, which might be why she just doesn't understand the dynamics at all. It's good now that that older student has left and graduated, which is probably the only reason why it's fine now...my other friend is aware of it, we're trying on our own to create a cooperative culture in our lab and talk to new students within our lab and other labs in our department. (Mid-Atlantic University)

Students understood the day-to-day dynamics of the lab setting and climate of the department and sought to create a more "cooperative" culture rather than an isolating and competitive culture. For example, graduate Students of Color, particularly at Northeast University, made strides towards improving the climate by creating programming to recruit and retain other Students of Color and building in social activities to encourage relationships both within and

across lab teams. In particular, students like Daniel sought to not only have their own story told but make the academic culture and climate better for future Students of Color:

I am the only one, the only African-American in my lab...there were stigmas against me that I didn't work hard enough...a lot of the stereotypical things that people like to say about People of Color I think were being attached to me...I wasn't productive enough... I have to prove myself to everyone in my lab...I would have to consult with [fellow graduate students] about my experience...my advisor's one of those people who's very passive, so it was never something that would actually be addressed. I had to do a lot of unpaid work to make my environment be sort of detoxified, so that way, if the next Person of Color came in...I had to grow from it, learn from it, be able to talk to other students about toxic situations that they're going through, and be able to help them through what I've been through...That's all that matters to me...to make sure that other people are successful throughout this academic space. (Northeast University)

Daniel, like other graduate Students of Color, recognized that their lab mates projected negative stereotypes upon them and that they were forced to do additional labor in order to improve the lab climate for themselves and others.

Unlike Daniel, other graduate Students of Color felt forced into creating these support structures because of their status as racialized minority students. Terrell, a Man of Color, articulated how a lack of leadership around diversity issues and his status as a Man of Color prompted him to engage in the work:

[Mid-Atlantic University tries] to paint all of their graduate students as basically the same. That we can give everybody the same things, and they'll do well, and it just doesn't work...I don't really feel like my department is doing anything...I

don't feel like our department is actively trying to do anything, and now that I'm in the lab whenever there's any type of diversity event I'm automatically "volunteered" to go because I'm a minority. (Mid-Atlantic University)

In contrast to the passive nature of many PIs, graduate Students of Color were proactive in their approach to shifting the accepted norms of the lab setting. However, some students like Terrell felt coerced into this work because faculty members and administrators would not create more inclusive lab settings. For some participants, this additional labor was necessary to survive rather than thrive in graduate school.

### **Summary**

Graduate Students of Color in STEM experienced laboratory environments that were often sites of isolation and competition. Participants highlighted the compounding ways in which marginalization could force graduate Students of Color in STEM to turn inward and be disconnected from other graduate Students of Color. While students recognized the close-knit family-like structure of lab teams, students also emphasized the dysfunction apparent in such structures. Dysfunction ranged from benign challenges around poor management and concerning behaviors associated with low expectations to blatantly malicious tactics such as withholding funding, visas, or project progress in order to produce desired results from students.

While this study did not directly compare the experiences of graduate Students of Color to white students, there are several distinct ways in which graduate Students of Color may experience laboratory environments which perpetuate isolation and competition and force students to create their own support systems (in many cases made up of other graduate Students of Color or students with other marginalized identities). Although all graduate students may experience these feelings and environments due to the nature of laboratory settings and graduate



education, Students of Color experience these challenges in unique, racialized ways. In particular, STEM faculty and graduate students may marginalize graduate Students of Color by making them feel as though they do not belong and they lack the knowledge and skills to succeed. Due to the limited or non-existent connections that students have with other graduate Students of Color, they may not know how to navigate experiences of racism and marginalization within laboratory settings. As a result, graduate Students of Color in STEM may create their own supportive structures in order to be successful and encourage a better outlook for future students. And, while this may serve as an immediate response to improving the laboratory climate and socialization processes around them, it may not address the issues on a systematic level.

### **Discussion**

Our work points to the unique setting of laboratory-based graduate training and demonstrates the importance of socialization within those spaces. Labs are where STEM graduate students spend the majority of their time and are essential spaces in which norms of the discipline are reproduced. Not only does this work have implications for socialization to the discipline, but also for what it means to be a STEM-engaged person within a lab-based setting. Within this study, graduate Students of Color are socialized to believe that STEM lab spaces are sites of isolation, competition, and dysfunction that are difficult to change without their, often underappreciated and uncompensated, labor contesting those norms. Although these experiences may seem more connected to lack of representation within the lab setting itself and not some unique isolation or ostracization of STEM graduate Students of Color, this is a false dichotomy. Yes, Students of Color are underrepresented in STEM graduate programs and increasing representation may indirectly improve lab environments. Broadening participation is certainly

important to growing peer and mentoring networks for graduate Students of Color. However, it is also important to recognize the undue persistent burdens graduate Students of Color experience due to institutional racism. Minimizing the racialized dynamics of STEM labs and using color-evasive ideology “protect[s] a racist educational system by minimizing the effects of racialized social systems” (McGee, 2020, p. 42) and renders STEM graduate Students of Color invisible.

In many ways, this study is consistent with previous research that has examined STEM graduate education and the experiences of graduate Students of Color. However, it also provides a unique contribution to our understanding of the socialization and graduate training of Students of Color. Scholars have established that the purpose of graduate studies is to socialize students to the norms and values of their disciplines (Gardner & Mendoza, 2010; Golde & Dore, 2001; Golde, 2006) and train students to sustain and advance their discipline (Bieber & Worley, 2006; Gardner & Mendoza, 2010; Golde, 2006). Within STEM fields, labs are key sites of socialization as graduate students learn the knowledge and skills associated with being a scientist (Borrego et al., 2017; Burt, 2017; Holley, 2009).

However, many models of socialization do not account for power, privilege, and oppression and how these concepts operate within the lab setting where people act in ways that perpetuate larger systems of inequity. Our findings complicate the idea of the lab itself and of team science as being beneficial for everyone (e.g., Burt, 2017; Villa et al., 2013). Prior research assumes that lab settings are spaces of cooperation and relationship-building, however, this ignores the power imbalance between PI and graduate students, particularly graduate Students of Color, and the evidence that lab environments are often identity evasive. Furthermore, our findings highlight the ways in which graduate Students of Color in STEM feel regularly marginalized and oppressed, whether explicitly or implicitly, by faculty members and labmates

who may hold racist ideologies and stereotypes about their STEM abilities and belonging within graduate student programs.

While our findings affirmed the power of labs as sites of socialization, they also revealed how lab experiences can be detrimental to STEM graduate Students of Color and subject these students to racialized instances of isolation, competition, and marginalization. Graduate Students of Color in STEM were often isolated from other Students due to the insular nature of labs. As a result, labs became racialized, toxic environments in which graduate Students of Color faced low expectations about their productivity and competence as well as perceptions from peers that any financial support benefits derived from their status as a Student of Color. When facing ostracization within their labs, graduate Students of Color often had no other People of Color to turn to due to under-representation within the labs and because they felt discouraged from engaging in communities or activities outside of the lab. In essence, graduate Students of Color were further isolated and came to believe that their racialized experiences were unique based on the norms of their lab settings. When graduate Students of Color sought activities outside of the lab advocating for more inclusive forms of socialization and treatment of Students of Color, they felt obligated by the norms of their labs to prioritize their research and limit diversity, equity, and inclusion (DEI) work. In contrast, Graduate Students of Color who prioritized their research were “volun-told” to engage in DEI work based on their marginalized identities.

Because labs are critical sites of socialization and spaces for sustaining STEM disciplines and fields, they have the power to advance diversity and inclusion for graduate Students of Color or sustain if not compound their marginalization. Our study demonstrates that lab settings are isolating and hostile, and, because of the small number of graduate Students of Color in STEM, these feelings become more salient since students do not see other people who share their racial

identities and challenges. Because graduate Students of Color felt it was the norm within their labs to pit extra-curricular activities against laboratory responsibilities, they often became isolated from each other and had few support systems to help them navigate the effects of racism within their labs. For many graduate Students of Color, their identities and racialized experiences were not attended to within the lab, particularly when there were competing priorities for faculty.

Our research reaffirms the power of the apprenticeship model and team-based learning in STEM graduate education (Bieber & Worley, 2006; Gardner, 2007, 2008; Feldon et al., 2016) and emphasizes the importance of advisors and lab structure as key elements in graduate socialization (Crede & Borrego, 2012; Burt, 2017; De Welde & Laursen, 2008). Prior research has explored the ways in which the apprenticeship model has been used to translate knowledge and skills within one's discipline (Bieber & Worley, 2006), yet, like others (Burt et al., 2018; Noy & Ray, 2012), our study also demonstrates how problematic the apprenticeship model of training can be if students do not have equal access to mentorship and advising from faculty members. Our study demonstrates how the advisor sets the tone for socialization to the field, and if the team is dysfunctional, a team-based approach cannot function, and graduate Students of Color are often left to deal with the compounding effects of isolation and competition. Sadly, our study reaffirms prior findings (Burt et al., 2018; Ellis, 2001; Joseph, 2012; Ramirez, 2017; Turner & Thompson, 1993) that graduate Students of Color receive less mentorship from their advisors than their white peers. Faculty members lacked confidence in the ability of graduate Students of Color in STEM and encouraged, whether explicitly or implicitly, further marginalization of students by their peers. In some cases, students like John were explicitly told they did not have the ability to complete a Ph.D. in STEM.

Moreover, our research illustrates how the apprenticeship model can be used by advisors to socialize students to work in isolation, encourage students to compete with each other, and exploit the labor of graduate Students of Color in STEM. Our findings support the concept that advisors set the tone for how lab groups will function (Burt, 2017; De Welde & Lauresen, 2008) and suggest that when advisors encourage competition, graduate Students of Color often become isolated and are forced to create their own support structures in order to persist. And, although all STEM students may experience feelings of isolation and hostility during their graduate programs due to the laboratory structure (e.g., individualized laboratories, lack of cross-laboratory collaboration), persistence may be especially challenging for graduate Students of Color as they navigate systematic racism within their laboratory environments (Borrego et al., 2017; Griffin et al., 2018).

Our findings also echo prior studies which suggest that larger lab groups encourage advisors to take a more managerial approaches focused on deliverables (Crede & Borrego, 2012). Our study extends the literature by explicitly addressing the problematic relationship between funding sources and socialization. Students felt as though faculty members often encouraged competition for guidance and socialized students differently depending on funding sources. Within our study, the focus on deliverables and production was closely connected to socializing students towards isolation and competition which further marginalized graduate Students of Color within their labs. Notably, some graduate Students of Color were engaged in research that was not core to the work of the lab or the main priority of the PI. Since their work was not viewed as a key deliverable, these participants' work received little guidance, support, and interest from their PI and from their peers which contributed to feelings of isolation. In particular, Graduate Students of Color who were paid via fellowship funding (many of which are

often marked for Students of Color or promoting broadening participation in STEM) often received less mentoring from faculty members who focus more on the graduate students who are being paid directly by the faculty member. Ultimately, this distance from the core work of the lab puts graduate Students of Color at a disadvantage for pursuing faculty careers since they have fewer opportunities to publish and to present their scholarship. Our study also points to a problematic reward system in which students produce research as a means to completing their degrees but may not receive equal publication opportunities that see a direct reward within competitive lab environments thus supporting a potentially unhealthy work environment.

Prior studies have described the tension between collaboration and competition within labs that can lead to decreased satisfaction, stratification, and exploitation (Borrego et al., 2017; Crede & Borrego, 2012; Feldon et al., 2016; Löfström & Pyhältö, 2015; Louis et al, 2007). However, the literature is evasive of the discussion of race and the ways in which racialization and racism manifest themselves within the context of lab settings. While we know that graduate Students of Color have less access to mentoring from faculty members than their white peers (Felder et al., 2014; Ellis, 2001; Noy & Ray, 2012; Ramirez, 2017; Turner & Thompson, 1993), our study suggests that encouraging peer competition and taking a hands-off approach to socializing graduate students only serves to further isolate and marginalize graduate Students of Color.

Graduate Students of Color are, therefore, socialized to create their own structures of support in order to be successful. Participants resisted against oppressive socialization practices that they saw in their labs and crafted more inclusive, cooperative, and supportive socialization practices. Given the perceived lack of support within the lab, our study points to the ways in which graduate Students of Color are resisting marginalization by seeking their own support

systems in order to persist (e.g., Burt et al., 2018; Perez et al., 2019). In contrast to prior studies, though, our study suggests that graduate Students of Color found supportive peers in their own labs (i.e., “families”) and outside of their labs (i.e., “extended family”) which might suggest the growing critical mass of graduate Students of Color who can support each other or the growing tide towards diversity efforts and collaborative STEM. However, our study also clearly demonstrates the unpaid, unrecognized labor that graduate Students of Color do for institutions of higher education. These efforts, while critical to the survival and success of students, represent labor that is not being done by white graduate student peers, faculty members, or the institution.

### **Limitations & Implications for Research**

This study was limited in several ways that pose implications for future research. First, for the purposes of this paper, which was focused on graduate Students of Color, we chose to center the voices of these students, rather than present data from other groups within the larger case study. Future research that presents perspectives from additional identities and institutional positions (e.g., postdocs, faculty, advisors) may provide important insights into lab dynamics that influence graduate Students of Color and other groups who are underrepresented in STEM programs. Second, the current study represents a single point in time at both institutions, which limits how we understand socialization over time. Future longitudinal research can give important insight into the effects of the lab relationships discussed in the current research, and how they impact retention and post-graduation employment and success. Next, while the findings of the current study suggest that there may be difference across lab structure and socialization processes, future research is needed to more fully understand these differences. Variation in lab structures between advisors and across programs and institutions became apparent and provides an important future research site. Understanding if or how varying lab set-

ups or rotations impact the experiences of Students of Color can provide additional insight into student experiences and potential opportunities for programmatic improvements.

Finally, there were several influences that the research team had anticipated but did not come up in the course of data collection that could be further explored. The STEM graduate Students of Color within this study did not articulate the influence of international peers or faculty members as particularly salient to their experiences. Future students might seek to better understand the nuances between the experiences of U.S. born and international graduate Students of Color in STEM as well as the influence of international faculty members on socialization processes. In addition, participants of the study did not discuss informal socializing outside of the lab setting with lab mates (e.g., going out together, traveling to conferences together), with the exception of those students connecting with others for individual support and advocacy. In the future, researchers might further explore how graduate Students of Color experience these informal spaces for socialization.

### **Implications for Practice & Policy**

This study has several implications for the policies and practices related to socialization in STEM education for graduate Students of Color. Institutions and STEM faculty members may consider shifting the norms and practices of socialization within lab settings. To combat issues of isolation and competition, institutions might consider a two-fold approach in which they enhance individual-, laboratory-, and departmental-level socialization practices for graduate Students of Color and implement institutional-level procedures for faculty training related to advising and supervising labs. To promote inclusion, cooperation, and support for graduate Students of Color, training and incentives for faculty members could focus on enhancing a variety of socialization practices as well as identifying and addressing racialized biases in lab processes.



To enhance the way in which individuals are socialized to their disciplines, institutions might consider practices which encourage Students of Color, thus giving them structure as well as agency, to connect with each other in collaborative, rather than competitive, ways. Institutions and faculty members can help students foster these meaningful connections by creating formal and informal socialization opportunities to build personal and professional relationships with STEM peers and faculty members. Formally, institutions and their faculty members can create opportunities to promote and incentivize collaborative STEM projects (e.g., recognition and seed money for collaborative projects) across labs, departments, and disciplines. In addition, institutions might consider assigning graduate students to multiple mentors or mentoring circles to facilitate a wider network of support. Informally, institutions and faculty members might look for ways to bring labmates or multiple labs together, including regularly scheduled group outings (e.g., dinners, research-focused visits of other labs) or department- or college-wide STEM-focused seminars to highlight graduate student research.

Institutions might also explore ways in which to create meaningful connections within graduate education between the academic and research context and extra-curricular activities for Students of Color. These connections may enhance the ways in which graduate Students of Color both learn and reimagine the norms and practices of within STEM disciplines. Because graduate Students of Color may feel further isolated and marginalized in the STEM context, providing these connections may encourage students to stay connected to their university communities and provide a means for connecting them to other People of Color, both inside and outside of STEM. Furthermore, institutions might also consider programming or curricula for graduate students which build awareness and understanding of race and identity within the STEM context. Such efforts might prioritize learning about and garnering resources to affirm and support Students of

Color much in the same way that professional development opportunities might prioritize learning about teaching or securing grant funding.

Because some PIs are so hands off, they are disconnected from the dynamics in the lab, do not know how to address conflict or other difficult situations, and do not have a pulse on the culture and climate of the lab. Consequently, Students of Color may have to do the unpaid labor of enhancing the lab setting and shifting the lab climate to be a more positive one if they are to persist. Students of Color have a vested interest in seeing other Students of Color be successful and making sure that they do not undergo the same trauma; however, this is viewed as being tangential if not unrelated to the work of the lab. As such, this labor does not get compensated, and is not acknowledged as real labor since it doesn't explicitly contribute to the deliverables of the lab. And while graduate student education should encourage students to become stewards of the discipline, such efforts at improving graduate student socialization should not be the work of graduate Students of Color alone. This work is vital to improving the experiences of graduate Students of Color in STEM, but it can come at the cost of their wellbeing and their degree progress. At times, institutions may think they are empowering Students of Color to "do the work" of diversity but simply shifts responsibility of graduate education and socialization to minoritized graduate students and away from the more structural efforts that are the responsibility of faculty members, departments, institutions, and disciplines/fields. Institutions, and by extension faculty members, should accept responsibility for DEI work. To address issues of isolation, competition, and lab environment, institutions may seek to implement department or institutional-level faculty training for promoting a supportive, engaging, connected, and identity-conscious environment in a way that promotes healthy competition and production of knowledge within graduate education. Faculty training might focus on management and mentoring best

practices, with a particular focus on how their actions within the lab can foster community building and belonging or encourage competition and isolation for graduate Students of Color.

At a basic level, institutions might consider training faculty members first on basic management and supervision skills, including how to handle conflict, provide constructive feedback, and create a positive work environment. To address the needs of graduate Students of Color, institutions should consider implementing faculty training focused on recognizing implicit biases, intersectionality, and color evasiveness. Training on implicit biases could focus on describing what it means to have implicit biases as well as how to address them on individual and structural levels. Training on intersectionality and color evasiveness might highlight the existence of racialized lab experiences for Students of Color as well as address any faculty who might try to avoid substantive discussion or acknowledgement of those racialized experiences. These trainings might also focus on how to create an inclusive and identity-conscious lab culture that attends to the needs of graduate Students of Color, including ways to infuse DEI work into traditional lab practices (e.g., lab meetings, seminars, collaborations). As individuals who set the tone of labs and establish norms around socialization, these trainings have the capacity to enhance graduate student experiences at individual, institutional, and field levels.

Institutions should thoroughly examine how they create accountability for DEI work and management and mentoring practices for faculty and PIs. By doing so, institutions hold their faculty and PIs responsible and accountable for these practices which are a component of their work. This includes thinking through structures that allow students to give feedback about their experiences without retribution, which may include periodic town halls, focus groups, or cultural climate surveys of STEM graduate students to examine lab and departmental well-being. Subsequently, institutions should be transparent about how these feedback sessions are used,

including thinking about who feedback goes to (e.g., faculty member, department chair, provost) and how it is presented or de-identified. Furthermore, institutions might consider tying accountability measures to institutional processes such as promotion and tenure, including regular evaluations of how faculty members are purposefully integrating DEI work into their responsibilities. However, institutions might also take into account how lab-based feedback might reveal implicit and explicit biases against women and faculty members of color, as sometimes seen with course evaluations (Chávez & Mitchell, (2020).

In addition, institutions might consider the ways in which graduate student funding is currently inextricably linked with advisor control, which can create hostile environments for graduate Students of Color. Institutions might move towards decoupling such funding support from the advisor in order to create more supportive environments. While students' contribution within lab settings may shift as the student advances within their program, which is developmentally appropriate, our study demonstrates that graduate Students of Color may not benefit from this normative approach. Although this is not unique to graduate Students of Color, this population may experience challenges that limit agency, support, and their ability to be successful within their STEM environment. In turn, institutions might consider measures that give students more academic and financial agency within their programs, including processes such as annual programmatic reviews where they may have open conversations about their progress, formal processes for multiple sources of faculty mentoring and support, and regular opportunities and avenues for graduate students to voice their concerns. Specifically, faculty members might also consider how to provide inclusive support to all of their students. Best practices around these concerns might include compensating graduate Students of Color with competitive salaries that increase each year as their responsibilities increase, outline clear

expectations concerning those responsibilities as well as compensation, and, finally, compensate graduate students for any DEI labor that they may desire to engage in. Compensation for DEI work could come in the form of increasing base pay, providing additional stipends, increasing professional development or travel funds, providing additional vacation or leave time, or allowing for flexible schedules or remote work arrangements.

In addition, practices of admitting more students than institutions can support may perpetuate this culture of competition, isolation, and marginalization and impede efforts to enhance socialization of graduate Students of Color since those with fellowships to support racially minoritized students were often assumed to be less capable or worthy of admission. Institutions might consider how they can support all admitted students, whether financially or procedurally to ensure that there is a cultural shift in how programs socialize their students to be “stewards of the discipline” (Golde, 2006, p. 5). Once admitted, programs might look towards structuring labs and departments in terms of how they can create developmental structures which provide support for learning the norms, standards, knowledge, and practices of the discipline and for advancing inclusion. Through these developmental structures, graduate Students of Color might have the agency and opportunity to create and use extended “family” for the support that their lab families are not giving them. These extended mentoring connections can also provide a means for mobilizing against pervasive negative racialized experiences and voicing those concerns to lab and departmental leadership in order to improve the way that graduate students are socialized to the discipline.

### **Conclusion**

This study expands the literature on graduate student socialization and illuminates how STEM labs can detract from and/or contribute to success for Students of Color. Since negative

lab climates are created by multiple actors, our findings highlight the need to address racial climate and the culture of competition in STEM labs with faculty, students, and post-doctoral fellows if we are to better support graduate Students of Color. Our study also calls attention to the labor of Students of Color who work to retain each other when labs and departments provide inadequate support.

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