Rethinking "Damage-Centered" Research and Individual Solutions: Cultural Humility as a Framework to Increase Student Diversity in Undergraduate STEM Departments

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This study examines data from a participatory research action study on the experiences of underrepresented students in Science, Technology, Engineering, and Mathematics (STEM) fields at a small liberal arts college in the United States. Our analysis aims to move away from the framework that students needed to be taught how to cope with and overcome the challenges they faced in their STEM experiences, including racism and sexism. Instead, we propose a stronger focus on how to end racist, sexist, and other forms of discrimination. We draw on the concept of "cultural humility" as a concrete framework that professors, departments, and institutions can use to approach their work of changing practices, policies, and systems. Results discuss specific strategies that educators and institutions can use to promote a cultural humility framework as one way to create anti-oppressive and equitable classrooms, departments, and institutions.

INTRODUCTION

Previous research examining the lack of racial and gender diversity in Science, Technology, Engineering and Mathematics (STEM) fields has delineated the effects of opportunity gaps on underrepresented students in STEM (Akiba et al., 2007; Flores, 2007; Pitre, 2014; Tsoi-A & Bryant, 2015) and has concluded that students of color, students from low-income backgrounds, and white women have had fewer opportunities in high schools to explore STEM and develop knowledge and skills (Saw et al., 2018; Tyson et al., 2007). Studies have also examined the stereotypes and discrimination faced by these groups of students in STEM classes, departments, and fields (Beasley & Fischer, 2012; Hall 2017; Makarova et al., 2019; Smeding, 2012). In this article, we examine data from a qualitative study, conducted in 2015-2017, about student experiences in STEM departments at a small, liberal arts college. Drawing on principles of participatory action research (McTaggart et al., 2017; Torre, 2009), the study involved underrepresented students as both researchers and research participants. In the study and this article, we define "underrepresented" as students from groups that have been historically underrepresented, and often continue to be underrepresented, numerically and culturally in STEM fields, especially on the basis of race, gender, and socioeconomic class. At the study site, Carleton College, the STEM departments included Biology, Chemistry, Computer Science, Geology, Mathematics and Statistics, Physics and Astronomy, and Psychology.

In our interviews with faculty and students in STEM departments, we initially posed questions similar to those asked in previous studies and generated similar results: students of color and students from low-income backgrounds attributed difficulties in their STEM classes to academic under-preparation in their high school STEM education; students of color and white women talked about experiences of discrimination and marginalization at the college, especially from their peers; and many students shared strategies they used to cope with such experiences as well as with stereotype threat and imposter syndrome. Students and faculty also described department-level and school-level systems—including academic resources, financial assistance, and mentoring—in place to support students from underrepresented groups. As a small, selective liberal arts college, Carleton College has structural

features described as "supportive" for students from underrepresented groups to enter and be successful in STEM majors, including "higher selectivity in enrollment, lower faculty-student ratios, and higher faculty-student interaction (monitoring, advising, counseling, and student involvement in faculty research)" (Seymour & Hewitt, 1997, p. 6). Despite having these beneficial features, our study indicates that students from underrepresented racial and gender groups continue to face challenges and that STEM departments still struggle to consistently recruit and retain students from these groups.

Previously, extensive research has focused on the importance of students from underrepresented groups cultivating a growth mindset and increasing their resiliency (Dweck, 2012). Our initial research framework used these concepts to generate research questions and to analyze our data. We catalogued the damages done to students from underrepresented groups as they made their way through STEM classes and majors. We focused on their experiences with racism, sexism, and classism to "show" the faculty and the college that changes were necessary. However, as Tuck (2009) explains, this approach can end up being harmful to underrepresented students while not actually leading to the necessary systemic and structural changes. While it is critical to remind all students that their talents can grow as a result of good teaching, effort, and perseverance (Dweck, 2012), it is more important to emphasize the role and responsibilities of those in positions of power, such as faculty and administrators, and the role of historical practices within STEM disciplines have played in making these disciplines exclusive (Miriti, 2019). Rather than trying to develop resilient students who can succeed in college environments that are actively hostile or passively insensitive and/or indifferent, we need instead to build anti-oppressive and equitable classrooms, departments, and institutions that are healthier, more nurturing, and safer for students from underrepresented groups and for all students (Hanna-Attisha, 2020; Kundu, 2020).

Given the striking similarities between the experiences of students in our study and those of students examined in previous studies, we decided to re-analyze the interview data to focus less on students, and more on the faculty and the institution. In our re-examination, it became clear that faculty are not getting the

support, preparation, or training needed to effectively educate and mentor students from underrepresented backgrounds. The faculty also receive little support to learn how to participate in and guide discussions about how the historical and contemporary practices in their disciplines are rooted in racial and gender exclusions (Arday & Mirza, 2018; Cronin et al., 2021; Miriti, 2019; y Muhs et al., 2012). Similarly, our findings also suggest that it is important for students with race, class, and/or gender privileges to gain a better understanding of how opportunities are structured by race and class in K-12 schools and in colleges; to gain skills to work effectively in diverse learning environments; and to intervene when they witness acts of discrimination.

In this article, we first describe the frameworks that guided our re-analysis of our study results. We focus then on interview data from students and faculty to explore how faculty had few opportunities in their training to teach a diverse group of students and to facilitate difficult conversations about racism, sexism, and other forms of discrimination with their students or colleagues. We focus similarly on the lack of opportunities for students, especially those from privileged backgrounds, to develop an understanding of structural disparities in STEM learning opportunities and the skills to work across differences in social identities and experiences. Based on these findings, we suggest that a cultural humility framework (Fisher-Borne et al., 2015; Foronda et al., 2016; Hodgin, 2014; Miriti, 2019) at the individual, department, and institutional levels might be helpful if institutions are interested in building equitable educational environments, rather than continuing to focus solely on addressing "skills gaps" among underrepresented students or on individualized frameworks such as growth mindset. Specifically, we suggest two concrete steps: (1) professors, departments, and institutions need to go beyond "understanding and responding to diversity" and actively work instead towards challenging systematic inequalities through "reflection, institutional and individual accountability, and the mitigation of systemic power imbalances" (Fisher-Borne et al., 2015, p. 173) and (2) departments and institutions need to provide ongoing opportunities for all faculty and all students to understand and analyze power and privilege in classrooms, in peer groups, in departments, in disciplines, in institutions, and in society.

The racial justice uprisings in 2020 in response to the police murders of George Floyd, Breonna Taylor, and too many other Black people have led to renewed calls by Black students and alumni at Carleton College to examine deeply the institution's racist practices and policies and to develop a racial equity plan (Ali et al., 2020). While the data for this article were collected a few years before these demands, similar calls for anti-racist pedagogy and policies existed at the time of our study (Melendez et al., 2016), and the need for students to continually demand such changes from institutions speaks to the difficulty of making structural, deep-lasting changes to institutional cultures. However, we remain hopeful that this work can be done, and we highlight a few recent efforts at Carleton to start this work in our discussion about strategies for systemic change.

Guiding frameworks for re-analysis of study data

Eve Tuck's (2009) "desire-centered" framework that asks researchers and communities to move beyond what she calls "damage-centered" narratives was foundational to our re-analysis of our study's data. Tuck (2009) explains that in "damaged-centered research,"

the main focus is on documenting "pain or loss" to an individual or community (p. 413). While this approach does account for social and historical factors that lead to these painful situations, Tuck argues that it is still a harmful lens because it is "research that operates, even benevolently, from a theory of change that established harm or injury in order to achieve reparation" (p. 413). Our initial questions and analyses were clearly framed in this mode--we asked about and chronicled the "damage" experienced by underrepresented students in STEM because of racism and sexism. We did so because we believed that we needed to show that the problems that have been widely documented in existing research were also problems at Carleton. When we presented our initial findings to faculty and staff (Chikkatur et al., 2016; Chikkatur & Valle, 2017), they were sympathetic, shocked, and eager to know what to do. As Tuck (2009) notes, this approach of chronicling harm and damage to marginalized groups or communities does often lead to short-term changes or gains. However, she asks, "Are the wins worth the costs of thinking of ourselves [or others] as damaged?" (p. 415), especially as Kumashiro (2002) notes, more information and knowledge about oppression does not necessarily lead to empathy or, more importantly, to action to change oppressive conditions.

In addition to a "damage-centered" approach to our study, our initial frameworks for understanding the experiences of students and for delineating necessary changes revolved around individualistic frameworks such as stereotype threat and growth mindsets. In our initial analyses, we noted that research on stereotype threat has demonstrated that people can face extra pressure about their performance on a task for which their group is negatively stereotyped (Spencer et al., 2016; Steele & Aronson, 1995; Stone et al., 1999). The effects of this threat can result in the attrition of white women and racial minorities from STEM fields (Beasley & Fischer, 2012). We drew on research focused on combating stereotype threat to suggest actions that professors could take such as teaching students about the concept as a means of improving academic performance (Johns et al., 2005), emphasizing the salience of group achievements (McIntyre et al., 2003), or reframing the threat as a challenge (Alter et al., 2010). Similarly, we discussed the benefits of asking students to adapt a "growth mindset," (Dweck, 2016) citing research findings that believing that intelligence is not fixed and can be developed helps combat the negative effects of stereotype threat, particularly on students from underrepresented groups (Xie et al., 2015). These suggestions, however, assumed that students needed to be taught how to cope with and overcome the challenges they faced in their STEM experiences, including racism and sexism, rather than focusing on how to end racist, sexist, and other forms of discrimination. Even seemingly positive frameworks such as "growth mindset" implies that it is students who need to think differently about or react productively to oppressive situations. However, as Love (2019) notes about K-12 students, "There is no amount of grit that can fight off the intersections of living in poverty, being pushed out of school, facing a world full of patriarchy and racism" (p. 86). The same is true for students encountering stereotypes and discrimination in their college STEM classes and departments.

Tuck's (2009) critique of "damage-centered" narratives and Love (2019)'s critique of concepts such as "grit" and "resiliency" forced us to rethink our approach to data analysis and to focus more on the structural and institutional changes necessary to create anti-racist, anti-sexist, equitable classes, departments, and

colleges, rather than on how to help individual students cope with racism or sexism or catch up with their privileged peers. We realized, however, that it can be difficult to know where to start with structural and institutional changes. As Sabzalian (2019) notes in her study about Indigenous students' survivance, it seems easier and more manageable to take on "the more immediate and satisfying project of adequately equipping [a] student to tolerate" the status quo when considering "the time, energy, and collective efforts it would take to transform complex, system issues" at an institution (p. 15). The fact our study results basically replicated the findings of so many other studies about racial and gender minority students in STEM demonstrated that the fact that even the desire to change among individuals, departments, and institutions is not enough. After all, faculty and administrators at our study site were eager to learn and make changes, as demonstrated by their financial investment to support this research project (all the STEM departments contributed funds to finance this study) and the robust attendance at presentations about our initial findings (approximately 70 faculty and staff attended at least one presentation), and yet the problems persist.

To that end, we draw on the concept of "cultural humility" as one concrete and holistic framework that professors, departments, and institutions can use to approach their work of changing practices, policies, and systems. This framework, developed initially in the fields of medicine, nursing, psychology, and social work, posits that it is essential that there is an awareness of power differentials when it comes to understanding the experiences of underrepresented individuals and groups. While cultural competency frameworks encourage an awareness of cultural differences, the cultural humility framework insists that those in power need to develop a "critical self-awareness that examines the inherent power imbalance" that exists in any context (Fisher et al., 2015, p. 169). In the context of a college, professors who come from dominant, mainstream groups need to pursue both "individual and institutional accountability in challenging barriers that impact marginalized communities" (p. 166). It means recognizing that the "gaps" we need to address urgently are not the gaps in STEM knowledge or skills that underrepresented students may have but instead the gaps that professors and students with privilege often have in understanding the role that historical and systemic oppression play in creating STEM departments that are mostly white and male. As Gorski and Swalwell (2015) explain, white students and professors "may have the steepest learning curve when it comes to learning about bias, discrimination, and inequity" (p. 39). Providing faculty and students with ongoing opportunities to reflect on "biases within society and within themselves" is a crucial part of adopting a cultural humility framework (Glowacki-Dudka et al., 2012, p. 2). It is also important to keep in mind that shifting cultures is a collective undertaking, not just about individual faculty members making curricular or pedagogical changes in their individual classrooms.

Faculty "diversity" training programs often are ineffective because they tend to be short-term (Booker et al., 2016, p. 1) and not necessarily focused on shifting deficit and biased frameworks that faculty bring to teaching. For example, many white instructors, including those who may consider themselves as not racist, are socialized to believe in ideologies such as meritocracy, individualism, and objectivity (Hudson, 2020, p. 2). While this article does delineate specific strategies and changes that individual faculty, departments, and colleges can pursue, we argue that an ongoing, collective examination of power and privilege, a central aspect of the cultural humility framework, is the most necessary step in creating anti-racist and equitable educational environments.

Research context

This study was conducted at a small, residential liberal arts college located in the midwestern part of the United States. Carleton College enrolls approximately 2000 undergraduate students. In the 2015-2016 school year, approximately 25% of the students were identified as racial minority students and 11% were considered to be first generation college students. Carleton is well-known for its STEM programs and the college's STEM departments routinely have some of the highest numbers of majors (Math & Science at Carleton, 2019). Carleton, along with other top liberal arts colleges, produce a large fraction of undergraduates who go on to earn doctorates in the science and engineering fields (Tilghman, 2010). Because smaller colleges tend to have fewer graduates than large research universities, examining what the National Science Foundation terms the "institutional-yield ratio" data demonstrates these colleges' true impact. For example, between 2002 and 2011, colleges that only or mainly award baccalaureate degrees accounted for 27 of the top 50 U.S. institutions from which science and engineering doctorate recipients earned their bachelor's degrees (Fiegener & Proudfoot, 2013). These data are not surprising given that research has indicated that selective, small liberal arts colleges have structural features that support students to enter and be successful in STEM majors, as noted earlier (Seymour & Hewitt, 1997). Our results, however, indicated that underrepresented students continue to face challenges even in an environment with these supportive features.

Over the past decade and a half, the college and the STEM departments have made specific changes and investments to address the obstacles that students from underrepresented groups faced. STEM faculty members we interviewed discussed strategies their departments have used to address the fact that not all students have had access to the same pre-college opportunities to take higher-level coursework in STEM fields. For example, departments have changed the structure of some sections of their introductory classes to meet the learning needs of students without much high school STEM experience—these sections meet more frequently, have fewer students, and emphasize more practice and hands-on experience. At the college-level, FOCUS, started in 2007, uses a cohort model to support students in their first two years. The STEM departments also have a summer program that provides funding for two years of research experiences at Carleton and at other institutions. A report by Carleton faculty and staff found that 86% of students who participated in these two programs over the course of four years had declared STEM majors and only four program participants left the college before graduating (Gross et al., 2015). These kinds of small, cohort-based learning communities can be particularly effective in recruiting and retaining underrepresented students in the STEM fields (Kolvoord et al., 2016; Piper & Krehbiel, 2015). However, while these efforts have made a difference for many individual students, including those involved in this study, they have not always succeeded in consistently creating safe and nurturing spaces for students from underrepresented groups in STEM classes and departments.

Research framework:
Participatory Action Research (PAR)

The research team, consisting of one faculty member and five students, drew on the principles of Participatory Action Research (PAR) framework to design the study. As an approach to conducting research and generating knowledge, PAR centers on the belief that those who are most impacted by research projects should take the lead in framing the questions, design, methods, and modes of analysis of such projects (Torre, 2009). Rather than imposing research studies or solutions onto a community, those who are most affected are given the tools to understand, critique, and change the way things are done (McTaggart et al., 2017). All five student researchers identified as students of color and many also were first-generation students. At the time of the study, all of the students were or were planning to be STEM majors. All five students have since graduated; four with degrees in STEM and one in humanities. The faculty researcher is an Asian American woman whose research and teaching focus on diversity and difference in educational institutions. This article is co-written by the faculty researcher (first author) and one of the original student researchers (second author).

In line with the PAR framework, the student researchers drew on their personal experiences in STEM classes and engaged with their peers to shape significantly the project's focus. Additionally, by having student researchers interview their peers, we hoped to minimize power differentials and the impact of stereotype threat on participants in the research process itself as the student researchers were sensitive to their peers' experiences, knowing when and how to delve deeper into a topic in an appropriate and supportive way. This strategy is in line with PAR principles that insists that the processes of knowledge production through research are not "objective" or "value-free" and encourages researchers to think deeply about the consequences of research methods and results (Torre, 2009).

RESEARCH METHODS AND
DATA ANALYSIS

During the 2015-2017 academic years, the research team interviewed 17 faculty from the college's seven STEM departments about their departments' efforts to support students and increase the diversity of their majors. Three TRiO program staff members were also interviewed. (TRiO is a federally funded program that provides academic, personal, and financial support to low-income, first-generation college students and to students with a documented disability.) Student researchers interviewed 45 students, recruited through personal and departmental networks. Codes for initial analysis were generated collectively by the team. We received IRB approval from Carleton College for both years of the study and all participants signed informed consent forms. All participants were at least 18 years old.

The following questions guided the development of interview protocols, data collection, and data analysis:

1. **What types of challenges do underrepresented students face in STEM courses at Carleton?**

2. **What support systems are available at Carleton to support underrepresented students?**

3. **What factors do underrepresented students view as important in creating both inclusive and welcoming STEM classrooms and departments at a small college?**

4. **What can individual faculty, departments, and the college do to better support underrepresented students in STEM?**

As noted earlier, these questions led us to focus on the "damage" done to underrepresented students at the college and our initial analyses of interview data focused mainly on individual level experiences and solutions. The fact that even researchers coming from "underrepresented" backgrounds chose this research focus demonstrates the power and appeal of this approach. As Tuck (2009) notes, "Many communities engage, allow, and participate in damage-centered research and in the construction of damage narratives as a strategy for correcting oppression" (p. 414). We used an inductive approach in the initial and second round of data analysis (Cho & Lee, 2014). In re-analyzing the interview data, the two co-authors individually re-coded the data in a shared document with a focus on what students and faculty/staff we interviewed shared about the impact of the institutional context and their preparation to learn or teach in diverse contexts. This re-coding led us to generate the three broad themes that we discuss in the findings section:

1. Preparation gaps among faculty related to teaching diverse groups of students and facilitating difficult conversations about racism, sexism, and classism with students

2. Preparation gaps among students related to (a) being able to understand and challenge racism, sexism, classism; (b) having difficult conversations about these topics; and (c) working with diverse groups of peers

3. Ideas for changes that focused on changing systems and structures, and not on changing underrepresented students

Once this initial re-coding was done, we decided that a cultural humility framework was a useful way to discuss how institutions could address these preparation gaps that we found.

Participant demographics

All of the college's STEM departments were represented among the 17 faculty members interviewed for the study; nine were women and three were faculty of color. Among the 45 students interviewed, 14 students identified themselves as being part of either TRiO, FOCUS, or both. At the time of the interviews, 16 students were seniors, 22 were juniors, six were sophomores and one was a first-year student. Two students had yet to declare a major, one was a social science major but had been a STEM major, and the rest were STEM majors with representation from all of the STEM departments. 33 students were female-identified; 11 were male-identified; and one student identified as gender nonconforming. Not all students chose to self-identify racially, though all were invited to do so; 22 students identified as students of color;18 students identified, at least in part, as White; and five chose not to provide a racial identification. Including all students in the study who self-identified as underrepresented served a practical research need—since the college only enrolls 2000 students, it was important to draw on a larger sample of students

to avoid potentially identifying student participants. It also allowed us to examine the experiences of students with a broad set of "underrepresented" identities, including racial, gender, and class identities. Because the numbers of students we interviewed and the number of students of color in the STEM departments are small, we have aggregated all the racial and ethnic identities used by students into these two categories to maintain confidentiality. We have also occasionally changed details about students we quote in the article to protect their identities (e.g. changing their specific major to a generic "STEM" major).

FINDINGS

The student and faculty interviews revealed three main factors that made pursuing and completing a STEM degree challenging for white women, students of color, and students from low-income backgrounds: preparation gaps among faculty and students around teaching/working with diverse group of students; being able to recognize and challenge bias; and facilitating/engaging in difficult conversations about how access to opportunities and resources have shaped by race, class, and gender for all students. In this section, we provided a detailed examination of these factors.

Preparation gaps among faculty

At least two faculty members we interviewed noted that they lacked preparation and training in how to teach diverse groups of students and how to facilitate difficult conversations about racism, sexism, and classism:

> Challenge number one is not having any particular training in this sort of thing and not that I really know any kind of training would necessarily work but we're not trained other than just having lived our lives with people. (white, male professor)

> The students would report other students saying horrifying things in classes, political science classes, economic classes, and the professor would do nothing. Now from my point of view empathizing with the professor, they did nothing because they didn't know how to handle it and you tend to err on the side of not doing rather than calling that out right away. (white, female professor)

Only two of the 17 faculty members we interviewed mentioned having any specific training about teaching in their undergraduate or graduate studies, let alone training around issues of diversity.

At the time of the interviews in 2015-2017, most faculty members we interviewed also noted that their departments did not necessarily have ongoing, structured conversations about diversity, bias, and discrimination in their departments and that often these discussions happened after a particular incident or series of incidents. As one white, female professor noted, "I think we don't have these conversations all the time, it tends to be more around when there's issues that come up." When asked by an interviewer if their department had processes in place to make sure that students who might be struggling in the classroom felt comfortable approaching a faculty member for help, a faculty member responded, "I don't know if we have processes, I think, we have, you know, at best we have attitudes."

The lack of training for faculty to address structurally and systemically issues of bias and discrimination in their classrooms and departments ultimately invalidates the violence and oppres-

sion experienced by marginalized groups. It can also make students from underrepresented groups doubt their own experiences or perceptions, as this female student did:

> Whenever we have meetings with the department it seems like the male professors just talk a lot and that's me again probably biasing like, oh guys tend to like talk more in discussions and whatever.

Research has demonstrated that people in positions of power do tend to dominate conversations and power in local contexts are a function of a complex interplay of many factors, including social identities such as race, gender, class, and age (Coates, 2015; West & Zimmerman, 1987). When students do report experiencing discrimination based on race, gender, or another aspect of their social identity from their peers or from other faculty, it is important that faculty have the skills and the knowledge to know how to respond to the students reporting harm and to the people causing harm, whether it is a student or a colleague. It is also important for faculty to self-reflect on their actions and words in classrooms, including off-the-cuff comments they might make that lead students to feel excluded. For example, a staff member from TRiO noted:

> The curriculum is really meant for an audience of affluent classmates. It might be a professor saying, how did everyone's winter break go? Did you just get to relax the whole time? And maybe someone in TRIO thinks, "no, I went home and I worked the whole time" and or, "actually, no, it was very triggering, it's hard going back to my family or I don't even have a family."

A female student from a low-income background reiterated this point as she discussed her experience:

> Since freshman year, I've had two jobs and I always tell my professors. But it's sort of slid under the table and I told the dean about it some time ago and it was sort of slid under the table then too. And so I feel like Carleton doesn't like to recognize the fact that they know they have people who are working outside of Carleton.

Another female student, also from a low-income background, noted:

> We don't talk about class at Carleton, which has both helped and harmed because people don't think about it and, which is good [in the sense that] you can interact with everyone like you're on the same ground socioeconomically but it's always in the background of my mind being like, wow this person talked about going to all these different places and doing all these really cool things over their vacation, I worked because I need to pay for tuition and that's something that even if it's not always conscious, it's always underlying in the things that I say and do.

Rather than "sliding" uncomfortable conversations "under the table," faculty need to openly create dialogue about socioeconomic status and its impact on students' access to opportunities and resources before college and on students' experiences in their classrooms, departments, and institutions.

Students' comments about gender also highlighted the important role that faculty members play in modeling biased behavior and the need for faculty to challenge such behavior in themselves, their colleagues, and their students. When asked to identify what makes for a good faculty role model, a white female

student from a lower socioeconomic status said "not being sexist". She then noted that sexist comments from faculty only enabled male students to do the same. A non-binary student noted how it was all too common in classrooms for faculty to split groups based on gender or not have multiple gender identities recognized. As students, faculty, and staff all noted in their interviews, it is definitely the responsibility of faculty to ensure that their classrooms are welcoming of all gender identities. As this white female professor noted,

> Increasing diversity is a priority but we don't have solutions. It's not only the right thing to do, it's a good thing to do for the health of the discipline that we are as inclusive as possible. It is 100% the faculty's responsibility to make sure students are included.

It is important for faculty and staff to be prepared for facilitating conversations about the impact of racism, sexism, wealth disparities and other structural and systemic factors on their students' educational experiences and on their own pedagogical practices. As the next section demonstrates, many students also lack preparation and skills to work with diverse groups of peers, to understand the impact of systemic discrimination and disparities on their and their peers' educational experiences, and to have conversations about issues of diversity and inclusion.

Preparation gaps for students

While students attributed their initial hesitancy to pursue a STEM major to concerns about their academic background and preparation, more than half of the interviewed students (26 out of 45) described instances of marginalization or discrimination based on their social identities in STEM classes or STEM-related activities at or outside of the college. These students noted that students whose access to opportunities and resources has been negatively affected by their social identities are often better able to discuss such challenges, compared to their peers whose social identities facilitated their access. As such, it is critical for all students to understand and challenge racism, sexism, classism in and out of the classroom, and be encouraged to have difficult conversations about these topics. Silence from faculty and peers about these issues leave underrepresented students feeling like they must carry the responsibility of initiating and facilitating these conversations. A male student of color described the importance of having everyone initiate these conversations and to carry some of the responsibility:

> I can notice that you know most of, half of the class is POC, half of the class is white, but who are the people who speak up the most? It's the white people and often I can see things from their point of view and it's often me or the other POC in the room that have to offer the other point of view...and it's interesting cause I barely see the white people in the classroom offering an alternative point of view.

As both students and professors we interviewed noted, peers can provide incredible support but also can behave in ways that lead to underrepresented students feeling excluded, ignored, or marginalized. Students we interviewed spoke about struggling with what to do when faced with stereotypes, noting that it may become their responsibility to educate their peers. As a female student of color noted, "You'll hear people say problematic stuff all around campus and I don't know if it's my obligation to step in every single time, because it gets really tiring, right?" A female

student talked about the pressure she felt to speak up in her computer science [CS] classes where she was one of very few women. She would tell herself, "I need to answer questions and speak up because I don't want to just support this stereotype that women aren't very engaged in CS." It is not the responsibility of individual students from underrepresented groups to take on the work of challenging the stereotypes of their peers or professors--it is everyone's responsibility, especially students and professors with racial, gender, and class privileges. As one student framed it, "this process requires more engagement to encourage people to learn how to talk to each other and deal with people who are different from each other." Otherwise, students can feel like their experiences are being dismissed or invalidated. A student of color recalled an instance during a community conversation about diversity within a department where a white male student said that race should not be a factor in interactions or in classrooms. He noted, "I felt a little slighted that he could not see or didn't seem to be able to entertain the possibilities of how race can be a factor in our classroom."

The students we interviewed did identify instances where students with privileged identities were able to recognize instances of discrimination, an important first step in being able to challenge and change exclusionary STEM culture on campus. Because we chose to have students self-identify as "underrepresented" across various social identities, we were able to hear about the experiences of students such as this male-identified STEM major who talked about the gendered patterns they noticed among their peers' attitudes towards male and female tutors. He described how students would always approach him first, "When I'm a tutor…[students will] come in and they'll talk to me first and that's one thing" and even when he makes it clear to students that he doesn't know the answer to their question but the female tutors do, "they still always ask me first." Similarly, a white female student noted:

> I mean I'm white, I'm privileged, I didn't really have to face any of those barriers just coming into Carleton. And so yeah in that part I didn't really have to seek out that part of myself here.

It is critical for students to reflect on the impact of their actions and to practice cultural humility in interactions with their peers from underrepresented groups (Weinstein et al., 2004). Rather than relying on individuals from underrepresented groups to raise issues of race and social class, it is important to have individuals in privileged positions carry that responsibility as well. As Kokka (2020) notes, privileged students need to develop critical consciousness because social justice work needs "the participation of the privileged and the oppressed" (p. 779). As this male student noted, it should be everyone's responsibility but especially that of peer leaders to be aware of how gender might impact students' experiences:

> We know that there are people who are turned away from wanting to practice science and especially physics because of perceptions or their past experiences or how they might feel inadequate and that might sometimes come down to those parts of identity. It's something that I was definitely hyper aware [of] when I had my lab assistant job where it was seven students, all male, except one student, and [a female professor.]...This being my first time, I wasn't sure like,

"Am I doing everything right? Is everything working out? Is everyone feeling comfortable?"

Such awareness is the first step to changing cultures and structures and speaks to the need to educate privileged students and faculty to notice and challenge racist, sexist, and classist behaviors. The ultimate goal is for STEM learning environments to be less biased, rather than needing to develop ways to support students to "cope with" biases. As such, a cultural humility framework at the individual, department, and institutional levels emphasizes building equitable classrooms, departments, and colleges, rather than continuing to focus solely on addressing "skills gaps" or on individualized frameworks such as growth mindset.

Strategies to change class, department, and college cultures

Cultural humility framework: An approach to change

We suggest a cultural humility framework as an overarching approach for individual faculty, departments, and colleges to adopt as they consider specific strategies of change. Cultural humility takes on a "commitment to self-evaluation and self-critique, to redressing power imbalances" (Tervalon & Murray-Garcia, 1998) with the goal of mutual empowerment, partnerships, respect, optimal care, and lifelong learning (Foronda et al., 2016). If institutions can move towards change with a better understanding of cultural humility, individuals and communities will be better suited to understand the limits of the status quo and to create a more inclusive environment. Cultural competency accepts whiteness as the norm creating a concept of an "other," rather than reflecting on whiteness. Cultural humility instead encourages the individual to reflect on their own experiences and historic realities, including their privileges based on whiteness, maleness, and wealth. Cultural competence in practice is best defined as a commitment to and active engagement in a lifelong process and requires humility as individuals continually engage in self-reflection and self-critique as lifelong learners (Tervalon & Murray-Garcia, 1998). While this lifelong commitment and engagement is certainly important, the cultural humility framework highlights the need to have a specific focus on power dynamics when thinking about cultural differences, rather than simply learning to navigate different cultural contexts or backgrounds (Fisher-Borne et al., 2015). Farrelly et al.'s (2021) Cultural Humility Learning Module, for example, relies on principles of "diversity, privilege and bias, cultural humility, fairness, and social justice" and ultimately encourages individuals to think about how they view themselves and interact with other individuals within a larger cultural system (p. 2). In the rest of this section, we describe some concrete strategies for change based on the cultural humility framework.

Encouraging the development of a positive peer culture

Colleges need to pay close attention to peer culture and community in their courses and departments. As both students and professors we interviewed noted, peers can provide incredible support but also can cause underrepresented students to feel like outsiders who do not belong in a particular course or field. Having a sense of community and belonging through positive peer relationships can be an influential factor in building students' confidence. As one female Computer Science major stated, "peers are super important in [my] department--they're the ones who are available late at night if you have a question--so peer support

and community is very important." Beyond providing academic support and camaraderie, a positive peer community also encouraged students to engage more with classmates and the class material. Students noted that the physical layout of departmental spaces, including places for student groups to meet in close proximity to faculty offices, can help support the development of a strong peer network. In addition to paying attention to such features, departments can also encourage all students to reflect on how their identities and experiences may influence their interactions with peers.

Another specific strategy, as indicated by our research findings, is to encourage students to start and/or to support existing department-specific groups tailored to particular underrepresented groups through mentoring and funds (e.g. Women in Physics). The Biology department at Carleton College recently instituted a peer mentorship program meant to foster community among students of color interested in Biology. This program is meant to identify concerns among students of color in the Biology major, and to work on creating a more inclusive and welcoming environment within the major for these students. Having such spaces where students can collectively analyze departmental culture can move the conversation from using individualistic frameworks to understand student experiences to identifying more systemic and structural factors within departments that impact individual student experiences. It allows students to reflect collectively on power dynamics and cultural norms, a central tenet of the cultural humility framework.

Changes at the individual faculty level

A key aspect of adopting a cultural humility framework as an individual faculty member is to develop the ability to self-reflect critically on one's own values, beliefs, and behaviors and to hear critical feedback from their students and peers about how their pedagogical practices or curricular choices might be non-inclusive. Drawing on Fisher-Borne (2015), we posit that professors who are white, economically privileged, or male need to understand that the dominant cultures of their disciplines often are ingrained with values that have led to narrow visions for who belongs in those fields. This understanding can be achieved through pedagogical strategies to increase awareness of oneself in relation to another person's intersectional identities as delineated by the Cultural Humility Learning Module (Farrelly et al., 2021). While Farrelly et al.'s (2021) module is designed for undergraduate students in psychology courses, elements of the module would be useful for STEM faculty as well. For example, they use the Visible Thinking framework developed by Project Zero to facilitate students' racial consciousness and to support them in "critically analyzing previously held beliefs through an inclusive, sociocultural lens" (Farrelly et al., 2021, p. 4).

In addition to reflection and training around pedagogical practices, faculty would also benefit from opportunities to learn about and speak to colleagues and students about how socioeconomic class and wealth structure access to educational opportunities and resources. Students' individual experiences of differential access to curricular and other educational resources reflect larger patterns of inequity based on the organization of K-12 schooling in the U.S. where school funding largely relies on local property taxes (Baker et al., 2014). The historical and ongoing neighborhood and school segregation along racial and economic lines (Orfield et al., 2016) means that students arrive at

college with different levels of access to preparation for college-level courses in all subjects, and often especially in STEM fields. For example, in a study of racial and class stratification across and within K-12 schools in the computer science field, Margolis et al. (2008) concluded that "preparatory privilege" leads to students of color in low-resourced schools being denied "access to learning opportunities, mentors, or sufficient preparation that are so sorely needed" and that those students "are disadvantaged at the starting gate" (p. 137). It is important to have faculty articulate publicly and constantly their knowledge about such disparities in their particular fields, so that all students can understand how their current skills are a result of varying levels of access to resources and opportunities, and not a reflection of their ability or capability.

Here, we want to stress that these discussions should discuss barriers caused by racism, sexism, and/or wealth disparities as well as about how being white, male, and/or economically privileged facilitates access to educational opportunities and resources. It is important for all students to understand how their social identities and contexts mattered in their experiences. A student of color we interviewed noted that it would be helpful to hear "origin" stories from faculty about how they got interested in their disciplines, and we would add that these origin stories need to account for the role that race, gender, class, and other social identities played in facilitating or making it more difficult for faculty to learn about, get engaged in, and become successful in their disciplines. Such stories can be one concrete way for faculty to adopt a cultural humility framework and to model being self-reflective about how structures supported or hindered them in their academic and professional endeavors.

Changing department and discipline cultures

At a departmental level, faculty and staff should ensure that all learning and social spaces reflect the actual and desired diversity in their fields. Research has found that situational cues, such as settings features (authors read, posters on the walls, and so forth) in a classroom or departmental space, can make individuals vulnerable to social identity (stereotype) threat (Murphy et al., 2007). This potential threat to students' sense of self and belonging is especially important to address in primarily white institutions, environments where students from minority groups may feel especially alienated and isolated (Loo & Rolison, 1986). Departments should examine the intended and unintended situational cues in their spaces, including classrooms, student lounges, and department offices, to ensure that they are not reinforcing cultural stereotypes about who belongs in STEM classes and fields (Cheryan et al., 2015).

Departments can signal that diversity, equity, and inclusion are important to the department in several ways. For example, the Physics & Astronomy and Chemistry departments at Carleton College now have clear messages on their departmental website emphasizing their commitment to continuing to work to support students from traditionally underrepresented backgrounds. In addition, the Physics and Astronomy department provides a list of lab expectations to all students (Department of Physics and Astronomy, 2016). We view this list of expectations as an excellent starting point in ensuring that all students take responsibility for creating a supportive, non-discriminatory learning environment for everyone, regardless of their identities or past levels of access to STEM educational opportunities and resources. Drawing on the cultural humility framework's insistence on ongoing reflections

and on shifting cultures, we would hope that the faculty in the department also create structured opportunities for themselves and their students to discuss how well these guidelines are being implemented, with a specific focus on how power dynamics play out in how students are taking on the responsibility for their actions and those of their peers.

Departments can also foster honest conversations about the origins and histories of their disciplines that have led them to be male- or white-dominated and how these demographics have shaped the disciplines (Miriti, 2019). Writing about the field of Environmental Sciences (EE), for example, Miriti (2019) notes,

> …if a person's concept of nature lies outside of the acceptable definition, for example, a person who has never been to a national park or does not enjoy being in remote areas, they are not recognized as valuing nature. This cultural mismatch can contribute to low diversity in EE (p. 4)

At Carleton, for example, the Biology department developed a series of seminar talks in Fall 2020, co-hosted by faculty and students, that examined the racist origins and histories of biology as a discipline, including sessions on the Tuskegee experiment and Henrietta Lacks (Hernández, 2020). Facilitating such ongoing reflections about the history of STEM fields would help faculty and students within a department have more informed conversations about the contemporary manifestations of bias in classrooms, departments, and the discipline. As Miriti (2019) argues, a "willingness to examine cultural biases…embedded in individual scientific disciplines" is a necessary step in recruiting and retaining diverse groups of students (p. 6).

Changing institutional culture

In interviews, students told us that when they encountered stereotypes or discrimination, they struggled with what to do, noting that while it may become their responsibility to educate their peers, perhaps it should not be their responsibility to do so. As we noted earlier, it is everyone's responsibility, especially students and professors with racial, gender, and class privileges to notice bias and discrimination and how this awareness is the first step to changing cultures and structures. Again, the goal is to create less biased educational environments, and not for students to become better at "coping with" bias. Faculty need to support the creation of concrete steps and strategies to challenge racist, sexist, and other forms of biased actions and speech, including their own. One central aspect of adapting a cultural humility framework on an individual, departmental, and institutional levels is the willingness to listen to critique, particularly around how one's positionality and biases might impact classroom and department cultures, and to initiate change at all those levels. Cultural humility stresses the need to challenge the institutions and systems in which we live and work that may, wittingly or unwittingly, enable injustices to continue (Greene-Moton & Minkler, 2020).

A student's story about how she and her peers approached a situation provides a good example of what to do, both for students from underrepresented groups and for students and faculty with privilege. This student--a female student of color from a low-income background--described how she and three of her male peers who tended to dominate class discussions (in a non-STEM class) had a conversation where she pointed out, "I am really a minority here because I'm the only girl, I'm older than all of you, I'm the only person of color and you guys talk a lot in

class." She noted that her peers were shocked, but listened and responded by saying, "Wow, thanks for pointing out that we're like three white guys who speak a lot in our [political science] class." We appreciate in this story both the willingness of the minoritized student to speak and say something directly to her peers and the willingness of her peers to listen to her criticism without becoming defensive. This kind of openness, especially from those in positions of power whose exclusionary behavior is being criticized, is key if the goal is to create less biased, supportive learning environments, rather than to teach students to cope with biased, unsupportive learning environments. We did not get more information about how this situation evolved in our original study; however, if we were to follow-up with all the students, it might be helpful to find more about how each of the students came to this point in their understanding and whether this conversation had a concrete impact on how the male students acted in the class. This example also points to the importance of dialogue and collective work for individuals to move beyond a basic understanding about social identities (cultural competence) and instead develop a deeper level of awareness of one's intersectional identity one's values and beliefs (cultural humility) that impacts how we teach and learn (Tervalon & Murray-Garcia, 1998). One concrete strategy that the first author uses in her classroom to ask students about the last time there was a shift in their understanding or position of a topic and ask them to reflect on what resources and conditions supported that shift. Rather than relying on individuals to "just" change their minds and be more open and willing to have difficult conditions, this question helps focus the conversation on resources and conditions that enable and encourage individuals to question their previous beliefs and ideas.

CONCLUSION
Much of the previous research on underrepresented students in STEM fields have focused on the challenges that come with being underrepresented in the field, exploring dynamics such as stereotype threat and growth versus fixed mindsets (Dweck, 2012, Spencer et al., 1999, Spencer et al., 2016). We instead would like to highlight the need for changing systems and structures and challenging privilege, rather than trying to change underrepresented students. We suggest that a cultural humility approach would be useful in shifting our focus to changing systems, instead of students. We suggest two main strategies for change: (1) professors, departments, and institutions need to go beyond "understanding diversity" and actively work towards challenging systematic inequalities through "reflection, institutional and individual accountability, and the mitigation of systemic power imbalances" (Fisher-Borne et al., 2015, p. 173) and (2) departments and institutions need to provide ongoing opportunities for all faculty and all students to analyze power and privilege in classrooms, in peer groups, in departments, in disciplines, in institutions, and in society. To that end, the initiatives described here by various STEM departments at Carleton College and the institution's recent decision to mandate a series of mandatory anti-racism trainings for all faculty and staff seems like a first, productive step towards changing institutional culture towards inclusion and equity.

ACKNOWLEDGEMENTS

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