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EDITED BY
Susannah McGowan,
Georgetown University, United States

REVIEWED BY
Desiree Forsythe,
Chapman University, United States
Morufu Olalekan Raimi,
Federal University, Otuoke, Nigeria

*CORRESPONDENCE
Alo C. Basu
✉ abasu@holycross.edu

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Embodied curriculum mapping as a foundation for critical self-reflection and culture change

Alo C. Basu*

Department of Psychology, Neuroscience Program, College of the Holy Cross, Worcester, MA, United States

This article describes a first-person qualitative research study to understand how common pedagogical approaches and cultural learning environments in STEM impact individuals. Prior to the study, the author observed that many students who were successful in advanced undergraduate neuroscience courses reported having struggled academically, socially, or emotionally in introductory STEM courses. The objective was to generate new ideas for approaches to address high rates of student attrition from introductory STEM courses related to this full range of issues through curriculum development. The author, a neurobiologist and tenured faculty member at the institution, audited four introductory STEM courses: Introduction to Cellular and Molecular Biology, Atoms & Molecules, Calculus 1, and Introductory Physics 2: Electromagnetism, Optics, and Modern Physics, offered by tenured colleagues in four different departments. A total of approximately 600 hours was spent by the author attending lectures, participating in classroom activities, completing homework, and studying for assessments. Homework, quizzes, and exams were marked by the course faculty using the same criteria as were applied for student work. In addition to measures of academic performance collected through the normal assessments, the author made note of her own emotional responses throughout the course of the study, which is why the process was dubbed 'embodied' curriculum mapping. The emotional responses revealed high levels of emotional stress associated with assessment, sensitivity to disciplinary boundary reinforcement, and a complex role of social and academic identity in all aspects of the experience. Given the first-person nature of the study, the potential future generalizability of the findings must be considered in light of the various revealed aspects of identity and experience of the author and subjected to further study using a broader range of empirical methodologies. The focus of this article's conclusions and recommendations is therefore the impact of the process on the author and the potential for a similar process to serve as a

foundation for critical self-reflection and learning for other STEM educators. The author recommends the process as a generative tool for pedagogical innovation and building faculty capacity for culture change in STEM.

KEYWORDS

curriculum mapping, embodiment, inclusive excellence, autoethnography, deficit thinking, identity, epistemic exclusion

1 Introduction

In 2018, I spent roughly 600 hours auditing four introductory STEM courses (in biology, chemistry, mathematics, and physics). At the time, I was focused on developing a neuroscience curriculum for the institution that would help students build broad-based proficiency across STEM disciplines through the use of inclusive pedagogical approaches and the formation of robust partnerships among faculty across the contributing departments. Accordingly, at the outset, I conceptualized this endeavor in terms of content-based curriculum mapping, and my goal was content-focused: to map concepts and skills that are foundational across STEM disciplines. As a secondary goal, I wanted to observe how disciplinary learning goals are achieved by experiencing the pedagogical approaches first hand.

What was originally primarily a content-focused quest to learn about disciplinary learning goals and pedagogy became a transformative personal and professional experience for me as a faculty member. Auditing four introductory STEM courses while trying to meet the requirements expected of students brought up thoughts and emotions from which over two decades of graduate training and acculturation as a faculty member had distanced me. Unanticipated feelings of self-doubt and vulnerability helped me understand the importance of the learning ecology (i.e., physical, social, and cultural factors that affect the learning context). I had not expected, as a tenured professor with a Ph.D. in neurobiology, to experience the introductory STEM curriculum at my own institution as intensely stressful, but I did. In this article, I share insights from an embodied curriculum mapping project and related exploration of social science concepts and findings that I undertook in the effort to understand my own experiences and that of students in STEM culture. I hope this approach will be useful more broadly in faculty and curriculum development efforts for inclusive excellence and centering humanism in STEM education.

In my case, paying attention to my physiological and emotional responses helped me appreciate the effects of social identity on performance and engagement as larger in scope and magnitude than I had previously. I noted subtle and overt communication and assessment practices through which educators with positive intentions (including myself) routinely reinforce disciplinary boundaries. These messages may be related to the broader phenomenon of epistemic exclusion, which disproportionately affects scholars of color, and likewise act to the detriment of the sense of belonging during the early undergraduate years. I present the embodied curriculum mapping approach as a way for faculty members to learn about institutional learning contexts through a self-reflexive process that can yield powerful professional and personal growth opportunities toward capacity for culture change.

Unexpectedly, in the course of this project and subsequently, I found myself in a continuous spiral of learning (Bruner, 1960) at the intersections of pedagogy, identity, and STEM culture, wherein new learning has cast new light on previous understanding that was contemporaneous to the classroom observation phase. I therefore request the reader's patience and open-mindedness as I attempt to relate some key points of this learning in an autoethnographic style, knowing that it deviates from the normal expectations of an empirical research article in STEM and STEM education. I have chosen to adopt a first-person narrative style because I feel this approach best conveys the holistic nature of the project, the iterative psychological processes I have been through in the years since my classroom observations, and therefore the connection of this type of project to processes of critical self-reflection and culture change for which I seek to advocate.

Beyond my interest in disciplinary learning goals and pedagogical approaches, I was aware of attrition from STEM courses and curricula, and I wanted to build a curriculum that would not only work against exclusionary forces but also build new opportunities for students to access STEM learning. Due to my position in a psychology department, unlike my colleagues in science departments, I was in contact with many students who had felt alienated by introductory STEM courses and moved away from STEM majors early on, but who continued to grow and excel as science students in advanced neuroscience courses and beyond. Perhaps due to my repeated exposure to this sort of trajectory, combined with a lack of any way to challenge a prevalent belief that such students were not suited to further studies in science, I took an 'embodied' approach, largely following the instructions for students as I audited courses alongside them. In other words, I wondered, publicly, how well I myself would fare in a system that had seemed to wear down so many talented and capable students as I had seen. I opened myself up to evaluation as a means to experience some social vulnerability in an academic context again and to engage the curiosity of my faculty peers. At the time, I did not have a formal conceptualization of what it meant to embody my own experience as distinct from holding my experience as commensurable with theirs—I wanted to understand something more holistic, beyond content and syllabi, about what they had experienced.

Through this project, as expected, I learned about the content of disciplinary curricula on which the integrative neuroscience program I was developing would rely, and also grew in my admiration of my faculty colleagues for their expertise in conveying disciplinary learning goals. At the same time, I was caught off guard by the thoughts and emotions I experienced as I adhered

to the embodied aspect of the project. The process of the study and the surprises it entailed in this regard motivated me to learn about concepts such as intersectionality, implicit bias, and social dynamics of power that I had previously considered to be beyond the bounds of my necessary professional development as a STEM educator. Reflecting on this project in light of the national and global events that have affected higher education since then, including an intensified focus on social justice following the murder of George Floyd and the global COVID-19 pandemic, I consider the most valuable outcomes for me to have been the enhanced appreciation of social and psychological dimensions of learning in the context of STEM culture. Combined with exploration of the research literature on the social science of learning, I believe that exclusionary dynamics in the STEM learning environment were rendered observable using this approach that had not been so from my habitual vantage point as a faculty member.

2 Literature review and theoretical framework

2.1 Social and cultural considerations in STEM education

The demographics of participation in STEM graduate programs reveal marked evidence of social identities related to race/ethnicity and gender affecting the participation of historically excluded groups in the USA (National Science Foundation [NSF], 2021). Within the context of US higher education, STEM programs, the patterns of attrition related to race/ethnicity are more acute than in other postsecondary fields, even when associated factors such as socioeconomic status and prior access to STEM knowledge in K-12 are accounted for Riegle-Crumb et al. (2019). Given that academic credentials in STEM disciplines are associated with relatively lucrative postgraduate career options, the patterns of disparities in access to STEM learning are consistent with the sociological phenomenon of opportunity hoarding, wherein the hegemonic group retains control of economic opportunity through the construction of boundaries that restrict the full participation of marginalized groups (Tilly, 2007).

As educators concerned with facilitating access to STEM knowledge for all students engage in pedagogical innovation based on the available literature on inclusive pedagogy, it is necessary to continuously seek new insights on social and cultural mechanisms of exclusion within STEM learning environments as faculties, student bodies, and the surrounding societies from which they are drawn undergo continuous social and cultural change. Students who do not identify with the dominant social group within a learning context face disproportionate challenges to their sense of belonging (O'Hara, 2022). While interventions that target student sense of belonging through general acknowledgment of emotional aspects of learning can be effective in reducing achievement gaps based on demographic factors (Freeman et al., 2007; Binning et al., 2020), pedagogical interventions that ignore the pervasiveness of negative social stereotypes in the learning environment can increase such gaps (Maries et al., 2020). Beyond the scope of individual instructor or course pedagogies, the curricular structures to which they are attached can serve as mechanisms of systematic exclusion, even as they are, and perhaps because they are, constructed to guide disciplinary acculturation (Fiorini et al., 2023). To overcome long-standing patterns of systemic exclusion, the ability to analyze, deconstruct and re-envision long-standing aspects of STEM culture will be necessary (Morton et al., 2023).

2.2 Purpose and applications of curriculum mapping

Curriculum mapping is a widespread approach to pedagogical inquiry directed at understanding the relationship between planned/designed/intended curricula and actual/taught curricula, in terms of learning goals and outcomes (English, 1984). The approach focuses on academic programs rather than teachers, gathering knowledge about the content of courses within curricula, the time allocated to and sequencing of that content, the depth/intensity of coverage, etc. (English, 1984). By virtue of its emphasis on explicit goals and outcomes, it can be applied in efforts to move from implicit to explicit understandings of curricular goals, as a foundation for innovation efforts (English, 1984).

As the scope of curriculum mapping encompasses the work of multiple educators, while eschewing the evaluation of individuals, it can also promote collaboration and collegiality among a group that is responsible for a common program (Uchiyama and Radin, 2009). When undertaken with a purpose to engage critically with questions about a curriculum within a social context, curriculum mapping can be a reflective process for educators that allows for individuals to learn about diverse conceptions of the purpose of the same curriculum among the group (Bester and de Graaff, 2012). These interpersonal dimensions of curriculum mapping projects have the potential to change the culture of an academic program and increase the capacity of a group to move toward curricular change in the direction of broader inclusion.

2.3 Role of embodiment in pedagogical inquiry

In this article, I define the term 'embodied' as having a quality of being related to the physical and physiological aspects of the subject's humanity, inclusive of and connected to the individual's social identities and positionality within the sociocultural context. Embodied cognition has been previously defined and used in cognitive psychology and neuroscience to comprise a range of concepts related to how an individual's bodily systems (*e.g.*, sensory and motor systems) may be constitutive of cognition (Adams, 2010) and perception (Aizawa, 2007). Feminist epistemologies have emphasized embodiment as a concept to elevate the relevance of social identity, positionality, and power in the construction of knowledge (Jagger and Bordo, 1989; Code, 1991). In Black feminist theory, embodiment is emphasized as it relates to emotional knowledge and lived experience, and as a means to elucidate cultural knowledge denied by dominant forms of inquiry (Collins, 1986). Methods of embodied inquiry in this tradition call on researchers to bring embodiment to their own roles and interactions with study participants (Alexander, 2023).

The use of 'embodied' in this article pays respect to these aspects of the preceding uses, and relates them to how an educator might analyze the content, pedagogical approaches, and social environments of courses and curricula. I argue that an embodied inquiry approach to curriculum mapping can serve as a component of faculty professional development to promote key aspects of capacity for inclusive excellence: empathy with students (Dewsbury, 2020) and self-reflection about identity, positionality, power, and privilege (Kishimoto, 2018); and to do so in a context that is conducive to direct application to pedagogical innovation by virtue of its groundedness in courses, curricula, and the social groups that control them.

3 Context and methodology

3.1 Institutional context and curricular starting state

The institutional context for this curriculum study was the small, private, residential liberal arts college in New England at which I am employed as a tenured associate professor in the psychology department. The institution describes itself as highly selective and, among its 'points of pride,' lists the strength of its academic programs and the medical school acceptance rate (College of the Holy Cross, 2022). The cultural identity of the institution is Catholic in the Jesuit tradition, and the demographics of the student body qualify it as a predominantly white institution (PWI). It began admitting women students in 1972 and was in a phase of striving to maintain gender parity in the composition of the student body during the year of observation. It maintains a high degree of socioeconomic diversity for a private institution through its full-need financial aid policy, which was paired with a need-blind admissions policy through 2018. Like most other PWIs nationwide, the representation of students from historically excluded racial/ethnic groups was lower in STEM majors than in the student body overall, so the task of building an inclusive STEM curriculum required grappling with exclusionary processes within STEM culture.

In the summer of 2017, I approached my Provost to propose auditing introductory courses as a deep dive into the general question: What is happening in the STEM curriculum? We were both aware of racial/ethnic gaps in persistence in the STEM curriculum, though at the time those concerns had yet to be explicitly formalized as a priority in curricular innovation. In contrast, collaboration across disciplines and interdisciplinary pedagogy had been highlighted by the academic administration as a priority through curriculum development initiatives. I thought my colleagues and I would generate a detailed description of content and instructional methods to be used in a variety of curriculum development projects. Curriculum mapping is useful for many purposes, including but not limited to: a curriculum review or transition; curriculum sequencing for coverage for integrating multiple courses for addressing gaps; or designing integrated courses. All three of these elements related to a process I was initiating at the time for a new integrative neuroscience core curriculum (Basu et al., 2017, 2021). Two years prior, in 2015, the Provost's Office had sponsored a faculty development workshop to promote interdisciplinary collaboration in STEM on curricular matters. The workshop attendance and discussions showed that this focus was an area of interest alignment with the administration and multiple colleagues across STEM departments and programs at the institution. In other words, curriculum mapping is an endeavor that garners broad buy-in among educators interested in a variety of curricular projects. Critically, I benefited from the Provost's strong moral and practical support for this project—before I entered the negotiation, I had decided I would not invest my effort in the absence of top-down support.

In this specific context, the effort to align the curriculum mapping proposal with institutional and national goals for STEM education was realized in a neuroscience curriculum development project. I proposed to identify concepts and skills that were introduced or used in or across foundational STEM courses that could be productively reinforced within an integrative core curriculum in neuroscience. As neuroscience is an integrative discipline (Snyder, 1984), drawing knowledge and methods from multiple disciplines to approach complex challenges (Kezar and Elrod, 2012), neuroscience education presents an excellent context for the development of interdisciplinary pedagogy (Ramirez, 1997). Interdisciplinary awareness gains had previously been shown to be a potential benefit of undergraduate neuroscience courses (Crisp and Muir, 2012), and curriculum mapping was acknowledged in the undergraduate neuroscience education community as a particularly useful component of curricular planning and assessment (Muir, 2015), especially since undergraduate neuroscience curricula typically require courses from multiple departments that are designed to meet the learning goals of multiple disciplinary major curricula. Our cross-disciplinary core curriculum development team had identified integrative thinking ability as a major learning outcome, along with ability to apply principles of neuroscience, broad-based proficiency in STEM, and an understanding of historical or philosophical perspectives on the intellectually sound and responsible conduct of science (Basu et al., 2021).

At the outset, as I embarked on this project during the 2018 calendar year, my first sabbatical post-tenure, my explicit goals were entirely content-focused. I sought to identify concepts and skills that were introduced or used in or across foundational STEM courses that could be productively reinforced within an integrative core curriculum in neuroscience. As neuroscience is an integrative discipline (Snyder, 1984), drawing knowledge and methods from multiple disciplines to approach complex challenges (Kezar and Elrod, 2012), the core curriculum development team had identified integrative thinking ability as a major learning outcome, along with ability to apply principles of neuroscience, broad-based proficiency in STEM, and an understanding of historical or philosophical perspectives on the intellectually sound and responsible conduct of science (Basu et al., 2021). I was anxious to ensure that the efforts neuroscience faculty and students were to expend on learning concepts from contributing disciplines should serve them well in the respective disciplinary criteria, minimizing the need to 'unlearn' idiosyncratic habits or terminology and maximizing transfer of learning. I wanted a greater ability to understand the sensibilities of my colleagues who teach introductory STEM courses with respect to how they presented foundational concepts, to pay attention to their emphases and learn from their examples. These partners were

and are tenured colleagues with stellar teaching records within the institution.

In the spring 2018 term I audited Calculus 1 and the second semester of general physics, and in the fall 2018 term (with mostly incoming first semester first year students as my 'classmates'), I audited the introductory courses in biology and chemistry. I had taken the equivalents of these 4 courses as a first year undergraduate at the Massachusetts Institute of Technology (MIT) in the academic year 1993–1994. I tried to do everything that students were expected to do in terms of attendance, assignments and assessments, with the exceptions of the separate laboratory sections for biology and chemistry. In physics, the lab and lecture were fused, so I participated in the lab. I tried to limit my weekly effort, in terms of time, to the 8–12 h per week indicated by the course credits attached to each course. A summary of my main grade components and the time spent on each course appears in Figure 1.

3.2 Qualitative research approach

My approach to learning about the STEM curriculum through this project, being qualitative in nature, was in many ways a departure from the modes of inquiry in which I had been trained as a neurobiologist. Like most STEM educators in the U.S., I was intellectually raised in a positivist culture of scientific inquiry—my primary ways of knowing, in the context of my professional work, were inextricable from scientific methodology, and that methodology, to me, was separate from subjective experiences. What drove me to a qualitative approach were several key virtues of qualitative inquiry when it comes to surmounting the limitations of existing frameworks: exploration of the subjectivity of experiences, maintaining flexibility in research design as befits research questions that are not immediately amenable to the assumptions of preconceived models/theories/hypotheses, and maintaining a holistic view of settings and people that does not reduce them to parts in ways that might obscure novel and/or intersectional patterns of observations (Taylor, 2015; Okoko et al., 2023). Though different from the standard empirical research approaches in STEM, these approaches do not represent a departure from empiricism, but rather help researchers to theorize and formulate questions that can then be pursued with diverse empirical methodologies. A prime example of an ethnographic study of undergraduate STEM education that has served this function for over two decades is *Talking About Leaving: Why Undergraduates Leave the Sciences* (Seymour and Hewitt, 1997), followed by its sequel (Seymour and Hunter, 2019).

Beyond conventional ethnography, autoethnography is an approach that can serve to 'bridge between the observer and the observed' (Hanson, 2004), as is called for in STEM curricular innovation, where the culture of academia functions to create distance between students and educators. Within the umbrella of qualitative approaches, autoethnographic approaches commonly combine elements of ethnography with elements of biography, often to motivate action toward change (Murray, 2023). However, the relationship between the observer and observed is complex, and ethnographic methods in general are to be undertaken with caution as to the assumptions of the framework and interpretation of findings across cultures.

After viewing my first full presentation on this subject, a colleague asked me to consider how this work resembles critical/autoethnography, a form of ethnography in which an autochthonous individual or team provides an ethnographic analysis of their own culture (Hanson, 2004). Beyond autobiographical narrative, this form of ethnography involves a form of resistance through negotiation with dominant cultural influences and conventions (Hanson, 2004). While early examples of autoethnography were situated in the context of colonial exploration, a widely lauded modern example of autoethnography that serves as an exemplar of ethnographic study of one's own culture is a work in which an anthropologist explores the psychological and sociopolitical context of her own childhood within her authentic family context of deindustrialized Chicago during the 1980s (Walley, 2013).

Examples of ethnographic works in which the observer is not a member of the culture under study but embeds themself within it as a means to connect personal experiences to an understanding of that culture are understandably controversial in that they might seem to supplant the voices and analyses of indigenous scholars (Flaherty, 2022). With respect for this critique, I emphasize that though I took an embodied approach, I make no claim that my embodied experiences were commensurable with those of students, given the differences in identity, positionality, and privilege inherent to our respective roles within the culture and context of STEM education. While I was a STEM student at one point in time, I was a faculty member at the time of this study, and those two vantage points are not the same. Nevertheless, the juxtaposition of the two perspectives within an individual who has held versions of both at different points of time can yield novel insights. For example, another noteworthy autoethnographic work by a faculty member, situated in the context of U.S. higher education, focuses on social challenges in the transition to college, within and beyond the classroom (Nathan, 2006). I argue that a change in vantage point, from faculty member to student within the same institution, and the telling of stories from that contrasting vantage point has the potential to effect change through the engagement of imagination among a peer group of faculty and the internal validation of critiques, many of which may have been previously articulated in by voices external to the group, but not been as readily taken up as the focus of discussion or change efforts.

3.3 Identity, positionality, and privilege

In the years since 2018, I have learned the utility of critical reflection on identity as a foundation for understanding and relating one's experiences in educational environments and educational research (Milner, 2007). Given that I went about this project in an embodied way, and subsequently focused on the strong bodily responses to different situations that I will describe, elements of my identity are relevant to the interpretation of my findings. I identify as a person of color (of South Asian descent), a cisgender woman, a neurobiologist, an educator, a graduate of universities that are widely recognized for academic excellence, and a member of a family with three generations of postgraduate education.

In each of these aspects of my identity, I can recognize associated privilege in academic contexts. My institutional and

Course	Exam 1	Exam 2	Exam 3	Exam 4	Exam 5	Final Exam	Course Grade	Hours per week	Hours Total
BIOL 161	98%	94%	83%			??	A-? (no lab)	4	71
CHEM 181	81%	91%	97%*	83%	88%	??	A-? (no lab)	6	98
PHYS 116	64%	93%	79%			95%	B-?	14	237
MATH 135	91%?	95%	98%	94%		88%	A	12	196
Total									**601**

FIGURE 1
My (unofficial) grades as I understand them. The question marks indicate grades that I do not remember, never collected, or could not be computed as they were for students due to missing components. The asterisk denotes a make-up exam that I completed in a self-timed fashion alone in the comfort of my faculty office.

family backgrounds feel uncomfortable to mention largely because of the associated privilege, cultural/gendered norms about self-presentation, and perhaps the challenge to deeply-held assumptions about meritocracy that they entail. Nonetheless, I feel obligated to acknowledge these aspects as relevant to internal and interpersonal dynamics with deep historical roots and that I rely on in how I engage with academia. There are people who do not have those privileges, and I need to be aware of the influence that they could be having on my experiences and perceptions. I also note that there are aspects to my identity that are uncomfortable to discuss because they feel stigmatized, and which I tend to deemphasize rather than present purposefully. I will comment on some of those in the discussion.

While, in this project, I sought to learn about the learning environment by putting myself 'in the students' shoes,' I recognize that my experiences are not commensurable with those of students. My identity and positionality are different from those of students: I am at a different stage of my life and career, with a much lower level of uncertainty than that faced by students, and I am a different type of stakeholder in the learning environment in terms of the range of outcomes and consequences related to my engagement in the same activities. Perhaps most importantly, I was in a position to pursue this project with faculty partners (those who permitted me access to their courses) with whom I had previously established relationships of trust, mutual respect, and common purpose that one would expect to be absent from the teacher-student dyad in introductory STEM courses. Thus, my colleagues' evaluation of my coursework, though meant to follow the same rules at the level of execution, held different meanings, implications, and consequences for me as compared to students.

4 Findings

4.1 Risks

I experienced and continue to experience feelings of risk associated with this project, both in terms of the validity of pursuing it as part of my portfolio of professional activities and in terms of my reputation as a STEM scholar. At the beginning of this project, a departmental colleague asked me whether the objectives of this project could not be achieved more efficiently with some meetings over syllabi and textbooks. A colleague at another institution I visited during the course of the year seemed to visibly recoil when I related my activities, and asked me why I would ever want to do such a thing with my sabbatical. My department chair told me that my pedagogical work would not count as scholarship toward my first annual evaluation post-tenure, and that my ability to meet criteria for merit pay, and eventually promotion, would necessitate a re-focus on publishing neuroscience research. The sense I got from these and several other similar interactions was that I should have been spending my sabbatical maximizing the productivity of my laboratory-based research program if I expected professional validation from my colleagues. Thus, I felt a sense of risk associated with the project in the sense of straying from the standard path to professional advancement in my local context as a tenured faculty member at a college with research expectations.

At the same time, I also felt a sense of risk in exposing my STEM knowledge and skills to evaluation. As a person trained in neurobiology and yet situated in a psychology department, I had experienced years of epistemic and related social marginalization at the interface of disciplines, and subjecting myself to public evaluation was and is a risk that could serve to validate or invalidate my work depending on the audience. It is exactly these feelings of risk and the associated emotional discomfort that I believe enabled me to understand something more about STEM culture—something beyond content—than I had previously. Therefore, for the potential benefits to be realized, it will be important for colleagues and institutions to understand and continuously develop approaches to mitigate risks for instructors seeking to pursue embodied curriculum mapping projects, while maintaining the emotional investment required to access insights related to embodiment and identity.

4.2 Intensity of coursework

In this article, rather than describing my work with faculty partners on the mapping of content and skills in the courses I

audited, I will focus on my subjective experience with standard course components and learning environments. The experience of auditing 4 introductory undergraduate STEM courses was extremely intense intellectually, socially, and emotionally. Aside from the absolute time spent, the intensity of effort required to carry out this objective felt very, very high. I suppose I had forgotten how much work it was going to be, and had not accurately anticipated how high the stakes would feel. Within the first couple of weeks, I was really feeling very stressed and overworked, and that was when I decided to limit my effort to 10 h per week, per course. I used the number of credit hours associated with the course to set a maximum average time per week. I was not entirely sure why I was doing it at the time, but I was sure that to really understand the learning goals and how the learning activities were targeted at them, it would be beneficial to try to do them myself. In this context of intensity, unexpected feelings of vulnerability came to the fore, as I felt them internally and observed the efforts of students around me to navigate the environments and work of these courses.

4.3 Symbolic dimensions of quantitative reasoning

Prior to this project, I understood access to previous experience with foundational quantitative reasoning skills to be inequitably distributed across different socioeconomic backgrounds, and my view of how gaps could be addressed by educators was limited to diagnostics and supplementary instruction. Through this experience, I found my view broadening as to exactly how quantitative reasoning skills can present equity issues in these classes not only in terms of preparation but also in terms of a student's sense of belonging. I gained newfound appreciation for the ways in which such feelings of vulnerability influence student choices. As might have been expected, the content-focused analysis my faculty partners and I conducted on concepts and skills covered in these courses before the first exam revealed a predominance of quantitative reasoning skills.

At the start of the semester in which I audited calculus and physics, I was rusty at using my scientific calculator. Based on my past experiences, I knew that I would get through the confusion with a bit of practice, and I did. In contrast, a student who dropped by my office around this time informed me of her intent to withdraw from an introductory chemistry course because of challenges with exponents. Prominent in her rationale was the sense that everybody else around her seemed to know how to handle exponents. I tried to explain that it was not a big deal. I told her we would figure it out together in my office by sitting down and doing some exercises with her calculator. I told her it was a matter of about half an hour to an hour and she would fully own that button on her calculator. I felt I could convince her because my awareness of the overall strengths of her academic record had me very convinced that she could work through this challenge in short order, but I was not persuasive. It was not just a matter of a button but rather a sense that if something considered basic was tripping her up, and if everybody around her really seemed like they got it, that meant something about how far off she was from others in her preparation for the course. These seemingly small or seemingly trivial issues with quantitative reasoning, which to instructors might be something we think people can address in a short amount of time, take on a symbolic meaning beyond the specific skill in question. They raise a specter of differences in skill level and what they mean for a student's growth potential in a broader, more general sense. Presenting the differences as large and insurmountable can discourage students, and presenting them as trivial can exacerbate a student's feeling of their own mismatch to expectations in the social context.

I previously attached value to incorporating supplemental resources for all students throughout my course syllabi, and minimizing the steps to access for students to the extent possible, and continue to do so. Through this embodied curriculum mapping experience, I learned to appreciate the necessity of socially normalizing learning assistance in teaching and advising by removing any form of verbalized judgment, however constructive the intent. The words exchanged with students in these matters are influenced by the current and former social environments the students are navigating, and in STEM learning environments, it is notoriously easy to pick up messages to the effect that one is not capable or does not belong.

4.4 Exams

Beyond the mastery of content within the compressed time frame of an academic semester, I noted several challenges associated with exams that radiate into psychological and social dimensions. During this project, I became reacquainted with the experience of anxious emotions not only during an exam but also leading up to an exam and after an exam. If I missed any class meetings, I found it very hard to figure out what I had missed and what was salient in the missed lesson. In the courses for which I had not established some approximation of a study group with one or more students, and since I had decided to limit my direct access to the instructors out of concern for their time (e.g., by not attending office hours or making appointments to discuss course material) and their notes, it seemed virtually impossible to identify the main learning goals of the lessons to be assessed. Social relationships were necessary to mitigate the inevitable need to occasionally miss a class.

I experienced inordinate time pressure and rediscovered an array of strategic challenges involved with exam preparation as well as test taking. As for most people, I had a variety of responsibilities and other classes to switch between, so I had to constantly revise and optimize my study plans. I had to regulate when to let go of reading the textbook at some point and decide the limits of what I knew so that I could start doing problems on what I still did not know, which felt very uncomfortable. I needed to minimize the amount of time spent thinking about strategy and maximize the time for conceptual work, both before and during an exam. Timed, in-class exams often seemed to have an overwhelming number of items to complete in the time allotted. Under these conditions of time pressure, I found myself flipping pages and checking the clock frequently as I tried to figure out whether I should attempt to collect partial credit on several questions or invest time in completing those which felt relatively familiar, all while second guessing any sense of familiarity. I realized that when I was not feeling 100% prepared for an exam, there was a lot of variability in my performance that seemed related to the amount of time I spent worrying about the strategy and feeling time pressure.

In that time, I also noticed a variety of unwelcome thoughts that were unrelated to exam content or strategy. They generally took the form of doubts, such as 'How come I don't know this? Do I not remember or did I never learn it? What will my colleague think of me while marking my exam? Will my colleague (and friend) think I am stupid? What if they no longer want to work with me after this?' I did not have time to spare for these thoughts during these exams. They were competing for time directly with my problem solving efforts. Furthermore, I was disturbed to notice that, ostensibly as an internal response to the doubts that were cropping up, I was having explicit thoughts about the strengths of my educational and family background, for example, 'My colleague will not think I am stupid because I graduated from MIT and Harvard,' and 'I know I can do this because my family is highly educated.' These thoughts are disturbing to my conscious mind for two reasons: First, I do not subscribe consciously to a concept of intellectual merit that is distributed according to the prestige of educational institutions or family background, so I was dismayed that the pressure to pull myself up by my bootstraps in a challenge took my mind to these thoughts rather than thoughts of my exam preparation. Second, I worry about what thoughts students encounter in these moments, with their large range of familial academic backgrounds and social identities. I believe I stumbled, through the visceral experience that was the embodied aspect of this project, on a long-established understanding of how stereotype threat (Steele and Aronson, 1995) and implicit bias (Greenwald and Banaji, 1995) can operate to thwart academic performance and play into expectations thereof.

The visceral experiences were at times overwhelming in themselves. At times, during exams, I could feel my heart rate and breathing were elevated. I could feel my pulse in my face and ears. My palms were sometimes sweaty. Sometimes I felt the effects of too much caffeine but I was not sure if I could afford to take a bathroom break, or whether a student would have been permitted to do so under the same general circumstances. I was physically very uncomfortable and felt unwell during exams. Undoubtedly, my physical fitness had declined in the decades since I was an undergraduate, but I nevertheless came away with concerns about the degree to which physical and emotional health, both of which interact with stress responses, factor into performance on conventional exams. Under these conditions of heightened emotion, variations in the functioning of tools such as writing implements or the setup of the physical environment seem to have an outsized psychological impact. In the physics teaching laboratory, extra tables were wheeled in so that students could spread out. I found some of those tables to be wobbly, and I think whether or not I was seated at a wobbly table contributed to the variability of my exam performance in that course. On a broader social scale, I noticed that while I was hanging back to let students select their places before I sat down to an exam, the students of color were overrepresented among those who tended to hang back in such situations of jostling for resources.

I was usually the last person to hand in an exam, or close to it. I found myself revisiting every question, checking for a new angle and re-reading those with complex wording or multiple possible answer combinations. I did a lot of underlining and marking up of the exam text. In one of the courses, I sat next to a student who also tended to use the full time. I perceived her to be a person of color who spoke English as a second language. As a bilingual/native English speaker, I had not previously thought about STEM classes as a location where language processing would play a big part in exam performance. One day after an exam, this student, whom I did not observe to engage in casual social interactions with any of her classmates other than me during class meetings, asked me whether I thought there might be a way she could get extra time on tests the way some students did through the accessibility office, because it was taking her a long time to understand the questions. I looked into it, and there was no such accommodation available to her. I became sensitized to the ways in which language facility impacts learning and performance in introductory STEM courses, where we tend not to consider it as a major factor, and the ways in which language differences intersect with racial/ethnic differences that influence students' sense of belonging. The neglect of this factor, reflected in our academic policies, is an example of how learners who do not conform to the norms of a hegemonic group are maintained at a systemic disadvantage as well as a call for educators to recognize the ways that language can operate more broadly as a mechanism of exclusion. Here was an example of how the particular issues faced by individuals who find themselves at intersections of identity categories are not acknowledged by the systems within which they are located, allowing them to continue to be negatively affected in complex ways (Crenshaw, 1989; Cooper, 2016).

Finally, subsequent to taking an exam, I experienced resurgences of stressful emotions and sensations whenever it came to getting back or reviewing the marked exam. The heart rate and perspiration started up again when the instructor was passing papers back in front of the class, and even when I was alone and it was time to pull a marked exam out of my bag and review it. Since these resurgences happened well after the challenge of taking an exam, I think they are related to feelings about assessment and the meaning thereof, and suggest, combined with the semantic content of my intrusive thoughts, that much of the contemporaneous exam stress may have been about assessment for me as well. Since this experience, I have become more attentive to methods for introducing more hope into how students can look at exams and use them as learning tools. I am less likely now than I was before to assume apathy on the part of a student who might seem to avoid picking up or going over an old exam, as I am less likely to assume anything about the quality of their effort or the strength of their underlying motivation based on their grades. I am more curious about an individual student's experiences in the course, and this is now the first question I ask, with holistic intent, when I meet with them one-on-one.

4.5 Classroom environment: engagement and isolation

I found the process of social integration in undergraduate STEM classrooms harrowing. Despite my protected position, I felt more socially and physically stressed on a daily basis throughout this project than I could remember, perhaps not since my undergraduate days. By the 'feeling of stress,' I refer to an emotional state as well as physiological responses such as increased heart rate and perspiration. In the absence of social inroads from other aspects of the student experience, I found it hard to figure out where to sit. In 'think pair share' exercises, I was frequently not paired with or

shared with. It was not just me. There were other people I could see in the classroom who were not engaging easily in think pair share, and they tended to be students who were visibly different from the norms either in physical features, presentation/dress, or mannerisms. Through these observations, I learned that the shared experiences of the classroom and associated groups such as study groups thus depend on how well the social environment of the classroom supports positive social interactions. I felt a new appreciation for the need to lower barriers for students to find some affinity with other members of the learning community, and to become proactive and artful as an instructor in encouraging students to participate in the cultivation of inclusive learning environments. For me, this process involves explicit discussions about teamwork and sensitizing all students to the importance of learning to work well in diverse teams for their development as future employees and leaders.

Despite my efforts to smile, it was difficult to engage socially with students in the classrooms I visited. I knew I was likely an odd presence for the students. They had minimal knowledge of my purpose—only that I was observing for the purpose of my own learning and had been invited by the professor based on a common interest in pedagogy, as I explained in an email to the class near the beginning of each semester. Particularly in the fall semester, most of the students were very new to the campus and had yet to form social relationships at all, let alone in the classrooms we shared. I taught some of the same students subsequently, and eventually came to know them as very friendly, lovely, warm people, but in those first few weeks of either term, I felt I could not get any student, of any demographic description, to crack a smile (not that any of them owed me one). I think the stoic lack of expression indicates something about how people feel in these classes. Oddly, at the time, I had a fleeting thought that the students were socially aloof. I speculate that they may have been steeling themselves for a challenging social environment, and I felt I could see the extra challenge for students whose outward presentation or other identities did not match the predominant demographic group in the peer-to-peer interactions I observed. I could better imagine the cumulative effect of encountering minoritization throughout multiple contexts within the institution, and the consequences for learning. The experience motivated me to radically increase my emphasis on promoting positive social interactions in the classroom as an instructor.

4.6 Navigating disciplinary boundaries

Aside from exams and thwarted attempts at forming social relationships, another, even more unexpected source of emotional intensity and challenge for me throughout this project was encountering and navigating disciplinary boundaries. It was not unexpected that several concepts and skills are used, but addressed differently in different disciplines. In fact, delving into these points of commonality and contrast with colleagues who touch on overlapping or adjacent content in different disciplines was the major goal of the project. In talking about these sorts of content I have made examples of the ways biology and chemistry courses differ in how they present concepts such as reaction equilibria and dipoles. The different disciplines emphasize and reinforce different examples and applications of these concepts, along with disciplinary conventions of presentation and notation that lay different foundations for further study. I was struck by the strong reinforcement of disciplinary conventions in particular, in terms of how student work was assessed. This phenomenon has been noted by education researchers interested in knowledge transfer and the development of tools to identify cross-disciplinary learning in student work (Borda et al., 2020; Haskell et al., 2022), and made me wonder how much time instructors may be able to recoup by working across disciplines to enhance the teaching and learning of shared concepts and skills. The unexpected emotions came from a very common form of instructor talk—one in which I had frequently engaged myself—that asserted disciplinary boundaries and invoked disciplinary identity labels (Figure 2).

Language that introduced and reinforced disciplinary identity, such as I observed it, was largely intended to be welcoming and inclusive. Like any aspect of a culture, it seems to have a function, and well-meaning people seek to capitalize on that function for positive ends, such as, in this case, prompting students to identify with the discipline they are seeking to learn about and visualize themselves as a member of a discipline as a means to promote their sense of belonging within a disciplinary context. Also, as with any aspect of culture, there are ways in which the outreach undertaken with positive intent can go awry. What if the suggested disciplinary identity does not match a student's developing academic identity? What if a student's previously held social identities (such as those pertaining to family educational background, race/ethnicity, LGBTQIA+ status, ability, etc.) are not well represented in the disciplinary group, or not widely known to be so? What if the discipline has historically mistreated or exploited members of a student's identity group? In these cases, might not the invocation or seeming assumption of these identities create internal conflicts or otherwise feel alienating to the student? Given the context of introductory STEM courses at a liberal arts college, a low proportion of students enrolled in each of these courses was fully decided on any specific disciplinary identity at the time. Given the requirement of these courses for a wide range of majors and future graduate programs, inculcating disciplinary identity in these contexts does not seem to reflect the purpose that many of the enrolled students are bringing with them, as they are by and large not decided to become a specialist in that discipline. I came to think that taking a student's view of the curriculum could open avenues for instructors to better align our messaging with student identities and motivations.

In reflecting on why my own responses to this sort of communication brought a surge of stressful emotions and physical sensations, I arrived at my own, relatively well-formed disciplinary identity as a neuroscientist, which has involved tensions at disciplinary boundaries throughout my career. I switched back and forth between two majors as an undergraduate before deciding to complete both. As a graduate student, I struggled socially in my desire to gain access to techniques associated with more male-dominated areas of my discipline. As a job candidate, I had apprehensions about joining a psychology department in terms of whether it would place limitations on my work and distortions in how I would be perceived professionally. Even now, almost 12 years into a tenure line faculty position, at times I feel as though I inhabit a gap between disciplines. As such, the aspect of STEM culture revealed in disciplinary identity talk and boundary reinforcement is

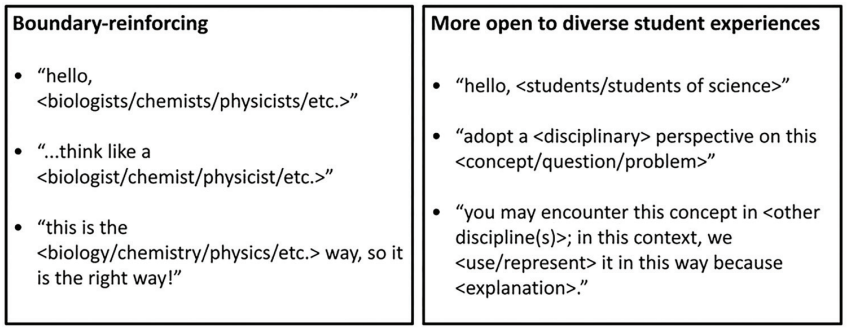

FIGURE 2
Common verbal references to disciplinary boundaries and identities in instructor talk, and alternative forms that may improve student sense of belonging by reducing boundary reinforcement.

a familiar and uncomfortable territory for me. In effect, the framing "Think like a. . ." constitutes, to my mind, a claiming of a certain sort of pattern of thought or cognitive skill, which, at some level of abstraction, is unlikely to be contained within a discipline. When we use this phrase, do we do so based on deep knowledge of the work of disciplines other than our own, or is it an assertion from within our own biased disciplinary perspectives?

Recently, I learned that most academics encounter exclusionary social phenomena related to disciplinary boundaries, in a phenomenon dubbed 'epistemic exclusion,' wherein a person's belonging in an academic context is scrutinized on the basis of the questions they ask or the methods they use. This form of exclusion disproportionately affects scholars of color (Settles et al., 2021). There are many possibilities as to why this may be the case, including increased likelihood that a minoritized scholar sees academic questions in a way that transcends the boundaries of disciplines that emerged from the dominant culture's historical framing, lower levels of exclusionary social phenomena in fields of scholarship where scholars trained in multiple diverse disciplines co-mingle, or the manifestation of implicit racial/ethnic bias as epistemic critique that is legitimized in academic settings (Settles et al., 2021). Perhaps I should not have been surprised to wrestle with disciplinary boundaries, given my stated purpose of gathering information to be applied in building an integrative interdisciplinary core curriculum. But I was surprised to think of the phenomenon as part of the broader structure of academia and disciplinary hierarchy that affects all of us, including students as they make their early curricular choices. The surprise, again, came not from the practical issues but from the emotional ones that related to identity and the personal history of identity-forming and identity-challenging experiences that every individual has.

5 Discussion

The purpose of this article has been to communicate some salient psychological and social experiences I had in the course of a curriculum mapping project—experiences I had because I approached it in an embodied way, and that I received the much needed encouragement to talk about, perhaps only because of the acute crisis in which U.S. higher education found itself in 2020. In my first public presentation about the content-related results from this project, I made an aside that "I felt like I was going to die pretty much the whole time." Up until that point in my professional experience, that sort of comment would have felt very much like an overshare, but the environment for educators had changed. The context was the urgently organized 2020 summer virtual meeting of the Faculty for Undergraduate Neuroscience, and the community of educators was grappling with our collective understanding of what students need from us in order to engage with learning, and our obligations as educators (Basu et al., 2022). Something about the mood of fellowship in adversity combined with a sense of reckoning drew out an unexpected level of emotional candor from me regarding my reflections on my discipline, reflections on how I design inclusive environments, and my reflections on how and what I wanted students to learn through assessment. At that moment and since then, I have been fortunate to meet many colleagues within and beyond my institution in emotional candor and sincere consideration of how the culture of STEM education can and should change, and I have come to see the potential of embodied curriculum mapping approaches such as the one I took to help individual faculty and groups of faculty to reflect on their own attitudes, beliefs, and collective culture, and implement changes as a community.

Educators can use embodied curriculum mapping to learn about learning environments and how to make them more inclusive. At present, there is a heavy emphasis on repeated student surveys and focus groups at many institutions, and student voices are needed to bring alive the findings of a large education literature that has gathered this sort of information over several decades, including large-scale quantitative research as well as detailed qualitative ethnographic studies (Seymour and Hunter, 2019). What an embodied curriculum mapping approach can add to the array of established approaches is a professional development opportunity through which instructors can learn about their own identities as they build knowledge and skills that will broaden their scope of operations within and between disciplines. If approached with an intent to experience and process feelings of psychological and social vulnerability associated with learning, it can be a way out of deficit thinking (Patton Davis and Museus, 2019), which challenges our efforts to cultivate a growth mindset (Dweck, 2006, 2015) in ourselves and our students and traps us in current patterns of exclusion in STEM (Asai, 2020; Basu, 2021).

Embodied curriculum mapping can also be used by educators to gather information about learning environments, and importantly, about ourselves, in pursuit of the inclusive excellence ideal, which requires institutions to build knowledge about how diverse constituents experience the institutional environment (Williams et al., 2005). The embodied component, especially when undertaken by diverse faculty as part of a collective learning community, is the key to building such a knowledge base. I submit that conceptualizing curriculum mapping as a key to building inclusive curricula *without* incorporating emotionally challenging, identity-conscious, critical self-reflection can in fact *reinforce* current patterns of exclusion. Such an approach poses no challenge to the racist assumptions underlying deficit thinking, because it reduces racial/ethnic gaps in persistence and achievement to matters of content and skills. It allows the pernicious belief that content is at the root of gaps to continue. Only if done in a manner that centers the human experience can embodied curriculum mapping help us access formative experiences that bring our identity-related challenges and identity-based assumptions to the surface as a foundation for the critical self-reflection necessary for the adoption of anti-racist pedagogy (Kishimoto, 2018; Kendi, 2019).

Centering the human experience also requires individualized approaches to embodied inquiry. A key feature of taking an embodied approach, for me, entailed subjecting myself to feelings of exposure through assessment. For another individual, there may be different risks associated with such a choice. I should reiterate here that I had the advantages of undertaking this project post-tenure and with trusted faculty partners with whom I had robust pre-existing social and professional relationships. In this social context, I judged the risk to my professional standing to be worthwhile. My faculty/instructor partners were also willing to be vulnerable by allowing me to observe them at work in such a comprehensive way, which required a great deal of bravery and generosity that extends through my subsequent speaking and writing on the subject. I expect that different individuals pursuing embodied curriculum mapping projects will do so in unique ways, using individualized approaches that are socially negotiated with their own partners and institutional parameters. I expect that different individuals carrying out variations of this sort of project will arrive at different insights based on their unique identities and patterns of exposure, and that not only faculty with marginalized identities, but also those with multiple privileged identities will find that reflection on the intersection of those identities with power and privilege yields useful insights (Phillippo and Nolan, 2024). Furthermore, given the disciplinary structure and culture of higher education, transdisciplinary projects are likely to present social challenges for most academics.

My work, as reported here, differs from standard ethnographic methods in several important ways. First, my interactions with others in the environment and culture I explored were spontaneous, casual conversations. A true ethnographic study would include exhaustive student interviews to extend beyond my own reactions. I had no procedure in place for systematically interviewing members of the cultural community as is the hallmark of ethnographic field methods. I had no approved interview questions or Institutional Review Board permissions in place. I do not advocate for STEM educators to become anthropologists when I advocate for more embodied curriculum mapping, but rather for a new form of immersive professional development opportunity—one that provides the potential for enhanced introspection and transformative change at home. I acknowledge dynamics of power and hierarchy within academia that motivated me to pursue this project as a mode of resistance and change, but they are not the same dynamics that are experienced by those who are students today. My more dominant motivation was one of trying to build relationships and develop myself as an educator within the existing structures of higher education in the U.S. context, and I see the function of such an experience for an educator as a means to travel in one's imagination to a time before having been acculturated as a faculty member through a systematic process of distancing one's identity from that of a student through specialization and credentialing.

Limited by its rootedness in my first-person perspective, the findings of this work are not generalizable to student experiences or the experiences of other educators until and unless they are validated by broader empirical studies that are designed to test hypotheses as they relate to specific subject populations. The purpose of this article has therefore been to show how the process I undertook led to an increased capacity for self-reflection and appreciation for how STEM pedagogical practices and culture relates to human social and emotional experiences. These changes in turn led me to focus my attention on learning in the social sciences in humanities as part of my professional development, and allowed me to generate novel ideas for further pedagogical research and curriculum development with culture change toward greater equity and inclusion as a goal. For example, as a result of the experience, I have increased my investments of time in community-building, developing culturally responsive teaching methods, and empowering students to participate in shaping present learning environments as well as the future of STEM culture. The only generalization I claim is that other educators following a similar process, with due attention to internal emotional responses as well as learning beyond STEM, may find similar benefits.

6 Conclusion

My own experience with this project yielded a number of insights that I have incorporated into my pedagogy since. I have a much more explicit focus on facilitating positive, identity-conscious peer interactions in my classrooms. I seek to de-emphasize and work across disciplinary boundaries in curricular and faculty development efforts. I seek to learn from scholars in the humanities and social sciences about the history, philosophy, and social science of academia, pedagogy, race, racism, intersectionality, and broader dynamics of social exclusion based on identity.

With every conversation I have had about this project, I have learned more about myself as I have learned more about STEM culture. In writing this article, I realized that I have been depending on nonverbal information exchange to convey aspects of my cultural identity, background, appearance, size, and physical ability that are relevant to how I negotiate STEM culture and spaces, but are difficult to verbalize due to privacy, complexity,

or heavy stigmatization. The purpose of embodied pedagogical inquiry is not to open the mind to the realm of intuition and to stay there, but rather to raise our own awareness of uncomfortable psychological, social, and cultural phenomena that arise in the learning environments we curate but that we may be prone to fear, avoid, or neglect (Imad et al., 2023; King et al., 2023). I hope to continue the conversation with more colleagues in the future and look forward to learning about their shared and unique insights. As a collective, STEM educators and education researchers stand to grow from centering humanism in this way, through which we may access a diverse array of insights and observations, and become more sensitized to a broader range of human experiences and dynamics in STEM culture.

Data availability statement

The original contributions presented in this study are included in this article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the study involving human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants in accordance with the national legislation and the institutional requirements.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Adams, F. (2010). Embodied cognition. *Phenomenol. Cogn. Sci.* 9, 619–628. doi: 10.1007/s11097-010-9175-x

Aizawa, K. (2007). Understanding the embodiment of perception. *J. Philos.* 104, 5–25.

Alexander, E. (2023). Becoming black women through embodied inquiry. *Affilia* 38, 687–702. doi: 10.1177/08861099231180163

Asai, D. (2020). Race matters. *Cell* 181, 754–757. doi: 10.1016/j.cell.2020.03.044

Basu, A. C. (2021). Are we ready? The future of inclusive excellence in STEM. The thinking republic, fulcrum issue. Essay. https://www.thethinkingrepublic.com/fulcrum/are-we-ready

Basu, A., Hill, A., Isaacs, A., Mondoux, M., Mruczek, R., and Narita, T. (2021). Integrative STEM education for undergraduate neuroscience: Design and implementation. *Neurosci. Lett.* 746:5660. doi: 10.1016/j.neulet.2021.135660

Basu, A., Kang, Y., Leussis, M., and Chan, J. (2022). Convening the undergraduate neuroscience education community in a period of rapid change: Insights from the FUN 2020 summer virtual meeting. *J. Undergrad. Neurosci. Educ.* 20, E24–E26. doi: 10.59390/TPQZ7702

Basu, A., Mondoux, M., Whitt, J., Isaacs, A., and Narita, T. (2017). An integrative approach to STEM concepts in an introductory neuroscience course: Gains in interdisciplinary awareness. *J. Undergrad. Neurosci. Educ.* 16, A102–A111.

Bester, M. M., and de Graaff, M. F. (2012). "Curriculum mapping as a responsive and reflective process," in *Proceeding of the higher education learning and teaching association of Southern Africa conference*, eds N. Tisani and M. Madiba (Stellenbosch: Stellenbosch University).

Binning, K. R., Kaufmann, N., McGreevy, E. M., Fotuhi, O., Chen, S., Marshman, E., et al. (2020). Changing social contexts to foster equity in college science courses: An ecological-belonging intervention. *Psychol. Sci.* 31, 1059–1070. doi: 10.1177/0956797620929984

Borda, E., Haskell, T., and Boudreaux, A. (2020). Cross-disciplinary learning: A framework for assessing application of concepts across STEM disciplines. *arXiv* [Preprint]. doi: 10.48550/arXiv.2012.07906

Bruner, J. (1960). *The process of education*. Cambridge, MA: Harvard University Press.

Code, L. (1991). *What can she know?: Feminist theory and the construction of knowledge, PhilPapers*. Ithaca, NY: Cornell University Press.

College of the Holy Cross (2022). *Points of pride*. Worcester, MA: College of the Holy Cross.

Collins, P. H. (1986). Learning from the outsider within: The sociological significance of black feminist thought. *Soc. Problems* 33, S14–S32. doi: 10.2307/800672

Cooper, B. (2016). "Intersectionality," in *The Oxford handbook of feminist theory*, eds L. Disch and M. Hawkesworth (Oxford: University Press Oxford), 385–406. doi: 10.1093/oxfordhb/9780199328581.013.20

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *Univers. Chicago Legal Forum* 1989:8.

Crisp, K. M., and Muir, G. M. (2012). Assessing development of an interdisciplinary perspective in an undergraduate neuroscience course. *J. Undergrad. Neurosci. Educ.* 10, A88–A95.

Dewsbury, B. M. (2020). Deep teaching in a college STEM classroom. *Cult. Stud. Sci. Educ.* 15, 169–191. doi: 10.1007/s11422-018-9891-z

Dweck, C. (2015). *Growth Mindset, revisited*. Bethesda, MD: Education Week.

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York, NY: Random House.

English, F. W. (1984). "Curriculum mapping and management," in *Promoting schools excellence through the application of effective schools research: Summary and proceedings of a 1984 regional exchange workshop*, ed. B. D. Sattes (Charleston, VA: Appalachia Educational Laboratory).

Fiorini, S., Tarchinski, N., Pearson, M., Valdivia Medinaceli, M., Matz, R., Lucien, J., et al. (2023). Major curricula as structures for disciplinary acculturation that contribute to student minoritization. *Front. Educ.* 8:1176876. doi: 10.3389/feduc.2023.1176876

Flaherty, C. (2022). *Black scholars demand retraction of autoethnography article*. Washington, DC.

Freeman, T. M., Anderman, L. H., and Jensen, J. M. (2007). Sense of belongingness of college freshmen at the classroom and campus levels. *J. Exp. Educ.* 75, 203–220. doi: 10.3200/JEXE.75.3.203-220

Greenwald, A., and Banaji, M. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychol. Rev.* 102, 4–27. doi: 10.1037/0033-295X.102.1.4

Hanson, S. S. (2004). "Critical auto/ethnography: A constructive approach to research in the composition classroom," in *Ethnography unbound: From theory shock to critical praxis*, eds S. G. Brown and S. I. Dobrin (Albany, NY: State University of New York Press).

Haskell, T., Borda, E., and Boudreaux, A. (2022). Cross-disciplinary learning index: A quantitative measure of cross-disciplinary learning about energy. *Phys. Rev. Phys. Educ. Res.* 18:010108.

Imad, M., Reder, M., and Rose, M. (2023). Recasting the agreements to re-humanize STEM education. *Front. Educ.* 8:3477. doi: 10.3389/feduc.2023.1193477

Jagger, A. M., and Bordo, S. R. (eds) (1989). *Gender/body/knowledge. Feminist reconstructions of being and knowing*. New Brunswick & London: Rutgers University Press.

Kendi, I. (2019). *How to be an antiracist*. New York, NY: One World.

Kezar, A., and Elrod, S. (2012). Facilitating interdisciplinary learning: Lessons from project kaleidoscope. *Change Mag. High. Learn.* 44, 16–25. doi: 10.1080/00091383.2012.635999

King, G. P., Russo-Tait, T., and Andrews, T. C. (2023). Evading race: STEM faculty struggle to acknowledge racialized classroom events. *CBE Life Sci. Educ.* 22:ar14. doi: 10.1187/cbe.22-06-0104

Kishimoto, K. (2018). Anti-racist pedagogy: From faculty's self-reflection to organizing within and beyond the classroom. *Race Ethn. Educ.* 21, 540–554. doi: 10.1080/13613324.2016.1248824

Maries, A., Karim, N. I., and Singh, C. (2020). active learning in an inequitable learning environment can increase the gender performance gap: The negative impact of stereotype threat. *Phys. Teach.* 58, 430–433.

Milner, H. R. (2007). Race, culture, and researcher positionality: Working through dangers seen, unseen, and unforeseen. *Educ. Res.* 36, 388–400.

Morton, T. R., Agee, W., Ashad-Bishop, K. C., Banks, L. D., Barnett, Z. C., Bramlett, I. D., et al. (2023). Re-envisioning the culture of undergraduate biology education to foster black student success: A clarion call. *CBE Life Sci. Educ.* 22:es5. doi: 10.1187/cbe.22-09-0175

Muir, G. M. (2015). Mission-driven, manageable and meaningful assessment of an undergraduate neuroscience program. *J. Undergrad. Neurosci. Educ.* 13, A198–A205.

Murray, L. B. (2023). "Autoethnography," in *Varieties of qualitative research methods. Springer texts in education*, eds J. M. Okoko, S. Tunison, and K. D. Walker (Cham: Springer), doi: 10.1007/978-3-031-04394-9_9

Nathan, R. (2006). *My freshman year: what a professor learned by becoming a student*. New York, NY: Penguin Books.

National Science Foundation [NSF] (2021). *Women, minorities, and persons with disabilities in science and engineering*. Alexandria, VA: National Science Foundation [NSF].

O'Hara, R. M. (2022). STEM (ing) the tide: A critical race theory analysis in STEM education. *J. Constr. Psychol.* 35, 986–998. doi: 10.1080/10720537.2020.1842825

Okoko, J. M., Tunison, S., and Walker, K. D. (2023). "Introduction to a variety of qualitative research methods," in *Varieties of qualitative research methods. Springer texts in education*, eds J. M. Okoko, S. Tunison, and K. D. Walker (Cham: Springer), doi: 10.1007/978-3-031-04394-9_1

Patton Davis, L., and Museus, S. (2019). What is deficit thinking? An analysis of conceptualizations of deficit thinking and implications for scholarly research. *Currents* 1, 117–130. doi: 10.3998/currents.17387731.0001.110

Phillippo, K. L., and Nolan, J. L. (2024). White-on-white research: A study of white qualitative researcher positionality among white participants. *Int. J. Q. Stud. Educ.* 37, 545–563. doi: 10.1080/09518398.2022.2061728

Ramirez, J. (1997). Undergraduate education in neuroscience: A model for interdisciplinary study. *Neuroscientist* 3, 166–168. doi: 10.1177/107385849700300309

Riegle-Crumb, C., King, B., and Irizarry, Y. (2019). Does STEM stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. *Educ. Res.* 48, 133–44. doi: 10.3102/0013189X19831006

Settles, I. H., Jones, M. K., Buchanan, N. T., and Dotson, K. (2021). Epistemic exclusion: Scholar(ly) devaluation that marginalizes faculty of color. *J. Divers. High. Educ.* 14, 493–507. doi: 10.1037/dhe0000174

Seymour, E., and Hewitt, N. M. (1997). *Talking about leaving*. Boulder, CO: Westview Press.

Seymour, E., and Hunter, A. (2019). *Talking about leaving revisited: Persistence, relocation, and loss in STEM education*. Cham: Springer Nature Switzerland.

Snyder, S. (1984). Neurosciences: An integrative discipline. *Science* 225, 1255–1257. doi: 10.1126/science.6433483

Steele, C., and Aronson, J. (1995). Stereotype threat and the intellectual test performance of African-Americans. *J. Pers. Soc. Psychol.* 62, 26–37.

Taylor, S. J. (2015). *Introduction to qualitative research methods: A guidebook and resource*. Hoboken, NJ: John Wiley & Sons, Incorporated.

Tilly, C. (2007). Unequal access to scientific knowledge. *J. Hum. Dev.* 8, 245–258.

Uchiyama, K. P., and Radin, J. L. (2009). Curriculum mapping in higher education: A vehicle for collaboration. *Innov. High. Educ.* 33, 271–280. doi: 10.1017/S1463423619000677

Walley, C. (2013). *Exit zero: Family and class in postindustrial Chicago*. Chicago, IL: University of Chicago Press.

Williams, D., Berger, J., and Mcclendon, S. (2005). *Toward a model of inclusive excellence and change in postsecondary institutions*, Vol. 39. Washington, DC: Association of American Colleges and Universities.