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Belonging in STEM: an interactive, iterative approach to create and maintain a diverse learning community

Marina J. Ayala,[1,3]
Javan K. Carter,[1,3]
Avani S. Fachon,[1,3]
Samuel M. Flaxman,[1,3]
Michael A. Gil,[1,3]
Heather V. Kenny,[1,3]
Zachary M. Laubach,[1,3]
Sage A. Madden,[1,3]
Molly T. McDermott,[1,3]
Angela Medina-García,[1,3]
Rebecca J. Safran,[1,3,*]
Ellen Scherner,[1,3]
Drew R. Schield,[1,3]
Sabela Vasquez-Rey,[1,3] and
Julie Volckens[2,3]

Diversity is a key driver of scientific innovation, yet fields in science, technology, engineering, and mathematics (STEM) have struggled to retain diverse communities. Research suggests that fostering a sense of belonging is critical for retaining diversity. We propose an iterative process that aims to improve sense of belonging among laboratory (lab) members through self-reflection and community collective action.

The importance of belonging for a diversity of STEM researchers

Diversity catalyzes innovation across fields. Innovation is a hallmark of great science and, thus, diverse perspectives are recognized as a critical asset in STEM. In spite of mounting efforts to foster justice, equity, diversity, and inclusion (JEDI) in STEM, women and racial and ethnic minorities remain under-represented (http://www.pewsocialtrends.org/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/) [1,2]. We therefore face a challenge: to support the best STEM research possible, we must attract and retain a greater diversity of STEM professionals. While positive interventions exist, minority students currently leave STEM fields at a higher rate than other disciplines [3]. Here, we focus on retention, as we see many opportunities where work in this area can happen quickly. We argue that to retain diversity, we must work to continually improve and value the experience of individuals once they have entered a learning or career path in STEM.

A sense of belonging and feeling valued as a member of a collaborative team predict retention in STEM [4,5]. Critical race theory (CRT), and the Community Cultural Wealth (CCW) model in particular, suggest promising practices to help instill a sense of individual belonging within communities [6]. CRT examines pervasive racism and challenges systems of oppression that disenfranchise individuals from nondominant racial or ethnic groups [4]. Nested within CRT, the CCW model describes distinct currencies of 'cultural wealth' that are typically unrecognized in institutions established by dominant cultural groups [6]. These often underappreciated forms of cultural wealth enrich academic communities and are foundational for innovative research programs in which team members feel valued (Box 1). Using the CCW model to appreciate the abilities, talents, and perspectives of underrepresented groups can formally increase recognition of these group members' contributions to their community. In turn, these individuals may feel a genuine connection and sense of belonging that can reinforce interest and investment in the community [5]. Thus, using CCW as a framework to iteratively evaluate and foster belonging provides a promising approach for retaining diversity in STEM. What is the appropriate organizational scale at which to stage such interventions?

Lab groups, characterized by small, interactive membership, are organizational units within the academic STEM pipeline through which individuals of variable rank can contribute to and foster cultural change. Lab groups are typically established and managed by a single principal investigator (PI), whose responsibility is the training of students at all levels [6]. As the PI is the leader and long-term member in an otherwise dynamic group, they, along with all in mentorship roles, including postdocs and graduate students, can quickly accelerate CRT-informed change. Mentors can form and promote respectful, intentional practices around race and culture while recognizing racist institutional practices [7]. In particular, group-wide discussion and adoption of CRT tenets, including: (i) the centrality of race/racism in human affairs, (ii) a desire to label and dismantle oppressive social systems, (iii) a commitment to social justice, (iv) the pragmatic value of experiential knowledge, and (v) the need for interdisciplinary approaches and solutions [8,9] offer great promise for rapid cultural change [10]. Cultural reforms can cascade within and beyond a lab to facilitate a cohesive, pervasive culture of empowerment. Because of their unique agility, lab groups can serve as a fundamental unit of change to rapidly improve the experience of a diversity of immediate members and, in aggregate across departments and colleges, catalyze bottom-up systemic reform that fosters institutional diversification (Figure 1A).

Here, we propose a two-step, iterative process to create and maintain a culture of belonging in which diverse members flourish, resulting in innovative research activities within a STEM lab group. Before getting started, we advise establishing, as a group, a formal set of guidelines to

Box 1. Forms of cultural capital according to the Community Cultural Wealth (CCW) model

The CCW model, presented by Yosso [5], comprises six forms of capital commonly held by historical minorities and under-represented groups. Aspirational capital signifies one's drive and motivation to pursue far-reaching goals, despite obstacles that may hinder progress towards those dreams; such barriers are often institutional or structural. Secondly, linguistic capital refers to the positive assets gained through multilingual identities or exposure to diverse communication styles; this capital can be leveraged in social encounters and intellectual pursuits. Exposure to strong kinship ties and cultural knowledge is key in developing familial capital, in which one prioritizes community well-being. Similarly, social capital is created through a web of community connection and resources, which can be utilized to advance in academic, career, and social endeavors and allow for a sense of personal empowerment. Additionally, when a historically under-represented individual must work within social institutions not created for them, they may attain a set of skills to better maneuver through these adverse conditions; these skills are a form of navigational capital. Finally, resistant capital is a set of behaviors that not only challenge oppression and inequality, but also seek to protect the cultural legacy of an individual. See Figure I for examples of how each aspect of capital can be integrated into a STEM lab group.

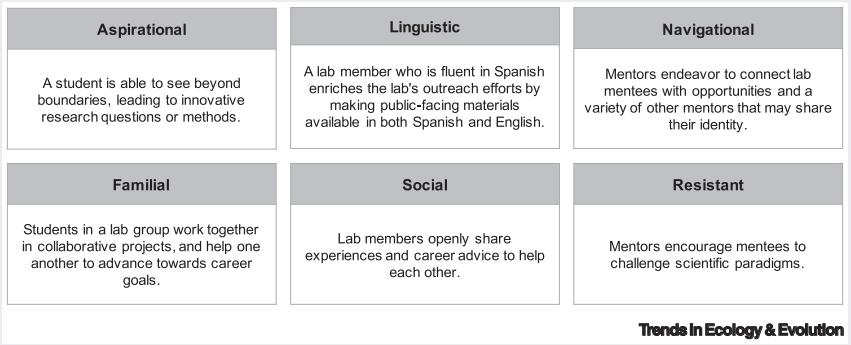

Figure I. Forms of cultural capital in the CCW model.

ensure confidentiality, open-mindedness, and a commitment to learning, to provide an equal opportunity for all members of the community to comfortably voice their opinions. We advise working collaboratively with your offices of institutional research and compliance.

First, lab group members document their experiences of how much they feel they belong and are valued within their lab community. Second, the group collectively modifies behaviors and community norms with the goal of improving members' research and learning experiences, by fostering appreciation for the value that different members bring to the group through a diversity of ideas, perspectives, and capital. As a community evolves and membership turns over, this approach should be implemented repeatedly (Figure 1B). Furthermore, it is generalizable to any small learning community because it is nonprescriptive in defining JEDI and promoting solutions to foster cultures of inclusivity. We do recommend having at least six participants and working with your office of institutional research to ensure anonymity of responses. This process could still be used by smaller lab groups if they joined with another lab group (or two). We outline each of the steps in greater detail, using the implementation of this process in our lab group as an example.

Proposed iterative approach for increasing belonging

Step 1: assess a sense of belonging and feeling valued

In Step 1 of the process, we ask lab group members to take a survey that aims to identify and assess each individual's sense of belonging and feeling valued. The survey used by our lab group is provided in the supplemental information online. The survey, which is an adaptation of the validated University of Colorado's Campus and Workplace Culture Survey, has three sections that evaluate participants' sense of belonging, perceptions of social norms, and social identity in the context of their lab group. Each statement is designed to be generalizable and anonymous, while still encouraging participants to explore their unique perspectives and identity. This survey is a flexible tool that can be leveraged by lab members at any level. For example, junior lab members may suggest this survey to begin conversations about JEDI, or PIs may use it to track progress towards JEDI goals over time.

Lab meetings are often reserved for discussing research and discipline-specific content; however, they also represent an opportunity for each member to engage in discussions about how to improve the lab environment and community. Thus, lab meetings are excellent opportunities for open and supportive exchange of diverse experiences and perceptions and to establish shared values and expectations. The anonymized overall survey results can help the group to assess success in fostering JEDI and to prioritize areas for intervention and modification. When administered iteratively, whether at predefined intervals or as group composition changes, this survey provides an efficient means to identify and track the experiences of diverse individuals within dynamic lab groups. An open exchange of experiences and cultural capital resources will ultimately facilitate individual agency and a sense of value among all group members.

Step 2: collective action and prioritization of desired forms of cultural wealth

The second step of the process identifies JEDI shortcomings experienced at the individual level and prioritizes corrective actions at the group level. Here, the process becomes even less prescribed. There is no tool, like a survey, that can be universally

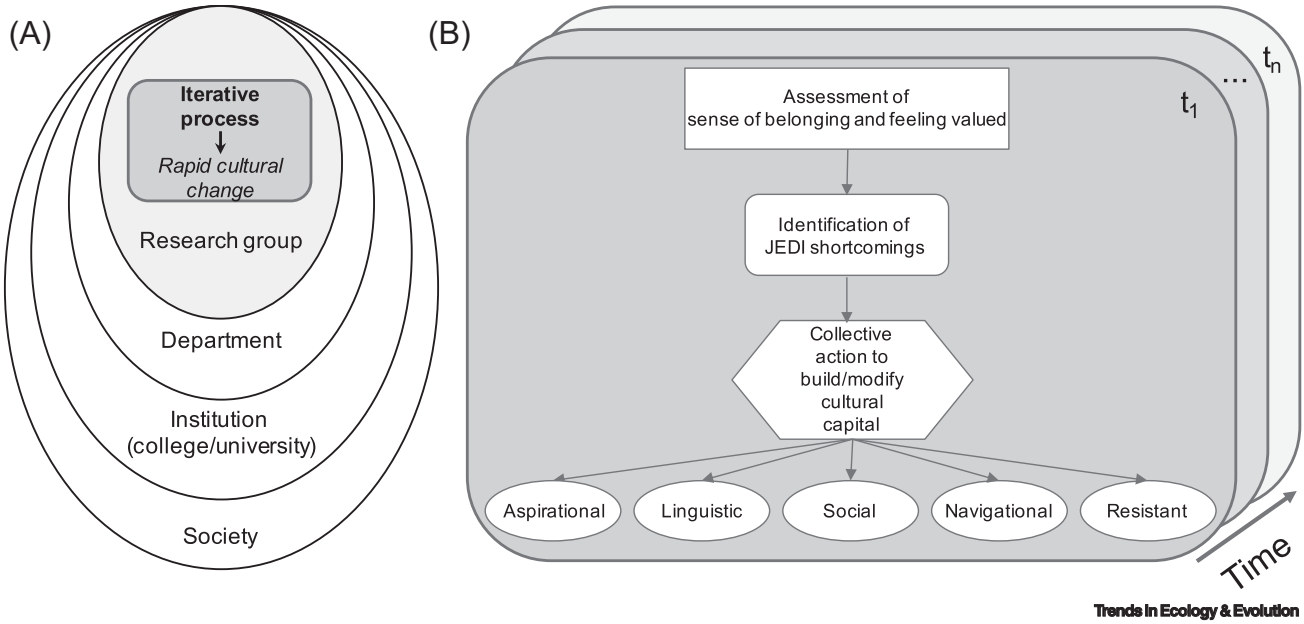

Figure 1. Iterative and ongoing study of belonging can help influence positive change in academic structures. (A) A typical academic organizational structure, with each layer of this power structure presenting new barriers to entry. For those who have overcome these barriers to become members of a lab research group, retention of a diverse community is still a critical challenge. We propose an iterative, bottom-up process to establish and maintain an equitable learning community and suggest that the resulting cultural change can spread through the broader academic structure. (B) Our proposed iterative process of reforming culture within a research group. Over time and through iterative cycles, these reforms can be continually expanded and refined to create academic communities that overtly foster justice, equity, diversity, and inclusion (JEDI), from the scale of laboratory groups up to the institutional level.

administered with the intended effect of improving group members' sense of belonging. Rather, feeling valued in a group relies on repeatedly integrating diverse forms of community cultural capital and modifying existing norms. Updating and building cultural wealth requires explicitly stating the desired outcomes and encouraging buy-in from all members of the community. To build and strengthen the different forms of cultural capital (Box 1 and Figure 1B), we have found that a 'living' text document, in which expectations can be continually and communally modified, anonymously or otherwise, allows everyone to voice their concerns and suggest modifications to the existing lab culture. Furthermore, this document provides a medium through which ideas can be constructively vetted and iteratively updated by all lab members. Importantly, this tool empowers each member of the lab, regardless of their position. Ideas and suggestions in this document can then be relatively free from natural hierarchies and power structures that exist in all lab communities (e.g., level of education, years of experience). Thus, a 'living' text document can be reviewed, criticized, supported, or modified in an equitable way by any member of the lab group while providing individuals with time and space to articulate concerns and outline possible solutions. We also encourage lab groups to engage in open dialogue on the challenging topics that arise in discussions of JEDI.

The future of diversity in STEM hinges on the ability to not only recruit, but also retain individuals from historically underrepresented and marginalized groups. To this end, we have proposed an iterative process that relies on self-reflection and thoughtful interactions among lab members to increase a sense of belonging within lab groups. We also argue that a lab group is a fundamental unit within STEM that can rapidly adopt cultural changes and implement progressive practices, such as the two-step iterative process described here. If many research groups adopt practices to quickly evolve and respond to the diverse needs of their members, with belonging as the goal, this may lead to an accelerated evolution of the culture of entire departments and larger academic units.

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Declaration of interests

No interests are declared.

Supplemental information

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[1]Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO, USA
[2]Office of Institutional Equity and Compliance, University of Colorado, Boulder, CO, USA
[3]All authors contributed equally to this work

*Correspondence:
rebecca.safran@colorado.edu (R.J. Safran).

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