Removing Discipline-Specific Barriers to Student Training and Belonging

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I've been teaching at North Carolina State University (NCSU) since fall 2019. We are a large land grant research institution, and my department doesn't (yet) have an undergraduate major, so my classes serve students from disciplines and departments across campus. I want to engage and prepare students effectively, regardless of their previous experiences or future goals. To that end, I've participated in an Open Pedagogy Incubator, HHMI Inclusive Excellence Scholars programs, and reading circles to hone inclusive teaching practices. Some of the approaches I've developed are "universal":

- I integrate open tools and materials wherever possible so students' access won't expire after they graduate. For example, NCSU is a Google campus, so everyone can access Google Workspace, which bypasses many platform-specific / proprietary programs and enables students to collaborate in shared digital spaces.
- I use Hypothes.is social annotation (https://web.hypothes.is/) to facilitate asynchronous conversations about assigned readings, which enrich in-class discussions and increase students' self-efficacy and belonging (McKenney et al., 2020, 2021).
- I also teach students to create scientific figures using BioRender (https://www.biorender.com/), which enables users to illustrate concepts without artistic "talent" or training in graphic design (Perkel, 2020).

In addition to these "blanket" teaching approaches, I have also designed and continually revise interventions in each of my courses to address training gaps and discipline-specific challenges. Creating access to research experience, cultivating personal relevance, emphasizing representation/identity, and foregrounding social support and belonging are strategies I use to reduce significant barriers to participation in STEM and especially ecology and evolutionary biology (Chemers et al., 2011; Fisher et al., 2019; Hunter et al., 2007; O'Brien et al., 2020; Rainey et al., 2018).

Creating access to undergraduate research

Science communication is an important skill; yet many undergraduates complete their degree without creating or presenting a research poster. In my flipped gateway course, Global Conservation Ecology (AEC 245), students work in small groups to research their choice of conservation issue, design a poster to educate the public, and propose SMART (Specific, Measurable, Achievable, Relevant, and Timely) strategies to address the issue. In spring 2023, I added a "campaign" component to challenge students to (1) consider which groups of people are directly impacted by each issue, and how they value natural resources; and (2) tailor their SMART goals to engage those different stakeholder groups. I structure my course with in-class project work days, scaffolded milestones to teach time management, and iterative feedback on writing and visual design (McKenny & Lafferty, 2021; McKenney & Lafferty, 2023). Students present their posters at the NCSU Undergraduate Research and Creativity Symposium – a professional first for ~90% of the students enrolled in my course. Student feedback suggests that they perceive that their scholastic and professional development are enhanced by this opportunity to present interdisciplinary collaborative research early in our curriculum. They also indicate that they value being able maximize personal relevance and motivation by selecting their research topic. Students have commented favorably on the experience:

- "I really appreciate the opportunity to present at a poster symposium, especially for a topic I feel so passionately about."

- "The milestone[s] were very helpful. Splitting a big project into smaller pieces helped us slowly develop ideas throughout the semester. It also helped us manage our time better, which also improved the quality of the work."
- "I think the most valuable thing I learned was how to trust my teammates as fellow researchers…"
- "This is my first opportunity working on research that's being treated as high-quality research, so I think it is a lot closer to a real life research experience than what I'm used to."

Cultivating personal relevance

Gut microbiology is relevant to everyone who eats and has a gut. Yet, despite gaining household buzzword status, many people are intimidated by the abstract or specialized nature of gut microbiomes. I minimize prerequisites for Gut Microbial Ecology (AEC 437/537) to attract diverse/nontraditional students by reducing barriers to enrollment. In the first 9 weeks of the course we build foundational knowledge of the driving forces that shape the gut microbiome: host taxonomy, gut morphology, diet, age, health / disease, lifestyle / Westernization, probiotics, and social inequities. After interpreting and discussing published research on each topic, students propose three action items that leverage what we've learned to maximize health and wellbeing. The week we discuss probiotics, students are blown away by the industry's lack of regulation – and realize they wouldn't be informed consumers if they hadn't enrolled in my class. With that newfound awareness, I ask them to revisit and reflect on their personal list of action items, identify biases and barriers to implementation, and submit a revised list of three "inequity-proof" action items that are maximally accessible to the public. Students comment that these "assignments are realistic and feel meaningful," and, "This class provided practical ways to implement our learning into real world use, which was one of the best things about this class."

Emphasizing representation and identity

Yet, however relevant or applicable science may be, representation can make or break a student's identity as a scientist. I redesigned Applied Ecology (AEC 400) assignments so that student works would contribute content toward a free digital textbook that centers student voices. In addition to creating BioRender figures that visualize and explain key concepts, students worked in small writing groups to synthesize and extend the topics we cover each week. The first year (2020) everyone wrote bulleted outline summaries – useful for reviewing course concepts, but not for building science writing skills – so in 2021 I revised the instructions to specifically require blog-style narratives. In 2022 I tweaked the prompt again to highlight ways that each topic manifests in North Carolina, in a "Spotlight on NC" (in keeping with our land grant mission). The figures and writing assignments grew students' self-efficacy; but I also wanted students to identify possible role models who share specific aspects of personal identity. For the "Featured Ecologists" assignment, each student highlights an ecologist of their choice by summarizing their research, contributions to ecology, and any compelling aspects of their personal or professional life. As of August 2023, the Applied Ecology PressBook is publicly available (McKenney & Rund, 2023); and I've revamped my course yet again so students can read, annotate, and continue to add to the textbook. I also included appendices in the textbook with Resources for Educators, which contain background information, instructions, and templates for each assignment. Students appreciate my efforts to emphasize their experiences, and tell me that it's "exciting and motivating to know that my assignments serve a greater purpose". The textbook project "helped me discover researchers who share my identify and interests" and makes their assignments "more meaningful, knowing my work might impact future student learning".

Foregrounding support and belonging

We must expand institutional support beyond the classroom to ensure that students' sense of belonging extends to the field. Marginalized communities including Black, Indigenous,

People of Color; people with disabilities; women; and members of the LGBTQIA+ community often face barriers and discrimination, whether in formal academic settings or just spending time out of doors (Marín-Spiotta et al., 2020; Morales et al., 2020; Tseng et al., 2020). I share this information with my Field Ecology class (AEC 460) on day 1, then describe the steps I've taken to support students in the field (Blonder, 2022; *Safety Guidelines for Fieldwork*, 2017) because, I tell them, "It's uncomfortable to know this and uncomfortable to talk about it, but worse to experience it." I provide high-visibility vests and research badges with my course and contact information, and I've created Field Site Assessments describing accessibility issues and environmental risks associated with each site (for example, see McKenney (2022)). Students agree that it's "good to have a class discussion or workshop on field safety, in particular the social aspects of field safety and how one's identity can impact this." After fall break, I invite diverse panelists to share their intersectional experiences practicing field ecology as graduate students, faculty, and in careers beyond academia. Our discussions normalize and validate diverse origins, paths, and practices; and welcome students to share their own experiences, questions, and ambitions. Students report that they "LOVED the panels, they were such a great opportunity to ask questions and hear about other pathways to science."

I continue to re/design my courses to address assumptions of preexisting access, ability, or experience; and to increase personal autonomy, relevance, and ownership. Some changes I dream up, others are suggested by students, or inspired by colleagues or conferences. As my department prepares to launch our new major, I'm building structure and flexibility into the curriculum, along with experiential and reflective opportunities to help our students build community and strong, resilient science identities. Specifically, an all-expenses-paid, field-based orientation would start students off with a common cohort experience, and annual written reflection assignments would help students build a personal narrative of accomplishment and belonging (Pelch, 2022). Together, I hope these interventions mitigate many of the barriers experienced by first generation students and other historically excluded populations, ultimately increasing persistence and retention in STEM.

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