Developing a Disciplinarily Diverse Course-based Research Experience: Outcomes and Design Considerations

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Abstract: Synthesizing data from three years of mixed methods classroom design research, this study reports on a model for a disciplinarily diverse course-based research experience (CBRE) to enhance university-based science learning. By emphasizing disciplinary mixing, mentorship and peer feedback, the experience develops scientific skills, identities and discourses within, across and outside of disciplines. Despite tensions introduced by disciplinary diversity, we find that students gain research confidence through classroom relationship-building and a collaborative unpacking of disciplinary norms.

Course based research experiences (CBREs) and course-based undergraduate research experiences (CUREs) are engaging and inclusive modes of instruction (Bangera & Brownell, 2014) capable of contributing not just to improved conceptual learning outcomes and gains in content knowledge, but also to enhanced science identities and diversity in STEM learning pathways (Auchincloss et al., 2014). However, despite the broadly recognized need for scientists that can think and work across and outside of disciplines, there have been few systematic studies of the how a CBRE approach can contribute to inter/trans/antidisciplinary science learning. CUREnet's valuable and growing database of model CUREs (https://serc.carleton.edu/curenet/collection.html), for example, includes exclusively discipline-specific research experiences. This study summarizes data on course dynamics and student outcomes from three sequential years of design research on a disciplinarily diverse science CBRE implemented at a large R1 university. We present evidence that the positive outcomes associated with discipline-specific CBREs can also be achieved with a CBRE approach that intentionally mixes the disciplinary backgrounds of students, that focuses on question-driven rather than discipline-driven science, and that engages participants in the difficult and potentially intimidating work of cross-disciplinary communication and feedback.

Framework and method

We use a late generation CHAT framework and related sociomaterial conceptions of learning as situated within and distributed across epistemologically heterogeneous ecologies (e.g. Engeström, 2008) to examine how students operate among networked mentors and peers to *integrate knowledge* (Linn, et al., 2015). We understand a *discipline* as having a characteristic style of communicating and interacting as well as an "important moral quality" and methods of conveying "proper conduct or action" (Stevens & Hall, 1998). In designing for *disciplinary diversity*, we aim to help students recognize and negotiate "microdisciplinary fractures," to situate themselves and their science in broader contexts, to gain a productively critical perspective on disciplines, and to explore and construct new and shared visions of science (Pickering, 1995, p. 216).

To these ends, we are developing a CBRE model called Curiosity to Question (CtQ). A CBRE in the CtQ model (1) encourages students to situate their research interests and identities around *questions* rather than strict disciplinary norms; (2) intentionally mixes disciplines, sociodemographics, grads and undergrads for a diverse classroom research community; (3) emphasizes iterative communication, representation and peer feedback to drive question formulation and knowledge integration; (4) explicitly develops research mentorship skills as core to scientific practice; and (5) prepares students to influence broader scientific and social cultures.

We are taking a mixed methods triangulation approach to design-based implementation research, integrating (1) quantitative self-reported student outcomes related to scientific skills, knowledge, understanding of practice, confidence, identity development, and professional intentions based on a modified URSSA (Weston & Laursen, 2015); (2) qualitative analysis of student coursework to understand knowledge integration and disciplinary positioning; (3) qualitative analysis of student journaling and interviews to understand the student experience and use of designed support; and (4) an egocentric network analysis to surface designed and emergent (informal) support interactions inside and outside of the classroom. A total of 66 students enrolled in the CBRE over the course of three spring semesters from 2017 to 2019, and 54 participated in this study.

Findings and discussion

Overall, students affiliated with ten different academic programs and represented twelve different subdisciplines, of which ten were STEM subdisciplines and six were geoscientific subdisciplines. Network analysis shows how students were supported and mentored in a distinctly distributed fashion by faculty and peers inside and outside of class (Figure 1), often from different departments and disciplines.

Some students reported being uncomfortable giving feedback to more advanced peers (e.g. late career graduate students) and to peers in other disciplines. Students also encountered contradictions among their distributed and disciplinarily diverse mentors. One research adviser external to the course, for example, took issue with the course's question- and writing-driven approach to science, telling their advisee who was in the class: "Well, maybe I would have done this backwards. Like some people write papers in real life. They get the data, what does it mean? Try to figure that out, try to write that up somehow…" (as quoted by the advisee).

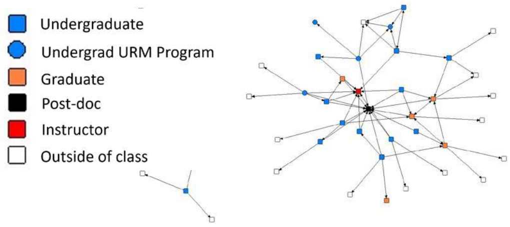

Figure 1. Example research support network (2018 cohort).

Despite such practical and philosophical contradictions--and indeed perhaps because of them--students generally responded positively to the experience on an affective level, and they reported gains in both research and writing skills as well as higher confidence in their scientific research abilities (Figure 2).

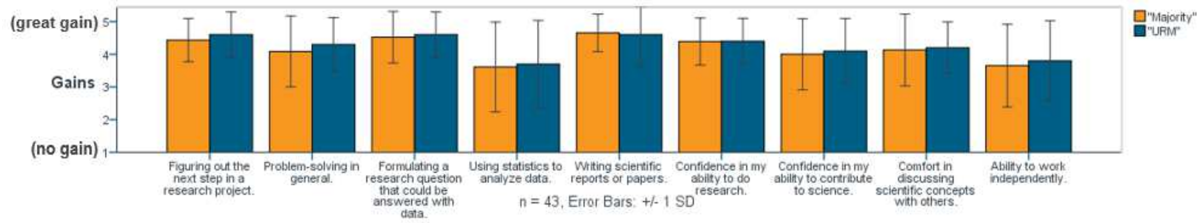

Figure 2. Self-reported student gains per URSSA (2017-18; URM is underrepresented minorities.)

Students sometimes attributed their gains in research confidence to the cultivation of a "safe" community in the classroom: "Doing a research project is so much work and can be completely overwhelming at times, but having a huge support group where I could openly discuss my research project without judgment was an amazing resource." At the same time, students found value in critically evaluating what counts as "good" scientific writing in different disciplines. Feedback suggests that student confidence gains are not only rooted in their classroom-cultivated scientific identities, but also in a critical demystification of disciplinary science. Disciplinarily diverse CBREs, therefore, should be designed to simultaneously cultivate a shared scientific culture as well as engage students in the interrogation, comparison and critique of disciplinary norms.

Adding 2020 data, we will more fully visualize diverse mentorship and support networks and present more detailed quantitative and qualitative characterizations of classroom dynamics as they relate to outcomes.

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