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Relational Pathways: Navigating science, education, and partnership for global futures

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This presentation explores how relational perspectives can support systemic educational design in response to planetary challenges. We focus on a classroom-driven participatory science initiative—Sonoran Photovoltaics Laboratory (SPV Lab)—that engages primary and secondary school students (ages 8-17) in exploring and shaping post-carbon futures in the US southwest. Across multiple courses in a graduate education program, we examine how university students partner with primary and secondary educators to enact and advance relational and pluriversal forms of engagement to support SPV Lab during a 15-week semester. First, guided by the Students-as-Partners (SaP) framework, we employed a mixed-methods design involving ten master's students and three educators. We used the SaP radar method to visualise and reflect on dynamics of collaboration—such as shared vision, trust, student agency, and inclusion—through survey data and focus groups. Second, we thematically analysed three course reports from three project teams to characterise varied three forms of relational engagement: retrospective, implicit, and emergent. While each team made progress towards relational engagement, pluriversality—the co-existence and legitimacy of diverse worldviews—remained aspirational. We conclude that collaboratories can support more relational, inclusive approaches to education and participatory science, but sustained and reflexive design is necessary to move beyond bounded co-design towards transformative, networked systems. Rather than offering fixed models, we propose a relational approach to inquiry that embraces complexity, fosters vulnerability, and centres co-creation as key to navigating shared global futures.

KEYWORDS: relationality, pluriversality, participatory science, students-as-partners, collaboratory, systemic design, energy transitions, graduate education

RSD TOPICS: Cases & Practice, Learning & Education, Socioecological Design

Presentation

Multipronged planetary challenges shape the ways we understand and speculate about possible global futures. Science and education each contribute to these futures but also remain entangled with these challenges, and with one another (e.g., Tolksdorf et al., 2023). Making progress towards planetary flourishing may depend less on scientific frameworks (e.g., climate science) or educational institutions (e.g., research-intensive universities) than on the interwovenness and interdependence among science and education as well as the nesting of both in wider systems of values, meaning, and identity (Gould et al., 2023). In this view, planetary challenges provoke us to navigate our human entanglements among complex, adaptive, more-than-human systems (Barad, 2007; Pendleton-Jullian & Brown, 2023; Escobar, 2024).

In this paper, we consider the transformative potential of relational perspectives in the systemic design of regional energy transitions in an ecoregion spanning northern Mexico and the southwest USA. Our work advances networked support for a classroom-driven participatory science intervention in primary and secondary schools called Sonoran Photovoltaics Laboratory (SPV Lab; Zuiker et al., in press). The current study focuses on involving university graduate students in supporting SPV Lab pathways of primary and secondary school student (ages 8-17) engagement across social and organisational contexts in relation to systemic tools for understanding and evolving student involvement at all educational levels. With this focus, our study is guided by the following question: How can student-educator-researcher partnerships support and advance relational, pluriversal thought and action in primary and secondary education?

Interweaving science and education

Western science and education share certain common conceptions about knowledge (epistemological assumptions) as well as knowable worlds and knowing humans (ontological assumptions) that tend towards divisions like nature and culture, mind and

body, and reason and imagination (Packer & Goicochea, 2000). In contrast, many non-western conceptions emphasise radical interdependence and relationality (Escobar, 2020). To design formal and non-formal learning opportunities for relational, pluriversal praxis, we view all disciplinary and classroom communities as complex social ecosystems. To understand and transform them requires a wider conceptual aperture, or an expanded scope, through which to design ecologically (e.g., Barnett, 2017; 2024).

We view co-creating systems of teaching and learning as opportunities to shape social ecologies in which science and all education institutions operate. The shaping influences of co-creation can emerge in multiple domains of engagement, including learning and teaching; curriculum development and pedagogical consultancy; the scholarship of teaching and learning; and myriad forms of disciplinary research (Healey, Flint & Harrington, 2016). Co-creation additionally entails partnership rooted in reciprocity and mutual growth (Cook-Sather & Felten, 2017) "through which all participants have the opportunity to contribute equally, although not necessarily in the same ways" (Cook-Sather, Bovill & Felten, 2014, pp. 6–7).

In educational research in primary and secondary school settings, reconciling goals for rigour and relevance reflects a complex interplay at work in classrooms, across schools, and within education ecosystems. One way to navigate the relevance-rigour interplay is through long-term partnerships between researchers and practitioners (Coburn, Penuel, & Geil, 2013), but these partnerships often omit a key stakeholder: students (e.g., Romers & Kitzmiller, 2021). Scholarship of teaching and learning in higher education, meanwhile, provides guiding principles for partnering with students through coursework (Felten, 2013), including (1) integrating inquiry into activities and assignments (2) embedding inquiry in authentic contexts, (3) organising it methodically, (4) conducting inquiry in partnership with students (e.g., Weimann-Sandig, 2024), and (5) mobilizing inquiry publicly (as appropriate). These principles can be examined in terms of psychological factors such as attitudes (e.g., Cook-Sather & Kaur, 2022) and socio-cultural concepts such as ecologies of participation (e.g., Matthews et al., 2018). Our work seeks to combine the strengths of researcher-practitioner partnership models in educational research and of students-as-partners models in higher education teaching and learning by employing the idea of collaboratories.

Collaboratories with and for classroom-driven participatory science

We integrate co-design into a partnership in education and science through the SPV Lab participatory science program that contributes to United Nations Sustainable Development Goals (e.g., Fraisal et al. 2023). Each SPV Lab project provided primary and secondary students with opportunities to engage with and contribute to a local community effort in which agrivoltaics served to explore post-carbon energy transitions. At the same time, it provided opportunities to engage and contribute to the efforts of a distributed scientific community seeking to understand agrivoltaics in relation to disciplines in engineering and human sciences (see Figure 1).

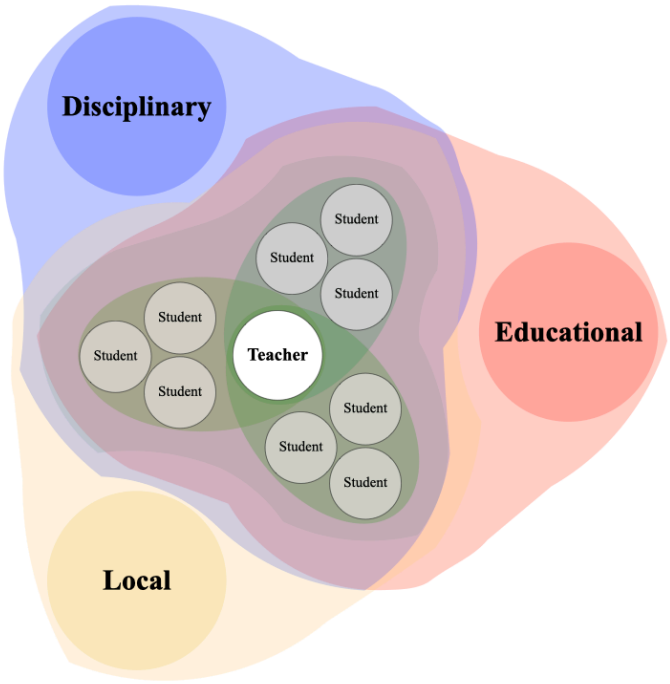

Figure 1. Classroom-driven participatory science engages youth with opportunities to connect with and contribute to disciplinary, local, and educational communities.

Our partnership model adapts collaboratories (Wulf, 1993; Dyllick & Muff, 2017) for graduate education in the learning sciences by organising semester-long educational co-design agendas that support SPV Lab. In partnership with primary and secondary school teachers and their classroom students, our collaboratory fosters understanding

and creates value in systems of teaching and learning (e.g., Zuiker et al., 2019) by inspiring and enabling coordination, cooperation, and collaboration on common challenges and shared goals in primary and secondary education. To organise engagement, three groups of graduate students partner with a separate primary or secondary school teacher who was actively facilitating SPV Lab classroom-driven participatory science projects (Zuiker et al., in press). In relation to these projects, the collaboratory provided graduate student groups with opportunities to connect with and contribute to one classroom-driven project (see Figure 2).

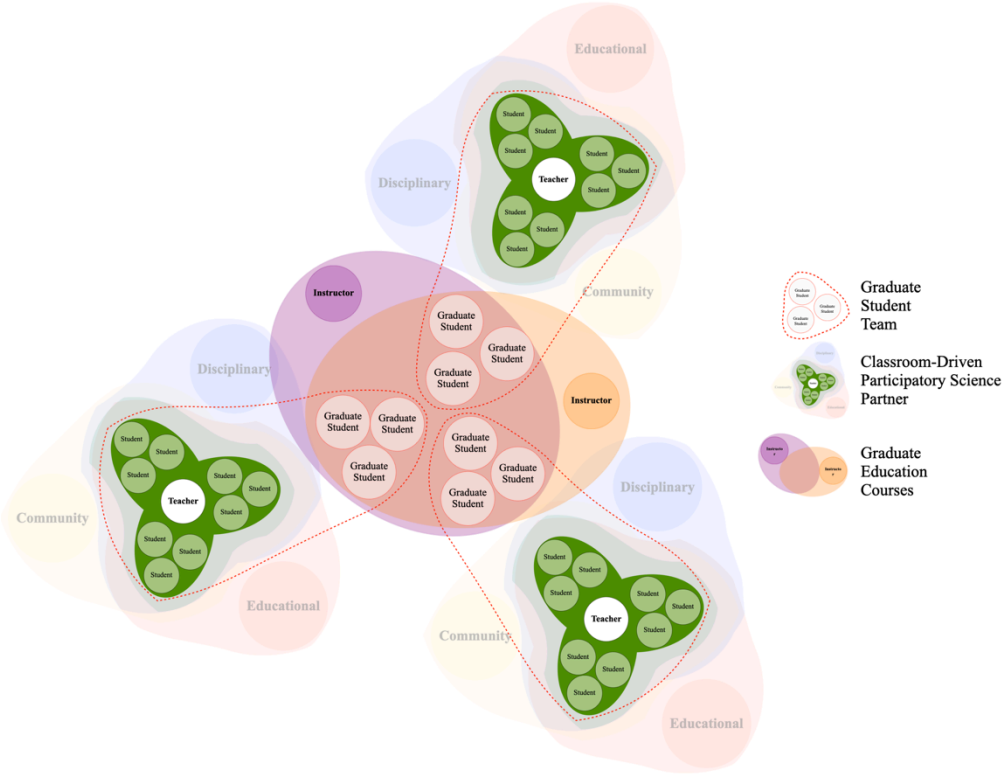

Figure 3. Partnership-driven collaboratory among instructors, graduate student teams, and educators and students enacting classroom-driven participatory science

Against this backdrop, we assumed roles as collaboratory designers and adopted a students-as-partners framework to (a) inwardly understand and enhance a collaboratory model for education (Zuiker, Jordan, et al., 2019) that integrates partnerships into graduate education coursework and (b) outwardly understand and enhance the partner roles and responsibilities that graduate students navigate in order to advance participatory science. We explore the evolving landscape of partnerships

with graduate students, focusing on how (online) systemic approaches can enhance collaboration and foster inclusive learning environments. By employing a mixed-methods design, we investigate the perspectives of graduate students, instructors, and partner-educators.

Methods

This mixed methods research study of an educational collaboratory enacted in late 2024 among graduate students, their instructors, and partner-educators co-creating learning opportunities for participatory science. Our participants include ten graduate students in a learning sciences master's degree program and three classroom educators in two primary and one secondary school, respectively.

As part of our methodology, we utilised a survey and focus group process associated with the Students as Partners radar method (SaP-rm; Rebac & Thölke, in review). SaP-rm illuminates the dynamics of partnership engagement visible in survey ratings and group discussions, including co-constructed visualisations annotated by participants. An early and late administration of the 46-item survey completed by all participants rated the collaboratory on nine partnership dimensions: shared vision, educational purpose, student involvement, teaching styles & methods, assessment & testing, student-educator dynamics, meaningful connections, diversity & inclusion, and individual purpose. Meanwhile, two-hour focus groups with the instructors and same three graduate student volunteers occurred one week after each survey administration. Focus group participants engaged in dialogue to understand and empathize with individual positions and perspectives on partnerships involved in the collaboratory (Cook-Sather, 2015). To answer our two-fold research question, we descriptively analyse survey responses and thematically analyse focus group discussions and artefacts as well as three collaboratory assignments completed by graduate students.

Findings

Engaging meaningfully in partnerships is significantly shaped by the relational and systemic supports embedded in the education collaboratory. The SaP-rm surfaced structural dynamics of partnership work associated with the model, making visible diverse priorities, assumptions, and lived experiences that co-exist within shared

educational contexts. Aggregated survey results incorporated graduate student, instructor, and partner-educator perspective for guiding focus group discussions using SaP-rm dialogic prompts for the Meaningful Connection in Education dimension. Responses explored how trust, inquiry, and shared commitment shape the quality of their relationships and illuminated educational change as not merely technical but deeply relational. One graduate student shared:

I find [the SPV Lab project] more engaging because it's a project that both Dr. Zuiker and Dr. Jordan are working on. I'm working on something that [they] work on so I view this as a conversation between me and them in a sense. [Graduate Student 1]

Comments like this advance collective meaning-making about relational practices—not as peripheral "soft skills," but as central, durable mechanisms for seeing and shaping the educational systems we inhabit and co-create. Later in the same discussion, one collaboratory course instructor (co-author Jordan) reflected,

The thing that I love about the collaboratory work is that I have to share my academic thinking, my thought processes, [and] the things I wrestle with because I know the history of the project and it behooves the project to share the struggles and the tensions I experience. It's the students' work to help move that [project] forward, and they can only do that if they understand where the tensions are and where the love is and where the purpose, at least for me, is. [Instructor 1]

The graduate student above perceived the collaboratory as a "conversation" while the instructor perceived it as an imperative to share not only academic thinking but also the underlying tensions, history, and struggles typically omitted from academic writing. They illustrate how the arc of SaP-rm focus group dialogue grounded in the aggregate of SaP-rm survey responses and the shared context of a collaboratory foster relational awareness and, in turn, relationally frame ongoing collaboratory work. This illustration suggests one way in which a collaboratory can support and advance relational thought and action in education but lends no insight into pluriversal thought and action.

Building on brief and partial engagement with SaP-rm, the collaboratory expanded the partnership by organising three graduate student-educator-instructor teams that partner with different primary or secondary school educators to understand and

improve how the SPV Lab program operates in the partner-educator's classroom context. Using three design-based research team reports, we examined how graduate students, partner-educators, and instructors supported relational and pluriversal thought and action in the SPV Lab participatory science project. The teams enacted distinct approaches to relational engagement with limited pluriversal engagement that we summarize and compare in terms of retrospective, implicit, and emergent relational engagement.

Team M – Retrospective Relationality

Team M co-designed reflective and explicitly socio-ecological activities by designing collage and "show & tell" presentations that invited primary school students to link individual identity, participatory science, and community relevance. Though largely retrospective, the team reports articulated relationality in terms of temporality (i.e., short-term actions building long-term values) and ecology (i.e., layered, interconnected systems) then speculated about how graduate student work might lead to action with others. However, it remained a conceptual reflection and was not operationalised in design.

Team T – Implicit Relationality

Team T's project focused on classroom-based activities, such as a paper chain assessment, that implicitly supported relational thinking through community-relevant themes (e.g., homelessness, extreme heat). Their efforts positioned primary school students within socio-ecological systems (i.e., agrivoltaics in the Sonoran Desert) that scaffolded collaborative meaning-making. Because the activities remained bounded within a single classroom, cross-context connections and community-linked interpretations remained written and spoken but not realised. Pluriversal possibilities were implied in abstract acknowledgments only.

Team J – Emergent Relationality

Team J's project exhibited a comparatively dynamic and forward-looking orientation. Through mechanisms like role cards, they supported situated learning, distributed agency, and equitable collaboration. These relational structures encouraged experimentation, power-sharing, and localized meaning-making. While the design itself

remained at preliminary and often implicit levels, the project constituted fertile ground for pluriversal engagement by embracing multiple identities, community-connected roles, and networked participation beyond the school. Still, the unevenness of the enactment and the nascent quality of the design suggested only emerging pluriversality.

Across the projects, relationality was increasingly explicit across the cases, moving from reflective framing (Team M) to embedded design principles (Team T) then participatory emergence (Team J). Pluriversality, by contrast, remained largely aspirational, with the most promising preconditions appearing in Team J's experiments with distributed agency and diverse identity work.

Conclusion

The changing landscape of science and education invites us to individually rethink and collectively re-story how we engage with knowledge, relationships, and systems. If progress relies on interdependence, how can we co-design more relational, pluriversal forms of inquiry? At its core, this study explores how education can re-story worlds that shape global futures. That is, traditional education often enacts systems of teaching and learning where small differences between individuals (e.g., grade point averages, aptitude tests, IQs) work to shrink and dissect individual and shared experiences into units, courses, and diplomas, typically at the expense of understanding what makes ideas individually useful (e.g., Lave & Wenger, 1991) , let alone collectively wise (e.g., Escobar, 2024). In contrast, participatory science programs like SPV Lab and the collaboratory featured in this study position primary, secondary, and higher education students as partners with instructors and educators and in relation to wider, extra-educational systems of teaching and learning that seek to remake disciplinary, educational, and community ecologies. Rather than educational systems optimized for individual performance, these design efforts intervene relationally both in, and on, educational systems to advance more lives-long and communities-wide sustainable and scalable systems of teaching and learning.

Looking forward, the relational achievements in this study realised modest shifts towards re-storying and remaking education. What emerged was constrained, in part, by the timescales of education (Lemke, 2000), which divide and disrupt course- and classroom-based partnerships. It was equally constrained by the limits of what we (Zuiker and Jordan), as instructors, presumed possible when beginning from the powerful, mythical, and seemingly immutable realities of our disciplinary and educational systems rather than from the relationships we do, and might otherwise, build with colleagues, students, educators, and others. Taking Escobar's (2024) call for relationality and pluriversality seriously invites us to reimagine what is possible in future iterations—beginning not from inherited systems, but from situated, co-constructed relationships that can sustain longer-term forms of educational transformation. In this sense, the work here should be seen not as an endpoint but as an opening to practices that nurture more just, plural, and life-affirming ways of learning together.

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