International Society of the Learning Sciences

Examining Teacher Supports for Visibility, Believability, and Meaningfulness in Place-Based Citizen Science

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Abstract: A limiting factor in school-based citizen science is teachers' capacity to facilitate active student engagement in place-based inquiry practices. We extend Harris and colleagues' student data interaction constructs of *visibility, believability* and *meaningfulness* using a design-based research approach to qualitatively examine professional development structures designed to enable teachers to foster students' contributions as visible, believable, and meaningful.

Introduction

The energy capacity of a community is dependent on the energy engineering activities within that community, including activities by youth, who arguably have the most to lose through failures to address post-carbon energy transitions needed to mitigate climate change and address inequities in current energy systems. Moreover, engaging K-12 students in community engineering promotes agentive participation in real work that concerns them (Jordan et al., 2021) and imbues rightful presence (Calabrese Barton & Tan, 2019). Hence, this study subscribes to a model of citizen science that recognizes the legitimacy of students to contribute to engineering research processes tailored to their own personal and community assets. The citizen science (CitSci) project that is the context for the study seeks to democratize and broaden participation in STEM by situating students from communities historically underserved by engineering as next-generation energy engineering researchers in agrivoltaics (agriPV), an innovative strategy for optimizing food, energy, and water systems with plants and solar panels. To achieve such engagement by students, this DBR study explores how STEM teachers can be supported to facilitate visibility, believability and meaningfulness in students' contributions towards place-based energy systems research through a practice-based professional development (P-BPD) program (Ball & Cohen, 1999).

Background and theoretical framework

Young students' participation in CitSci projects is typically limited to data collection and reporting to scientists (Carson et al., 2021). Interactions with student-obtained place-based data mediates student perception of the use of the data, their agency, and their sense of community. Moreover, students benefit when they see themselves as contributing to a body of scientific knowledge (Ballard et al., 2017). However, not all students believe their contributions to generation of data is meaningful in scientific research. According to Harris et al. (2020), when students see how their data is nested within a larger dataset, they develop a sense of being *visible* to other contributors, scientists and the community. Interactions with end users of their data lead students to *believe* their data are being used. For some students, data becomes *meaningful* when they suggest solutions and provide value to end users. Yet few studies to date investigate how PD programs can build teachers' capacity to work productively with scientists to support students in meaningfully contributing to CitSci (But see Benichou et al., 2022). Building on the work of Harris et al (2020), we conjecture that STEM teachers – like students – may benefit from P-BPD designed to foster teachers' own visibility, believability, and meaningfulness and thus adopt these aspects of their experiences into their facilitation of student inquiry and collaboration with professional scientists.

Methods

This design-based research (McKenney & Reeves, 2018) employed qualitative methods to investigate how PD support structures facilitate a network of teachers in recognizing their and their students' collaborative CitSci contributions as visible, believable, and meaningful. This study is guided by the question: *How can P-BPD foster visibility, believability, and meaningfulness for teachers learning to facilitate school-based CitSci?* Participants were ten STEM teachers (5 elementary, 4 middle, and 1 high school) from different schools in the same ecoregion who participated in a six-week summer agrPV CitSci PD experience. P-BPD activities sought to provide teachers with place-based data literacy to (a) develop their knowledge and capacity to facilitate data interactions between their students and research garden sites, and (b) co-design CitSci protocols for the agriPV CitSci network. Many of the P-BPD activities are similar to what the participating teachers engage in with their own students after completing the PD. Moreover, we conjecture that P-BPD design enactment provides opportunities for teachers to engage in activities that allow them to experience CitSci knowledge purposes and procedures as learners and to engage in reflective dialogue about their pedagogical experiences and thereby make their own judgments about how to pedagogically incorporate agriPV CitSci processes into their own classrooms.

Primary data sources were audio-video recordings of teacher interaction in agriPV CitSci PD sessions and post summer PD interviews with all ten teachers. Artifacts served as secondary sources (e.g., co-designed lab report forms, slidedecks, schedules). Analytic processes combined interaction analysis (Jordan & Henderson, 1995) with theory-driven coding and thematic analysis to examine teachers' visibility, believability, and meaningfulness which were initially operationalized drawing on Harris et al (2020) and further informed by initial viewings of a purposefully sampled subset of the data to contextualize and operationalize these concepts in the teachers' P-BPD experiences. Working in iterative cycles, individual researchers viewed video recordings, created data logs to identify rich episodes, conduct coding, and create memos, followed by collective work sessions to develop insights and negotiate interpretations.

Findings

Preliminary analysis suggests that P-BPD learning activities that support visibility, believability, and meaningfulness for teachers can be distinguished as *experiential support structures* or *social support structures*. Engaging in experiential activities that offer hands-on experiences in the garden spaces (e.g., teacher displays of consequential learning and findings from their summer gardens) helped teachers see their contributions as visible. Opportunities to co-create, test, and critique data collection protocols, lab report design, and take steps toward making use of the data for end-users helped teachers believe their contributions are useful. Finally, contextualizing the impact of their contributions on the larger desert ecoregion that is the context for the study helped foster meaningfulness for teachers. Social activities situated teachers in collaborative discourse. An example of a social activity that appealed to visibility for teachers is one where the teachers shared and compiled their findings from their own independent development and research of a miniature agriPV garden. Socially, believability was approached by having teachers co-create lab reports for continued refinement based on sharing of professional experiences and knowledge of gardening and energy. Lastly, meaningfulness was fostered through opportunities that allowed teachers to interact with other teacher cohorts and students with prior experience in the agriPV CitSci program, and consultations with the engineers.

Significance

Findings contribute to understanding how visibility, believability, and meaningfulness are understood by teachers and how they inform teachers' pedagogical practices that can make school-based CitSci more supportive of students' rightful presence in STEM and sense of place towards their local campus, community, and ecoregion. Interdependent relationships may exist among the three core constructs that have implications for how they can be fostered during P-BPD. First, initial findings suggest that visibility is a precursor to indicators of and may be necessary for believability and meaningfulness. Additionally, *believability* and *meaningfulness* may have a reciprocal relationship in which appealing to or minimizing the effects of one construct may amplify or reduce the effects of the other dimension.

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Acknowledgments

This work was supported in large part by the National Science Foundation (EEC-2055726).