

REPRESENTING KNOWLEDGE AND PROCESSES IN COLLABORATION ACROSS BOUNDARIES

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Despite repeated calls internationally for teacher preparation programs and schools to form partnerships, few such sites exist in the research. We posit that in this relative absence, a comparison of multi-institutional sites even within one region may hold lessons for international partnerships. We contribute findings drawn from 20 multi-institutional collaborations encompassing 40+ institutions at secondary or tertiary level. We examine how artifacts of iterative design research used by these sites represent knowledge and processes among cooperative agents. We suggest ways that artifacts in iterative design research may constrain and complicate collaboration across boundaries.

INTRODUCTION AND BACKGROUND

Governments worldwide see teacher education as a lever for improving inequitable outcomes (Murray et al., 2019). To create productive change levers, educators must “commit to quality education and to improving learning outcomes, which requires strengthening inputs, processes and evaluation of outcomes and mechanisms to measure progress” (United Nations, 2015, p. 8). Iterative design research (Van den Akker et al., 2006), or cyclic design, is aligned with this commitment.

Our purpose is to examine how artifacts of cyclic design across boundaries function in collaboration for improving secondary mathematics teacher education. Scholars study improvement efforts across boundaries – be they disciplinary, experiential, or geographic – to see new possibilities for improving policy and practice at scale (e.g., Murray et al., 2019). These arguments apply to international studies (e.g., Tatto et al., 2012); they apply as well to multi-site studies within one region with disparate cultures. Mathematics courses are required worldwide, and mathematics teacher preparation needs improvement in many countries (e.g., Tatto et al., 2012).

Despite theorized benefits for teacher education, cyclic design is hard to enact in practice (Bryk et al., 2015). Even with repeated calls worldwide for schools and teacher preparation programs to collaborate, few such partnerships appear in the research (Coburn & Penuel, 2016; Groß Ophoff & Brown, 2021; Menter, 2023). Efforts to improve teacher education are shaped by cultural, political, and economic context, which shape leadership moves (Elrod et al., 2023). Scholars need more understanding of how context shapes cyclic design practices and sustainability (Coburn & Penuel, 2016). Our research questions are: *What are roles of cooperative agents in constructing artifacts to represent a collaborative cyclic design process? How do such artifacts afford or constrain collaboration across boundaries?* We contribute data and findings that address the gap in research with data drawn from 20 partnerships.

The artifacts we consider are Plan-Do-Act-Study (PDSA) cycles and Driver Diagrams, whose principles align with cycles and rationales of cyclic design in general (Bryk et al., 2015). We see the U.S. as a productive region for a multi-site study due to local autonomy and distinct cultural regions. We study cooperative agents in locations ranging from rural to urban, and politically conservative to liberal. As professionals, they include mathematicians, education researchers, teachers, and school leaders. Our study participants encountered disciplinary, experiential, cultural, geographic, and political boundaries. The barriers and affordances encountered by teams in our study may well have a form in international collaborations. In this way, we may contribute to TSG 5.11. As well, we are eager to learn from all TSG 5.11 work.

CONCEPTUAL PERSPECTIVE

Following Akkerman and Bakker (2011), boundary crossing entails entering into unfamiliar professional territory, and agents negotiating and combining resources from different contexts, such as distinct departments or institutions. Boundary objects facilitate boundary crossing when agents use them to articulate implications from different perspectives for different contexts.

Following Bryk et al. (2015), Networked Improvement Communities (NICs) facilitate cyclic design by focusing on a common aim, defining a plan of action, engaging in data-informed improvement cycles, and sharing lessons learned. In our study, NICs crafted PDSA cycles and driver diagrams with hypothesized levers (drivers) to test iteratively. These artifacts and their concomitant processes can function as boundary objects. Overall aims and metrics are a minimal structure that may be held by agents across institutions, while particular efforts take on additional structure contingent upon individual institutions' culture and constraints.

DATA AND METHOD

This study was conducted by members of the Mathematics Teacher Education Partnership (MTEP), a partnership of 20 multi-institutional NICs (across 40+ secondary or tertiary institutions). Some NICs have worked together since 2012, and others are more recently formed. MTEP seeks to improve the quantity and quality of secondary mathematics teachers prepared through programs in tertiary institutions. Each NIC is led by a project leader, who acts as a cooperative agent. MTEP collects annual NIC artifacts including current driver diagrams and PDSA cycle documentation. Here we focus on 35 video-conference interviews conducted in 2022-2023 from a purposive sample of 10 NICs, representing stages of NICs from beginning to sustaining. We interviewed team leaders, tertiary institution administrators, and focus groups of NIC members. Researchers coded interview transcripts for cultural, political, and economic factors that shaped leadership context and moves (Elrod et al., 2023), and for use of NIC artifacts. We then “[moved] from the particular to the general” (Boaler et al., 2003, p. 505) to identify broader issues in the roles of cooperative agents in using artifacts. This analysis produced three themes, which form our results.

RESULTS

First, cooperative agents, even those in willing collaborative multi-institutional teams, face challenges inherent in boundary crossing. One challenge is the effort needed to learn new systems. As one mathematics teacher educator stated, it took “several years to understand the structure” of their institution's administration and state's educational policies. Only after significant investments in time, discussion with other NIC members, and attending institutional and state meetings, were they able to

solve an enrollment problem the NIC faced. A different team negotiated across multiple departments (including education and mathematics) to develop a new teacher preparation program.

Second, cooperative agents used intended boundary objects from superficial to intensive ways. MTEP intended for NICs to use PDSA cycles and driver diagrams as boundary objects. Yet, for one long-running NIC, when the current leader was asked to describe processes, they stated, “I move ahead with the things I ... think are important, and I can backfill to make them fit into MTEP but I also feel a little bit disingenuous doing that.” In contrast, agents in another NIC described the impact of four consecutive PDSA cycles in developing an equity-focused intervention to use across institutions. One NIC agent, who taught in a tertiary institution with racial diversity, said, “We went through PDSA cycles with that to improve it ... I notice that [teachers] think about equitable teaching in a different way ... than [teachers] prior to using this activity did.” Another NIC agent, in an institution with little racial diversity, described the insight of focusing “more about poverty in my region, thinking about different characteristics of diversity than the more traditional things that come to mind.” Then, whereas previously “[teachers] made assumptions that everyone that looked like them was exactly like them, they don’t do that anymore.” In superficial use, agents used artifacts to document activity without intentional iteration. With intensive use, agents negotiated across contexts to specialize common drivers across sites to accomplish common aims.

Third, PDSA cycles and driver diagrams only partially represent cooperative agents’ knowledge and processes. Driver diagrams include a “shared goal”. Yet we found instances of inconsistent conceptions of goals within NICs. In one NIC where agents professed to use a common PDSA cycle and driver diagrams, one agent described the common vision as “forming a [professional] support network” among NIC members, while another agent stated that the vision was to “increase in number and in diversity the number of teachers that we are preparing in our programs.” And, as one NIC participant said, “while we are all aiming towards the same thing, I think, which is to improve [educational] outcomes ... the avenue by which we can affect that ... [depends] on the institutions where we work.” Finally, artifacts constrain representation. Not all effort can be recorded in PDSA cycles and driver diagrams. For some NICs, this constraint is a source of frustration. Sometimes, tools are not represented, making resources harder to share.

DISCUSSION AND CONCLUSION

We examined the role of cooperative agents and the function of intended boundary objects across a purposive sample of 10 multi-site collaborations. Our findings include challenges of boundary crossing, unintended use of intended boundary objects, and artifacts’ only partial representation of knowledge and processes. Whereas prior literature documents barriers to establishing partnerships (e.g., Menter, 2023), our results document barriers overcome so that cooperative agents can begin the negotiations needed in boundary crossing to improve mathematics education.

We suggest that these findings may hold lessons for international collaborations related to mathematics education. Although our data was from only one nation, our findings result from analysis across cultural, disciplinary, and geographic boundaries. Even in international work, the use of artifacts for boundary crossing may be uneven across collaborative sites. Our results echo those of lack of capacity and power dynamics (e.g., Coburn & Penuel, 2016; Menter, 2023), but move beyond these challenges to document how cooperative agents developed capacity to work within known power dynamics.

Boundary objects provide evidence of affordances and constraints of collaboration across boundaries. Artifacts that document cyclic design efforts help by providing structure. However, they may constrain collaboration when there is uneven understanding of the aims and the presence of a PDSA cycle. Illusions of tight mutual understanding and cooperation across the boundaries are not necessarily supported. Rather individual team members are more or less engaged which may bring variance in the amount and type of work produced at individual institutions in a partnership.

Ultimately, cooperative agents by design lead an iterative design process. They must navigate their role as boundary crossers as well as the implications of how to navigate the uneven engagement of agents, as they meet the ultimate goal of transformation in mathematics education.

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