Technology-Mediated Teacher-Researcher Collaborations: Professional Learning Through Co-Design

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Abstract: Collaborative co-design between teachers and researchers can provide the kinds of learning opportunities for teachers that lead to teacher agency, and flexible, adaptive, principled pedagogy. This symposium features four projects in which teachers and researchers engaged in technology-mediated collaboration to design inquiry-based learning environments to engage students in authentic disciplinary practices in a variety of content areas, including literary reading, literacy in mathematics, science, and engineering design. The size and scope of the collaborations vary, ranging from one-to-one to larger groups, as does the time span of the collaborations, providing opportunities to examine temporal affordances of technology supports. All four papers discuss collaborative co-design as sites of professional learning for teachers. We argue that these are excellent cases of CSCL and that they afford new insights into roles for technology in supporting and facilitating teacher and researcher learning.

Overview

This symposium features four projects involving teachers and researchers collaborating in co-design of inquiry-based learning environments. Across the projects, technology mediated the collaborations in two primary ways (Hmelo-Silver, et al., 2016): (1) As a *context* for reflection on implementation of the designs via video capture of classroom instruction, and (2) as a *conduit* for connecting participants and facilitating communication during various phases of the process. As context, video of classroom instruction or of the design process itself can serve as a boundary object (Akkerman & Bakker, 2011) that focuses discussion and inquiry by teachers and researchers. In this way, boundary objects mediate sharing perspectives, joint construction of knowledge in use, and potentially the emergence of negotiated perspectives on various aspects of teaching and learning processes (Hmelo-Silver, et al., 2016). As conduit, video conferencing and other forms of communication technology (e.g., web-based forums, chat rooms) enable collaboration, reflection, and analysis across time and space.

The collaborative co-design efforts described in the four presentations aimed to engage student learners (ages 8 – 17 years) in authentic disciplinary practices in a variety of content areas, including literary reading, literacy in mathematics, science, and engineering design. As such, the four contributions reflect what might be called a second generation of (computer) technology-supported collaborative learning research in the following sense. Co-design involves working with teachers throughout all phases of the iterative design cycle (design, implementation, reflection, and redesign). This can be contrasted with design-based research wherein researchers created designs for teachers to implement. (See for discussion Penuel, Fishman, Cheng, & Sabelli, 2011.) Collaborative co-design throughout all phases of the design cycle reflects perspectives grounded in practice as well as in learning theory and research. Rather than teachers being positioned as the "end users," they are agents in co-designing what they will implement. This second generation of CSCL creates new opportunities to study learning as it occurs in the course of iterative design cycles (e.g., Ko, et al., 2016).

In this symposium, three of the papers (Gomoll & Hmelo-Silver; Hall, Ko, Goldman, & Fortune; Kyza & Agesilaou) focus on different ways in which technology creates artifacts that provide contexts for reflecting on implementations and redesign. Two discuss how technology enables communication across time and space among co-designers (Gomez, et al; Kyza & Agesilaou). The size and scope of the collaborations vary, ranging from one-to-one to larger groups. The papers differ with respect to the time span of the collaborations, providing opportunities to examine temporal affordances of technology supports. All four papers discuss collaborative co-

design as sites of professional learning for teachers. Details of each presentation are provided below. The discussant for the symposium is Iris Tabak, Ben Gurion University. Dr. Tabak, former co-editor of the *Journal of the Learning Sciences,* is an extremely accomplished learning scientist who has created and researched science inquiry learning environments and teachers' professional learning throughout her career.

Rationale and background for the symposium

Collaborative co-design between teachers and researchers throughout the design-implement-reflect-redesign cycle has emerged as an alternative to earlier design-based research (DBR) paradigms. Prototypical early DBR (Brown, 1992) involved researchers designing, teachers implementing, and researchers reflecting and then redesigning. Researchers sought teachers' input as part of the reflection and redesign process, but teachers did not have agency in redesign beyond providing input based on their experiences with what they had been given to enact. One lesson from early DBR is the highly embedded nature of classroom practice. For example, even the same teacher's implementations of the "same" lesson over three different classes of students are not identical in part because the students are different from class to class. This context-specificity creates the need for design modifications and adaptations in response to local circumstances *during* implementation. Hence, though the resultant implementations bear a family resemblance to one another (Wittgenstein, 2009), they are not identical. For teachers to adapt and modify, they need to understand the principles underlying the designs and how to flexibly implement them in ways that are consistent with the underlying principles (e.g., Brown & Campione, 1996). In other words, teachers need adaptive expertise to be able to respond to changing sets of demands (Hatano & Inagaki, 1986; Bransford, Derry, Berliner, & Hammerness, 2005). This is especially so when they are teaching for deep learning (National Research Council (NRC), 2012; Wang, Derry, & Ge, 2017).

The adaptive expertise perspective on the teaching process calls for shifts in the teaching practices of the vast majority of teachers. They need to change what they do, how they do it, as well as their understanding of why they do it (Bereiter, 2014). Just as transmission models of student learning fall short of the goal of deep learning (NRC, 2012), transmission models of professional development are inadequate in supporting teachers in developing flexible knowledge and adaptive expertise (Darling-Hammond & McLaughlin, 1995; Guskey & Huberman, 1995; Joyce & Showers, 2002). Rather, teachers need professional learning opportunities that build a principled knowledge base and sustainable, responsive pedagogical knowledge. This form of professional learning empowers teachers as agents of change by engaging them as co-creators of curriculum that directly addresses their problems of practice in their own contexts in response to their own students.

Collaborative co-design between teachers and researchers is one way in which learning scientists attempt to provide the kind of learning opportunities for teachers that lead to teacher agency, and flexible, adaptive, principled pedagogy (e.g., Kyza & Georgiou, 2014; Kyza & Nicolaidou, 2016). There are several variants of collaborative co-design. Some of these models draw from principles of improvement science and negotiate common goals for improvement efforts as well as sources of evidence that allow close monitoring of anticipated and unanticipated outcomes of implementation (Bryk, Gomez, Grunow, & LeMahieu, 2015). Others expand the DBR process to embrace practitioners in Design-Based Implementation Research (DBIR). DBIR confronts the realities of implementation from the very initial phases of design (Penuel, et al., 2011). In a similar vein, Research-Practice Partnerships (RPPs) reflect long-term commitments to collaborative co-design to address problems of practice (Coburn & Penuel, 2016). All three models tend to situate teacher learning in problems of practice that teachers see as relevant to their own circumstances and hold much promise for productive adaptation to new settings and problems of practice. (See for elaboration Gomez, Kyza, & Mancevice, 2018.) The collaborative co-design projects discussed in this symposium are instances of one of these three forms of professional learning experiences. We argue that these are excellent cases of CSCL and that they afford new insights into teacher learning and, although not discussed here, researcher learning as well.

Organization of the symposium

A short introduction to the symposium is followed by four presentations plus a discussant. The presentation order of the papers moves from work in technology-mediated, one-on-one collaborative co-design (Gomoll & Hmelo-Silver) to professional learning in several one-on-one cases and in teacher-researcher multi-discipline communities (Hall, Ko, Goldman, & Fortune). The third paper examines professional learning in hybrid co-design environments (Kyza & Agesilaou). The fourth paper marshals technology to enable rapid and agile learning from practice among researchers and community college instructors of developmental mathematics (Gomez, Gomez, Pressman, & Rodela). Tabak offers a discussion and takes questions from the audience.

Co-designing Problem-Based Learning (PBL) experiences using video as a boundary object

Andrea Gomoll and Cindy E. Hmelo-Silver

This presentation explores how a co-design experience that leveraged video analysis supported the design of a problem-based robotics curriculum. This curriculum was grounded in user-centered design and asked students to address local problems using innovative technologies. Within the research-practice partnership (RPP) described here, collaborative video analysis of past and current implementations of our robotics curriculum served as a boundary object (Akkerman & Bakker, 2011) for design partners. Video analysis collaboratively done by the first author and the teacher allowed us to communicate around the curriculum design and how it was enacted via in-class facilitation. To support development of user-centered design practices and the coordination of functional design teams in the classroom, we used video reflection to interrogate what collaborative student work can and should look like as well as how to support it in real time.

The specific focus of this presentation is an ongoing partnership with one teacher and our co-design experience orchestrating CSCL experiences for students. In our earlier work with the robotics curriculum, this teacher was inspired by high levels of student engagement. The school and community were concerned about student safety, a concern exacerbated by the increasing frequency of shootings in US schools. Students acted on this concern and opted to design robots that served an emotional need in the school—helping students to feel safe during school shooting drills. We converged on a focus for the robotics curriculum: how robots might enhance school safety.

In this presentation we focus on the co-design process between teacher and first author as we designed and implemented a robotics unit for students (ages 13 – 14) taking an elective science course in a rural community. Students engaged in the work of co-design as they designed and built safety-focused robots for their local community. Thus, in this case study, co-design is positioned as a means of learning for teacher and researcher as well as the process engaged in by the students. Through co-design, students are better supported in their efforts to collaborate effectively and to learn with and through user-centered design and computing. The co-design process between the teacher and researcher, specifically joint video analysis played an important role in supporting the effort to create, deepen, and sustain a locally meaningful engineering design experience for students. Prior research has highlighted that for teachers to develop robust practices, they need to develop rich professional vision (PV)—the ability to see nuanced issues of teaching and learning in their environment (Borko, 2004; van Merriënboer, Kirschner, & Kester, 2003; Rehak et al., 2016). Carefully organized viewing of classroom video can make PV visible and inspire action. For example, video analysis of prior and current implementations helped the teacher and researcher to refine their understanding of what productive collaboration looks like within engineering design as well as how to best support collaborative group work.

In the teacher-researcher collaborative design of this robotics unit, school stakeholders were contacted who could identify safety issues in the school that could potentially be addressed by a robot (e.g., students who have disabilities need additional assistance evacuating during emergencies; providing a live video feed to the police station during active shooter scenarios). These stakeholders agreed to play the role of design clients within the robotics unit. The unit was designed to promote authentic engagement with local issues—asking student groups to select clients they would like to design and build robot prototypes for.

We explore how the teacher refined her PV as a designer and facilitator—focusing on the ways that she oriented to and facilitated collaboration in student design groups. We illuminate the role collaborative video analysis played in co-design and implementation using discourse analysis methodology (Potter & Wetherell, 1987). In attending to discursive patterns related to PV in the work of co-design and facilitation, we study how the use of video as a reflective tool can support the development of PV and the design of CSCL experiences.

Preliminary results highlight discursive patterns including the teacher's attention to establishing and maintaining group norms (e.g., ensuring that all voices are heard), emphasizing the iterative nature of design (e.g., modeling how to talk about work as "in progress" and "a prototype"), and helping students build on each other's design ideas (e.g., modeling how to summarize and respond to a peer's comment). Teacher-researcher reflection on video of the teacher's classroom during the implementation allowed the teacher to view group work that she had not experienced in real time—informing interventions made during future class periods. Furthermore, the instructor was inspired to integrate video analysis into students' design work. The instructor used her own experience of co-design to inform the design work that her students engaged with in real time. Throughout this RPP, both teacher and researcher used video to communicate and collaborate as well as to design rich CSCL experiences for students.

Teacher-researcher collaborative reflection supported by classroom video

Allison H. Hall, Mon-Lin Monica Ko, Susan R. Goldman, and Angela Fortune

Facilitating productive disciplinary discourse (PDD) in classroom discussions is a complex and multi-faceted task: teachers need to make *in-the-moment* decisions as they elicit and problematize students' ideas (Hammer, Goldberg, & Fargason, 2012; van Es et al., 2017). Teachers need to consider these ideas in light of the learning goals and respond in ways that lead to the development of disciplinary knowledge and skills. Moreover, teachers' in-the-moment responsiveness is shaped by the constraints of their teaching contexts and informed by their knowledge of their students, the curriculum, the discipline, and its epistemic commitments. There is a dearth of research on how teachers learn the requisite skills and knowledge to engage in this work and the kinds of learning experiences that may promote these pedagogical shifts.

This paper discusses ongoing work in the context of a larger project whose overarching aim is to promote PDD in literary reading, mathematics, and science. We are pursuing three goals in collaboration with middle and high school teachers: 1) to understand how teachers learn to facilitate productive disciplinary discourse (PDD), 2) to characterize what aspects of facilitating PDD are specific to the disciplines of math, science, or literature, and 3) to co-design models of professional development to support teachers in developing knowledge and skills to facilitate PDD. This paper focuses on the first two goals in literary reading and science.

To address the first goal, we are drawing on a library of classroom videos recorded during a prior multi-year, design-based research project. During that work, teachers and researchers collaborated in disciplinary design teams to design curricular modules to promote disciplinary reasoning about multiple texts. Teachers implemented these modules in iterative cycles across several years. For the current project, we recruited two literature and two science teachers for whom we had multiple years of classroom video from the prior project. These teachers are collaborating with researchers on the current project to try to understand how they learned to facilitate PDD. During one-on-one teacher-researcher meetings, the pair engages in collaborative reflection on the teacher's classroom videos to identify shifts in teacher practices over successive iterations of the co-designed modules. As well, they explore what may have induced noticed changes (e.g., discussions in design teams, other professional learning opportunities from the prior project, responses and reactions from students during the implementations). Thus, the classroom videos serve both as tools to identify what changed in teacher practice over time and as "video triggers" (Hmelo-Silver et al., 2016) to prompt teachers to reflect on events or experiences they think contributed to changes in practice. Videos are sampled from beginnings and ends of implementation cycles and from events or moments identified by teachers as potentially significant or critical to their own or their students' learning. To address the second goal of the project, these videos are also being used as "context-rich cases" (Hmelo-Silver et al., 2016) for cross-disciplinary conversations. In cross-disciplinary groups, teachers and researchers view and discuss video segments in service of identifying and describing characteristics of PDD within and across disciplines—what's common; what's unique. We documented the one-on-one as well as the larger group meetings via audio and/or video recordings and analytic memos. The data from each context were analyzed using open-coding and constant comparative methods (Corbin & Straus, 1990) to determine themes across teacher-research teams and across disciplines.

Analyses of these two contexts revealed common themes in what practices changed, in experiences that influenced changes, and in what teachers identify as being disciplinarily specific to facilitating PDD in classrooms. One common theme that emerged in the video co-analysis with individual teachers was around the amount and type of teacher talk and how it shifted over successive iterations of the co-designed modules. Teachers indicated surprise at how much they talked in their early implementations and noticed themselves doing much of the intellectual work during discussions. In later enactments, sometimes of the same modules, teachers re-positioned students by removing activities where content was 'given' to students and opening up space for ideas to be contested and resolved among students (as opposed to students looking to the teacher to validate the "correct" response). This pedagogical shift created room for students to ask questions, propose alternative claims, and engage in debate about disciplinary questions and problems. The teachers cited the implementation and reflection on the co-designed modules that occurred during the design team meetings of the prior project as a powerful influence on making these pedagogical shifts. They also reported that using the modules in their classrooms enabled teachers to see that students were indeed capable of engaging in sophisticated intellectual work. Reflecting on opportunities to learn during the prior project, the teachers reported that engaging in conversations with researchers before and after the enactments helped them in the recursive process of soliciting and responding to students' ideas. They said that the conversations fostered a deeper understanding of the epistemology of their discipline. Analyses of the larger group meetings brought to light both similarities in guiding discussions (e.g., types of questioning, participation structures, setting expectations) and differences (e.g., what counts as evidence and justification within each discipline).

Our findings point to the benefits of using video as a trigger for supporting teacher learning and reflecting on teacher's growth over time. Using videos to reinstate the teachers own prior contexts provided a natural point of comparison to their existing instructional practice, illuminating their trajectory of learning

across time. Viewing and discussing clips outside of their own disciplines pushed teachers to articulate their taken-for-granted and tacit knowledge of their own disciplinary practices and how that influences their facilitation of classroom discussions.

Co-designing at a distance: An investigation of teacher-researcher interactions in video-based and face-to-face meetings

Eleni A. Kyza and Andria Agesilaou

Teacher-researcher collaborations, and, in particular, the co-design of innovative learning environments can lead to professional learning and serve as contexts for teacher professional development (Kyza & Nicolaidou, 2016; Kyza & Georgiou, 2014). Nonetheless, teachers are often hesitant to commit to extended professional development programs due to challenging schedules and multiple demands on their personal and professional lives (Loucks-Horsley, Stiles, Mundry, & Love, 2009). In previous work (Kyza & Georgiou, 2014) we introduced a hybrid model of teacher professional development (TPD) in which face-to-face meetings were interspersed with video-mediated meetings and electronic communication technologies (i.e., email, instant messaging) to support collaboration and co-design. In this case, technology serves as a conduit for learning and communication (Hmelo-Silver, et al., 2016). Reports of video mediation of computer-supported collaborative work are not common (Brubaker, Venolia, & Tang, 2012). The goal of this study was to investigate the nature of interactions during technology-mediated teacher-researcher co-design sessions in relation to teachers' professional learning. The collaborative co-design was focused on generating inquiry learning environments around controversial socio-scientific issues that were to be enacted in the teachers' classrooms.

As part of a broader project, four in-service science teacher co-design teams (a total of 27 teachers), each led by a university researcher, developed inquiry learning environments that integrated Responsible Research and Innovation (RRI) ideas. RRI seeks to involve stakeholders in the processes of research and innovation so that the final outcome meets the needs and expectations of society (Owen et al., 2012) and advocates a more dynamic and inclusive relationship between scientific advancements and societal involvement. In this context, teachers participated in a year-long professional development (PD) program which placed them in the roles of learners, designers, instructors and reflective practitioners. Teachers along with researchers worked in co-design teams in biology, chemistry, and elementary school science to develop and implement with their students an RRI unit, based on the pedagogical framework known as Socio-Scientific Inquiry Based Learning (SSIBL) (Levinson et al., 2017). SSIBL, an approach to engage students in inquiring about contemporary socio-scientific controversies, operationalizes how RRI can be integrated in science teaching. Specifically, SSIBL requires students to make decisions about how to actively address particular socio-scientific issues in their school, communities, or broader societal context (critical citizenship). The co-design teams developed learning activities using the SSIBL framework to engage students in inquiring about the relation between the quantified self movement (also known as lifelogging), that advocates the use of technology to study one's data from daily activities, and privacy issues related to sharing personal data in a networked society. The co-design teams adopted a hybrid mode of collaboration. Some collaboration was conducted online in technology-mediated meetings, while other meetings took place face-to-face. Teachers enacted the learning materials with their students and then used these experiences to revise the curriculum they had co-designed. Thus, the co-design cycle consisted of the initial design, which was concluded in five months, the enactment phase, which took place during a period of two months, and the reflection and redesign phase which happened during three meetings in the months that followed the enactment.

In this paper, we draw from four face-to-face (f2f) and six online meetings from one of the elementary school teachers' co-design teams. This team consisted of seven elementary school teachers and a university researcher. Data were collected from co-design videos, teacher interviews, and researcher reflections and field notes. These data were analyzed qualitatively using the Actor-Network theory (Latour, 2005), to examine how the setting (f2f, technology-mediated) influenced the teacher-researcher co-design discourse and interactions. Drawing from studies on telepresence (e.g., Rae, Venolia, Tang, & Molnar, 2015) and analyzing both the videos of the sessions and the transcribed interactions, we examined dimensions such as power dynamics and hegemony (e.g., who initiated discussions), participation of both teachers and researcher, and the nature of the co-design talk (e.g., pedagogical, design thinking, communicative, technical, knowledge co-construction) during the f2f and online (video) meetings.

All teachers consistently reported, and highly rated, the importance of the co-design context to their professional learning. In their interviews, they commented on how this collaboration differed from their usual adaptations of curricula and how it contributed to their professional learning and led to more sophisticated curricular materials for their students. The analysis of the co-design interactions provided evidence that teachers

participated as reflective practitioners, once given the opportunity to feel like an equally respected member of the design team. The teachers emphasized the socio-technical support provided by the researchers, while acknowledging the challenges that professionals face in such experiential approaches to learning due to conflicting responsibilities. The technology enabled continuous teacher collaboration and coordination of co-design; however, the teachers still pointed to the challenges around the use of technology, such as finding common time to meet due to hectic schedules. Accordingly, they sought different types of technology-mediated communication, such as instant messaging. There were important differences in how the various technologies contributed to the co-design process as might be expected given the affordances of each. Finally, data from the teacher interviews indicate that both the ability to creatively explore ideas in the supportive environment fostered by the research team and the joint development of something innovative with the potential to change current practice contributed to the teachers' feelings of ownership and feelings of being intellectual partners in the co-design process.

The agile process in collaborative co-design: Implications for community college developmental mathematics pedagogy

Kimberley Gomez, Louis Gomez, Emily Pressman, and Katherine Rodela

This presentation reports on a project that used technology as a conduit for creating a design and implementation community among instructors of developmental mathematics courses in community college settings located across the United States. Developmental mathematics courses have been called "the graveyard of dreams and aspirations" (Merseth, 2011). Over 60% of community college students in the U.S. take at least one developmental mathematics class before they can take credit-bearing courses, yet 80% of these students do not complete college-level mathematics courses within three years (Bailey, Jeong, & Cho, 2010). Many of these students—increasingly ethnically, linguistically, socioeconomically, and age-diverse—spend years repeating courses and may leave college altogether. Mathematics is inextricably coupled to being able to use and express mathematical reasoning and understanding through language in fields as diverse as nursing, environmental science, and medical technology. Instructors across the country teach these courses, often, like their K-12 colleagues, working independently and in isolation. On campus professional development opportunities may not address their specific concerns and are often diffuse (Murray, 2002). What is needed is a professional community experience in which instructors who share similar students, similar issues, and similar challenges are able to share their pedagogical strategies with colleagues locally and nationally. To address this need, we embarked on a two-year long project in which video-based technologies enabled collaborative design and communication about implementation experiences across 13 instructors of community college developmental mathematics courses located across the United States. All of the instructors were implementing Quantway developmental mathematics curricular lessons (Carnegie, 2014). The collaborative design was aimed at enhancing the lessons with additional language and literacy supports that would connect with students' language and literacy needs as well as with student workforce training programs offered in community colleges (e.g.. healthcare, information technology, and environmental science). Our guiding hypothesis was that using iterative design cycles to engage community college faculty would offer key opportunities for faculty learning about how to support mathematics through language. Specifically, we hypothesized that engaging in design activity, such as iterative testing, influences change in instructor knowledge, beliefs, and attitudes, and in their professional experimentation with the designed content and materials.

Inspired by "agile software process" commonly used in software design, we chose an agile process to guide our design work because of its attention to cycle-time reduction, iteration, resource management, and collaboration (Agile Alliance, 2013). We used rapid and iterative cycles of enactment, analysis and refinement during which data were continually analyzed to make improvements to lessons in between instructor enactment of lessons. During a single agile cycle, two to three instructors taught a newly designed lesson, and we conducted a quick analysis of data (interviews, surveys, student work, videotapes) to determine the need for immediate, medium, and long-term revisions to the lesson. Once we determined changes, we redesigned the lesson quickly so that two to three instructors in a second agile cycle were able to test the redesigned lesson. This process continued until all the instructors in the enactment group had tested the lesson. To ensure that we were promptly learning about instructor in-the-moment changes, as well as instructors' post lesson enactment recommendations for changes, we employed classroom video observation (SWIVEL), post-enactment online surveys and video-based interviews with instructors immediately (within 24-36 hours) following lesson enactment and analyzed the nature of in-the-moment and/or instructor recommended changes. Once the changes were categorized as immediate (e.g., change some details of the materials), we determined if they called for intermediate (e.g., change a specific problem in a math lesson) or long-term change (e.g., shift the problem

context). Recommended changes and the redesigned lessons were posted to the virtual community website so that they were immediately available to all of the project's Quantway instructors.

Using Clark and Hollingsworth's (2002) professional growth analytic model, we analyzed the data to identify change in three instructors' experiences, focusing on (a) instructor knowledge, beliefs, attitudes or skills about supporting mathematics learning through literacy supports, and (b) classroom practice. Our findings suggest that participation in design, regardless of extent of involvement, led to instructor changes in practice and in beliefs about the role of literacy in mathematics. Although we did not collect process or outcome data from students, interview and survey data collected from the instructors suggest that the instructors believed that the design process, and designed materials, contributed to improved student outcomes.

We argue that design experiences help community college instructors address their students' language and literacy needs. The technology enabled typically isolated instructors to overcome physical separation and form a virtual collaborative design and implementation community in which they rapidly learned from each other's practice.

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