Co-Design of Innovations with Teachers: Definition and Dynamics

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Abstract: Researchers in the learning sciences have explored a collaborative approach to developing innovations that fit into real classroom contexts. *Co-design* relies on teachers' ongoing involvement with design of educational innovations. To date, investigators have described the application and results of co-design, but have not defined the process nor explored how it plays out over time. In this paper, we define co-design, suggest seven key process components, and use data from interviews to illustrate how dynamic tensions in the process can unfold over time.

Introduction

We know from studies of educational innovations that teachers' interpretations of their classroom contexts strongly influence the level and nature of adoption (Cohen & Hill, 2001; Talbert & McLaughlin, 2002). Likewise, studies of technology-supported curricula shows that adoption depends on how well teachers' perceive them to "fit" within their goals for students, teaching strategies, and expectations for student learning (Blumenfeld *et al.*, 2000; Means *et al.*, 2001). Researchers in the learning sciences have explored a collaborative approach to developing innovations that "fit" into real classroom contexts. *Co-design* relies on teachers' ongoing involvement with design of educational innovations, which typically involve technology as a critical support for practice. Innovations resulting from co-design processes include a wide range of curriculum materials in school science (Reiser *et al.*, 2000; Shrader *et al.*, 2001) and mathematics (Roschelle *et al.*, 1999). In addition, co-design has been used to develop assessment materials in science (Atkin, 2001; Edelson, 2002) and in reading and mathematics to help teachers improve instruction (Shepard, 1997).

The co-design approach to the problem of "fit" differs from top-down approaches in that the process pays close attention to teachers' everyday work practices. Co-design practitioners pay attention to broad goals for learning and large-scale systems. In contrast to approaches to reform in which teachers are simply expected to follow scripts for teaching, teachers are active participants in co-design and are viewed as professional contributors to reforms.

The co-design approach has close affinities with several other traditions of design. For example, in its attention to teachers' goals for learning, co-design parallels the tradition of *value-sensitive design,* in which successful adoption is assumed to depend on whether designs reflect users' core values and needs (Friedman, 1996). Co-design requires attention to the usability of designs in particular learning contexts, which makes it similar to the focus in *user-centered* (Carr, 1997) and *scenario-based* design processes (Carroll, 1995). In its commitment to the active participation of teachers in the design process, co-design shares many of the same values of *participatory design* (Ehn, 1992; Muller & Kuhn, 1993), a tradition with a rich history in the development of workplace technologies. It also shares assumptions of researchers who have advocated for *learner-centered design* (Soloway *et al.*, 1994), which emphasizes the need to develop tools that can motivate students in a wide variety of contexts. Finally, it shares assumptions with researchers who conduct *design-based research* (Cobb *et al.*, 2003; Design-Based Research Collective, 2003) into the effects of innovations in education.

Co-Design: A Definition

We define co-design to be *a highly-facilitated, team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes, and evaluate each prototype's significance for addressing a concrete educational need.*. Although there are significant roles for teachers as participants in co-design, it is not a fully democratic process. Instead, accountability and ultimate responsibility for quality and decision making rests with the project leaders. In this section, we describe seven characteristic features of co-design as a method.

1. Co-design takes on a concrete, tangible innovation challenge. Like participatory design, co-design begins with a goal of creating a tangible innovation.. At the same time, this aspect of co-design distinguishes it from open-ended, exploratory research on learning innovations in which the goal is to explore a problem-space or theoretical construct.

2. The process begins by taking stock of current practice and classroom contexts. The co-design process begins with field work to understand how potential adopters (teachers and students) perform tasks that are expected to be transformed by the innovation. Ideally, this field work also documents key elements of the context—classroom and student characteristics, community values and perspectives, and local reform initiatives. In this aspect, "taking stock" in co-design has many similarities to rapid ethnographic techniques that are used in the design of workplace technologies (Millen, 2000).

3. Co-design has a flexible target. Flexibility is also important because the input of teacher participants in the design process is likely to alter researchers' conceptions of an educational resource. Co-design differs from traditional waterfall design in this respect; it is related to rapid prototyping methods which gather user input iteratively.

4. Co-design needs a bootstrapping event or process to catalyze the team's work. By "bootstrapping," we refer to a shared experience—such as a design workshop or retreat—that establishes common understanding of the need and requirements for a particular resource to be of help to teachers in the classroom.

5. Co-design is timed to fit the school cycle. Because it involves teachers, the work of design must be timed to fit the school calendar and teachers' work schedules.

6. Strong facilitation with well-defined roles is a hallmark of co-design. Both researchers and software developers actively work to keep everyone involved and excited through what is often perceived by teachers as a long process. Researchers facilitate by helping keep the team focused on educational goals; software developers help the team attend to feasibility and the development process. Teachers help construct the key problems co-design must address, help frame the vision for what is to be created, test the innovation in their classrooms, and provide feedback.

7. There is central accountability for the quality of the products of co-design. Unlike some approaches to participatory design, in which there is formal, shared accountability among workers, designers, and managers for system design, co-design has a central accountability structure for ensuring quality in the co-design of educational innovations. Often, this accountability rests with the Principal Investigator of the grant that funds the effort.

The Dynamics of Co-Design

Co-design often elicits strong emotions among participants. The process of coming to terms with one's role and with the possibilities contained within the scope of a single project often brings alternating feelings of joy and frustration, excitement and boredom. Past research reveals tensions that occur in co-design. We review these briefly below and then illustrate how these tensions played out dynamically over time in one case.

Tensions Revealed in Prior Studies

From studies of participatory design, we can learn about the tensions associated with engaging users in the process. For example, studies have pointed out that end users and designers often have different criteria for success (Blomberg & Henderson, 1990). These differences in goals arise because users and designers occupy different social worlds. Success or failure often turns on whether there is mutual understanding of the unique competencies and contributions of different team members (Bowers & Pycock, 1994).

Educational applications of participatory and co-design ascribe similar importance to developing a common understanding of goals, roles, and contributions of team members (Shrader et al., 2001; Shumar, 2003). At the outset of the project, teachers' notions about curriculum and about goals of projects often differ from developers' notions (Shrader et al., 2001). Overly technical discussions among software developers exacerbate barriers (Bowers & Pycock, 1994). Teachers often see researchers' solutions as too theoretical and not practical enough for real classrooms (Shrader et al., 2001). By contrast, researchers often view teachers' limited content knowledge as a barrier to contributing effectively to design efforts (Brown & Edelson, 1998).

The fact that teachers and researchers who engage in co-design together follow different workplace norms poses a second challenge to the process (Reiser et al., 2000). Through the course of the co-design process, teachers' concerns often focus on usability and on students' capabilities much more than on teaching considerations. By contrast, researchers tend to take a more analytical stance and push teachers to justify goals. Teachers can find such talk unsettling.

Time and productivity pressures are yet another threat to the success of co-design. A principal complaint about co-design is that it is very time intensive. In practice, involving users in design is complicated; it takes time, and users' input is often contradictory (Rheinfrank et al., 1992). Many users find the design process boring (Ehn, 1992). Designers must sift through the contradictory input and are often the only ones with the expertise to implement a new program or software design. Attending to these difficulties is a central problematic of co-design.

Dynamic Pattern Over Time: Trajectory of Co-Design in One Project

In the current study, we sought to investigate teachers' experiences and roles in co-design as they evolved. Appreciating how the dynamics unfold over time can help researchers and teachers understand how the tensions of co-design can be addressed in the context of a project. Further, this knowledge can help participants in the co-design process recognize what kinds of confusions and difficulties are possible and perhaps even appropriate at different phases of a project.

The Project

The project that is the focus of this paper was a research and development effort that explored how handheld computers might support improved classroom assessment in science classrooms at the middle-grades. The design products were three distinct handheld software applications students could use during hands-on activities or other class time to compose questions, review knowledge, or collect data. The design process, facilitated by the researchers and developers, had three phases over the course of the school year that evoked distinct teacher involvement and reactions: (1) collecting requirements, (2) rapid prototyping, and (3) software solidification.

Participants

Teachers of students in grades 4–9 were recruited in a coastal, Southern school district with high ethnic and economic diversity. 10 teachers applied, and all were accepted. Only 7 were able to attend the week-long design conference to kick off the project. The teachers who were selected and who were participants in this study were mostly women ($n = 5$), and were an experienced group (median years teaching = 21). They were mostly White but the classrooms they taught were diverse, with some teaching in classrooms where the majority of students were African American or eligible for free or reduced price lunches.

Sources of Data

The primary source of data was a collection of *interviews*, conducted roughly once per month with all of the team members (including researchers and software developers) throughout the design process by a researcher not involved in the co-design. Interviews took place from September 2002 to May 2003, covering the full course of the design process. The structured protocol asked about the participants' contacts, participants' activities, how the participant saw her or his role on the team, what decisions or progress had been made, what was going well, and what was not going well or was a concern. Teachers' answers to questions (a total of 900 responses) were entered into a database. A team of three investigators made several iterative passes through the data, building categories in the style of grounded theory. Through this process, we came to see how teachers experiences' progressed through three distinct phases of co-design. Providing rich description with a seven-page limit is a challenge; the best we can do is to provide the representative snippets of our data.

The Beginning: "I'm impressed that the team is sticking to it."

In the collecting requirements phase, teachers participated in several intensive interviews about their practices and shared information about the different types of lessons they did, the lab activities their classes did, and the problems they experienced in the classroom. They also provided their opinions about what their needs were and how tools might be able to help. The researchers had the teachers walk through detailed scenarios of how they imagined particular activities playing out in their classrooms.

In this phase, teachers experienced many demands on their time and little that they could directly see or use. Laura, for example, said in September, "I feel like I'm putting a lot of effort into this, but not getting anything in

return. I haven't seen any fruits of my labor. I'm not sure they realize how much work is involved for the teachers." An essential dynamic of this phase was around building commitment to a long-term design process that was unfamiliar to teachers. The respect that teachers experienced was core to their continued involvement.

Many teachers felt good about their contributions. One teacher, Sharon, stated, "They're sincerely interested in our opinions on things. We're the teachers. We let them know what works in the classroom, what needs to be tweaked, what a 4th or 5th grader is able to do, and how they handle these things." Edward, in December, stated, "The fact that the researchers could incorporate our ideas into the software is outstanding. Usually in teams like this they don't take laypeople's opinions seriously. They were concerned about our concerns."

Teachers also voiced many concerns and frustrations during this phase. A central concern, which came up month after month for every teacher, was finding time in their already overbooked schedule. As Emily described, "You're 24 hours, 7 days a week working for and with your students. On my weekend, my personal time, that's the only time I get to work on this…It's super demanding to do all our responsibilities and serve on all our committees. It doesn't give us a lot of opportunity to play with technology. As anywhere, everything is due yesterday." The developers and researchers people also noticed that this tension was occurring. Several discussed this in their interviews. One of the developers noted in October,

> I had to clench my teeth…hearing for the 20th time [from a teacher], "It's really simple, if it's a ridiculous answer…" Getting teachers to consider the possibility that it's not quite as straightforward as they think it is, to see that it has more depth to it…I don't think we're trying to be pedantic researchers…if you are going to put it into software, you have to be specific. It's a learning process. We'll get there.

Another researcher reflected, "I'm impressed that the team is sticking to it. The teachers are finding out that they got in for more than they bargained for. But they are still engaged."

The Middle: "We're trying it out in the real world."

As the projects moved forward into rapid prototyping, the teachers' roles shifted. It became more multifaceted: they participated both as designers and practitioners.

As designers, they described their role as "giving feedback," "input on what I see as potential for using the Palm," "tester," and "guinea pig." They were on the front lines trying out prototypes in their classrooms. As Janet described, "We're trying it out in the real world situation to see if what we think will work in theory will actually work in practice." They were observed by the researchers and developers, collected data about the students, and communicated to the team what was going on in their classrooms. They also worked on creating lesson plans to incorporate the tools, offered informed opinions about the software, and worked on more and more refined articulation of their needs. As Emily described, "One of my contributions is that I'm always looking for opportunities and ways to test the program out."

Teachers reported increased engagement during this creative phase. Many were putting substantial effort into finding new ways to integrate the prototypes or actual software into upcoming lessons. Several of the teachers described the excitement of their students with participating in the project. Many also discussed their appreciation of the researchers' openness and ongoing support, as well as their increasing coherence as teams.

Teachers also expressed several concerns and frustrations throughout this phase. Again, time was the most prominent issue. Teachers had difficulty finding the extra time to do all the planning and preparation for the activities.

In parallel with their work as designers, the teachers were also shifting and expanding their teaching practices. Several teachers reported growth over the year in how they were approaching teaching. They reported that the detailed reflection for both the design work and the issues around formative assessment expanded their awareness of their practices and increased their ability to reflect. For example, Emily reported in September, "The process is pretty amazing to us. We are learning so many different ways that our problems can be solved." In February, Emily said,

> The people I'm connecting with are giving me a diversity of opinions to work with about best practices and worst practices. It's catalyzing my growth as a teacher and also myself as a person. It gives me a higher level of satisfaction and enthusiasm. For going into the classroom and teaching with my students, I know that there's something new and better for me to be doing, and a way of doing things more effectively. So it yields a more positive outcome in their learning. If you want to teach, that's everything.

The End: "We're where we wanted to be—even if it was a bit slow"

As rapid prototyping phased into software solidification, the teachers' roles shifted yet again. As Greg put it, "I see my role as somewhat different…. The first year was development, and we're pretty much done with that. Now it's implementing." Teachers could shift their focus toward practice; they spent more time thinking about how to integrate the handhelds into their classrooms.

Furthermore, the teachers found themselves in roles they described as "liaison," "salesperson," and "mentor." Emily and Janet found themselves talking with parents in the community about the project and the use of handhelds. Janet also felt that she was now trying to "sell the benefits of Data Doers to new teachers, especially the new members of the team." Kevin also had begun looking ahead to working with the new teachers next year: "It will be a mentor kind of thing." Sharon also stated, "I'm anxious to see what happens when we add the new people. There are people on our staff who are excited. We'll build the team larger."

In the end, the teachers were pleased with the outcomes of the project, and all expressed satisfaction. Kevin, for example, stated, "I'm very happy about the project; to have had input and really seen come to fruition is really nice. Good stuff." And Greg, who had often expressed frustration over the course of the year, stated, "What's going well is that we got to the point at the end of the year that we wanted…I was frustrated it took so long. But I'm optimistic that we got done what we want to accomplish. We're where we wanted to be—even if it was a bit slow."

Discussion

The key tensions of co-design persist across phases: teachers never have enough time; software developers and teachers never share the same workplace norms; a common language is always a work in progress. Yet, within these tensions, the social dynamic between teachers and researchers evolves over time, particularly with regard to agency and ownership. In the beginning, teachers did not begin with a strong sense of ownership in the project or a clear sense of the roles that they would play. It was not until handheld computers arrived in their classrooms and classroom testing began that teachers began to feel as if the project was at least partly theirs. As teachers came to see how excited their students were about the handheld computers and how pilot versions of the software worked in their classroom, they began to adopt more active roles within the project. By the end of the year, teachers had become strong advocates for the software. They recognized that they would play an important role in introducing and encouraging the use of the software to teachers who would participate in the field trial and the school community.

A key benefit of engaging the teachers in co-design was professional development. The co-design process offered teachers a chance to develop and refine their own ideas about teaching in the framework of exploring how new software works in the context of their classrooms. Two of our teachers reflected on multiple occasions about how they benefited from the opportunity to reflect on their teaching as part of the co-design process. One middle school teacher commented that researchers' perspectives were so different from their own that they gave her a new way to look at her own classroom teaching. She said that their design team meetings included:

> Phenomenal conversations about what improves learning. The team is making me realize that I have always focused on classroom management, not on how the kids are actually learning. This affects my teaching tremendously.

Another elementary teacher observed changes in how her students learned with the software, and these were changes she had not expected. When she introduced her students to software that collects students' questions, she noted:

> I was amazed at the impact of using questions as an assessment tool. When I had the kids ask questions, even on information we had covered and tested before, it really helped me to see the flaws in their understanding. We could then go back and discuss them.

Conclusion

By defining co-design and describing key process steps, we have sought to contribute to refining and spreading this promising method of design. Our account of teachers' experiences in co-design, based upon a systematic database of interview data, suggests the importance of the process steps in managing the tensions that arise as researchers, developers, and teachers work together over an extended period of time. Our case study suggests that managing these tensions led to increased agency on the part of the teachers, increased reflection on their practice, and increased ownership of the resulting design. Technology integration remains an elusive yet important goal. Based upon our experience, the co-design process can play a role in creating a tighter integration of curriculum and technology through the involvement of teachers in the design of innovations that they can meaningfully use in their classrooms.

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