Embedding Computational Thinking in the Elementary Classroom: An Extended Collaborative Teacher Learning Experience

Diane Jass Ketelhut, University of Maryland, College Park, djk@umd.edu
Emily Hestness, University of Maryland, College Park, hestness@umd.edu
Kelly Mills, University of Maryland, College Park, kmills1@umd.edu

Abstract: We used design-based research to investigate an extended professional learning experience to prepare teachers to embed computational thinking in elementary science. Opportunities to interact synchronously in a community of practice - including through in-person engagement in embodied challenges, discussion, and resource sharing, appeared to productively support teacher preparedness to embed CT in their science teaching. However, asynchronous collaboration via an online platform was less effective. We describe planned adjustments for future iterations of the program.

Introduction

The centrality of computing in modern science has elevated the importance of computational thinking (CT) as a critical skill for everyone (Wing, 2006). Elementary teachers have the potential to play an essential role in developing foundational CT competencies among all learners. However, there is a fundamental need for effective approaches to supporting teacher learning in this novel domain (Hestness, Ketelhut, McGinnis, & Plane, 2018). Because CT is heavily embedded with technological tools, we are particularly interested in the role of CSCL environments for facilitating teacher learning experiences. We are exploring the research question: "What computer supported design elements can help promote collaborative learning for enacting CT, a novel and potentially intimidating topic, in elementary science?" Because communities of practice (CoP; Lave & Wenger, 1991) have shown promise to support novices (i.e. teachers) enact new practices (i.e. CT-infused science pedagogies), we are seeking to cultivate a community of practice among veteran and preservice elementary teachers to support teacher learning related to CT integration in the classroom. To realize this goal, we created the CT Science Teaching Inquiry Group (STIG^{CT}), a collaborative learning experience designed to create new knowledge of effective strategies to embed CT in the elementary science classroom.

Methods

We adopted a design-based research (DBR) approach, entailing iterative cycles of design and analysis. For the first iteration of the STIG^{CT}, we designed and facilitated seven 90-minute in-person professional development sessions that met monthly throughout the school year. The sessions began as primarily facilitator-directed, in which members of our team led collaborative learning activities and discussion. Midway through the year, we shifted the design of the sessions to be primarily participant-directed, in which participants worked together to create, share, and discuss learning activities to support CT integration. Between sessions, participants were invited to collaborate by sharing ideas and resources via an online platform (piazza.com). Participants (N=24) included practicing teachers (n=11) and preservice teachers (PSTs; n=13).

We used qualitative research methods (Miles, Huberman, & Saldana, 2014) to analyze the session plans and field notes for each STIG^{CT} session, identifying key design elements included throughout the PD experience. Next, we analyzed data including field notes, written reflections collected at the end of each session, and focus group interviews collected at the end of the full experience. Where the focal design elements were referenced, we coded evidence of how (or whether) they appeared to promote collaborative learning toward CT integration.

Findings

We describe how three focal design elements appeared to contribute to teacher collaborative learning related to CT integration in elementary science. A summary and examples are provided in Figure 1.

First, we found that collaborative engagement in hands-on activities, both computer-supported and not computer-supported, appeared to foster collaborative learning about CT conceptually and improve participants' perceptions of their CT understandings. However, we did not encounter clear evidence that this design element on its own supported teachers in transferring conceptual CT understandings into their own classroom practice.

Second, incorporating intentional discussion opportunities within the sessions helped participants generate ideas about how CT concepts could relate to the teaching of elementary science curriculum topics. In addition, preservice teachers expressed a sense of empowerment when able to learn from experienced teachers about how they were applying (or considering applying) CT in their classrooms. We encouraged participants to continue sharing their CT integration ideas with one another outside of the in-person sessions, but participants rarely made use of the online platform which was set up for this purpose.

Last, sharing resources to support CT integration helped participants design lesson plans to enact CT in their elementary science classrooms. We found that resource sharing that was both lead by facilitators and codesigned by participants appeared to promote a sense of empowerment. Participants understood and had the resources to enact strategies for applying CT in their classrooms. We noted, however, that the participant-designed lesson plans varied in the extent to which they accurately represented CT or integrated it into curricular content in science. As with the discussion design element, participants rarely made use of the online platform to share resources between sessions, which was one of its intended purposes.

Element	**Activity examples**	**Example participant response**
CT sensemaking through collaborative challenges	-Teachers manipulate an online ecosystem to learn about models -Teachers "program" a blindfolded teammate to walk a specified path, modeling problem decomposition	*"[Problem decomposition was… a really big and newer topic for a lot of us… I said something out loud to the class… I was approaching being right, but I was maybe 65% right, and you were like, "Um, let me refine that." And then I was like, "Oh, okay. Now I get it a little bit more."*
Discussing classroom applications of CT concepts	-Teachers examine standards and discuss opportunities for CT integration -Teachers encouraged to update each other asynchronously on CT integration efforts via online platform	*"[At first, I wondered] how realistic is it to think that people are implementing these things in the classroom for real? ...Seeing teachers here [in the STIG] that have taught for many years kind of implementing it [CT] …. I think it just made it… seem like it was more attainable."*
Sharing resources to support CT integration in elementary science	- Teachers are invited to borrow educational robotics tools for use in their classrooms and report back - Teachers co-author and present learning activities (lesson plans) that integrate CT into elementary science	*"I really liked the activity of having people create lessons and then teach it to us. Because… it gave people the opportunity to learn from different teachers, people they might not know. But also, I really liked learning how different people might take a lesson and interpret it in their own way. I thought it was really helpful."*

Conclusions and implications

The STIG^{CT} design elements offered affordances and limitations relevant to promoting a CoP focused on collaborative learning of how to enact CT in elementary science. Specifically, we found that hands on experiences, discussions and resource sharing were helpful in facilitating collaborative learning around CT. However, we struggled to maintain our CoP virtually, with low participation in the asynchronous, online space. We plan to modify future iterations of the STIG^{CT} by: 1) Retaining the collaborative design of CT-infused elementary science lessons to promote participant-created resource sharing, with greater facilitator support and more consistency; 2) Encouraging participants to test participant-created resources in their classroom and to share their experiences online between in-person sessions; 3) Considering an alternate, more familiar online platform to promote participant discussion between sessions, and incorporating the online discussion into in-person sessions; and 4) Inviting teachers from the first iteration of the STIG^{CT} to continue their participation in the second year and serve as mentors for newcomers. Through our ongoing process of design and refinement, we plan to use our learning to develop empirically-supported resources, tools, and measures to connect physical and virtual spaces in order to support teacher education around CT integration in elementary science.

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