Empowering Teacher-Driven Computational Thinking Integration through Collaborative Partnerships

Abstract

Recently, there has been a growing emphasis on training teachers to integrate computational thinking (CT) practices into disciplinary instruction. However, many current approaches involve a "top-down" method, where CT concepts and teacher training are dictated by external CT "experts," often in an abstract and generalized manner, rather than being developed collaboratively or contextually with the teachers. These approaches typically treat CT as a set of abstract concepts, which can fail to promote a holistic understanding of the purposes and disciplinary value of CT. Consequently, teachers may feel less inclined to integrate CT into their regular teaching practice beyond the confines of professional development sessions. Furthermore, teachers are frequently positioned as novices awaiting the transmission of relevant CT knowledge rather than as agentive knowledge-builders with valuable expertise. This can undermine their autonomy, ownership, adaptability, and long-term commitment to implementing CT effectively in their teaching practice. We propose an alternative, "bottom-up" approach to supporting teachers in CT integration through a collaborative partnership between researchers and practitioners. We share evidence that this partnership led to understanding CT as inherently contextualized and productive for disciplinary problem-solving.

Introduction

While many thought leaders agree that young students should have access to the ideas and practices of computer science in classroom settings (ESSA, 2015; NGSS Lead States, 2013), considerations of how it could be integrated into curricula pose several critical problems of practice (Ryoo, 2019). In recent years, there has been a growing emphasis on supporting these goals by equipping teachers with the knowledge and skills to integrate *computational thinking* (CT) into their STEM instruction (Lee et al., 2020; Voogt et al., 2015). Many contemporary methods tend to adopt a "top-down" approach, orienting to computational thinking as discretized and decontextualized practices. These approaches typically involve rigorously defining and fully conceptualizing computational practices in the abstract before delving into curricular or disciplinary applications (Barr & Stephenson, 2011; Csizmadia, 2015; Dong et al., 2019). Accordingly, in the context of teacher education, there is often a presumption that the researchers or professional development (PD) facilitators are the computational thinking experts and teachers are novices awaiting the transmission of relevant expertise. However, such "top-down" approaches often fail to resonate with teachers, especially when it comes to the sustained implementation of the learned concepts and strategies (Angeli & Giannakos, 2020). While teachers may be able to identify discretized practices, they often question their practical utility and find it challenging to incorporate these abstracted practices into their teaching effectively. We propose an alternative approach to the curricular integration of CT, wherein computational practices are contextually situated and teachers collaboratively inform the integration of them into existing curricula in ways that are meaningful and relevant. Roughly put, instead of teachers learning about CT *from* researchers and *then integrating* CT into STEM instruction, teachers learn about CT *with* researchers *through integrating* CT into STEM instruction. Teachers are positioned as collaborators in the process of developing situated experiential knowledge of computational practices and tools, rather than mere recipients of researchers' fully-formed expertise. By involving teachers as equal participants in the development and exploration of these practices and tools, we intend to foster a sense of ownership and empowerment, leading to more effective integration into their curricula and teaching methods.

Here we share an example of a collaborative partnership between researchers, teachers and other local stakeholders that resulted in the development of “bottom-up” conceptualizations of integrated computational thinking. We demonstrate how the flattened power structures and collaborative relationships within the partnership facilitated the joint construction of contextualized CT knowledge that enabled meaningful CT integration.

Theoretical Framework

Contextualized Computational Thinking

In 2006, Jeannette Wing famously coined the term “computational thinking” (CT), arguing that “it represents a universally applicable attitude and skill set everyone, not just computer scientists” (Wing, 2006, p. 33) can learn and use. Wing conceptualized CT as extending beyond the narrow act of programming to broadly encompass the practices, skills, and habits of mind of computer scientists, which enabled educators and researchers to apply it to a diverse repertoire of disciplines, particularly within STEM fields. In recent years, several frameworks, taxonomies, and tools have been developed to support potential alignments between CT practices and existing school curricula (Grover & Pea 2013). Many of these efforts have been valuable for developing collective understandings of where and how CT might fit into the traditional K-12 instructional programs, however, top-down recommendations for implementing CT practices in classroom settings tend to focus primarily on maintaining “fidelity” to CT taxonomies rather than flexibly attending to ways the practices are pragmatically used as tools to accomplish particular pedagogical and/or learning goals (Kafai et al., 2020; Wilkerson et al., 2020). Such framings emphasize cognitive understanding of CT concepts while neglecting learners’ agency, existing funds of knowledge, and personally meaningful applications. As a result, there is a risk that students may simply replicate computational actions without fully comprehending the reasons behind their necessity, value, or applicability in diverse disciplinary contexts.

In response, some researchers argue for the application of a learning sciences lens to consider “how the complexity of everyday spaces of learning shapes what counts, and what should be counted, as ‘computational thinking’” (Wilkerson et al., 2020, p. 265). Subsequent grounded approaches to CT integration may more authentically allow for practices to be employed purposefully and contextually, in the process of sense-making about phenomena and solving real and meaningful problems anchored to existing curricula.

Engaging Teachers as Partners in Professional Learning

These calls, to engage *students* in purposeful and contextual CT learning, are equally relevant for *teachers*' learning. However, teacher education programs and PD efforts continue to focus on definitions and taxonomies of CT practices (Ketelhut, et al., 2020), disconnected from teachers' disciplinary and curricular contexts. These programs also tend to employ top-down structures that position the researchers as "experts" and teachers as "novices" given their lack of formalized computer science knowledge and experience (e.g., Yadav et al., 2014). Thus, there is a growing need for alternative approaches, which introduce teachers to CT in a way that is experientially rich and relevant to their instructional contexts and also recognize teachers' expertise as central to building grounded conceptualizations of CT.

One such alternative approach that has been taken up more widely in recent years is a Research Practice Partnership (RPP), which Coburn & Penuel (2016) define as "long-term collaborations between practitioners and researchers that are organized to investigate problems of practice and solutions for improving schools and school districts" (p. 48). These partnerships are an alternative to more traditional PD models in that they extend over years, are highly collaborative, and position every member as both a learner and a contributor of valuable expertise. In RPPs, time spent on relationship- and trust-building and on developing shared visions and goals is viewed as necessary for supporting co-design and collaborative knowledge-building. This model encourages groups to establish consensus around foundational constructs and capacities before or alongside engaging in practical design work. As a result, members orient to the work as more meaningful, purposeful, and aligned with their own personal and professional goals, which increases the chances that the work will get integrated into instructional environments and live on beyond the project.

Study Context and Methods

The data for this paper come from an NSF-supported RPP project in which a group of 9 researchers, content specialists, and classroom teachers (in two of the most populous counties in a mid-Atlantic state) addressed problems of practice in elementary STEM curriculum refinement: integrating CT and sustainability education. Our team implemented a "bottom-up" approach to both understanding CT and organizing opportunities for collaboration and professional learning.

The RPP met once monthly, over Zoom, starting in November 2022. Meetings were planned and facilitated by the first two authors, and ample space was made for both large and small group discussions. Each two-hour meeting began with icebreakers, which encouraged RPP members to share personal experiences and stories, and ended with members providing reflective feedback in an "exit ticket." Meetings were spent developing shared visions and goals, reflecting on our professional practice, diving deeper into issues of sustainability and CT (with a focus on purposeful integration), jointly analyzing various institutional documents (e.g., UN sustainability goals; State CS standards), engaging in contextualized CT inquiry activities and analyzing/modifying county curricula.

In our analyses of connections between the "bottom-up" collaboration structures of the RPP and "bottom-up" contextualized orientations towards CT integration, we draw on field notes, video recordings, artifacts, and exit tickets, as well as interviews with RPP participants conducted after the project's first year. First, we identified moments in the interviews and field notes relevant to partnership-building and/or computational thinking, and conducted a low-inference content analysis of what was happening in the meetings and how participants experienced the year's activities. We then look more closely at the 5 video-recorded meeting segments most often identified by participants and by our field notes to do an interaction analysis attending to framing, positioning, and power dynamics. We used the interaction analysis to confirm, flesh out, and/or refute the patterns we saw in the interview data. We used all of these analyses to identify connections between the collaboration structures and how participants conceptualized computational thinking over time. Due to the brevity of this proposal, we share only a small sample of our larger analysis.

Results

For several reasons, team members valued the initial time spent together to begin forging shared vision, goals, and understandings of constructs. It allowed our group to establish a sense of mutual trust and establish productive patterns for collaborative sense-making and problem solving. It also allowed us to more deeply understand the disciplinary context, in this case, a 5th grade life science lesson, and provided members with ample opportunities to integrate what they were learning about and within CT into other areas of their life, and bring those experiences back to the group for reflection, further refining and enhancing our understanding of the utility of integrated CT. Data indicate that team members viewed these discussions as deeply contextualized, rooted in what they knew or wanted to know about sustainability and CT and what was happening on the ground in teachers' classrooms.

For example, one RPP member, a 5th-grade teacher, recognized and shared an example of what she viewed as a missed opportunity for authentic CT integration. She described a district-led PD focused on introducing block programming into a lesson on pollinators, where the only objectives were to "make the [bee] move, forward, left, right." She explained that before participating in the project, she would have thought that this was a "cool" way to integrate CT, but now she saw it as "simplistic"—CT for its own sake, not in service of making sense of pollination. She critiqued this approach, and wanted to "push the envelope a little further and challenge kids in a different way" through CT integration.

Engaging in deeply contextualized CT activities and joint reflection took time, but RPP members recognized that this collaborative work was necessary for developing a shared lens. For example, another RPP member commented on the impact the project has had on her perspectives on integrating CT. She said, "When I first popped on board, I thought it was gonna be…straightforward, how to integrate all these things…Like you, you know, you throw in, um, a Scratch project or um, you just kind of like change the activator, but now I'm realizing like it can be, one, much more meaningful than just like, including it…doing it in a way that's much more purposeful is possible." This purposeful work was facilitated by the relationships RPP members built with one another. For example, another RPP member said she felt comfortable sharing her ideas and what was coming up in her classroom because "we kind of have that rapport with each other, it makes it an easy open space to talk." In this way, the group's development of trusting relationships and engagement in collaborative learning supported one another.

Significance

Our work holds both theoretical and practical significance for efforts to integrate CT into formal instructional domains. Like many other contemporary perspectives on CT integration, our work recognizes the importance of teacher learning in the process. In contrast to top-down approaches that focus on imparting particular definitions and tools to teachers, our work offers grounded examples of computing practices as authentic and productive tools for disciplinary sense-making with intentional considerations of agency and purpose. We highlight how bottom-up approaches to teacher professional learning for integrating CT that are grounded in collaborative group structures like RPPs can support deep CT integration and pedagogical sense-making.

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