Examining the Role of Mentor Teacher Support in a Professional Learning Experience for Preservice Teachers on Integrating Computational Thinking into Elementary Science Education

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Abstract. We investigated preservice teachers' (PSTs) (N=13) experiences in a science teaching inquiry group professional learning experience on integrating computational thinking (CT) into elementary science. A subgroup of PSTs (n=6) participated alongside their mentor teachers. The others (n=7) participated independently. Our research question was: *To what extent, if any, did participating in a professional learning experience on CT along with their mentor teachers appear to enhance PSTs' learning and practice related to CT integration?* We analyzed evaluation feedback, interviews, participant-developed lesson plans, surveys, and attendance data. Findings suggested that participants in both groups reacted positively to the learning experience's content and approach, and expressed similar perceptions of their CT integration knowledge. PSTs participating with their mentor teachers felt slightly more successful in their CT integration efforts, and perceived CT integration as more feasible in their teaching contexts. However, differences between the groups were minimal. We also noted possible of influence of PSTs' perceptions of the districts in which they were teaching. Our findings underscore the importance of PSTs' perceptions of their teaching contexts when bringing a new innovation to the classroom - namely, perceptions of their mentors and curricula as supportive of the innovation. Through this ongoing work, we seek to identify empirically-supported strategies for preparing PSTs to integrate CT into their future classrooms.

Introduction/Problem

Computational thinking (CT) is essential for the practice of modern science. To prepare students to live, learn, and work in a world increasingly influenced by computing, today's science educators must have the capacity to integrate CT into learning experiences for all students, beginning in the elementary grades. As a relatively new endeavor for the field of science education, little is known about how to best introduce CT to preservice teachers and support them in developing pedagogies for integrating CT into their science instruction.

In this poster presentation, we describe our team's ongoing efforts to address this problem through design-based research in which we are iteratively developing a model for the inclusion of CT in preservice elementary science teacher education. We highlight in particular our explorations around engaging preservice teachers alongside their mentor teachers in professional learning on CT. The impetus for this approach came from our pilot work, in which we observed that some preservice teachers perceived their mentor teachers as unfamiliar with CT. We wondered whether this perception had the potential to discourage preservice teachers from experimenting with bringing CT into their professional development school (student teaching) placements, where they could be gaining valuable experience in practicing CT integration.

To explore this question, we designed and implemented a voluntary, afterschool professional development experience for preservice teachers and mentor teachers on integrating CT into elementary science education. Our research question was: *To what extent, if any, did participating in a professional learning experience on computational thinking (CT) along with their mentor teachers appear to enhance preservice teachers' learning and/or practice related to CT integration?*

Background

There is growing interest in the inclusion of CT within the K-12 science classroom as a means of: 1) engaging students in modern science and engineering practices and, 2) providing opportunities for all students - not just those enrolled in elective computer science courses - to build skills necessary for possible future careers in STEM (NGSS Lead States, 2013; Orton et al., 2016). To achieve the goal of effectively integrating CT into the teaching of compulsory K-12 curriculum areas, such as science, there is a need for relevant preservice teacher education and professional development (Ketelhut, Mills, Hestness, Plane, & McGinnis, 2018; Yadav et al., 2011, 2014, 2016). Prior research has suggested that when introduced to new curricular innovations, preservice teachers are better able to translate intended teaching practices into action in their classrooms when they perceive their mentor teachers as supportive (Sadaf et al., 2016). Therefore, our project brought preservice teachers and mentor teachers together in a professional learning environment to explore CT.

Our Approach

We are engaged in a multi-year process of developing and implementing a voluntary afterschool professional development experience on integrating computational thinking into elementary science instruction, the Science Teaching Inquiry Group on CT ($STIG^{CT}$) (McGinnis, Ketelhut, Hestness, Jeong, & Mills, 2018). The $STIG^{CT}$ was designed and led by an interdisciplinary team of computer science education, science education, and technology education instructors and researchers. Participants in the first year were: a) senior-level undergraduate elementary education majors (N=13) who were placed in professional development school (student teaching) internships, and b) interested mentor teachers (N=11) from our university's professional development school network. Of the preservice teacher participants, a subgroup was participating in the professional development experience alongside their mentor teachers (n=6) and the rest were participating independently, without their mentor teachers (n=7).

The $STIG^{CT}$ experience included seven 90-minute afterschool sessions (see Table 1 below), which were held approximately monthly throughout the school year. Prior to the first session, participating preservice teachers had engaged in an introductory module on CT within their Elementary Science Methods course. Participating mentor teachers had engaged in two Saturday workshops that mirrored the content and activities included in the Elementary Science Methods course CT module. The first half of the year was dedicated to introducing CT concepts, providing opportunities for participants to engage in hands-on activities illustrating the concepts, and considering how these concepts could be applied in the elementary science classroom. The second half of the year was focused on engaging participants in the process of developing and sharing original CT learning activities appropriate for the elementary science classroom. The goals of the $STIG^{CT}$ were to: 1) provide preservice teachers and mentor teachers a space to explore CT and its inclusion in the classroom, and 2) to provide a context in which we, as researchers, could explore how preservice teachers best learn CT and CT integration.

Focus	Description
Session 1: Algorithms and procedures	Participants completed a self-assessment of their understanding of select CT concepts, then focused on the concept of algorithms and procedures using an "unplugged" programming activity.
Session 2: Problem decomposition and parallel processing	Participants explored the concepts of problem decomposition and parallel processing by working in small groups to simultaneously sequence segments of a story.
Session 3: Systems thinking	Participants rotated through four stations focused on aspects of systems thinking, and discussed how systems thinking could apply to their elementary science curricula.
Session 4: Models and simulations	Participants explored three online simulations designed to support the teaching of elementary science topics. They discussed affordances and limitations of these tools.
Session 5: CT-infused science lesson planning	Participants worked in small groups to design elementary science lesson plans that integrated CT.
Sessions 6 and 7: Lesson presentations	Groups of participants presented their CT-infused lessons and engaged in reflective discussion in which they identified the lessons' CT practices, and provided rationale for how the CT integration supported instructional goals in elementary science

Table 1. Overview of afterschool inquiry group session activities (from Ketelhut et al., 2018)

Data Sources

To gain insight into our research question, *To what extent, if any, did participating in a professional learning experience on computational thinking (CT) along with their mentor teachers appear to enhance preservice teachers' learning and/or practice related to CT integration?,* we used a mixed methods approach that examined quantitative and qualitative data. Our data sources included: 1) mid-year program evaluation; 2) mid-year and end-of-year focus group interviews, 3) mid-year participant-developed science lesson plans infusing CT, 4) survey of participants' views of CT integration, and 5) attendance data.

Findings

Our data indicate findings in terms of residents': 1) reactions to the PD approach, 2) self-perceptions of CT integration knowledge and abilities, and 3) perceptions of the feasibility of CT integration in their teaching contexts.

Reactions to the PD Approach and Content

We examined how both groups of residents – those participating in the PD experience with (n=6) and without (n=7) their mentor teachers – reacted to the PD approach and content (i.e., CT integration in elementary science). Qualitative analysis of participants' written reflections suggested that, in general, participants in both groups expressed positive attitudes about CT integration in elementary science, and that they found the PD content and activities engaging. In addition, on the midyear program evaluation, a majority (84%) of all participants either

agreed or strongly agreed that the PD approach of involving a mixed grouping of residents and mentor teachers enhanced their experience. These positive reactions to the PD experience were reflected in relatively high attendance rates (considering the voluntary nature of the PD) for both groups of residents. We found no considerable differences in attendance between the group of residents participating with and without their mentor teachers. The average attendance rate per session for those participating *with* their mentor teachers was 69%, and the average attendance rate per session for those participating *without* their mentor teachers was 73%. Therefore, we inferred that the two groups had the potential for comparable changes in their CT knowledge and practice in response to the PD experience itself.

Self-Perceptions of CT Integration Knowledge and Abilities

This category of findings describes to how the two groups of residents perceived their understanding of CT and their ability to integrate it into their science teaching practice. Our survey data suggested that there was no significant difference between the groups in terms of their perceptions of their knowledge of CT or CT integration pedagogies following their participation in the STIG^{CT}. Our analysis of participant-generated science lesson plans (created midway through the year) likewise suggested that the two groups were similar in their abilities to plan for CT integration into elementary science lessons. However, we observed potential evidence of a difference in participants' perceptions of their success in implementing CT-integrated lessons. Residents participating in the PD experience with their mentor teachers typically used positive language (e.g., "I did a good job" (Lisa); "I was extremely successful" (Leslie)) in their reflections on their teaching experiences, while those participating without their mentor teachers used more variable language (e.g., "I was able [to integrate CT]… but I could have done more" (Carrie); "I do not think my learners gained an increased understanding of CT specifically" (Melanie)). However, we also noted at least one counterexample within each of the groups.

Perceptions of CT Integration Feasibility

Finally, we gained insight into the two groups of residents' perceptions of the feasibility of CT integration in their elementary science teaching contexts. Our survey data suggested only one significant difference between the groups: a difference in perceptions of resource availability for integrating CT into science teaching. Residents participating in the PD experience with their mentor teachers were more likely to believe they had the resources they needed to integrate CT. However, we also noted a potential relationship between participants' perceptions of the feasibility of CT integration and the school district in which they were teaching. While participants from one district typically described their elementary science curriculum as flexible and conducive to CT integration, residents from another district described their curriculum as less flexible and primarily promoting textbook-based teaching.

Discussion

Overall, our data analysis suggested many similarities between the groups of residents participating in the science teaching inquiry group with and without their mentor teachers. Both groups appeared to benefit similarly from the experience, as well as face similar challenges. Residents participating with their mentors may have felt slightly more successful in their CT integration efforts, and more able to access the resources they needed to support these efforts. However, our analysis led us to infer that the differences we observed among residents may have been the result of a number of intersecting factors, and not directly tied to the single factor of the participation or non-participation of their mentor teachers in the experience.

We believe these intersecting factors relate more broadly to residents' perceptions of their teaching contexts – and these perceptions may have a potential impact on residents' practice related to CT integration. First, residents' perceptions of their mentor teachers' support of science instruction in the elementary classroom may have an impact on their CT integration practices. Those residents participating *with* their MTs often described their MTs as valuing science instruction. However, there were also residents participating *without* their MTs, who described their MTs as science supportive. It may be the case that residents who perceived their mentor teachers as valuing (and making time for) science instruction may have had more opportunities to practice CT integration. Second, residents' perceptions of their school districts' curriculum may have had an impact on their CT integration practices. Residents teaching in one district, with a curriculum perceived to be inflexible, felt that the feasibility of CT integration in science lessons was limited. Residents teaching in another district, with a curriculum perceived to be flexible and CT-supportive (i.e., NGSS based), described CT integration as possible to do.

As we continue our work investigating strategies for preparing preservice teachers to integrate CT into their science teaching practice, we will continue investigating the potential role of perceptions of context – including mentor teachers - in shaping CT integration practices among preservice teachers.

Significance

This ongoing work is important to the field of science teacher education, as it has the potential to inform strategies for preparing preservice teachers to integrate CT – an essential literacy for the 21st century (Wing) – into science learning experiences for all students, not just those enrolled in specialized computer science courses. Through this work, our team has a goal of developing an empirically-based framework to support elementary teacher educators in preparing all preservice teachers to integrate CT into their science teaching practice. We believe that including CT in the preparation of elementary science educators has the potential to address gender and racial gaps in STEM education and careers by preparing teachers to provide foundational opportunities for all learners to develop critical CT skills.

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