The Role of Instructional Goal Setting for Teaching Computational Thinking in Robotics Classrooms

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Abstract: Robotics curricula offer rich, applied opportunities to learn computational thinking. However, these opportunities are likely to vary, as educators adapt curricula to their learning environments. A comparative case study approach is used to examine how two middle school Technology Education teachers conceptualize and articulate instructional goals when incorporating a novel computer science curriculum in their robotics classrooms. Evidence suggests tacit differences in teacher's framing of instructional goals around computational thinking, with implications for curricular design.

Computer science education is now widely considered to be an integral part of a well-rounded science, technology, engineering and mathematics (STEM) education. In the United States, the fastest growing careers are likely to require some degree of computational literacy, and the ability to use computers and programming logic to solve problems in a variety of applications. Researchers have used the term computational thinking to describe this particular 21st century skill, as "an approach to problem solving in a way that can be solved by a computer...a problem solving methodology that can be transferred and applied across subjects" (Barr & Stephenson, 2011). However, still relatively little is known about particular pedagogical practices that might be linked to effective instruction in this class of generalizable computational skills.

Robotics education is one field that has been studied by educational psychologists as learning environments that could provide authentic opportunities to learn generalizable computational skills in an applied setting (Grover & Pea, 2013). In the last few decades, robotics programs have become nearly ubiquitous in primary and secondary schools in the United States, both as elective after-school programs and recently within general education classrooms. Many of these technology-rich programs are situated in Technology Education ("Tech Ed") departments, which have historically focused on vocational training in specific and often localized industrial technologies, and are taught by teachers with varied training and experience in computer programming (Shields & Harris, 2007). Therefore, there is likely to be large variance in the particular focus and pedagogical approach to teaching computational thinking across robotics programs, as well as in learning outcomes for students.

Theoretical framework

Research has shown that teacher beliefs about pedagogy and content interact with curriculum to determine ways that materials are implemented, often creating disparities between the curriculum as designed and curriculum as enacted (Remillard, 2005). Instructional goal setting provides one useful framework for predicting how teachers activate resources in ways that differ from the intent of the designed curriculum (Stein & Meikle, 2017). Goals that are explicitly stated and refined into sub-goals at the lesson planning stage may improve the design of instructional activities that increase student achievement (Hiebert, Morris, & Spitzer, 2017). However, in complex and ill-defined learning environments like Tech Ed classrooms, it is likely that teachers hold multiple goals simultaneously, arranged in hierarchical systems that determine which goals are activated in certain situations (Davis, Janssen, & Van Driel, 2016; see Figure 1). In this framework, *horizontal incoherence* represents directly competing goals, which can lead to disparities in enacted curriculum as teachers prioritize one goal over another. *Vertical incoherence* arises when the pedagogical skills to plan and enact lesson activities aligned with higher level goals are unavailable, or not activated during a particular lesson.

Methods

This study employs a comparison case study design to examine the following research questions: 1) How do robotics teachers conceptualize and articulate computational thinking goals, particularly in a Tech Ed setting? 2) How do instructional goals play out in teachers' enactment of curriculum, through planning and classroom interactions?

Interviews and classroom observations were conducted with two in-service Technology Education teachers who were teaching an online, problem-based robotics curriculum that emphasizes computational thinking concepts. These teachers were purposively selected for analysis as their classroom observations and interviews revealed interesting contrastive cases of instructional goal setting, despite the overall similarity in their years of teaching experience, student populations, and content. In addition to classroom observations, teachers were asked to complete brief goal setting sheets during their planning period prior to each class. Data were analyzed using a

grounded theory approach, including iterative qualitative coding, and a constant comparison technique to identify themes across cases.

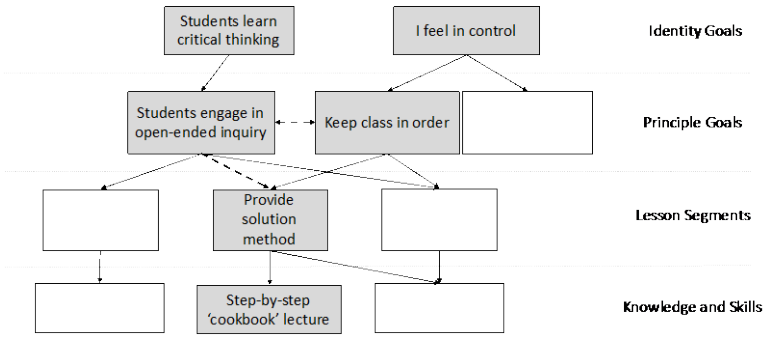

Figure 1. A sample hierarchical goal system, adapted from Davis, et al., 2016. Dotted arrows at the same level represent *horizontal incoherence*; dotted arrow across levels represent *vertical incoherence*.

Preliminary findings and implications

Overall, while both teachers initially expressed similar high-level instructional goals for their students, differences appeared in their enactment at the lesson planning stage, and during individual instructional interactions. For example, both teachers identify "using technology to solve problems" as a high-level goal. However, analyses of planning documents and classroom observation suggest different conceptualizations of the role of computational thinking in solving problems with technology: as either a specific and explicit set of skills learned separately from the technological content, or as more general, implicit problem-solving heuristics acquired through hands-on experiences with technology, and extensive trial and error. In a hierarchical goal system, these different conceptualizations of computational thinking may relate to the level of *vertical* and/or *horizontal incoherence* between computational thinking goals embedded in the curriculum, and competing instructional goals held by Tech Ed robotics teachers.

Further analyses using this approach could inform the design of curriculum that acknowledges and incorporates teachers instructional goal systems in educative materials, as well as have implications for the content of professional development in computational thinking for robotics teachers. It is also likely that unobserved, external barriers influenced how our case study teachers interpreted and implemented the curriculum. Future work that incorporates an organizational perspective could help account for these broader influences on teacher implementation.

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