Productive tensions: Computational things in preschool and school practices

Abstract

This study contributes to current research on how designs for learning computational thinking (CT) are practically implemented in education. By examining learning activities in Danish preschools and elementary schools, we investigate how computational things, such as microcontrollers and robots, are employed in activities of learning CT. Data consist of video observations and are analyzed with a focus on tool mediated and situated activities. In accordance with elaborations on CT as a problem-solving strategy, we focus on how participants use computational things for problem-solving activities that appear central to the observed designs for learning CT. We investigate situations where participants employ computational things in ways that partly differ from the sequential problem-solving procedures of the intended task. These situations challenge underlying notions of CT-pedagogies that define outcomes as algorithmic solutions to well-defined problems. However, the observed tensions between intended task and participant orientations are discussed as potentially valuable learning situations rather than mere obstacles for learning. These tensions allow participants to imbue problem-solving activities with own intentions while still dealing with central aspects of CT. Thus, CT does not unfold as a universal and context-independent skill set, but rather as one structuring resource interlacing with other resources in situated practices.

Extended summary

We report on a small-scale empirical study investigating practices that unfold when designs for learning computational thinking (CT) with computational things are implemented in Danish preschools and elementary schools. Along with Wing's (2008) revitalization of CT as a formative skill at the same level as reading, writing and arithmetic, the wider framework of 21st century skills (Trilling & Fadel, 2009) has intensified an educational focus on technology skills at all levels.

In Denmark, the new discipline *technology comprehension* (Tukhala et al., 2019) is currently under implementation in elementary school, framing CT as one of four competencies.

In Danish preschools, no curricular CT-demands exist, but CT-related aspects are locally integrated through maker-pedagogies, playful coding, etc. In current initiatives in schools and preschools, tangibles such as microcontrollers, robots or electric circuits play a central role. In our study, and in line with elaborations on CT as a problem-solving strategy, we conceive of these tangibles as computational things implemented to support participants' creation of a solution to a problem, first by decomposing it and then developing a structured and algorithmic solution.

The study examines activities in preschool and elementary school (8th grade), respectively. All observed activities are characterized by three interrelated features:

1. Activities are initiated and facilitated by an external educator through a fictitious narrative framing.
2. Participants are invited to make the narrative proceed through problem-solving tasks.
3. Participants must employ computational things for solving these problems.

From this outset, we ask the following research question:

How do computational things mediate participants' problem-solving in the observed designs for learning computational thinking that take place in preschool and school settings?

Methods and empirical settings

Data consists of video observations (Derry et al., 2010). Informed consent was obtained from parents of all children and students, and in situ assent was also secured (Dockett & Perry, 2011).

Data consists of thirteen hours of video observation, nine in preschool and four in school. In preschool, sixteen children participated, along with three preschool professionals and an external educator, in activities of helping a penguin into space to explore a planet of robots. In school, four groups of five to seven students participated, along with an external educator, in activities of solving escape puzzles to avoid hackers to spread a digital virus worldwide.

Video data were reviewed and transcribed, and analysis relies on data-driven codes that describe participants' orientations and tool use in the problem-solving tasks. Mediated activities are the unit of analysis (Wertsch, 2007).

Findings

Central to our findings is a recurrent tension between designed tasks and actual orientations of participants. Thus, in the problem-solving activities participants often employ computational things by creating own narratives or by exceeding intended procedures. Two empirical examples will serve to exemplify this:

1: In preschool, a narrative of finding gold on a planet includes a CT-task of programming a robot to reach a yellow "gold" brick lying on the floor. Two children combine coding with physically moving the robot, thus swiftly making it to the gold. Disagreement on ownership to the treasure makes one child tiptoe to the far end of the room, quietly fetching another "gold piece". Friendship is reconciled, both children put a yellow brick on their index finger and start a playful fight with "golden swords".

2: In school, specifically designed computational things must be employed to "prevent the digital virus from spreading worldwide". As time is running out, one object fails to work. The students eagerly disassemble it, thus skipping central elements of the task. Although strongly immersed, their orientations shift towards completing the final task in time, thereby exceeding the intended sequencing.

As exemplified above, certain tensions challenge the overall coherence of intended designs. However, participants' engagement is intense within these examples. By examining playful subversions of the designed tasks (Fróes & Tosca, 2018), we claim that they are not merely obstacles to learning. Rather, the tensions between task demands and participant orientations represent social situations of development (Hedegaard, 2020) central to learning. This challenges underlying assumptions of CT-pedagogies that suggest a logical step-by-step trajectory in problem-solving activities and define outcomes as algorithmic solutions to well-defined problems. Our findings show that participants' complex actualizations of diverse structuring resources enable them to make sense of the joint enterprise (Molin & Lantz-Andersson, 2016). By approaching the observed tensions as valuable pedagogic opportunities, rather than mere disturbances, our study displays that thinking with computational things are not operations by the mind in isolation, but part of a larger enterprise involving different resources which calls for open-ended orientations in rich pedagogical environments.

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