How Embodied Interactions Manifest Themselves During Collaborative Learning in Classroom Settings

Zuzanna Lechelt, Yvonne Rogers, Nicolai Marquardt
z.lechelt@cs.ucl.ac.uk, y.rogers@ucl.ac.uk, n.marquardt@ucl.ac.uk
UCL Interaction Centre, University College London

Abstract: New physical computing toolkits offer much promise for promoting collaborative learning by engendering embodied interactions that can support collaborative discovery. To examine how these can unfold during a learning activity, we conducted a classroom study where pairs of children explored mappings between various sensors and actuators embedded in a physical-digital artifact. We found how a number of embodied interactions emerged that were effectively used to progress learning through the processes of showing, sharing and contesting.

Introduction

A new generation of physical toolkits has emerged over the last few years, intended to teach young children about computing in fun and collaborative ways. These include the micro:bit (2018) and LittleBits (Bdeir, 2009). These toolkits offer new opportunities for learning about electronics, coding and the Internet of Things, by enabling children to connect the digital with the physical. A key property of these types of physical-digital artifacts is their visibility coupled with shareability and portability; they can be picked up, shown to others, pointed at and passed around. In this way, children can focus their attention to what is happening around them as they move, manipulate, and connect physical objects in front of them. To this end, our research is concerned with uncovering the range of embodied interactions that are engendered when interacting with handheld physical-digital artifacts. The aim of our research is to investigate how groups of children, aged 9 to 12, use embodied interaction strategies to explore and discover core physical computing concepts – namely, the physical-digital mappings between sensors and actuators – while learning together in a classroom setting. We present an analysis of how pairs and small groups of children exploit the physical properties of an interactive physical-digital artifact called the Magic Cube to learn about its functionality.

Methodology

Groups of children in a classroom setting were asked to explore and uncover various physical-digital mappings using the Magic Cube (Lechelt et al., 2016). This is a hand-sized, electronic cube with embedded sensors and actuators, designed to teach children about computing (Figure 1, left). The goal was to determine how the form factor and the physical-digital mappings enabled by the device give rise to embodied interaction strategies, and where these would occur in the learning process. A discovery-based task was designed to enable the children to explore what happens between the sensors and actuators embedded in the cubes, in terms of what they are and how they work. Different physical actions were designed to result in different digital effects using the same cube. For the study, three sensor-actuator mappings were pre-programmed in the cubes. Specifically: 1) covering the light sensor on the cube turned on the embedded light inside the cube, 2) shaking the cube at different speeds changed the color of the embedded light and 3) blowing hot air into the temperature sensor made a 'fire' animation appear on the LED matrix in the cube.

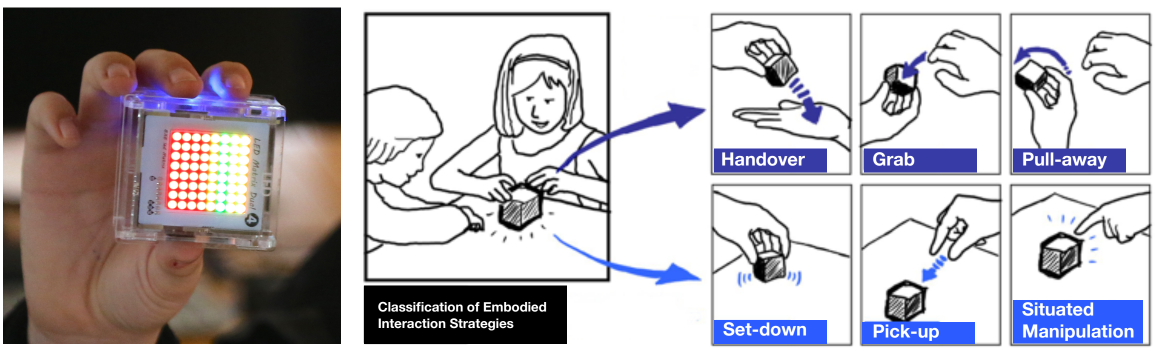

Figure 1: (left) The Magic Cube. (right) Classification of six embodied interaction strategies.

The study was conducted in computing classrooms in two primary schools in England. Participants were aged between 9-12 years. During each session, the children were asked to work in groups of two or three; one cube was provided for each group. The children were told that there were hidden mappings within the cube but not told what these were. Their challenge was to collaboratively discover what they were by testing out various physical actions (e.g., covering the cube sides with their hands, blowing into the cube, shaking the cube) to elicit the digital effects on the cube (e.g., change the color of light, make a 'fire' appear on the LED matrix). Video data was collected of the children's gestures and embodied interactions when using the cube for the specified learning activities. Based on the video data a classification was derived of the embodied interaction strategies that the children used.

Findings

Overall, our analysis of the video data collected showed that the children used a range of embodied interaction strategies (see Figure 1, right). In particular, we found that the children alternated between handing over, grabbing the cubes and interacting with them together simultaneously, as a way of implicitly negotiating what to do next and changing their group's course of experimentation with the cubes. By analyzing the embodied interaction strategies in terms of when they occurred in the context of the task, we found how specific strategies contributed to negotiating discovery of the physical-digital mappings together. For instance, we found that when starting out with exploring the cube, the children mainly interacted with the cube individually, and then changed control of the cube by handing it over to and grabbing it from their peers. Throughout the task, there were many moments when the children uncovered a new effect. During these "moments of discovery", we found that when one child in a group discovered how a sensor-actuator mapping worked, rapid sequences of handovers and grabs ensued, in which the other(s) in the group imitated the physical movement to reach the same level of understanding. Handovers were most prevalent when the person currently holding the cube had figured out how the effect worked, while the other(s) in the group had not. In these situations, the person holding the cube handed over the cubes to the other(s) to give them the opportunity to try it. Less frequently, the children were seen to hand over the cube to group members as a prompt to "show me how it works." Setting the cube down and picking the cube up occurred most frequently during "dead ends" of interaction, when a type of physical action did not work as expected. These were observed to be implicit indicators of change of turn for control of the cube. For example, after tilting the cube in a variety of different directions to no avail when trying to figure out what was making the light turn on for one of the mappings, the current grasper in one group set the cube down on the table, where another group member immediately picked it up and began testing other physical actions.

Conclusion

Physical-digital interfaces provide much scope for promoting collaborative learning. Our analysis of children's interactions with a hand-sized physical computing cube demonstrates how children were able to draw upon a diverse repertoire of embodied interaction strategies, that enabled them to readily change control, take control and hand over control when learning together. We also found how collaborative learning can be positively influenced by interactions that might otherwise be deemed un-collaborative (e.g., grabbing). Taken together, the results from our classroom study suggests that the extent to which new physical toolkits, aimed at teaching groups of children computing will be successful, depends on how well they 'fit' into their hands and what this then enables them to do together, by way of sharing, showing, and contesting.

References

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