Robot Block-Based Coding in Preschool

Jim Gribble, University of California, Santa Barbara, jgribble@ucsb.edu
Paul Reimer, AIMS Center for Math and Science Education, paul@aimscenter.org
Aileen Rizo, AIMS Center for Math and Science Education, aileen@aimscenter.org
Steve Pauls, AIMS Center for Math and Science Education, steve@aimscenter.org
Brittany Caldwell, University of California, Santa Cruz, bbettner@ucsc.edu
Meghan Macias, University of California, Santa Barbara, meghanmacias@ucsb.edu
Alexis Spina, University of California, Santa Barbara, adspina@ucsb.edu
Leah Rosenbaum, University of California, Berkeley, leahr@berkeley.edu

Abstract: This work explores the ways children learn mathematics through playing with coding (programming) and a robot in a preschool setting after a teacher expressed interest in robot coding at a summer institute. Drawing on the importance of learning mathematics through play in early childhood, this paper examines the affordances and constraints of implementing robot coding in a preschool setting across two initial screen-less coding sessions with the robot. Our findings suggest that children were challenged to connect the symbolic markers with the robot's movement, requiring teacher scaffolding and facilitation. Nonetheless, we argue that coding experiences can support preschool mathematics learning outside of traditional pathways.

Keywords: Mathematics, Professional Development, Coding, Preschool, Constructionism

Introduction

Early mathematics teaching approaches which focus on playful interaction with objects and environments can support children's learning of key mathematics content (Gregory, Kim, & Whiren, 2003; Wager & Parks, 2014). In particular, tangible and digital robotics and programming interfaces can be supportive of young children's development of sequencing skills, such as "retelling a story in a logical sequence, ordering numbers in the correct sequence, and understanding the sequence of a day's activities" (Kazakoff, Sullivan, & Bers, 2013). This paper is based on a coding session we created for preschool educators from across a Western U.S. state during a summer early math institute. The session was designed to provide early childhood educators experiences in a variety of coding options including pre-coding skills. The session provided participants with autonomy through free play and exploration with coding blocks in the form of Scratch Jr. coding on iPads, and a Matatalab screen-less coding robot. After the session, a participating educator was interested in the coding robot and wanted to implement the activity at their preschool. This paper focuses on the implementation of the Matatalab Robot in the preschool classroom setting. In this paper we focus on the following research questions: What are the affordances and constraints of implementing a coding robot in a preschool classroom?

Theoretical framework

We drew on conceptualizations of coding and programming for learning developed by Seymour Papert and his team at MIT. Their team created the coding language Logo, which was the prequel to Scratch. Papert and Harel (1991) wrote:

> Constructionism—the N word as opposed to the V word— shares contructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe. (Papert & Harel, 1991, p.1)

In our case, the public entity is the robot and children are constructing what the robot will do (move, sing, dance) by placing blocks on a white plastic pad near the robot (See Figure 1). In designing, testing, and revising programs for a robot to complete, children drew on resources such as artifacts, tools, and observed processes. We viewed a child's collaboration with a robot as a form of mathematical play that offers agency and goal-selection to the child. This happens in tandem with "social interactions and negotiations while playing to learn, and learning to play" (Bers, 2008, pg. 4).

We also drew on the notion of flexibility in lesson implementation. Elkin and colleagues (2014) highlighted this: “Diana (preK robotics teacher) was able to adapt her curriculum to meet the needs and expertise of her students. While Diana created a comprehensive curriculum based on what she had learned at the summer institute regarding robotics and engineering concepts, she adjusted the pace and content of her curriculum” (Elkin, Sullivan, & Bers, 2014, p. 164). Curricular flexibility is a key piece to success in working with robots and requires responsive pedagogical decision-making for teachers.

Finally, following Wagner, Herbel-Eisenmann and Choppin (2012) who discussed how discourse shapes inequity in mathematics education, we suggest that because block-based coding is a language which is generally new to teacher and students, this assists in distributing mathematical agency between teacher and student and opportunities for collaborative meaning-making.

Figure 1. Matatalab Robot.

Methods

The coding blocks used in this study were modeled after Scratch (see Figure 2) and Scratch Jr computer coding languages which were developed with children in mind. Colorful blocks fit together to carry out various child-friendly coding functions. The robot draws on technology without using a screen, a preferable affordance to many educators given too much screen time is on the list of concerns for many preschool teachers.

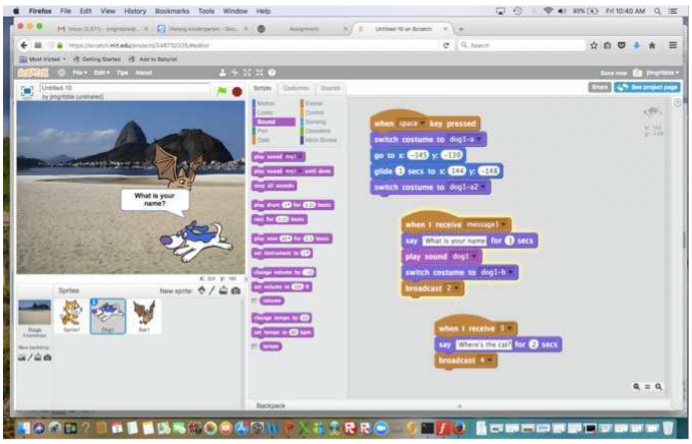

Figure 2. An example of the Scratch environment.

In using the robot, children have to determine where they are in relation to the robot, as well as which way the robot is facing and how it relates to the board where they place the coding blocks. The blocks–which tell the robot what to do–are read from left to right and starting at the top down to the bottom of the white board, similar to reading a story. Since they do not have significant experience reading standard text, preK children are still working on learning these sequences. Having a physical connection to the robot aids in their understanding of many embodied math concepts such as spatial reasoning and directionality. Once children start to grasp where the robot exists in space, they are able to put the coding blocks in order to determine a path for the robot to travel. When comparing their blocks to the movement of the robot, children find that the robot often does not do what they had intended, so children play around with "fixing the bug" in the code to make the robot move where they want it to. This challenge persists as children navigate the relationship between themselves, the coding blocks, and the robot's movement.

Data sources

This paper draws from the larger professional development institute data set via surveys, interviews, audio recordings, and video recordings of participants during and after their professional development. We interviewed the participating educator about their experiences following the classroom implementation.

Results

When asked what they anticipated learning at the summer institute, a participating educator replied, "A more comprehensive view of the continuum of math/science development." This was one of the main goals of our particular robot coding session: for educators to grapple with what mathematics development could look like outside of more traditional approaches.

Figure 3. Matatalab Robot preschool project with directions and marker.

The coding robot caught the interest of one participating educator and was subsequently introduced to their 3-year-old preschool class (see Figure 3). We suggest that this immediate implementation illustrates an interest in robot coding for learning among preschool teachers. In our interviews with the preschool teacher implementing the coding robot, we asked how the implementation was going and they shared:

> The children were not expecting that form…that's where they were like 'that's not a robot, that's not what a robot is supposed to look like' but um, it was just one-on-one with the child that was really interested in it and we were really focused on how to put the pieces, the little tiles in the right orientation for the camera to be able to read it, was kind of the first part of it (with regards to the robot).
>
> They just were interested in the sound that it made or the dance that it did. I did it with a larger group at the table and some of them were starting to realize it (robot) was moving in the direction indicated by the tiles. In thinking about it, the next time I'm going to have it (robot) start on a piece of paper and have it draw its path, and so it may be with just, like, two tiles, and maybe have a starting point. For our young children it was hard for them to understand it's moving in the direction we're telling it to, or the tiles (interview).

When later asked if the new strategy was implemented, the teacher responded:

> I tried the Robot again today, this time I used a piece of paper to map the path to support the connection of the path changing. We worked on adding a line at a time and resting (putting it in the same place to start each time). Once we created the three rows of code we changed the marker to form a new path. I started with a small group but it quickly became a whole group activity...of 14 3- and 4-year-olds squished around the table. There are a few things I will change like trying to keep it a small group, or only having the one marker available...the younger children made their own paths. I had a few that continued to stay with it once outside was available...without the overwhelming presence of 13 other children they were really ready to explore how it was creating the path (interview).

Discussion

While there were elements such as the sounds and dancing which engaged children, the actual coding appeared to be challenging during the first attempt except in a one-on-one situation. Some small changes in robot appearance from the creators may assist with child engagement in the future. It also appears the symbolic nature of the arrows was challenging for preschool students on the first attempt. We followed up after the teacher's second attempt and learned the paper and path follow up lesson had more success than the first attempt due to a smaller group setting. It is also clear there was more mathematical thinking happening after the second attempt. The educator broke the lesson into parts for the second session and focused on doing one row of directional code instructions for the robot at a time and changed marker color for a new path after three rows so students could see what they were asking the robot to do. In addition to the strategies used on the second attempt and discussed during our coding session at the summer institute, we have seen teachers facilitate coding lessons where children pretend to be robots on squares on the carpet while other children place arrows on the board telling the "robot" where to move. Our findings suggest that scaffolding strategies such as these can harness children's natural engagement with the robot toward more concrete mathematical learning goals.

Our results also surface questions regarding screen-less coding interfaces and the constraints of physical materials such as the tangible coding blocks. Robots controlled by iPad interfaces may offer young children more flexibility in manipulating coding sequences, allowing them to create, save, and compare a robot's action sequences. Although this coding robot presented some initial challenges, there is much to gain as educators continue to explore early coding as a way to engage students in mathematical learning outside of traditional pathways and in a transdisciplinary, cross-curricular manner.

References

Bers, M. U. (2008). *Blocks to robots: Learning with technology in the early childhood classroom*. New York, NY: Teachers College Press.

Elkin, M., Sullivan, A., & Bers, M. U. (2014). Implementing a robotics curriculum in an early childhood Montessori classroom. *Journal of Information Technology Education: Innovations in Practice, 13,* 153-169.

Gregory, K. M., Kim, A. S. and Whiren, A. (2003). The effect of verbal scaffolding on the complexity of preschool children's block constructions. In D. E. Lytle (Ed.), *Play and Educational Theory and Practice*. Westport, CT: Praeger. pp. 117–33.

Kazakoff, E. R., Sullivan, A., & Bers, M. U. (2013). The effect of a classroom-based intensive robotics and programming workshop on sequencing ability in early childhood. *Early Childhood Education Journal*, *41*(4), 245–255.

Papert, S., & Harel, I. (1991). Situating constructionism. *Constructionism*, *36*(2), 1-11.

Wager, A. A., & Parks, A. N. (2014). Learning mathematics through play. In E. Brooker, M. Blaise, & S. Edwards (Eds.), *The SAGE Handbook of Play and Learning in Early Childhood* (pp. 216–227).

Wagner, D., Herbel-Eisenmann, B., & Choppin, J. (2012). Inherent connections between discourse and equity in mathematics classrooms. In B. Herbel-Eisenmann, J. Choppin, D. Wagner, & D. Pimm (Eds.), *Equity in Discourse for Mathematics Education* (pp. 1-13). Springer, Dordrecht.

Acknowledgements

Special thanks to our project partners, institute facilitators, and to the California preschool teacher and team for all of the time they dedicated to answering our questions and for the excitement they brought to the learning process for their preschoolers with this robot.