Two Approaches to Teaching with NetLogo: Examining the Role of Structure and Agency

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Abstract: This study is from a larger design-based research project contributing to efforts to incorporate CT into K-12 education by studying how middle school students can learn about CT in the context of programming and art. During the first year of the study, we held a five-day summer camp taught by four mathematics teachers using NetLogo. This poster begins to examine the role of the teachers, focusing on the strategies they used to position themselves and the structure and agency of each task.

Introduction

It is clear there is a lot of interest in incorporating programming into K-12 schools. By incorporating computing into existing school subjects, researchers hope to address several factors that hinder "computational thinking (CT) for all" efforts (Hu, 2011; Weintrop et al., 2016; Wilensky, Brady, & Horn, 2014). This project contributes to efforts to incorporate CT into K-12 education by integrating CT with mathematics and art for middle school students. We decided to use an agent-based modeling (ABM) environment because ABM provides opportunities to create many types of computational art (e.g. Abelson & diSessa, 1986; Bontá, Papert, & Silverman, 2010; Resnick et al., 2009). We used NetLogo (Wilensky, 1999), a multi-agent programming environment, to create art using a grid of immobile "patches" (similar to pixels in an image) or movable "turtle" agents. The patch grid in NetLogo allowed us to connect to students' developing understandings of Cartesian coordinates.

Recent research has identified some strategies teachers use to incorporate CT into their classrooms (e.g. Fields, Lui, & Kafai, 2017; Griffin et al., 2016; Yadav et al., 2014). To contribute to this emerging work, this study examines the strategies used by experienced middle school mathematics teachers facilitating programming activities for the first time. The research team led a weeklong professional development to review the curriculum and to instruct the teachers in programming and CT. The teachers followed the same curriculum and implemented the same activities in their classrooms, but the two classrooms were facilitated very differently. This poster examines the role of teaching in the implementation of various NetLogo programming activities. In particular, I ask: how did teachers facilitate students' engagement with differing activities in a multi-agent programming environment, and what role did structure and agency play in the types of supports teachers provided?

Structure and agency

While research on teaching CT and programming is relatively new, there is a rich history of research on teaching mathematics that demonstrates the various types of interest and engagement that emerge when students participate in mathematics through concepts and practices rather than just memorization. Tasks can be designed with more structure or with more opportunities for individual agency and exploration (Henningsen & Stein, 1997). Cognitively complex tasks, or tasks with high levels of cognitive load, help students develop thinking and problem solving skills (Stein & Lane, 1996). Studies of effective mathematics classrooms that encourage diverse forms of participation often focus on the balance between structure and agency in relation to both task design and teacher support. We draw on the idea of structure and agency from mathematics education research to frame the programming tasks teachers facilitated in this study, and we focus on the role of the teacher in supporting these different types of activities.

Project overview

The implementation involved a five-day summer camp held at a middle school in a southeastern U.S. city in 2018. The camp included rising 6th, 7th, and 8th grade students from nearby schools. Students were divided into two groups with 16 students each, and each group was co-taught by two mathematics teachers: Tracy and Isabel taught group 1, and Kiara and Neil led group 2. This camp was the first time they taught together. Students ultimately created digital works of art shared on the final day in a gallery walk for peers and families. There were three different types of programming activities that students engaged in throughout the week. They were given open-ended challenges to introduce NetLogo and help explore programming concepts, they completed debugging challenges, and they created their final projects. These three types of programming activities gave students different levels of structure and agency. The initial coding challenges were structured but open-ended, since students could explore and modify them in any way they desired. The debugging models were structured

activities with a clear end-goal defined by the teachers and researchers. The final projects, on the other hand, gave students full agency to create any types of digital art they could using their knowledge of NetLogo programming. The teachers also introduced more or less agency depending on how they implemented the activities.

Methods
The data in this poster comes from the NetLogo activities during the camp. Screen-capture software recorded students' work in NetLogo. Standing video cameras were placed in each classroom to record the teachers. In addition to the video data, the research team took field notes during the camp. This poster reports initial findings from the analysis of recordings of teachers' interactions with students during the NetLogo activities. We will create a coding scheme by drawing on prior research identifying productive teaching strategies with mathematics and CT, along with codes that emerge by watching the videos. Finally, we will look at how teachers facilitated the structured debugging challenges in contrast to the exploratory activities in NetLogo and the more open-ended work on final projects.

Initial findings
Overall, the teachers led the two classrooms very differently. Classroom 1 with Tracy and Isabel was informal, summer camp-like, and provided many opportunities for students to explore in NetLogo. The teachers also asked the researchers to step in and help facilitate more often in classroom 1. Classroom 2 with Kiara and Neil was structured and school-like, with defined start and stop times for each activity. It is worth mentioning that all four teachers attended the professional development session together, the week before the camp. They all taught mathematics, but computer programming was new to them. During the session, the research team worked together with all the teachers to modify the curriculum with their input. The four teachers also had time to plan their implementations together. Despite this group preparation time, the choices the teachers made in the moment to support students' engagement changed the way the two classrooms unfolded. I report on early findings by describing how teachers approached the different tasks based on initial viewings of the videos and field notes, with more detailed findings, including examples of the strategies that are identified through coding, to be added later.

References

Abelson, H., & diSessa, A. A. (1986). *Turtle geometry: The computer as a medium for exploring mathematics.* MIT press.

Bontá, P., Papert, A., & Silverman, B. (2010). Turtle, art, turtleart. *Proceedings of Constructionism 2010.*[1,SEP]

Henningsen, M., & Stein, M. K. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for research in mathematics education*, 524-549.

Hu, C. (2011). Computational thinking – What it might mean and what we might do about it. *ITiCSE '11: Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer Science Education* (pp. 223–227).

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., … Kafai, Y. (2009). Scratch: Programming for All. *Communications of the ACM*, *52*, 60–67.

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation*, *2*(1), 50-80.

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & f, U. (2016). Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Science Education and Technology*, *25*(1), 127–147.

Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL.

Wilensky, U., Brady, C. E., & Horn, M. S. (2014). Fostering Computational Literacy in Science Classrooms. *Communications of the ACM*, *57*(8), 24–28.