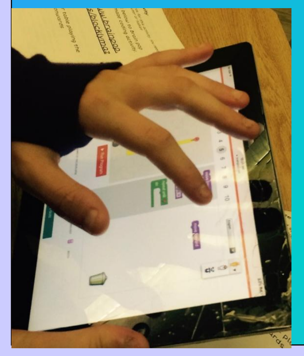
Computational Thinking Tools as a Platform to Teach Mathematics



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ABSTRACT

As society becomes more technology driven, computational thinking skills are essential in preparing students to be creative, innovative and to develop novel solutions. This project is aimed to answer the research question: What might computational thinking integrated with mathematics thinking look like? The researcher worked with eight K-8 class teachers in five schools implementing CT and Math activities in the classroom. The researcher collected surveys, audio recordings, interviews, field notes and photo data. First year findings show that students are enthusiastic and engaged in the coding and math activities. Students enjoy programming robots, making the characters move in apps as well as changing movement patterns. Use of CT tools in teaching mathematics appears to create more conducive learning environments where students, for instance, are willing to explore, tinker, make mistakes, and troubleshoot.

INTRODUCTION

- Computational Thinking (CT) tools can be used to teach and learn mathematics and to make abstract concepts more tangible (Wing, 2008; Xu, 2005)

"Thoughtful use of CT tools and skill sets can deepen learning of mathematics and science" (Weintrop et al. 2016, p. 128)

- CT tools are objects-to-think with (Papert, 1980)

CT/Math activities can be considered

- "warm" math tasks because they provide "non-traditional ways of teaching math with variable entry and non-standard rich learning tasks that go beyond mere practice and procedure" (Namukasa, Gadanidis, & Cordy, 2009, p.49)
- "low floor, wide wall and high ceiling" approach to learning because it provides multiple entry points so that students of all ages can participate (Gadanidis, 2012, p. 21)

METHODS & DESIGN

Study design:

The researcher:

- Worked with eight K-8 classroom teachers in five schools and directly collaborated with the teachers to create activities that met the curriculum standards.
- Collected field notes, teacher surveys, audio recordings of interviews with teachers as well as photos of students' work and teachers' presentations.

Research questions:

1. What might computational thinking integrated with mathematics thinking look like in K-8 classrooms?
2. What are its affordances, enablers, and constraints?
3. What are the students' attitudes towards it?

CT Tool categories explored in the context of Mathematics:

Block-based/visual programming languages; digital making, programmable materials and tangibles; programming blocks; and programming learning apps, games and simulations.

Students were provided with brief introductory step-by-step instructions on how to engage with the CT tool. They used different skill sets to plan, code, simulate, manipulate, and then challenge themselves or each other at distinct exploration centers, each based on a tool.

RESULTS

Math Concepts Embedded in CT tools: Through CT and mathematics activities students had the opportunity to be creative, innovative and develop novel solutions to mathematics problems.

CT and Mathematics Complementary Concepts:

- Instructions/steps/code/algorithm
- Motion Commands
  - Turns, angle measures, direction, magnitude
  - Distance, time, speed measurements
  - Coordinate planes, grid, orientation, mapping, geometry
  - Translations, dilations
  - Clock direction and measures
- Iterations, loops
- Debugging/checking for errors
- Problem solving
- Logic, Flow charts
- Functions and Variables
  - Expressions and algebra
  - Basic math operations, order of operations
- Conditional statements: If, then, else

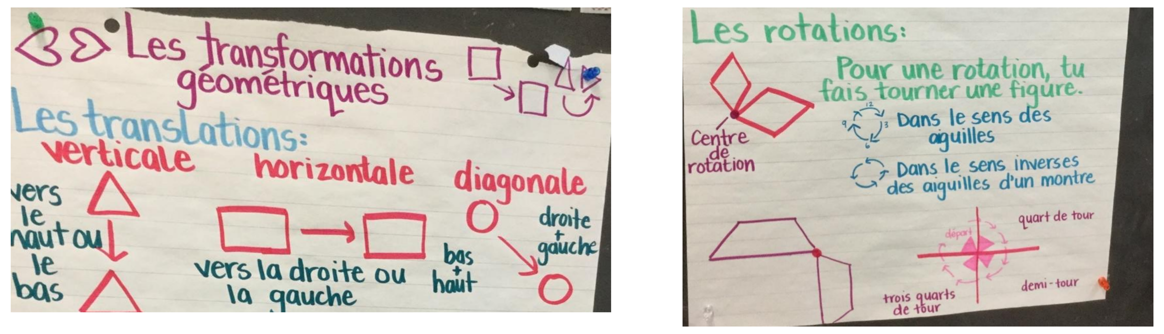

Figure 1. *A chart with vocabulary for a Grade 2 and 3 math lesson*

Teacher Collaborators/Participants:

- Used own teaching practices
- Engaged with the students, challenged students to try new tasks in small groups
- Observed the activities and gave feedback on future lessons that could be taught (e.g. using the Cubetto world map to not only teach programming, but getting students to think about coordinate planes and connect that to storytelling and social studies).

Figure 2. *Navigating a maze with hybrid user interfaces of physical programming OSMO blocks, accessories and apps*

Student Participants:

- Eager to touch the materials, although reluctant to wait for or read instructions. Were willing to listen to video based manuals.
- Eager to remotely drive robots, to code, to enact code, and to set challenges with CT tool.
- Okay with making mistakes, able to troubleshoot and problem solve, frustrated when technology did not work.
- Tinkered when playing with robots, created math games/apps, and imagined other possibilities.
- Engaged in multiple ways with the CT tools—some comfortable with enacting code developed by others.
- Multiple sessions, more time to explore/discover reinforced the CT/Math concepts taught, and made them fluent by the third center rotation as they took less time and asked fewer questions.
- Made connections between the programming language used in one tool in Scratch to that used in a physical programming kit such as Kibo block programmed Robots, a sign of abstracting concepts.
- Centers also provided more for the students to explore as well as communicate (save, write and talk).

Resources:

- Grade 7/8 students worked on improvised activities. For example, when they designed apps or machines in Scratch, played own web-based games with MaKey MaKey; designed a complicated course or race for the two Sphero robots to navigate.
- Certain centers such as the mBot center provided unique ways for students to program other attributes such as Sensors and Sound.

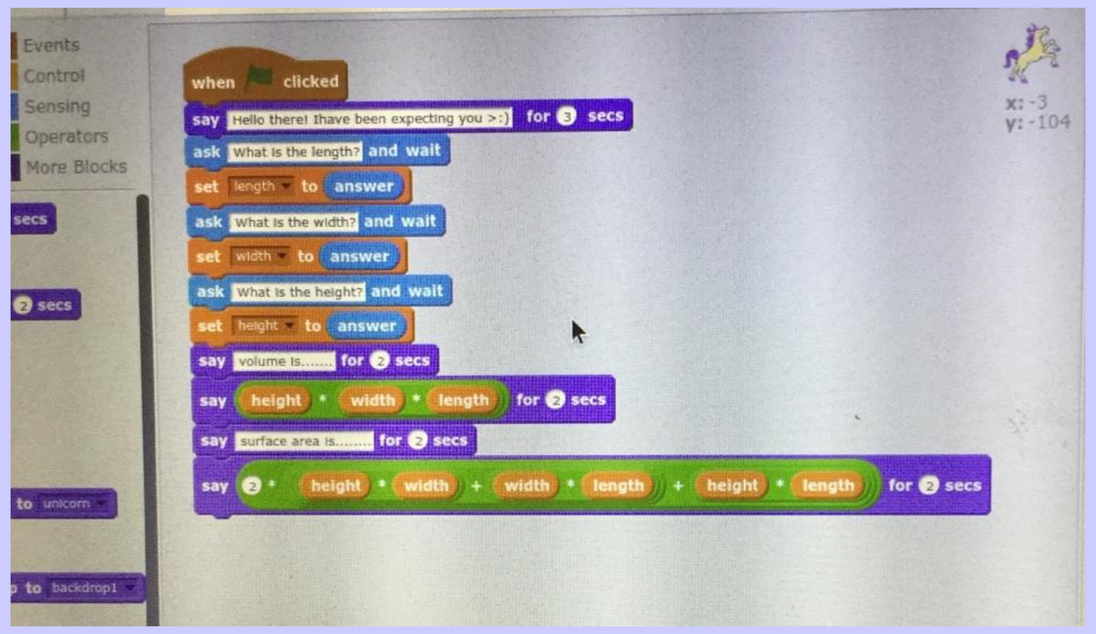

Figure 3. *A grade 8 student writes code for calculating surface area in Scratch*

DISCUSSION

Attitudes toward CT and mathematics activity:

Students were enthusiastic and engaged in the coding/math activities. They really seemed to enjoy the first day of centers because they got to experience a variety of ways to learn coding and mathematics. Students familiar with the technology such as the MaKey MaKey and Sphero tended to skip the exploratory and discovery stage, reducing the level of problem solving or critical thinking skills used. Older students also tended to jump right into the activity and skip the discovery/ investigation stage. When students deviated from the handout they tended to miss the rich math learning or CT skills embedded in the lesson.

It was also noted that some students were more creative when they deviated from the instructions provided. To encourage students to be more creative and innovative the tasks became more open ended and less defined as the lesson progressed (especially during multi period or multi day sessions). A specifically selected grade 7/8 class created a math game or math app in Scratch.

Most of the students were engaged, but there were some students (1 to 7 out of a class of 30) that did not seem to enjoy working for a prolonged period of time on the same CT tool or task. This appeared to be a student-based factor, but at times some messaging from adults present in the class led students to state preferences, or opt out when faced with a challenge.

Teachers and students alike are able to understand a mathematical concept in greater depth if they are given a physical manipulative like a robot or a CT tool (Vinson, 2001) These tools allowed students to use different skill sets to problem solve and manipulate the materials, making abstract concepts more tangible (Xu, 2005).

CONCLUSION

There is potential for CT tools to support the learning of mathematics curriculum among other subject areas as well as to excite students about learning concepts.

It helps when sufficient time to explore is given to students. This in turn reinforces the teaching of mathematical and CT concepts.

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