# Computational Thinking in Mathematics: Undergraduate Student Perspectives


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*Computational thinking (CT) is understood as the thinking, strategies, and approaches for solving complex problems with algorithmic considerations and in ways that can be executed by a computer. This survey study (n=104) reports on the conceptions of undergraduate mathematics majors and future mathematics teachers enrolled in a sequence of programming-based mathematics courses. Results suggest that students' emerging conceptions of CT became relatively well-aligned with expert views and that their characterization of CT included many computational practices (e.g. from modeling and simulation) and related affordances (e.g., creativity, agency) and outcomes (e.g., benefits learning, deeper mathematics understanding).*



*Keywords:* Computational Thinking; Concept Image/Definition; Taxonomy of Practices


Computational thinking (CT) has had a place in mathematics learning and education research since early experiments with Logo (e.g., Papert, 1980), and the push to introduce learners to CT practices has also recently increased in conjunction with the integration of computational applications into professional mathematical endeavors (e.g., Weintrop et al., 2016). Whereas research has been focusing primarily on school learning (e.g., Gadanidis, 2015) and more recently on ways computer programming can be used in undergraduate mathematics (Leron & Dubinsky, 1995), much work still needs to be done to understand how learners are engaging with CT practices, how they come to understand the mathematical content, procedures, and skills associated with computational applications, and what instructional interventions can best support student learning and achievement. With this in mind, we sought to investigate mathematics undergraduate students' conceptions of CT practices as they emerged during one of their three programming-based mathematics courses.

We addressed the following research questions:

1. How do undergraduate mathematics students characterize CT?
2. In what ways do undergraduate mathematics students' emerging understandings of CT align with expert categorizations of CT?

We use the framework of concept-image / concept-definition (Tall & Vinner, 1981) to analyze the evoked conceptions of undergraduates as they reflected on their understanding of CT during various stages of their course. For a concept definition of CT, we draw upon descriptions of CT mainly from the work of Wing (e.g., 2008, 2014) as well as the taxonomy of computational practices in mathematics and science proposed by Weintrop et al. (2016). Participants in our survey (3 times during the term) study were 104 undergraduate students enrolled in one of the three project-based mathematics courses at Brock University at which they learn to design, program, and use interactive computer environments to investigate mathematics conjectures, concepts, or real-world applications (Buteau et al., 2015). The specific items of the questionnaires were designed to elicit participants' personal conceptions of CT as related to their experiences coming into, and working through, the courses. Results suggest that overall by the middle of their CT-based mathematics course, students' emerging conceptions of CT became relatively well-aligned with expert views. Their characterization of CT included many computational practices, mainly from modeling and simulation, and computational problem solving; for example, a participant wrote: "[CT] is the ability to look at a problem and use models and computer simulations to solve and understand problems".

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