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How to Bring Computational Thinking into Mathematics Classrooms: Designing for Disciplinary-Specific Computational Thinking

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KEY IMPLICATIONS

- The first concept of computational thinking (CT) as a generally useful problem-solving skillset is more successful and popular with mathematics teachers and students.
- The second concept of CT as an application of computing in mathematics problem solving or learning is currently more difficult and requires better conditions before it can take root.
- We recommend that policymakers deciding how to integrate CT across the curriculum to consider the end goals when choosing a conception of CT in which to invest resources.

BACKGROUND

In 2020, Singapore's MOE introduced the National Digital Literacy Programme. One component of this effort is to enhance CT skills in the secondary mathematics curriculum. CT involves formulating solutions for computing agents to carry out to solve various problems.

FOCUS OF STUDY

There have been decades of work on using computers, including programming, to learn mathematics. However, recent ideas about CT as a problem-solving skillset have not been well defined within the mathematics subject. The existing practice and research of teaching CT in the context of mathematics education have the following gaps: CT is traditionally taught in the computing subject or through computer programming. Little is known about how to teach it in mathematics.

KEY FINDINGS

CT can be effectively integrated in several ways: (1) topical worksheets, (2) a modelling performance task, (3) using spreadsheet software, and (4) computer programming. The topical worksheets use CT as a framework to guide the learning of mathematics by having students engage in thinking processes that include generating data (decomposition), analyzing the data for patterns, selecting important patterns to generalize (abstraction), and creating flowcharts to summarize a procedure (algorithms). The advantage of this approach is that teachers could teach content that they would teach anyway, while also engaging students in learning and practicing CT.

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SIGNIFICANCE OF FINDINGS

Our study showed that there are multiple ways of conceptualizing CT in the mathematics subject, and they appear as different kinds of learning and towards different goals.

Conception 1: CT is a problem-solving skillset that overlaps with skills in other subjects and is generally useful. This view treats CT as a toolkit, made up of problem-solving strategies such as decomposition, abstraction, pattern recognition, and algorithmic thinking. These skills are explicitly named and taught using high-level definitions. When framed this way, CT skills can be applied to many problems in many contexts. This malleable conception of CT makes it easier to integrate CT across subjects because it enables teachers to identify similar thinking skills in their subject areas and adapt CT to meet their instructional goals.

Conception 2: CT is used to develop solutions that can be carried out by a computing agent in a mechanistic manner. CT is conceptualized as a special kind of tool, rather than an all-purpose toolkit. This view of CT emphasizes the need to define the problem in computational terms, so that it can be solved using computational methods. This conception of CT is harder to integrate because it requires deep changes to mindsets and values, teacher training, curriculum development, timetables, and subject boundaries.

PARTICIPANTS

Four schools, 20 teachers and about 400 students were involved in the study.

RESEARCH DESIGN

A design-based research methodology was adopted. Research methods include surveys, interviews, observations and experimental designs.

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