Chapter 14
Computer Science in Mathematics Preservice Teacher Education

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ABSTRACT

In recent years, significant resources have been invested in increasing access and opportunities to computer science (CS) for elementary school students in the US. However even with the increased advancements and initiatives to embed CS into the elementary school curriculum, little has been done to examine the curriculum and pedagogical implications for mathematics preservice teacher education. For these initiatives to be successful, there is a need to train preservice teachers to integrate CS concepts into their teaching. This chapter reports on a research project that investigated the use of a visual programming language on pre-service teachers' understanding of basic computer science ideas and how these can be integrated into the teaching of mathematics. The purpose of the project was to help preservice teachers develop a basic knowledge of computer science concepts and to help develop subject-specific understanding of how to integrate these concepts.

INTRODUCTION

States are beginning to prioritize computer science education with statewide standards and initiatives to increase computer science exposure in schools (Harmon, 2018). For instance, school districts such as Los Angeles Unified, Chicago, and New York City have committed to the mission of every child learning computer science every year in their schools (Krauss & Prottsman, 2017). According to Code.org

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(2019), as of 2018, 22 States had K-12 computer science (CS) and 33 states had teachers' certifications. Internationally countries like the United Kingdom, recognizing the importance of computational thinking, have mandated the introduction of a coding curriculum for all K-12 students in England.

The believe that computer science is a necessary 21st century skill has led to a number of initiatives to integrate CS concepts in elementary and secondary schools. A significant amount of time and resources have been invested in increasing access and opportunities to computer science for students in elementary and secondary school in the US as well as other developed countries. These initiatives have ranged from exposure to computational thinking (CT) through hour of code type activities to computer science courses such as the Advanced Placement (AP) computer science principles course (Yadav, Gretter, Good & McLean, 2017). This increased interest in CS has been as a result of the availability of visual programming languages such as Scratch (Burke, 2012) and Alice (Graczyn´ska, 2010), that are more user-friendly as opposed to the use of traditional programming languages in which both students and teachers have to use complex programming syntax. In these visual languages students simply need to drag and snap the command blocks instead of having to worry about the mechanics of writing the programs. With the visual languages, the learners are able to more easily acquire computer science skills and in the process helping them strengthen their problem-solving skills.

This study aimed to introduce preservice teachers to computational thinking and computer science ideas using a visual programming language and investigate how these can be integrated into the teaching of mathematics.

Computational Thinking and Computer Science

Computer science (CS) concepts ideas are being introduced under the umbrella of computational thinking (CT). Wing (2006) defines computational thinking (CT) as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent. According to Wing (2006) computational thinking involves three key constructs: Algorithms, Abstraction, and Automation. Yadav, Hong & Stephenson (2016) further expanded on the three key constructs stating that the essence of computational thinking involves breaking down complex problems into more familiar/manageable sub-problems (problem decomposition), using a sequence of steps (algorithms) to solve problems, reviewing how the solution transfers to similar problems (abstraction), and finally determining if a computer can help us more efficiently solve those problems (automation). Computational thinking can also be viewed as thinking algorithmically by using principles from computer science as a guiding structural, and sometimes metaphorical, framework (Shodiev, 2013).

Computational thinking does not exclusively equate with computer science or with programming, but rather, it represents key computer science practices that can be applied to a variety of problem-solving tasks (Yadav, Gretter, Good & McLean, 2017). Coding is an example of an activity that makes use of computational thinking. In their effort to make computational thinking more applicable to K-12, the Computer Science Teachers Association (CSTA*)* and International Society for Technology in Education (ISTE) developed an operational definition of computational thinking that includes nine core CT concepts and capabilities (Barr and Stephenson 2011). These core CT ideas include: data collection, data analysis, data representation, problem decomposition, abstraction, algorithms & procedures, automation, parallelization, and simulation.

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