Chapter 37
Computational Thinking and Mathematics:
Possible Relationships Revealed by an Analysis of National Curriculum Guidelines

Thiago Schumacher Barcelos
Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, Brazil & Universidade Cruzeiro do Sul, Brazil

Ismar Frango Silveira
Universidade Cruzeiro do Sul, Brazil & Universidade Presbiteriana Mackenzie, Brazil

ABSTRACT

On the one hand, ensuring that students archive adequate levels of Mathematical knowledge by the time they finish basic education is a challenge for the educational systems in several countries. On the other hand, the pervasiveness of computer-based devices in everyday situations poses a fundamental question about Computer Science being part of those known as basic sciences. The development of Computer Science (CS) is historically related to Mathematics; however, CS is said to have singular reasoning mechanics for problem solving, whose applications go beyond the frontiers of Computing itself. These problem-solving skills have been defined as Computational Thinking skills. In this chapter, the possible relationships between Math and Computational Thinking skills are discussed in the perspective of national curriculum guidelines for Mathematics of Brazil, Chile, and United States. Three skills that can be jointly developed by both areas are identified in a literature review. Some challenges and implications for educational research and practice are also discussed.

INTRODUCTION

In Latin America, poor educational attainments in Mathematics are a commonplace for students in basic education. The results of international exams such as PISA (Program for International Student Assessment) show that, even though Latin American countries have improved over time, they still remain among the worst performers in Mathematics. According to Aedo and Walker (2012), the average score in PISA Mathematics exams of Argentina, Brazil, Chile, Mexico and

DOI: 10.4018/978-1-4666-9624-2.ch037

Peru is about 100 points lower than the average obtained by students in other OECD (Organization for Economic Co-operation Development) participating countries. This is roughly equivalent to a lag of two years of education.

Nonetheless, difficulties with the learning of Mathematics are found even in developed countries. For instance, the Royal Society of Arts in United Kingdom recently found out that some Universities are not publishing the mathematical prerequisites necessary for enrollment in their courses to avoid losing some of the potential students (Paeton, 2012). Hanushek, Peterson, and Woessmann (2010) compare the Math educational achievements in United States and conclude that only 6% of students reach an advanced level at the end of the 8th grade. An interesting fact is that even privileged groups – according to the authors of the study, white students with parents who had college education – do not generate a higher proportion of students who achieve an advanced level in Math. This may indicate that, as a whole, U.S. schools may be failing to reach adequate educational levels.

On the other hand, the Computer Science (CS) Education community has recently started to consider CS as a subject that should be part of the school curriculum since the initial series, being thus put at the same level as those sciences currently known as "basic sciences" – namely, Physics, Biology and Chemistry. However, the motivation for this has been often "self-triggered" by CS, as the main incentive to teach basic computational skills in initial series was to improve people's abilities to deal with computational devices. For instance, Hood and Hood (2005) affirm that "a key to achieving widespread fluency on Information Technology is to make it part of the K-12 curriculum." Clearly, the pervasiveness of computer-based devices in everyday situations poses a fundamental question about Computer Science being part of those known as basic sciences. However, such skills should not exactly be taught as a collection of techniques, but instead as a way of organizing thinking for concrete problem solving.

For this reason, a subset of skills and basic skills related to the area of Computer Science should be developed by students since the earlier series of elementary school. This subset of skills and abilities was defined by Wing (2006) as Computational Thinking (CT). This term is currently used to describe the cognitive processes related to abstraction and problem decomposition to allow their resolution using computational resources and algorithmic strategies, among other skills. This definition has been criticized by some authors for being too wide (Hu, 2011; Hemmendinger, 2010); however, it is possible to immediately identify a convergence to skills that are related to Mathematics. In his classic work about problem-solving skills, Polya (2004) pointed out that abstraction (analogy, generalization and specialization) and problem decomposition skills are crucial for a Math student to succeed in problem-solving tasks.

When the incorporation of Computational Thinking to basic education is considered, some questions arise: would this new competence support a more effective learning of critical areas like Mathematics? Would it be possible to achieve some kind of "skill transfer" among different knowledge domains? Would a curriculum that merges Computational Thinking and Mathematics eventually motivate students for higher achievements in this discipline? In this sense, this chapter discusses some research trends related to the teaching of Computer Science as a basic science. First, we briefly discuss how Mathematics and other knowledge areas have been historically used to support the development of Computer Science. Most recent works have used the term Computational Thinking to refer to skills related to Computer Sciences developed by students; so, we also compare definitions to this concept made by different authors. Then, the possible relationships between CT and Mathematics are discussed through skills defined in three national curriculum guidelines for Math.