



Chapter 9

Teaching Computational Thinking Unplugged: A Review of Tools and Methodologies

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ABSTRACT

This chapter focuses on the “unplugged” approach for teaching computational thinking (CT), that is, teaching without the use of computers or digital equipment. After a short discussion of the different definitions of CT, the chapter presents the most well-known tools and methodologies of unplugged philosophy, with a connection to CT concepts. The chapter also summarizes the main advantages of the unplugged approach to CT education and furthermore, the most important design principles of unplugged, kin-aesthetic activities. A separate section is dedicated to blended approaches of plugged and unplugged activities and the evaluation of unplugged approaches. While more large-scale implementations are still required to fully evaluate the benefits of unplugged approaches to CT education, existing studies report positive findings, especially in relation to the use of unplugged approaches for CT education. The majority of these resources are available for use by educators free of charge on the internet, which makes them very useful as a CT teaching approach.

INTRODUCTION TO COMPUTATIONAL THINKING

This chapter presents a review of unplugged approaches (teaching without use of computers or digital equipment) in teaching Computational Thinking (CT) in K-12. It consists of six parts: a) quick review of CT definition attempts, b) a report of basic design instructions in order to create unplugged activi-

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ties, c) a meticulous report of unplugged tools and methodologies, where apart from the description of each tool, a connection of the tool with CT concepts is attempted, when applicable, d) a report of blended research approaches, using both unplugged and plugged activities, e) a report of advantages of using unplugged teaching resources and of research articles about the efficiency and effectiveness of unplugged approaches in teaching CT, and finally f) a report of evaluation approaches of unplugged activities. In conclusion, this chapter states some outcomes and future research directions, summarizing the data presented in its main section.

CT has been attracting increasing attention since Wing's (2006) first attempt to conceptualize and analytically describe the term. Papert had used the term back to 1980 (Papert, 1993) to refer to the change of thinking processes in mathematics' education due to the use of computers in education, without giving a detailed definition, while Grover and Pea (2013) place the origins of the idea of CT even earlier, to Alan Perlis' references in 1960s. A widely accepted definition of CT has not still been formed, but several researchers have tried to review existing definition attempts, concluding to some basic common characteristics and concepts of CT.

In 2010 Cuny, Snyder and Wing (2010, cited in Wing, 2011) proposed a definition of CT: *Computational Thinking is 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*. The International Society for Technology in Education (ISTE) and Computer Science Teachers Association (CSTA) in USA published an Operational Definition (ISTE & CSTA, 2011) for K-12 education which characterizes CT as a *problem-solving process*, which includes characteristics and dispositions or attitudes, based on feedback by survey from nearly 700 Computer Science teachers, researchers and practitioners. Main characteristics are the formulation of problems in a way that computers or other tools can help to solve them, the logical organization and analysis of data, the representation of data through abstractions (models, simulations), the automation of solutions through algorithmic thinking, the identification, analysis and implementation of possible solutions (achieving the most efficient and effective one) and generalization, transfer of this problem solving process to a wide variety of problems. Dispositions and attitudes include confidence in dealing with complexity, persistence in working with difficult problems, tolerance for ambiguity, the ability to deal with open ended problems and the ability to communicate and work with others to achieve a common goal or solution.

Barr and Stephenson (2011) also report some core concepts in the context of capabilities, such as design of solutions, implementation of designs, debugging, modeling, simulations, systems analysis, reflecting on practice and communicating, using the vocabulary, recognition of abstractions, innovation, exploration, and creativity across disciplines, group problem solving and employment of diverse learning strategies. Moreover they report dispositions and pre-dispositions, such as confidence in dealing with complexity, persistence in working with difficult problems, the ability to handle ambiguity, the ability to deal with open-ended problems, setting aside differences to work with others to achieve a common goal or solution and knowing one's strengths and weaknesses when working with others. They also give some examples of core CT concepts and capabilities, such as data collection, data analysis, data representation, problem decomposition, abstraction, algorithms and procedures, automation, parallelization and simulation, in different teaching subjects.

In UK, The Royal Society published in 2012 a report about computing in education and presented another definition of CT (The Royal Society, 2012): *“Computational thinking is the process of recognising aspects of computation in the world that surrounds us, and applying tools and techniques from Computer Science to understand and reason about both natural and artificial systems and processes”*. A

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