Chapter 1
Robotics as a Powerful Vehicle Toward Learning and Computational Thinking in Secondary Education of 21st Century

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ABSTRACT

This chapter focuses on the design and implementation of robotics activities in authentic classroom conditions in secondary education. It suggests that robotics can provide a powerful educational vehicle for guiding high school students toward learning in 21st century. It presents a constructionist approach to foster computational thinking and creativity by engaging in robotics and programming activities in real-world classroom. More specifically, this chapter presents teaching interventions that have been implemented in real conditions to high school students during robotics courses at Arsakeia Schools Psychikou in Athens, Greece. It describes robotics activities employing the Edison educational robotics system. Main features of teaching interventions concerning the utilization of Edison robot, digital learning environments, and unplugged activities in the classroom focused on 21st century skills, computational thinking, and creativity development as well as findings, solutions, recommendations, and future research directions are discussed.

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INTRODUCTION

Nowadays, "21st Century skills" is considered as a growing international movement focusing on the skills required for students to master in preparation for success in a globalized, interconnected, digital world.

Robotics could function as a base towards a meaningful and interactive 21st Century education characterized by an increased demand for high-tech applications, concepts and values, such as computational thinking, problem solving, creativity, innovation, team collaboration, noble competition, and progress. The engagement of students and teachers in robotics activities contributes to the development of essential skills needed in the 21st century. Unquestionably, in order to succeed in the future, students must learn much more than the "three Rs" (: reading, writing, arithmetic) and basic computer competency. A widely circulated social media post calls out "We are currently preparing students for jobs and technologies that don't exist yet … in order to solve problems that we don't even know are problems yet."

Over the last few years, research in the field of educational robotics has placed emphasis on the interplay between the invention of new robotic systems and the development of innovative ways of teaching and learning. Research has shown that providing meaningful robotics experiences for students within all school levels positively impacts their perceptions and dispositions towards learning, STEAM (Science, Technology, Engineering, Arts, Mathematics) education and computational thinking (e.g. Bers, 2010; Benitti, 2012; Lee, Sullivan, & Bers, 2013; Elkin et al, 2014; Chevalier et al, 2016; Mondada et al, 2017; Constantinou & Ioannou, 2018; Glezou, 2020). Robotics offers special educational leverage as it is multi-disciplinary and involves a synthesis of many subjects, concepts and topics, including mathematics (algebra, geometry and trigonometry), programming and electronics, science (e.g. forces and laws of motion, materials and physical processes). Robotics, both as a learning object and as a learning tool, provide students with a rich constructionist environment for communication, collaboration, exploration, meaning negotiation, tinkering, artifact construction and learning. Students are invited to work on experiments, authentic problem-solving, problem-finding and problem-posing; they collaborate, discuss alternative strategies and improvements for a simplistic engineering design and build robotic artifacts; they use sensors in order to connect the robot with the external environment and program the robot behaviours; they find and fix bugs when things don't work out the way they wanted. In parallel, they learn core principles of design, about how to experiment with new ideas, how to take complex ideas and break them down into simpler parts, how to collaborate with other people on their projects, how to keep persistent and to persevere in the face of frustrations when things are not working well. The idea of "learning by design" is central in the project-based learning approach developed around open-ended problems according to students' interests. Students are willing to experience hands-on activities, acquire new knowledge and skills and gain understanding of how the world works with their sense of creativity, curiosity, and persistence.

Although today's students belong to digital natives, it becomes mandatory for teachers to develop students' digital competencies, with particular care to the development of computational thinking, problem-solving, creativity and collaboration. There is a widespread recognition of the need to train teachers - digital immigrants in the vast majority - regarding coding, programming and robotics activities in classroom settings. The introduction and exploitation of educational robotics in real-world classroom conditions has gained increasingly significant attention over the last decade but it still remains largely underexplored (e.g. Kopelke, 2011; Kazakoff & Bers, 2012; Kazakoff, Sullivan & Bers, 2013; Komis & Misirli, 2012; Eguchi, 2014; Chevalier et al, 2016; Mondada et al, 2017; Atmatzidou & Demetriadis, 2016; Glezou, 2018; Ioannou & Makridou, 2018).

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