

Chapter 17

The Use of 3D Technologies to Support Computational Thinking in STEM Education

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ABSTRACT

Computational thinking (CT) is increasingly emerging as a thinking skill to support the development of 21st century skills such as critical thinking, creativity, collaboration, or technology literacy, essential for students to become successful in an increasingly complex society. Educators are always looking for new strategies for developing these skills in students. Three-dimensional (3D) printing and scanning technologies are sufficiently mature and economically accessible to be used at the school level. By using 3D technologies, students explore, invent, discover, and engage in real problems and situations. This study explores the use of 3D printing technologies in a secondary school in Athens over the course of two school years. The study investigates if 3D technologies can support the development of CT skills in students.

INTRODUCTION

According to the Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA, 2018) 2018 report, which tested more than half a million 15-year-old students in 79 countries (including OECD countries) and economies in reading, mathematics and science, "about 20% of students across OECD countries perform below Level 2, considered the baseline level of proficiency in science (at Level 2, students can draw on their knowledge of basic science content

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and procedures to identify an appropriate explanation, interpret data, and identify the question being addressed in a simple experiment) while in the majority of countries with comparable data, students' performance in science remained essentially unchanged since 2006. Only 8% of students across OECD countries are top performers in science". In the report it is also noted that "Experiments and hands-on activities can be inspiring and can help students develop a conceptual understanding of scientific ideas and transferable skills, such as critical thinking". Also, it is noted that "On average across OECD countries, mean performance in reading, mathematics and science remained stable between 2015 and 2018". In the case of Greece, the mean performance remains almost the same recording a slight drop overall.

For this reason, there is an emerging need for innovative teaching approaches, to increase student motivation towards science, technology, engineering and mathematics (STEM) subjects, to develop computational thinking skills and to offer a more attractive school environment. However, what constitutes an attractive school environment has changed over the years. Thirty years ago, it would have been sufficient if classrooms were equipped with maps, plaster anatomical models and basic laboratory instruments, as most students had not access to them at home. Today, homes are better technologically equipped than schools in many ways. Although 3D technologies have become reasonably affordable in recent years, 3D printers and / or scanners are not gadgets that can be found at home and their use at schools creates an attractive learning, exploration and collaboration environment that fuels students' imagination. At the same time it is a means for students to become more productive, creative and enthusiastic in both STEM and traditional learning objects.

People define themselves by their creations and actions and students can examine works to define a story, a period, an important event in history. Simultaneously, teachers use these experiences to get the students talking and thinking about the topic. Following stories, and important events, students can freely express themselves and produce their own creations and proceed to the construction of objects used at those periods, through the utilization of digital 3D technology.

Also, Papadakis & Kalogiannakis (2017) notice that "there are concerns among researchers and education professionals that students in our classrooms are bored, unmotivated and disengaged from school. One of the reasons is that old teaching methods are no longer beneficial to the students. On the other hand, game-based learning can improve learning motivation of students. Compared with traditional lectures, digital game-based approaches can indeed produce better learning effects, which underscore the need to develop appropriate instructional materials.

THEORETICAL FRAMEWORK

The term Computational Thinking was already known through the work of Seymour Papert (1980), while many recent works refer to both the historical course of computational thought and its spiritual roots. Although, it seems that there is not yet a commonly agreed definition of CT, Nardelli E. (2019) notices that after the widely cited communications viewpoint by Jeannette Wing an extensive discussion opened with hundreds of subsequent works and papers analyzing the expression and arguing about what Computational Thinking is. In this work we argue that occupation with 3D printing technologies helped students to develop skills considering that Computational Thinking (CT) is a problem-solving process that incorporates a number of features and processes, delivering questions and problems to students in a way that allows to use a computer and other tools and procedures to solve them, such as logically organizing and analysing data, system design and understanding of human behavior, utiliz-

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