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A Framework for Educational Robotics in Kindergarten:
A Systematic Literature Review and Analysis

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ABSTRACT

This systematic review defines a framework for educational robotics in kindergarten. The authors performed their search in online databases via keyword search and snowball sampling. At the end of the process, they analyzed 46 papers. In-depth analysis of them has led to the identification of a four dimensions framework: (1) design and execution of robotics curricula: most of them us programmable floor robots, like Bee-Bot, but also more sophisticated tools, like KIBO, and tend to be created from scratch, often designed and carried out by researchers directly; (2) design and implementation of the research studies: a balance among adopted research methodologies (qualitative, quantitative, and mixed), non-experimental, collected by observations, tests, and interviews; (3) outcomes on the participants' skills: other than technical skills, also investigating the impact on soft and cognitive skills, learning engagement, and emotions; (4) the gender dimension: around one in five papers investigated it.

KEYWORDS

21st-century Abilities, Coding, Computational Thinking, Early Years Education, Floor Robots, Gender and Robotics, Robotic Kits, Soft Skills, Software Programming and Kids, STEM in Kindergarten

1. INTRODUCTION

The aim of this systematic review is to identify the dimensions of a framework for educational robotics in kindergarten.

The first educational robots were small turtle-shaped devices and they appeared in the late 1940s (Walter, 1951). Turtle robots are also associated with the work of Seymour Papert about Logo (Papert, 1980), a programming language that aimed to improve the way children think and solve problems. Nowadays, educational robotics (ER) is a way to enhance learning through the design, creation, and assembly of robots (Di Lieto et al., 2017) and, contemporary, it is a way to impart knowledge regarding software programming and computational thinking (Bers, González-González, & Armas–Torres, 2019). ER saw, in the second decade of the present century, a big diffusion (Benitti, 2012).

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For all these factors, there have also been ER initiatives flourishing in kindergarten and preschools. Indeed, in modern times children are completely immersed in technology and they would find it strange to attend primary school completely immune from the technological environment of their daily experience.

In this paper, we will use the word kindergarten to indicate the school grade for children starting from three and up to six years. In many countries of the world (e.g. France, German, Italy, Spain, Russia, China, Japan, Brazil), this is indeed the age range related to kindergarten whereas in other countries (e.g. USA, Canada, Poland) the three to six years range includes pre-kindergarten as well, which is also called preschool (USA) or infant school (UK).

In 2015, the Italian Cabinet's Equal Opportunity Department published a call for projects titled *STEMs are learned in summer*. The initiative provided funding for projects aiming at the development of in-depth studies in scientific subjects (mathematics, scientific and technological culture, information technology and coding) to be carried out during the summer, targeting mainly female elementary and middle school students. Mich & Ghislandi (2019) described an initiative founded by the above-mentioned call, that stemmed from the need to overcome the stereotypes and prejudices that feed the knowledge gap between female and male students with regard to STEM subjects, as part of their studies, as well as professional orientations and choices. We decided to perform this systematic literature review and analysis because our research group meant to activate new projects and initiatives concerning educational robotics in general, specifically for pre-schoolers and kindergarten children, with a more solid theoretical background and more resources to this research field.

The originality of our work is that, to our knowledge, our research review is the first reporting only studies on ER activities in kindergarten education. Indeed, many literature studies reviewed initiatives performed from primary to higher education (e.g. Xia & Zhong, 2018; or Benitti, 2012), and some studies that did consider the kindergarten level (e.g. Jung & Won, 2018) did not do so exclusively.

Our study not only lists the researches regarding the topic of interest, but the papers deemed relevant are also theoretically and critically analyzed following precise research questions for adding significance to the state-of-the-art knowledge. In this context, we decided on the following preliminary research question to guide our first phase of research: *What are the studies done in the last 10 years about robotics, for kindergarten education?*

In the next section, we briefly analyse eight reviews related to educational robotics. Then, we present the protocol used for our systematic literature review, and the research questions we formulated. Finally, we report the results and the discussion of our analysis performed following the research questions, summarizing them in a four dimensions framework for educational robotics in kindergarten.

2. LITERATURE REVIEW

This literature reviews' main goal is to find literature regarding the topic of educational robotics, as to identify our research keywords and better define our research questions. Using a snowball process, we found eight reviews remarkable for our goal. In the following paragraphs, we will analyze them.

Benitti (2012) explored a synthesis of the available empirical studies on the educational effectiveness of robotics and stated that "educational robotics usually acts as an element that enhances learning, however, this is not always the case, as there are studies that have reported situations in which there was no improvement in learning" (Benitti, 2012, p. 978).

Eguchi (2012) affirmed that "educational robotics is a unique learning tool that creates a learning environment that attracts and keeps students interested and motivated with fun, hands-on, learning experiences'' (Eguchi, 2012, p. 1). The scope of Eguchi's work was to present pedagogical theories related to educational robotics, and tips for how to do it right, learning experiences provided by educational robotics were also described.

García-Peñalvo and colleagues (2016) described the results of the project TACCLE 3, an Erasmus+ project that aimed to produce educational materials for teachers who want to teach