Employing Educational Robotics for the Development of Problem-Based Learning Skills

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INTRODUCTION

The technological improvements within the robotics field and its expansion to various fields such as medicine, industry and education, calls for robotics integration within the educational practice as learning tools. Robotics in the classroom has taken a global momentum especially because of its positive contributions in the teaching of science, technology, engineering and mathematics (STEM) (Benitti, 2012). Additionally, research has shown that robotics integration in education promotes the development of various non-cognitive skills, however extremely important life skills. For example, reasoning, problem solving, tinkerning, sequencing, computational thinking, decision making, scientific investigation, collaboration, knowledge construction, critical thinking, creativity, communication (Bers, Ponte, Juelich, Viera & Schenker,, 2002; Benitti, 2012; Chambers & Carbonaro, 2003; Eteokleous, 2016; Miglino, Lund, & Cardaci, 1999; Resnick, Berg, & Eisenberg, 2000; Williams, Ma, & Prejean, 2010).

Educational systems are responsible in preparing students (future citizens) for this ever-changing Hi-Tech, globalized, interconnected world. Numerous 21st century skills are reported in the literature as important to be developed by future citizens as the means to address the needs and demands of the society. The 21st century skills have been outlined and described by various researchers and reports (e.g. Ananiadou & Claro, 2009; Bybee & Fuchs, 2006; Griffin & Care, 2105; Mojika, 2010; Rotherham & Willingham, 2010; Trilling & Fadel, 2009), and can be summarized as follows: communication, collaboration, critical thinking, problem solving, knowledge construction, creativity – innovation, self-directed learning, global citizenship and digital literacy. The changes in the global competition and collaboration, the focus on service economy, as well as the information growth, constitute the development of the 21st century skills extremely important. Given the aforementioned, the workforce needs have changed, the job tasks and type of work are changing and consequently the required skills are changing.

Problem solving and digital literacy is one of them and robotics and programing are becoming important elements within the educational settings. The students need to be provided with the opportunities to experience tinkering, fabrication, design and create technological artifact & interactive objects, construct their own meaningful projects, experience the scientific method of inquiry (Bers, 2008a; Bers, 2008b; Bers, Matas & Libman, 2013; Bernstein, Mutch-Jones, Cassidy, Hamner, & Cross, 2016; Eteokleous, 2016). Consequently, educators need to design the appropriate learning environments where students have the opportunity to develop the aforementioned skills.

Main Aim

Robotics activities are related to addressing a problem, and usually problems in authentic, real situations. The students are given a driving question and are requested to solve a "problem". Having noticed this connection in relation to the pressing need to develop 21st century skills, the

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current study evaluates the integration of robotics as an educational tool within the teaching and learning process where the problem based learning (PBL) method and the interdisciplinary approach are intertwined. Specifically, robots are used as cognitive-learning tools in order to apply the problem based learning method in early elementary grades (2nd and 3rd graders) in curricular-integrated activities (interdisciplinarity). More importantly, the study aims to examine whether the integration of robotics as cognitive-learning tools influence the development of the following PBL skills: creativity - innovation, critical thinking, and collaboration.

BACKGROUND

Educational Robotics

The idea of robotics integration in education has been around for more than 20 years (Miglino, Lund, & Cardaci, 1999; Papert, 1980). However, the great revolution in the field of educational robotics has been achieved throughout the last decade, where robotics escaped the laboratory and made efforts to connect to education (Chambers, & Carbonaro, 2003). The robotics materials (building blogs/ bricks, sensors and motors) are perceived as toys by the children and research revealed that regardless of age, educational background and interests, students consider working with robots to be "fun" and "interesting". (Chambers & Carbonaro, 2003; Williams and Prejean, 2010). Numerous research studies suggest that robotics integration for educational purposes is an effective teaching method; arguing that if robotics activities are appropriately designed and implemented have great potential to significantly improve and enhance the teaching and learning process (Benitti, 2012; Bauerle, & Gallagher, 2003; Bers et al., 2002; Eteokleous, Demetriou, & Stylianou, 2013; Papert, 1993).

Research has shown that robotics integration in education promotes the development of student higher-order thinking skills such as application, synthesis, evaluation, problem solving, decision making, and scientific investigation (Bers et al. 2002; Chambers & Carbonaro, 2003; Resnick, Mojica, 2010; Berg, & Eisenberg, 2000). In order to achieve the above, robotics need to be integrated as tools and not as subject matters in the educational practice. When robotics is integrated as a subject matter, as an autonomous entity, and not within a well-designed lesson plan, there is limited educational potential and value. On the other hand, robotics integration as a learning tool, in selected teaching cases exploits its full potential; therefore it upgrades and enhances the teaching and learning process and promotes school transformation (Eteokleous, et al., 2013). The intention of this approach is not to learn how to use the robotics package, and its programming software, but to use it as a tool within a specific educational context to achieve learning objectives. In other words, robotics is employed as a tool to teach and deliver concepts within various subject matters such as Mathematics (Whitehead, 2010), Engineering (Craig, 2014), Science (Vollstedt, 2005), Physics, and even in non-technology related fields such as Biology, Psychology (Bers, Ponte, Juelich, Viera & Schenker, 2002; Eguchi, 2007, Eteokleous, et al., 2013; Craig, 2014). *Robotics integration* in the teaching and learning practice is defined as the use of robotics by students as a tool that enhances their learning experience and supports the achievement of specific learning goals (Ward, et al., 2012; Eteokleous, et al., 2013).

Problem-Based Learning (PBL) and Robotics

Problem-based learning is an instructional method characterized by the use of "authentic" problem sets, as contexts for students to develop critical thinking and problem solving skills, and acquire the necessary course concepts. Along the same lines, problem based learning is defined as "a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, au-