Chapter 2
An Early Childhood Introduction to Robotics as a Means to Motivate Girls to Stay With STEM Disciplines

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ABSTRACT

This research examines the design, implementation, and impact of an educational robotics intervention for first and second grade students. It controls for gender-related performance differences and compares the interest shown towards robotics. The authors also examine if factors such as students' stance towards different professions can contribute to a difference in performance. In the course of its work, custom designed worksheets for the UARO educational robotics product were used, as well as questionnaires given to students after meetings. The results showed that all genders responded equally well and with the same enthusiasm to the robotics activities and understood concepts of physics, mechanics, and mathematics through them. Participants differ in how they use their leisure time and in their professional orientation; however, this didn't affect their performance in the robotics activities. These results highlight the need for further examination of the social institutions and factors that influence the formation of gender orientations during the early childhood age.

INTRODUCTION

Means and approaches in childhood education advance and evolve rapidly, empowered by internet and social media connectivity, as well as the abundance of inexpensive, readily available technology; Friedman states that innovative tools may enter our lives as quickly as every six months (Friedman, 2012).

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In this context, research conducted as early as 1980 shows that girls fall behind in distance learning and using educational software, and this may be attributed to the stereotype of technology being a boys-only activity (Hilbert, 2011). This early gender gap leads to an even wider gap in STEM-related studies, which only worsens in academia and high-level job posts related to Science and Engineering, even though the interest shown by girls has increased recently (Makarova et al., 2019).

In order to tackle the STEM gender gap issue, many research and development efforts have focused on primary and secondary education. However, there are only a few approaches fit to be deployed in pre-school and early childhood (Sullivan, 2016). In our work, we investigate gender differences with respect to interest and performance in STEM in children aged 6-7, as well as students' outlook on STEM-related professions, in general. To this end, we designed and tested a set of robotics and make-ing activities using RoboRobo's UARO platform [http://www.uaroedu.com/en] . We opted to use an educational robotics platform, assorted with simple engineering and make-ing activities, since research has shown that it can be used to advance cognitive and teamwork skills to young children, besides technical and scientific subjects (Malatesta, 2009). More specifically, a wide range of experiments and tasks can be built using an educational robotics platform, including introducing students to algorithmic thinking and problem solving; such activities typically also require interaction and cooperation between students, leading to their use as a team building activity (Nugent et al., 2014). With respect to 'hard' STEM skills, educational robotics have been used to teach Physics, Mathematics and Geometry, Engineering and Technology, History, and also interdisciplinary subjects, such as STEM combined with art or environmental studies.

Beyond these disciplines, educational robotics have been associated with a number of 'soft' skills, both cognitive and emotional/social (Cowie et al., 2008; Cowie et al, 2011). Often termed '21st century skills', these include teamwork, problem solving (analysis, design and development of solutions, experimentation, and evaluation), innovation, project management and scheduling, communication and creativity. The pedagogical contribution of educational robotics is consistent with Piaget's theory of affective and cognitive development (Richmond, 2013), who suggested that learning is an active process of constructing knowledge based on experiences from the real world; it also matches Vygotsky's philosophy of Constructivism (Liu, 2005) with respect to the social dimension of constructing knowledge. In essence, both theories assume that learning is based on the experiences of students, their pre-existing knowledge, and the ways to organize emerging learning experiences (Jonassen, 2000): in its foundation, constructivism includes rich, user-focused interaction, dealing with authentic problems to be solved, cooperative learning and the teaching experience of building new knowledge. Educational robotics is especially instrumental to this approach, since it involves building and manipulating a tangible object or simple machine, thus offering students the opportunity to work in groups and build mental models more easily. In addition, they cater for exploration and creativity when it comes to how robot assemblies can be built (Resnick, 2005) and offer important feedback about their functionality. According to Merkouris et al. (2017), integrating a robot-related activity in learning is a four-step process: imagining and visualizing how to build a robot, develop the operating software using visual programming, downloading the software to the robot, and executing the software.

An important aspect of our research has to do with investigating how and when the gender gap is founded. Underrepresentation of women in STEM is a multi-faceted issue: according to NSF, women are awarded 59% of Biology, 43% of Mathematics and 41% of Science degrees, but only 18% of Computer Science and 19% of Engineering degrees. Research has shown that the gap across genders with respect to STEM fields begins to appear as early as primary school (Ceci, 2010) and that targeted educational interventions can be extremely effective in reducing it, by increasing engagement and self-esteem in

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