Chapter 6

Control Technologies as Mind-Tools:
Emerging Mathematical Thinking Through Experiential Coding Activities in the Preschool Classroom

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ABSTRACT

In mathematics education, especially in early childhood that is considered the most formative period in children's lives, there is an always growing need to design, test, and validate tools and activities that take advantage of recent pedagogical and technological advancements but still focus on the creative learning process, instead of quantifying the outcomes and emphasizing numerical data and performance. Educational robotics as a context for interdisciplinary problem-solving scenarios in preschool education can be an interesting starting point, since modern control technologies are usually thought to provide a rich variety of mind-tools that encourage active learning and children's creative thinking. Such activities may stimulate students to "do" mathematics in a seamless, creative, playful way in order to solve meaningful and appealing (for them) problems. The study tries to explore and validate emerging preschoolers' opportunities to unconsciously "mathematize" their environment in everyday playful robotics activities in the context of brief teaching experiments.

INTRODUCTION

Educational Robotics (ER) is a rather recent learning approach that is known mainly for its effects on scientific (academic) subjects such as Science, Technology, Engineering, and Mathematics (STEM). Interest in educational applications of robotics has risen sharply in the last 20 years or so, culminating in the most recent decade, mainly thanks to the advent of more advanced, affordable devices and specialized software. The increased and more complex possibilities offered as well as the wider availability of

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new tools and applications based on "open architecture" and cheaper material resources, allow further experimentation and dissemination of the "makers" philosophy and practices to a wider age base of users.

The use of robotics and programming has a long-standing history in mathematics education as well with tools such as "turtle" geometry or Logo explored in classrooms for almost 50 years (Papert, 1980). In the late 1960s, Papert and his floor turtle "launched" the field of educational robotics based on tangible tools and artefacts, giving children the ability to not only process materials and create structures, but also to define and control their behavior. Since then, a new kind of hands-on material, either tangible or digital (digital manipulatives) has made its appearance and is constantly evolving, offering the opportunity to kids and their teachers to experiment with dynamic ideas and affordances that other traditional tools, actually, have never been able to offer (Moyer- Packenham et al., 2015; Skoumpourdi, 2010). It should be mentioned, however, that the use of artificial intelligence and robotic devices and constructions implies a connection with tangible tools that, since the time of Fröebel and Montessori, still support learning through exploration and experiential practices (Brosterman & Togashi, 1997). There also seems to be a direct link with Resnick & Rosenbaum's (2013) "tinkering approach" which refers to activity that engages children in a playful, experiential and iterative way of doing things with or even without the aid of advanced technology.

For the above reasons, the trend of ER deliberately focuses on a range of control-technology educational tools in a variety of fields, addressing a variety of learning objectives (Keren & Fridin, 2014; Benitti, 2012 Eguchi, 2010; Nugent et al. 2010) and outcomes such as improving problem-solving skills (Alimisis, 2013; Benitti, 2012), cultivating cognitive flexibility and metacognitive practices in early and late childhood (Mioduser & Levy, 2010; Sullivan, 2008) as well as encouraging a positive attitude towards the STEM field (Lindh & Holgersson 2007; La Paglia et al, 2011) etc. In addition, recent studies have assessed the effects of robot programming on cognitive and learning processes, such as decision-making, self-awareness, problem-solving, and computational thinking (La Paglia et al., 2011; Kazakoff and Bers, 2014; Atmatzidou et al., 2018; Tuomi et al., 2018; Atmatzidou & Demetriadis, 2016 · Eguchi, 2014 · Keren & Fridin, 2014 · Alimisis, 2013 · Bers et al., 2014).

In this chapter, through our research work, we intend to point out that teaching experiments based on ER in preschool classrooms, are indeed capable of generating an infinite variety of tangible representations and mediators that encourage experimentation with mathematical concepts and facilitate mathematical thinking in its whole. Our aim is to investigate how ER contexts can potentially lead to concrete mathematical constructs which can retain their dual role either as tools that model real world processes and events, or as means of (logical) reasoning. Our study explores emerging preschoolers' "mathematizing opportunities" in everyday robotics play activities in the context of brief teaching experiments. Building on an ethnomethodological and multimodal discourse analytic framework, we suggest that mathematics (i.e. representations, spatiality, spatial reasoning, basic arithmetic operations such as addition, subtraction and even multiplication etc.) are expressed and actualized in children's verbal and embodied interaction with their peers, material environment and more "experienced others". We argue that new understandings and powerful ways of reasoning become possible on the basis of culturally mediated mathematical constructs produced in the context of creative and collaborative play of preschoolers with robots (floor turtles and more complex kits), coding and open-ended scenarios. As an additional supportive tool, the multiple implications of Vygotsky's theoretical work, and especially the approaches that have emerged concerning the analysis of classroom interaction, such as the work of Rogoff (2003) and Kumpulainen & Wray (2002) can clearly complement teachers' concerns and work. Basic concepts and pillars of our