Chapter 1
Aligning the Design of Educational Robotics Tools With Classroom Activities

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ABSTRACT

This chapter addresses the alignment of educational robotics (ER) tools with classroom activities. To this end, it first introduces a conceptualization of ER activities describing the relevant cognitive artifacts and the learning theories underlying such activities. Based on this conceptual framework, a set of design and evaluation heuristics are presented, aimed at supporting developers and educators in aligning ER tools with classroom activities and vice versa. The heuristics were elaborated in several focus groups with 35 developers and educators experienced in the domain. To evaluate the methodology in authentic contexts, two case studies with groups of developers will be presented. Moreover, to illustrate the usefulness from an educator's point of view, another example will be presented in which the devised methodology was used to guide the design of an ER classroom activity.

INTRODUCTION

Previous research has acknowledged the potential of Educational Robotics (ER) as an innovative pedagogical approach for both technical and non-technical disciplines (Anwar, Bascou, Menekse, &

DOI: 10.4018/978-1-7998-7443-0.ch001

Kardgar, 2019; Benitti, 2021; Jung & Won, 2018; Toh, Causo, Tzuo, Chen & Yeo, 2016). For instance, ER is increasingly being used to foster the development of students' 21st century skills (Eguchi, 2014; Khanlari, 2013; Negrini & Giang, 2019) as well as computational thinking competencies (Atmatzidou & Demetriadis, 2015; Bers, Flannery, Kazakoff & Sullivan, 2014). Furthermore, ER can represent an important building block to implement progressive continuing professional development programs (CPD) in computer science for primary school teachers (El-Hamamsy et al., 2020) facilitating the adoption of computer science content by both pioneer and novice teachers (El-Hamamsy et al., 2021).

As for any kind of educational tool, the successful integration of ER in classroom education requires a proper alignment of the tools with the classroom activities. However, previous research has argued that in practice, this is often not the case for educational technology (Antonenko, Dawson & Sahay 2017). According to Antonenko et al. (2017), one possible reason is that only little conceptual research has been performed to construct useful frameworks helping educational technology developers to align the affordances of their systems with the needs of the target users (i.e., teachers and students). As a matter of fact, such conceptual frameworks are also scarce for the specific case of ER. Not surprisingly, previous research has suggested that "*future research needs to deal with the more effective design of robots to align with the educational need*" (Pachidis et al., 2018, p.7).

Proper alignment, on the other hand, is also important when conceiving classroom activities involving ER tools. Well-designed tools are meaningless if they are not appropriately used in teaching and learning activities. However, the use of ER in formal education is a relatively recent trend and it still appears that more educators need to develop the required technological pedagogical content knowledge to effectively integrate ER into classroom activities (Koehler & Mishra, 2013; Sisman & Kucuk, 2019). As Sisman and Kucuk (2019) have pointed out, many educators are still not aware of the benefits of ER, and those who are, are not prepared to leverage ER for teaching. A framework providing a comprehensive conceptualization of ER classroom activities could hence better guide educators in preparing and implementing such activities.

The technological advances of the past decades have given rise to an increased integration of educational technology in classrooms and in this context, different alignment frameworks have been developed, for instance, for the design of computer supported collaborative learning (CSCL) environments (Kirschner, Strijbos, Kreijns & Beers, 2004), e-learning tasks (Bower, 2008) and educational technologies as a whole (Antonenko et al., 2017). However, these frameworks were devised for entirely screen-based implementations of educational technology. ER activities, in contrast, often also involve objects in the physical world, suggesting that the existing frameworks may not be unreservedly applicable in these cases. Indeed, ER activities correspond to what Heersmink (2013) has denoted as "situated cognitive systems", involving three types of cognitive artifacts: Apart from the robots, they also involve programming or interaction interfaces as well as playgrounds for the learning tasks (Chevalier, Giang, Piatti & Mondada, 2020). A framework that conceptualizes ER activities thus needs to consider how these artifacts can be meaningfully integrated in the learning system as a whole in order to align with the learning goals as well as with instructional and assessment activities.

SCOPE AND MAIN FOCUS OF THE CHAPTER

The main focus of this chapter is to introduce a conceptual framework, that can support developers in the design of ER tools as well as educators in the preparation and implementation of ER classrooms

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