Chapter 115
Robotic Teaching Assistance for the "Tower of Hanoi" Problem

Nguyen Duc Thien
Sapienza Universita di Roma, Italy

Luca Iocchi
Sapienza Universita di Roma, Italy

Annalisa Terracina
Sapienza Universita di Roma, Italy

Massimo Mecella
Sapienza Universita di Roma, Italy

ABSTRACT

In this work the authors investigate the effectiveness of robotics in education. Rather than creating excitement for children when playing with robots in games, they are examining the overall learning environment where a robot acts as a teaching assistant. They designed a suitable lesson plan when groups of teenagers participate in activities involving the use of the robot: the authors first performed experiments for the robot to solve the "Tower of Hanoi" problem; then, they designed a lesson plan to teach the "Tower of Hanoi" problem using a KUKA youBot as a teaching assistant. The experiment involved two groups of students: one group was taught with the robot and the other group without the robot. Finally, the authors present results of a comparative study based on questionnaires, in order to understand if the effectiveness of the teaching has been greater with the robot as teaching assistant.

1. INTRODUCTION

In recent years, robots have started to become a tool for teaching assistance. "Educational robotics" is the term now commonly used to refer to robotics being used as a tool for learning (Papert 1980, 1986, 1993; Eguchi 2012). Since the early 1980's, robotics platforms designed for education present a wide range of costs, types of parts, and complexities (Grandgenett et al. 2012; Miller et al. 2008; Melchior et al. 2005). Many robotics kits include a programmable brick or controller and can be programmed in one or more languages (Eguchi 2012). Educational robotics initiatives can be grouped on the basis of the purpose for using robots: using *(i)* robots as the learning objective, *(ii)* robots as a learning aid, and *(iii)* robots as a learning tool like a practical teaching assistant (Eguchi 2012). In the latter case, educators find robotics appealing because of the robots' ability to catch the attention of youth; robots are highly

engaging and motivating and encourage learning about STEM - Science, Technology, Engineering, and Mathematics - concepts (Grandgenett et al. 2012; Miller et al. 2008; Melchior et al. 2005).

Robots provide a way for youth to quickly apply abstract concepts like mathematical equations to tangible tasks (Nelson 2012). Further, robotics activities promote collaboration, teamwork, positive youth development, and foster learning of 21st century skills and computational thinking (Eguchi 2012; Elizabeth et al. 2003; Sklar et al. 2000; Lund et al. 1998). For example, in an introductory engineering course project, robots inspired increased shared leadership and engagement when compared to a similar assignment without robots (Melchior et al. 2005); robots have even been used for storytelling (Melchior et al. 2005) and by kindergartens to express aspects of their identities (Elizabeth et al. 2003).

In this work, we are first questioning the relationship between robotics and educational outcomes. We investigated the effectiveness of robotics in education when a robot acts as the teaching assistant. Rather than focusing just on the robotic technology itself, we examined the overall learning environment where the robot becomes a teaching assistant and groups of students participate in team activities helped by the robot. We begin by outlining the history of educational robotic in practice, illustrating its growing popularity on international scale and describing how it has been evolved into the international uses. Then, we describe the robot used in the experiment. In order to involve robotics in education, we performed several experiments; the robot, beyond attracting the attention of students, also supports the teachers in the teaching process.

We also designed a lesson plan involving the robot to help the teacher in the classes. For validation, we made questionnaires in a case of study for lectures with and without using the robot. To clearly recognize the effect of using the robot in the classes, we designed the questionnaires and clustered the group study with and without the robot to perform statistical analyses and comparisons. Based on this case study, we also made several observations about factors that we believe contributed to the success of the education.

Finally, we present results from the questionnaire study conducted with the robot and comparing two groups. As a primary results, the use of the robot as teaching assistant has improved the percentage of correct answers of roughly 15%, level of attention of roughly 12%, and the comprehension of roughly 11.2%.

2. RELATED WORK

The theoretical basis for educational robotics dates back in the '80s (Papert 1980, 1986) and have evolved during time (Papert 1993, Eguchi 2012 setting the foundation for the impact of educational robotics on learners. According to (Elizabeth et al. 2003; Sklar et al. 2000; Lund et al. 1998), experience learning is an active process of constructing and reconstructing knowledge through interactions with the environment (referring to constructivism theory) and learning occurs when youth manipulate physical objects and observe their interactions. Learning works properly when youth are provided the tools to support their learning and are engaged in self-directed, interactive exploration (Sklar et al. 2000; Lund et al. 1998).

Beyond the benefits of youth learning skills relevant to their current development, educational robotics promotes learning skills directly transferable to the workplace. Nelson (2012) lists transferable skills as: use of the scientific method and engineering design, applied math and logical reasoning, computer literacy, technical communication, creativity. Generally applicable skills include: vision, leadership, work ethic, initiative, goal setting, time and resource management, working with teams. Barriers to the implementation of robotics activities exist for many educational organizations. Challenges include lack

Related Content

Groupwise Non-Rigid Image Alignment Using Few Parameters: Registration of Facial and Medical Images
Ahmad Hashim Aal-Yhia, Bernard Tiddeman, Paul Malcolmand Reyer Zwiggelaar (2019). *Handbook of Research on Human-Computer Interfaces and New Modes of Interactivity (pp. 361-384).*
www.irma-international.org/chapter/groupwise-non-rigid-image-alignment-using-few-parameters/228536

Intelligent Environmental Monitoring System Based on Multi-Sensor Data Technology
Qiuxia Liu (2020). *International Journal of Ambient Computing and Intelligence (pp. 57-71).*
www.irma-international.org/article/intelligent-environmental-monitoring-system-based-on-multi-sensor-data-technology/262648

The Application of ICT in the Area of Value Co-Creation Mechanisms Support as a Determinant of Innovation Activities
Dorota Jelonekand Iwona Chomiak-Orsa (2018). *International Journal of Ambient Computing and Intelligence (pp. 32-42).*
www.irma-international.org/article/the-application-of-ict-in-the-area-of-value-co-creation-mechanisms-support-as-a-determinant-of-innovation-activities/205574

Extension of the TOPSIS for Multi-Attribute Group Decision Making under Atanassov IFS Environments
Deng-Feng Liand Jiang-Xia Nan (2013). *Contemporary Theory and Pragmatic Approaches in Fuzzy Computing Utilization (pp. 241-255).*
www.irma-international.org/chapter/extension-topsis-multi-attribute-group/67494

Stream Processing of a Neural Classifier II
M. Martínez-Zarzuela, F. J. Díaz Pernas, D. González Ortega, J. F. Díez Higueraand M. Antón Rodríguez (2009). *Encyclopedia of Artificial Intelligence (pp. 1497-1503).*
www.irma-international.org/chapter/stream-processing-neural-classifier/10436