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EDITORIAL

by Veronica Rossano and Rita Francese

Focus on:
Educational Robotics: Research and Practices of Robots in Education

Educational Robotics is an innovative way for improving effectiveness in learning and teaching processes. While in the past Game-based learning (Prensky, 2003) has been one of the most used approaches in different contexts to enhance the effectiveness of education (Di Bitonto *et al.*, 2012, Brezovszky *et al.*, 2019, Francese *et al.*, 2018, Hung *et al.*, 2018) , at the present educational robotics is one of the most popular at all school levels. The integration of robotics in teaching and learning processes and its effectiveness in achieving specific learning objectives has been deeply studied in the latest years (Mubin *et al.*, 2013, Toh *et al.*, 2016). The success of this approach is based on Papert's Constructionism Theory (Papert, 1980): learning can be more effective when people are active in making tangible objects in the real world. Students are more engaged in the learning process through design, creation and programming of tangible artifacts for creating personally meaningful objects and addressing real-world needs. This is particularly true for digital natives who need to be actively involved in the learning process to make it successful.

There are different kinds of robots used for educational purposes, such as improving social skills or learning to program. For example, humanoid robots, such as Nao, Pepper, Robovie and EZ-Robot JD, are useful for their social interaction skills. Their capability of exhibiting social supportive behaviors by using speech, gestures and emotional expressions with a physical robotic embodiment allow us to make the learning process more engaging (Saerbeck *et al.*, 2010). Moreover, it has been proved that robots are particularly effective when used with children with autism spectrum disorder (ASD) (Amanatiadis et al., 2017), or in language learning (Belpaeme *et al.,* 2015) contexts.

Robotic education is based on the idea of creating artifacts that can be programmed to perform some tasks. For instance, LEGO® Mindstorms allows children to build robots using special LEGO blocks and to program them to solve specific problems. This kind of activity has been proved to be effective in different contexts (Haak *et al.,* 2018, De Vries *et al.,* 2018, Umbleja *et al.*, 2017). Arduino board (Plaza *et al.*, 2018) or BBC micro:bit (Rogers & Siever, 2017) are adopted to allow students to implement IoT-based (Internet of Things) applications. Robotics is widely adopted to support the learning of Science, Technology, Engineering and Mathematics (STEM). Accordingly, this special issue aims at exploring the challenges and opportunities of Educational Robotics and its vast combination and integration in traditional learning processes.

The special issue opens with a paper by **Donato Malerba *et al.***, *Advanced Programming of Intelligent Social Robots*, which describes the main computational methods required to program a social robot and equip it with intelligence to enhance the learning process. Social robots are very interesting in the educational technological field, since they are able to interact with people in everyday environments, using social behavior typical of humans. The paper describes the main skills for social intelligence and proposes a framework of design issues for the advanced programming of social robots, that make social robots effective in educational contexts. A brief state-of-the-art of some applications of social robots in Education is described as a starting point for further research that authors would like to investigate.

Also the paper by **Hagen Lehmann** and **Pier Giuseppe Rossi**, *Social Robots in Educational Contexts: Developing an Application in Enactive Didactics,* discusses how social robots can enhance learning processes. The authors propose a theory-driven approach based on the idea that the combination of enactive didactics and social robotics holds great promise for a variety of tutoring activities in educational contexts. The proposed approach, named Enactive Robotic Assisted Didactics, is used in the paper to give an overview of how humanoid and semi-humanoid robots have been adopted in educational contexts in the last two decades.

The paper by **Berardina De Carolis *et al.***, *Social Robots supporting the Inclusion of Unaccompanied Migrant Children: Teaching the Meaning of Culture-Related Gestures* proposes using social robots to support the integration of unaccompanied minor migrants in a new culture. The idea investigated by the authors is to exploit a social robot for teaching culture-dependent gestures to children coming from other countries. The collateral effect that the research wishes to have is to support the social operator in establishing a contact with these children, who do not trust adults because of the difficulties encountered during their journey. The pilot study was conducted with Italian children, but the results seem promising; the application to this particular context appears to be difficult but hopeful.

There is much scientific evidence to prove the effectiveness of humanoid robots in children with ASD. Following these routes, the paper proposed by

Valentina Pennazio and **Laura Fedeli,** entitled *A proposal to act on Theory of Mind by applying robotics and virtual worlds with children with ASD,* uses robotics and a 3D virtual environment to support the development of social behavior and relations in children with ASD. The final idea is to gradually support the subjects in interactional settings, in order to help them acquire the self-confidence needed to finally interact with a classmate in the virtual environment. The technological mediators would activate communication and improvesocial interaction, that can represent a barrier for the active involvement of children with ASD in the school community. The results of this type of study are difficult to generalize, since the dimensions to be evaluated are multiple and vary depending on the individual child's attitude.

Educational robotics is naturally applicable to STEM disciplines, and in particular computer science and computational thinking skills, but in many cases, it is used also to improve creativity and collaboration among children. This is the objective of the study reported by **Lucio Negrini** and **Christian Giang**, in *How do pupils perceive educational robotics as a tool to improve their 2st century skills?* The paper describes their experience with robot Thymio II, a small robot with a large number of sensors and actuators which can be programmed using a visual environment. The results of the study are very interesting: the girls perceived a greater impact on collaboration and creativity skills rather than on technical skills, while boys perceived a higher impact on their technical skills. This unfortunately means that it is not easy to attract girls to technological studies, so other more attractive activities should be studied to address this current worldwide challenge in the field of STEMs.

Robotic education could be effective not only with children but also to make complex concepts easier for adults. This is the objective of the experience described by **Flaminia Luccio** in the paper *Learning distributed algorithms by programming robots.* The Lego Mindstorm EV3 robot and Makeblock mBot robot were involved in a project-based learning approach at a university to introduce theoretical models and algorithms in the area of distributed algorithms. The students were asked to replace the traditional exam with a practical project using distributed algorithm models to program robots. The activities were engaging for students and their motivation led to excellent final grades and also increased collaboration skills among students.

Finally, experience of tinkering is described by **Antonella Poce *et al.***, in *From Tinkering to Thinkering. Tinkering as support for the development of Critical and Creative Thinking.* Tinkering, is an informal method to engage students with STEM subjects. It is employed to develop students' scientific knowledge and to support thinking processes such as Critical Thinking and Creative Problem Solving. Tinkering often incorporates different kinds of "languages", from painting to coding. The authors propose a pilot study involving STEM teachers and museum educators to measure how Tinkering could influence Creative and Critical Thinking levels. The activities designed concerned different school levels, from primary school to secondary school pupils, and different topics such as Electricity, electro-magnetism and reflection of light. Some necessary materials were given, and the participants were required to plan their own Tinkering activity. The feedback was positive; participants showed significantly higher Creative Thinking levels.

The issue faces several kinds of applications of educational robotics, starting from humanoid robots up to Tinkering activities. Regardless of the technological tool used, all these experiences show a great impact on students' engagement and motivation, which are key components for successful learning processes. One of the main drawbacks of this technology is the cost of these robots, such as Pepper or Nao. Fortunately, at present the cost of hardware is decreasing, thus teachers at all school levels may have access to it. In the future, if public funding is available for financing this type of experience in educational institutions, as happened in the past with the Interactive Whiteboard, robotics-based learning could be applied more widely, giving all our students the opportunity to be more engaged in the learning process.

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