Artificial Intelligence and Robotics in Education

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Abstract

This contribution aims to focus attention on the research that the working group of the Department of Educational Sciences of the University of Bologna is developing in the field of Artificial Intelligence and Robotics (AIR). In particular, the research group is developing two lines: AIR for Learning with a focus on learning processes and levels of personalization supported by AI and ER; Learning for AIR with a focus on AI and Robotics education and the need to integrate the school curriculum.

Keywords 1

Educational technology, Artificial Intelligence, Educational Robotics, Teaching and Learning Tool

1. Introduction

This contribution aims to focus attention on the research that the working group of the Department of Educational Sciences of the University of Bologna is developing in the field of Artificial Intelligence and Robotics (AIR). The application of AI and robots in education is innovating teaching and learning methods and tools, redefining the roles of teachers and students respectively [1] [2]. The concept of learning environment is also evolving towards an open ecosystem in which multiple stakeholders interact (children, teenagers, teachers, educators, families, policy makers, producers/suppliers of technological tools, …).

In this general context, AI and ER become both objects of study and tools/environments to support the processes of cognition and metacognition and open up to the experimentation of new spaces of action, communication and intersection between the different areas of knowledge and creativity [3]. With reference to the scientific literature [4] [5], two main lines of research specifically emerge: *AIR for Learning* with a focus on learning processes and levels of personalization supported by AI and ER; *Learning for AIR* with a focus on AI and robotics education and the need to integrate the school curriculum. On these two lines, an experimentation is being launched which will involve some schools of the first and second cycle of Emilia-Romagna.

2. AIR for Learning

Recent studies and research [6] [7] highlight how the use of educational robots within socio-

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constructivist teaching activities has a significant impact on the learning of the younger generations: it stimulates their interest and their motivation towards knowledge; encourages interaction with the environment through realistic challenges [8] [9]; enhances the playful dimension of the teaching experience. Starting from kindergarten, many experimentations have already introduced different types of robots [10] [11] [12] within interdisciplinary projects [13] involving different fields of experience (the self and the other, the body and movement, images, sounds and colours).

Cheng, Su, and Chen [6] identify two main potentials in the use of robots in teaching. First, robots have several characteristics that make them particularly useful in supporting students' acquisition of knowledge and skills: the ability to reproduce and perform repetitive tasks accurately; flexibility, interactivity, humanoid aspect; the ability to move and move one's body. Secondly, robots can facilitate learning, acting on student motivation, through practical experiences that create an engaging, attractive, and interactive learning environment. Specifically, sector studies highlight how educational robotics:
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i. favors the development of computational thinking [14]
ii. develops problem solving by facing and solving real situations and challenges [15]
iii. promotes the learning of abstract concepts in concrete contexts of exploration and discovery [16]
iv. supports students with attention difficulties by making them more responsive and inclined to listen [17]
v. improves relational skills [18]
vi. supports the development of creative thinking [19].

1.1. AIR for personalized learning

Recent developments in AI and robotics support teachers by automating activities based on predefined formats that deliver personalized and adaptive instruction [20] [21]: from monitoring student progress [22] to designing teaching activities through management tools based on AI tutors. Currently the main applications subject to experimentation of AIR in school contexts refer to the field of personalized learning in relation to the individual needs of students.

Personalized learning prioritizes the specificities of each student, allowing them to offer differentiated and flexible teaching solutions. In particular, tutoring systems based on AI and robotics, which consider the different elements that are involved in the knowledge processes of students, can have a relevant impact and make learning more meaningful.

In educational-didactic contexts, robotics finds application above all in contexts in which reinforcement learning is necessary to progressively adapt the difficulty of the proposed exercises to the knowledge and skills achieved by the students [23]. Specifically, Han, Kang and Hong [24] highlight how robot-assisted learning (RALL- Robot-Assisted Language Learning) can positively contribute to improving students' motivation and performance in language learning.

Huang [25] reports the results of an experimentation that involved the use of an AI-based educational robot to innovate English language teaching resources in primary school (vocabulary, role-playing games and free dialogue) to support attention and initiative of children. Specifically, some experimentations have introduced an educational artificial intelligence robot based on voice interaction to promote the development of personalized, accurate and intelligent teaching.

The system is based on three aspects: speech recognition, interaction management and speech synthesis. The recognition accuracy is improved by the algorithm. The results show that the accuracy of the AI speech recognition system can reach 90%, allowing the robot to communicate with students and timely answer their questions [26]. In this regard, Karales et al. [27] highlight how artificial intelligence and educational robotics can effectively support teaching scenarios in future K-12 curricula.

1.2. AIR for creative learning

There is a growing scientific literature concerning educational robotics, artificial intelligence, and creative learning [28] [29] [30] [31]. In this regard, there are two main points of attention:

1. educational robotics and artificial intelligence to promote and develop creativity, with reference to the processes of construction and programming of

robots in the context of existing models of creative cognition;
2. educational robotics and artificial intelligence to study and better understand the creative process embodied in artificial agents [19].

With reference to the first point, the process of building robotic models is characterized by a constant search and movement between thought and generative strategies and thought and exploratory strategies and vice versa. In relation to the second point, to be able to simulate the creative process, robots as autonomous agents must be able to:

- Acquire and lean new knowledge.
- Activate and re-use knowledge in a wide range of environments.
- Select and modify problem solving strategies.
- Use meta-reasoning to define and redefine problems, evaluate process and artifacts.

AI embodied inside a robot poses new and interesting challenges to educational robotics. The AI machine must be able to incorporate new input data generated by multiple sensors and to update its internal representation of the world, integrating the new information with what the robot itself already has.

In this way, the robot can "learn" from its own experience, read data, and build hierarchical architectures of knowledge that provide advanced levels of input and output [32].

3. Learning for AIR

The growing development of AI technology and robotics in society finds a fundamental interlocutor in school education. In response to this necessary dialogue, recent studies and research have developed innovative teaching materials for AI and robotics education, as well as proposals for integration into the school curriculum [33] [34] [35].

Williams, Won Park, Oh and Breazeal [36] propose an early childhood AI curriculum based on knowledge of AI principles through the construction and programming of robots. Children are confronted with AI in the form of smart toys (Bee Bot, Blue-Bot, Cubetto, Ozobot and Dash and Dot) and educational and entertainment content declined in the classroom with a computational approach.

Pre-schoolers train and interact with social robots to learn about knowledge-based intelligent systems, supervised machine learning and generative AI. An example of a curriculum promoting AI education in kindergarten was proposed by Williams et al. [37] in the experimentation of the “PopBots”; it is a hands-on toolkit and curriculum designed to support children in learning about AI by building, programming, training and interacting with a social robot.

Hsu et al. [38] identify some key strategies that place in successive phases from primary to secondary school: integrate the knowledge base within the curriculum; select some content for systematic knowledge; develop AI talents in the profession.

In response to the growing demand for AI education, development environments integrated with programming blocks such as Machine Learning for Kids, eCraft2Learn and Cognimates have been developed on specific online platforms.

These environments provide many AI experiences and learning activities that allow young users to engage in the creation of a customized AI project and to understand its applications [38]. In this context, the open-source project AIR4Children: Artificial Intelligence and Robotics for Children [11] is significant: on the one hand it addresses aspects concerning inclusion, accessibility, transparency, equity and participation, on the other it aims at the design and creation of open learning materials on AI and ER, made available to children from different socioeconomic backgrounds.

Specifically, educational materials with child-focused programming languages and customization of open source robots aim to refine an AIR curriculum for children. STEM-based robotic tools, especially select robotic kits with machine learning (ML) capabilities, can be used to address ML concepts in K-12 classrooms [27].

These elements of attention have led to the progressive development of a training system. In fact, since AIR is an integral part of the industry 4.0 era, it becomes necessary to introduce AI and Robotics literacy with reference to primary and secondary education. Hence the need to train educators and teachers by providing them with adequate tools and methods to achieve this goal.

This need has led to the definition of a standardized and internationally recognized certification system – European Patent for Robots and Intelligent Systems – EDLRIS – for AI and robotics at K-12 level, aimed at teachers and students to promote their literacy. This license is based on several projects previously implemented and evaluated and includes teaching curricula and training modules on artificial intelligence and robotics, following a blended learning approach based on the acquisition of specific skills.

The application, through an innovative approach, of a standardized and widely recognized training and certification system for AI and robotics at the K-12 level for both high school teachers and students, thus aims to promote the literacy on AI/Robotics [33].

4. Conclusions

With reference to the studies and the proposals and experimentations presented here - which demonstrate a growing interest in AIR systems to support teaching and learning processes - it should however be noted that:

1. scientific research on the theme of the curriculum for Education to the Artificial Intelligence and robotics, especially in early childhood, is particularly lacking;
2. the use of AI and robotics applications is still limited in school teaching, following resistance given both by economic concerns (high costs and adaptation to system requirements) and by aspects concerning privacy (Bailey, 2019).

In fact, in the face of a growing number of RE and AI experimentations in education, most of the proposed projects tend to focus more on the development of technical skills than on critical reflection which presupposes adequate training upstream. Therefore, it is urgent to invest in the construction of curricular proposals that also take into account ethical, cultural and social aspects and that promote an AI culture.

Specifically, a training in AIR represents a priority condition for making students critical users, planners responsible for the educational dialogue and for the construction of knowledge.

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