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A COMPREHENSIVE REVIEW OF THE USE OF ROBOTS IN EDUCATION

Malak T. Pashazada

Baku State University

Abstract

This paper presents a comprehensive review of the application of robots in education. The review explores how robots enhance learning experiences across different educational levels, their impact on student engagement and cognitive development, and the perceptions of educators, parents, and students regarding their use. The challenges and future directions in this field are also discussed to provide a roadmap for further research.

1. Introduction

With the rapid advancements in technology, robots have become integral to various aspects of modern education. Their role extends beyond traditional teaching tools to actively engaging students in interactive and immersive learning experiences. This review analyzes various perspectives to provide a holistic understanding of the effectiveness, challenges, and future potential of educational

** Corresponding author.
E-mail address:

robots.

The Role of Robots in Education

Robots serve multiple functions in educational settings:

a.   Teaching Assistants – Robots can assist educators in delivering lessons, answering queries, and providing personalized learning experiences.

b.   Interactive Learning Companions – Robots enhance student engagement by creating interactive and dynamic learning environments.

c.   Skill Development Tools – Robotics fosters problem-solving, teamwork, and computational thinking skills among students.

d.   Language and Social Development – Robots aid in language learning and social interactions, especially among young learners.

2.   Key Areas of Impact

2.1. Cognitive and Conceptual Development

Studies show that robots contribute significantly to cognitive skill development, including problem-solving abilities, logical reasoning, and conceptual understanding of subjects like mathematics and science. Robotics-based learning encourages hands-on activities that improve students' engagement and retention of knowledge.

2.2. Social and Collaborative Skills

Robots facilitate teamwork and collaboration [4] in classroom environments. Group-based robotics activities help students develop essential skills such as cooperation, leadership, and communication.

2.3. Language and Communication Enhancement

Humanoid and interactive robots have been successfully used in teaching second languages, storytelling, and interactive reading exercises. Their ability to provide immediate feedback and encourage participation improves students' confidence in communication.

There are several examples to usage of robots in education. Let's take a look to them and their benefits and downsides.

3. The Role of Robots in Education: Benefits, Challenges, and Future Prospects

3.1. Pepper.

Firstly, Pepper robots can be example of robots. İt developed by SoftBank Robotics (initially developed by Aldebaran Robotics, later acquired by SoftBank in 2015), released year is 2014, and origin country is Japan. [1]

Pepper is a sociable humanoid robot designed to serve as a home companion and assist customers in retail environments. It engages through speech, gestures, and an expressive demeanor aimed at spreading positivity. İt didn't use for education, but if it improve and donate some features, it can be used, and even now it gives positive result on children.

3.2.Kaspar.

Second example can be Kaspar. It developed by researchers of University of Hertfordshire in 2005. Origin country is United Kingdom. [2]

Kaspar is a humanoid robot, roughly child-sized, with a simplified yet expressive face. It has been utilized in therapeutic settings for children with autism and serves as a research tool for studying social robotics. Cost: €250,000.

3.3.AV1.

The AV1 robot, developed by Norwegian company No Isolation, helps chronically ill children stay connected with their classrooms by serving as their eyes, ears, and voice. [3] The device, which resembles a simplified human head and torso, is equipped with a camera, microphone, and speaker, allowing students to control it remotely through an app. Currently, 3,000 AV1 units are active in 17 countries, with over 1,000 in both the UK and Germany. In the UK, schools can rent the robot for £150 ($200) per month or purchase it for £3,700 ($4,960), with an optional annual service package costing £780 ($1,045).

3.4. Social robots.

Social robots in education, [5] particularly as tutoring agents rather than instructional tools for STEM subjects. The study addresses three key questions: (1) How effective are robot tutors in improving learning? (2) How do a robot's design and behavior influence education? (3) What roles can robots play in learning environments? A meta-analysis of existing literature supports the findings.

Key Insights:

- **Advantages over virtual agents**: While virtual tutors on screens are cost-effective and easy to maintain, **physically present robots** foster better engagement, encourage social behaviors beneficial to learning, and lead to greater educational gains.

- **Physical presence matters**: Robots are more effective for **teaching skills requiring physical interaction**, such as handwriting or sports, and for **young children and visually impaired learners**, who may struggle with screen-based education.

- **Better engagement and compliance**: Students respond **more positively to physical robots**, increasing their willingness to follow instructions and actively participate in learning activities.

- **Enhanced learning outcomes**: Compared to virtual agents, robots **accelerate cognitive development, promote positive behavioral changes, and improve task performance**.

4.Perceptions of Stakeholders

4.1. Educators' Perspectives

Teachers acknowledge the benefits of robots in making learning more engaging and effective. However, some express concerns regarding the technical complexity and the need for specialized training to integrate robots into their teaching methodologies.

4.2. Parents' Views

Parental perception of educational robots is mixed. While many see the potential benefits, others are skeptical about over-reliance on technology and the cost implications.

4.3. Students' Reactions

Children generally respond positively to robots, perceiving them as engaging and helpful learning companions. Their interaction with robots fosters curiosity, motivation, and a more profound interest in STEM subjects.

5.Challenges in Implementing Educational Robots

Despite the numerous benefits, several challenges hinder the widespread adoption of robots in education:

5.1.   High Costs – The cost of acquiring and maintaining robotic systems remains a barrier for many institutions.

5.2.   Technical Complexity – Teachers require adequate training to effectively integrate robots into their curricula.

5.3.   Limited Research on Long-Term Effects – While short-term benefits are evident, long-term studies on the impact of robots on education are limited.

5.4.   Design and Usability Concerns – Robot design influences students' engagement; more research is needed to optimize their appearance and functionalities for educational purposes.

This table outlines key challenges associated with integrating robotics into education, including financial, technical, and design-related barriers. It also presents potential solutions to enhance accessibility, usability, and long-term effectiveness, ensuring that educational robots can be successfully implemented in learning environments.

Challenges and Solutions in Educational Robotics

Challenge	Description	Potential Solutions

High Costs	The acquisition and maintenance of educational robots require significant financial investment, making them less accessible to many institutions.	Develop cost-effective robotic solutions to make them more accessible.
Technical Complexity	Teachers need specialized training to effectively integrate robots into their curricula, which requires additional time and resources.	Provide comprehensive training programs and support systems for educators.
Limited Research on Long-Term Effects	While short-term benefits are evident, long-term studies on the impact of robots in education are limited, leaving uncertainties about their effectiveness over time.	Conduct longitudinal studies to assess the long-term benefits and challenges.
Design and Usability Concerns	The design of robots plays a crucial role in student engagement. More research is needed to optimize their	Enhance the design of robots to align with students' learning preferences and engagement needs.

	appearance and functionality for educational purposes.	

6.Future Directions and Recommendations

To maximize the potential of robots in education, the following areas require further exploration:

• Developing Cost-Effective Robotic Solutions – More affordable and accessible robotic systems should be designed for widespread educational use.

• Enhancing Teacher Training Programs – Comprehensive training should be provided to educators to ensure effective implementation.

• Expanding Research on Long-Term Impact – Longitudinal studies should be conducted to assess the long-term effectiveness of robots in education.

• Improving Robot Design – Considerations should be made regarding the physical and interactive design of robots to enhance engagement and learning outcomes.

At the same time, the research and integration of previously developed and utilized program modules in education, as well as their further improvement, remains a subject of future study. In our modern era, where technology integrates into every field, it is essential to flawlessly implement it in the education system. To achieve this, all existing programs, online meeting platforms designed for schools, and similar systems must be thoroughly examined. Later, integrating them into educational robots and combining their capabilities will bring innovation to the field of education, fundamentally transforming learning methods in a positive way.

Educational robots hold immense potential to transform traditional learning methods and foster an engaging and interactive learning environment. While challenges remain, continued research and technological advancements will likely lead to broader acceptance and integration of robots in educational settings. By addressing cost, training, and design concerns, robots can become indispensable tools for the future of education.

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