Research Article

Exploring the Potential of Educational Robots in India: A Study of Scope and Challenges

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Abstract

India's development is significantly influenced by education. The education system in India dates back to ancient times and has evolved substantially over the years. India has always encouraged innovative methods of instruction to raise the standard of education in the country. However, the education system had not undergone major structural shifts until the pandemic. Since the pandemic, innovative online tools and media have become an essential part of the education system, and the education system in India has gradually shifted from the traditional model to a hybrid mode of education. This gradual shift offers space to study the potential scope and challenges of introducing educational robots into the system. Studies in countries like the US demonstrate that learning with the help of educational robots from an early age can enable children to enhance multiple capabilities. This paper titled 'Exploring the Potential of Educational Robots in India: A Study of Scope and Challenges' aims to analyse the scope and challenges of using educational robots in India at various levels and attempts to expand the pedagogical possibilities of this field. Based on an analysis of existing literature on the benefits of educational robots and the socio-cultural background of education in India, the study looks at the various possibilities of incorporating educational robots in India and puts forth certain recommendations based on studies conducted in other countries to integrate educational robots into the education system in India effectively.

Keywords: Educational robots, challenges, new technology, pedagogical possibility, scope

Introduction

Technological advancements in robotics and artificial intelligence have accelerated in the past decade, leading to the development of humanoid robots with human-like features. From their humble beginnings as single-task machines, robots have evolved remarkably, inspiring great possibilities in their interaction with humans (Sisman et al., 2019). These advancements have led to the integration of humanoid robots, designed to interact with humans, in various sectors worldwide, including healthcare, business, and education.

Within the field of education, the emergence of educational robotics has gained significant traction in recent years. Educational robots emerged from the combination of electronics and mechanical toys in the 1980s, giving rise to simplified versions of commercial robots explicitly designed for educational purposes (Leoste & Heidmets, 2019). The potential of educational robots was first explored

through the Logo Turtle project, initiated by Seymour Papert and Marvin Minsky at the MIT Artificial Intelligence Academy in 1967 (Leoste & Heidmets, 2019). This early endeavour laid the foundation for the development of educational robots, aiming to enhance the learning experiences of students. Further, Seymour Papert expanded the Logo computer language in 1969, introducing the first educational robot, the Turtle, to educate children. Notably, a study conducted in 1976 by MIT and Edinburgh University showcased the benefits of using a robot Turtle to assist a child with autism. According to the study, the interaction with the robot resulted in significant improvements in the child's communication skills and language development (Catlin & Blamires, 2019).

Today, various types of educational robots are available in the market, such as pre-assembled robots and robotics kits. While pre-assembled robots offer ease of use but limited customisation, robotics kits provide flexibility, allowing users to design and build robots tailored to specific tasks. The applications of educational robots extend to technical teaching, language studies, and science and technology, demonstrating their versatility and potential (Broadbent, 2017), and subsequent studies have shown the positive impacts of educational robots in various educational contexts. As a result, numerous countries, including the United States, have incorporated educational robots into their education systems to enrich teaching and learning experiences, fostering enhanced knowledge, cognitive skills, mathematical and computational thinking, and interactivity among students (Iberdrola, n.d.).

As a developing country embracing educational innovations, India presents a fertile ground for introducing educational robots. The Indus International School in Bengaluru has already introduced an Eagle 2.0 humanoid robot into its classroom on an experimental basis to unlock the potential of humanoids within the education sector. However, the adoption of educational robots in India faces challenges stemming from socio-cultural and economic factors. Overcoming these challenges requires supervised and efficient implementation, leading to the effective utilisation of educational robots, which can revolutionise the learning experience and drive technological advancements within the country.

Therefore, this article aims to analyse the scope of introducing educational robots into the Indian education system, with a focus on enhancing the education system in India. By reviewing existing studies on the use of educational robots and addressing the significant challenges that hinder the introduction of educational robots in India, this study seeks to provide recommendations for overcoming these obstacles and promoting the effective integration of educational robots in the Indian context.

Research Objectives

- To study the scope of incorporating educational robots into the Indian education system through a review of existing literature
- To trace the challenges of incorporating educational robots within the Indian education system.

Methodology

The data for this research paper was collected through an extensive review of available literature. A comprehensive search was conducted to identify relevant research articles, seminar papers, conference proceedings, reports, discussions, and website information pertaining to the use of

educational robots and the challenges associated with their integration into the Indian education system. Keywords such as "educational robots," "robotics in education," "Indian education system," and "challenges" were used to ensure the inclusion of relevant studies. The review aimed to gather insights and expert opinions on the scope and challenges of using educational robots in the Indian education system. The data collected from the literature review was subjected to a thorough analysis and the findings below are supported by evidence and examples drawn from the reviewed literature.

Scope of Educational Robots: An International Perspective

Educational robots have gained significant popularity and have been widely utilised in classrooms and extracurricular activities in schools (Ben-Ari & Mondada, 2018). Many countries have incorporated educational robots within their education system as instructional tools (Lau et al., 1999; Wang, 2004), learning aids (Kory & Breazeal, 2014; Kory et al., 2013), and teaching companions (Han & Kim, 2009; You et al., 2006). For example, over the last decade, Spain has been using a Python-based Arduino robot called PYBOKIDS. Similarly, as studies suggested that educational robots facilitate learning and enable students to efficiently understand concepts, an educational framework using real and simulated robots was successfully used by more than 2000 real students in six schools (Vega & Canas, 2019). Similarly, the number of robots that are used in educational activities in kindergarten and primary school has increased exponentially over the decade (Papadakis, 2020). They were found to increase students' attention and involvement (Rubenstein et al., 2015), particularly in STEM subjects (Khanlari & Mansourkiaie, 2015; Zhong et al., 2020; Cetin & Demircan, 2020). The hands-on nature of educational robotics was found to engage students and spark their interest in the topic, leading to improved cognitive and social skills (Papadakis, 2020). As a result, the application of educational robots extended across various disciplines, including science, mathematics, and engineering. In these fields, robots played a crucial role in demystifying abstract concepts and improved essential skills such as spatial ability, selective attention, risk-taking, and decision-making (Papadakis, 2020).

Studies have also consistently shown that robots have the potential to inspire and engage students in the classroom while fostering the development of mathematical abilities (Leoste & Heidmets, 2019). Moreover, robots have been found to positively impact students' learning motivation (Leoste & Heidmets, 2019) and cognitive skills (Iberdrola, n.d.) and educational robotics have been found to be effective in promoting innovative thinking, successful teamwork, and effective communication among students. Participating in educational robotics environments allowed children to construct models of cognitive processes, fostering their problem-solving abilities and encouraging collaboration (Papadakis, 2020). For example, in the World Robot Olympiad, where participants were tasked with building robots using LEGO, students experienced enhanced communication skills, problem-solving capabilities, and overall knowledge of robotics (Chiang et al., 2020).

Internationally, educational robots were also found to play a crucial role in special education needs. They have been utilised for the intellectual growth and development of children and youth, offering new possibilities in the educational field (Mubin et al., 2013). Research indicates that educational robots increase the attention span

and efficiency of students with poor concentration ability, providing them with additional support in their education (Sillanpaa, 2021). Thus, the findings of numerous studies emphasise the positive impact of educational robots on the educational landscape (Reich-Stiebert et al., 2019), and the wide acceptance and positive outcomes observed in different countries emphasise the transformative power of educational robots in enhancing education and knowledge transfer on an international scale.

Scope of Educational Robots in the Indian Context

India's education system has a long and esteemed history rooted in ancient traditions of knowledge dissemination. From the Gurukula system, where students learned through personal interactions with gurus, to the establishment of renowned centres of learning like Nalanda and Takshashila, education has always held a pivotal role in Indian society. The modern education system in India was introduced during the colonial era, heavily influenced by European college systems and printing. However, it was post-independence that India made significant strides towards providing universal access to education and enhancing the overall educational landscape. Recognising the importance of technological advancements, India integrated ICT into its education system in 2004, embracing the potential of digital tools to enhance learning experiences and knowledge dissemination. Today, India's educational system stands as the world's largest and most potent, with a literacy rate of 73 per cent as of 2011 and more than 315 million students (Talentedge Learning Series, n.d.).

In recent years, India has witnessed significant changes in the teaching-learning process, particularly due to the impact of the COVID-19 pandemic. The pandemic initially caused disruptions and chaos in the education system. However, it also presented an opportunity to accelerate the integration of technology and enhance the technological infrastructure in India's education sector (Jena, 2020a). As schools and institutions adapted to the new normal, a shift towards blended learning, the use of Learning Management Systems, online collaborative work, and enhanced digital literacy became prominent features of education in India (Jena, 2020b).

Looking ahead, India aims to restructure its education system by 2025, as outlined in the National Education Policy (NEP) 2020. The policy emphasises the equitable use of technology in education and calls for a change in the current pedagogical practices. In this context, introducing educational robots holds tremendous potential to facilitate the necessary pedagogical shifts envisioned by the NEP 2020. By leveraging the capabilities of educational robots, India can enhance the learning experience, foster student engagement, and promote innovative and interactive teaching methods that align with the evolving needs of students and the goals of the education system.

Primarily, educational robots can offer a viable solution for one of the significant challenges that persist within the Indian context, that is, the lack of necessary resources and teaching faculties, as well as a reduced number of children attending school, especially in rural areas. With an estimated 430 million children aged 0-18, a substantial portion of the population resides in rural areas where the rural-urban enrolment ratio stands at 7:5 (Barik et al., 2019). Alarming statistics from the Annual Status of Education Report (ASER) 2019 reveal that nearly 60 per cent of rural students up to the age of 10 struggle with reading, and even after completing higher classes, many lack the ability to solve basic mathematical problems

or comprehend textbooks from lower grades (Barik et al., 2019). Thus, the introduction of humanoid robots holds tremendous promise, particularly in locations across India with a scarcity of teaching faculties. Humanoid robots offer superior performance, as they can teach anywhere without experiencing stress or fatigue. Unlike humans, robots can maintain high levels of consistency and accuracy for extended periods without breaks. Given the increasing shortage of teachers in rural areas, the introduction of a single humanoid robot can have a profound impact, surpassing the capacity and performance of human teachers in terms of numbers (Barik et al., 2019). Also, these robots have the potential to revolutionise the learning experience of students by providing consistent and quality education to students in remote areas. Deploying humanoid robots can also supplement the existing educational infrastructure, offering personalised instruction, interactive learning experiences, and continuous support. This innovative approach can play a pivotal role in bridging the educational gaps and empowering students with the necessary skills for a brighter future.

In line with the findings of Barik et al. (2019), the introduction of educational robots in India also holds the potential to increase literacy rates and facilitate error-free knowledge transfer significantly. Firstly, educational robots provide 24/7 accessibility to educational content. Students can engage with the robots' interactive lessons and materials at any time, allowing flexible learning opportunities catering to individual schedules and preferences. This accessibility promotes continuous learning and enables students to reinforce their understanding of concepts outside traditional classroom hours. The automatic updates and extensive databases of educational robots ensure that students receive the most up-to-date and accurate information. These robots can access a wealth of knowledge across various subjects and disciplines, providing comprehensive and interdisciplinary learning experiences. Also, educational robots simplify the testing and evaluation processes by utilising real-time data analysis and offer personalised instruction. They can track students' progress, identify areas of strengths and weaknesses, and provide immediate feedback. This enables students to track their own growth, address areas that require improvement, and engage in targeted practice and revision. By collecting and analysing data on individual student's performance and learning patterns, robots can tailor instruction to meet each student's specific needs. This personalised approach enhances engagement, promotes a profound understanding, and supports individualised learning pathways.

Moreover, educational robots offer cost-effectiveness in comparison to traditional teaching methods. Once the initial investment is made, these robots can simultaneously deliver instruction to numerous students, reducing the need for additional resources and personnel. This cost-effectiveness makes educational robots a viable solution for resource-constrained settings in India, such as in rural areas, where access to quality education is often limited. Additionally, the multilingual capabilities of humanoid robots are particularly valuable in a diverse country like India. These robots can communicate and interact with students in different languages, accommodating linguistic diversity and ensuring effective communication between the robot and students (Engwall & Lopes, 2022). This facilitates better comprehension and engagement, especially for students who may feel more comfortable

expressing themselves in their native language.

Thus, the integration of educational robots within the Indian education system represents a transformative opportunity. By leveraging technology and embracing the potential of educational robots, India can enhance the accessibility, quality, and equity of education. These robots have the capacity to support personalised learning, bridge resource gaps, and cater to the diverse needs of students across the country. As India continues to navigate the changing landscape of education, educational robots offer immense potential to revolutionise teaching and learning practices, ensuring a brighter future for all students.

Major Challenges

Although the introduction of educational robots in India is promising, the process must address numerous challenges for successful implementation. One of the major challenges is the lack of resources, including infrastructure, funding, and technological support. Many schools in India, particularly those in rural areas, face significant resource constraints, making it difficult to integrate educational robots into their classrooms. The quality and infrastructure of educational institutions vary widely across India (Sankar, 2020). While some schools may be well-equipped to integrate educational robots, others may lack the necessary resources and support systems. Limited access to technology and inadequate facilities hinder the adoption of these advanced tools (Kumar, n.d.). Addressing these institutional differences and ensuring equal access to educational opportunities for all students is crucial to avoid exacerbating existing educational inequalities.

India's cultural diversity is another significant factor that must be considered. With a multitude of languages, customs, and traditions across different regions, adapting educational robots to suit the diverse cultural contexts of India becomes a complex task. It is essential to ensure that the content and instructional methods employed by educational robots are inclusive and sensitive to the cultural nuances of the country.

The digital divide within the country also poses a significant challenge in India (Laskar, 2023). While urban areas have witnessed advancements in technology, a significant portion of the population, particularly in rural and remote areas, still lacks access to reliable internet connectivity and basic technological infrastructure. Bridging this digital divide and ensuring equitable access to educational resources and opportunities are crucial for the successful integration of educational robots across the country. Technological illiteracy among educators and students is another hurdle. Many teachers and students may need to gain the necessary skills and familiarity with educational robots and their functionalities. Providing comprehensive training and support to educators is vital to enable them to utilise these tools in the teaching-learning process effectively. Simultaneously, students must be empowered with the digital literacy skills required to engage with educational robots and benefit from their use.

The level of education provided by educational robots is also a pressing concern specific to India (van Ewijk et al., 2020). While robots can deliver strategies and solutions, they may lack the deeper understanding required to foster critical thinking and conceptual understanding in students. Striking a balance between providing guidance and promoting independent thinking is essential for educational robots to complement and enhance the existing pedagogical approaches in India.

Moreover, the psychological well-being and emotional growth of students must be considered (van Ewijk et al., 2020). Human interaction and emotional connection play a crucial role in the Indian education system. The consistent and neutral responses of robots may pose challenges in fostering emotional development among students. Creating a supportive and nurturing learning environment alongside the use of educational robots is essential to address this concern.

Finally, privacy becomes a critical aspect when implementing educational robots in India. The collection of sensitive data, such as audio and video recordings, during interactions with students, raises concerns about privacy and data protection. Safeguarding student privacy through robust security measures, informed consent, and data anonymisation is essential to build trust and ensure the ethical use of educational robots (van Ewijk et al., 2020).

Thus, the integration of educational robots within the Indian education system encounters specific challenges, including resource constraints, cultural diversity, the digital divide, technological illiteracy, institutional differences, level of education provided, psychological well-being, and privacy concerns. Addressing these challenges within the Indian context requires a comprehensive approach, including adequate infrastructure, cultural adaptation, training programs, digital literacy initiatives, and privacy safeguards. By addressing these challenges, India can harness the potential of educational robots to enhance teaching and learning experiences and promote equitable access to quality education.

Recommendation

Based on the analysis of challenges that hinder the effective implementation of educational robots in India, several measures can be taken to ensure the proper integration of educational robots into the Indian education system. First and foremost, it is crucial to create awareness among the general population about the benefits and potential of educational robots. Generating a positive attitude towards the implementation of educational robots can be achieved by educating people about the positive impact they can have on learning outcomes. According to Reich-Stiebert et al. (2019), involving stakeholders, including educators, policymakers, and the general public, in the design and decision-making processes can foster a sense of ownership and acceptance of educational robots.

Likewise, introducing educational robots at the early stages of schooling can be challenging, as it requires technical requirements and a supportive environment. To overcome this, educators must develop methods and approaches that make robotics fun and interesting for students. Educators can engage students in the learning process by incorporating hands-on and interactive activities using educational robots, fostering a sense of curiosity and exploration. Furthermore, providing quality training to teachers is crucial to equip them with the necessary skills to integrate educational robots effectively into their teaching practices. This training should focus on creating an interactive and engaging learning environment that maximises the benefits of educational robots (Papadakis, 2020).

Privacy and ethical considerations should also be made essential when dealing with personal details and interactions of students. Establishing secure privacy settings and adhering to ethical guidelines are necessary to protect the confidentiality and privacy of students. It is crucial to maintain trust and confidence in the educational system by ensuring the responsible

use of personal information and data (van Ewijk et al., 2020) collected by educational robots.

Additionally, efforts should be made to bridge the digital divide and ensure equal access to educational robots and technology. Introducing educational robots initially in rural areas, where the digital disparity is more pronounced, can help address this divide. While it may require additional investment, ensuring equal access to technology across rural and urban areas is vital for providing equitable educational opportunities to all students.

By implementing these measures and investing in comprehensive planning, the potential challenges associated with integrating educational robots into the Indian education system can be overcome. This will pave the way for the effective use of educational robots and significantly enhance the learning experiences of students across the country. With proper awareness, engaging teaching practices, privacy safeguards, and bridging the digital divide, educational robots can become a valuable tool in transforming the Indian education system.

Conclusion

The transition from the traditional education system to educational robots is gradually progressing around the globe. Further research and improvement in artificial intelligence might come up with humanoids that could create paradigm shifts in the global education scenario. As a country leaping towards becoming a global leader, the introduction of humanoids into multiple sectors in India, especially education, is prospective. This can not only diminish the educational disparity and digital divide within the country but also enable rapid technological and economic advancement. With up-to-date knowledge transmission and personal attention using educational robots, the Indian education system can ensure quality education for rural and urban populations. In the Indian context, the introduction of education robots has the scope to boost its technological advancements. Although the process of integrating educational robots into the current education system has to overcome socio-economic, cultural and geographical challenges, the gradual introduction of educational robots within the country, especially in areas that do not have access to quality education, and further large-scale implementation-based on effectiveness, can be helpful. Thus, with the proper integration of educational robots into the education system in India, both the students and teachers can enhance their skills and knowledge and add to the nation's development.

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