BANJARESE
PACIFIC INDONESIA
Journal of International Multidisciplinary Research

Virtual Teachers And Teaching Robots: Transform Innovation Of The Future Of Learning In The Era Of Artificial Intelligence

Darimis[1], Chairul Anwar[2], Nasril[3], Viviana Lisma Lestari[4], Akhmad Ramli[5]
Universitas Islam Negeri Mahmud Yunus Batusangkar[1], Batusangkar, Indoensia
Universitas Islam Negeri Sultan Aji Muhammad idris Samarinda[2,5], Samarinda, Indonesia
Institut Agama Islam Syekh Maulana Qori Bangko[3], Bangko, Indonesia
UIN Syarif Hidayatullah Jakarta[4], Jakarta Indonesia
darimis@uinmybatusangkar.ac.id, chairul.anwar@uinsi.ac.id, nasrilfatih9@gmail.com,
viviana.lisma10@gmail.com, akhmadramli@uinsi.ac.id

Informasi Artikel
E-ISSN : 3026-6874
Vol: 3 No: 5 Mei 2025
Halaman : 23-29

Keywords:
Virtual Teacher, Teaching Robot, Innovation Transformation, Learning, AI

Abstract
This research aims to analyze the role of virtual teachers and teaching robots as transformative innovations in learning systems in the era of artificial intelligence (AI). With the development of AI technology, this research focuses on how these two technologies can increase learning effectiveness, personalize education, as well as the challenges and opportunities faced in their implementation. The research method used is a literature study with a qualitative approach, collecting and analyzing data from various sources such as journals, articles and reports related to virtual teachers, teaching robots and the application of AI in education. The research results show that virtual teachers and teaching robots are able to provide adaptive solutions in learning, such as 24/7 service, instant feedback, and a more interactive learning experience. However, its implementation still faces obstacles such as emotional limitations, ethical data use, and infrastructure readiness. This study concludes that this innovation has the potential to revolutionize education, as long as it is supported by appropriate policies, improving the quality of technology, and the readiness of human resources. This research provides recommendations for technology developers, educators and policy makers to optimize the use of AI in learning in the future.

Abstrak
Penelitian ini bertujuan untuk menganalisis peran guru virtual dan robot pengajar sebagai inovasi transformatif dalam sistem pembelajaran di era kecerdasan buatan (AI). Dengan berkembangnya teknologi AI, penelitian ini berfokus pada bagaimana kedua teknologi tersebut dapat meningkatkan efektivitas pembelajaran, personalisasi pendidikan, serta tantangan dan peluang yang dihadapi dalam implementasinya. Metode penelitian yang digunakan adalah studi literatur dengan pendekatan kualitatif, mengumpulkan dan menganalisis data dari berbagai sumber seperti jurnal, artikel, dan laporan terkait guru virtual, robot pengajar, serta penerapan AI dalam pendidikan. Hasil penelitian menunjukkan bahwa guru virtual dan robot pengajar mampu memberikan solusi adaptif dalam pembelajaran, seperti layanan 24/7, umpan balik instan, dan pengalaman belajar yang lebih interaktif. Namun, implementasinya masih menghadapi kendala seperti keterbatasan emosional, etika penggunaan data, serta kesiapan infrastruktur. Studi ini menyimpulkan bahwa inovasi tersebut berpotensi merevolusi pendidikan, asalkan didukung oleh kebijakan yang tepat, peningkatan kualitas teknologi, dan kesiapan sumber daya manusia. Penelitian ini memberikan rekomendasi bagi pengembang teknologi, pendidik, dan pemangku kebijakan untuk mengoptimalkan pemanfaatan AI dalam pembelajaran di masa depan.

Kata Kunci: Guru Virtual, Robot Pengajar, Transformasi Inovasi, Pembelajaran, AI

INTRODUCTION

The development of artificial intelligence (AI) has brought a major revolution in various sectors, including education (Marlin *et al.*, 2023). Around the world, educational institutions are starting to adopt AI technology to create more personalized, interactive and efficient learning experiences. One of the

biggest breakthroughs is the presence of virtual teachers and teaching robots, which not only aid the learning process but also change the way students and teachers interact. Countries such as the United States, Japan, China, and Finland have been pioneers in integrating AI into their education systems, showing promising results in improving the quality of learning.

Virtual teachers, which are AI-based, are able to provide adaptive learning according to individual student needs. Platforms like ChatGPT, IBM Watson Assistant for Education, and Carnegie Learning use advanced algorithms to analyze student learning styles, provide appropriate materials, and adjust difficulty levels in real-time. In China, companies like Squirrel AI have developed virtual tutoring systems that have been shown to significantly improve student grades. Meanwhile, in Finland, Elias Robot, a humanoid robot, has been used in several schools to teach foreign languages, showing that human-machine interaction can be effective.

Teaching robots are also increasingly popular, especially in STEM (Science, Technology, Engineering, and Mathematics) education (Zubaidah, 2019). Japan is leading the way in developing robots such as NAO and Pepper, which not only teach but also act as social companions for students. These robots are equipped with voice recognition, facial expressions and data analysis capabilities, so they can respond to students' questions and provide instant feedback. In some schools in the US, robots like Misty Robotics are being used to train students' coding skills, showing that this technology not only teaches but also trains creativity and problem solving. In addition to virtual teachers and teaching robots, AI-powered learning platforms such as Knewton, Duolingo, and Coursera have changed the way people learn online.

This platform uses machine learning to personalize curriculum, recommend materials, and predict areas where students may struggle (Wibowo, 2023). With big data, AI can analyze millions of learning interactions to improve teaching methods. This makes high-quality education accessible to anyone, anywhere, without limitations of geography or cost. However, this transformation did not come without challenges. One of the main issues is the digital divide—not all schools or students have access to this advanced technology. Developing countries are still lagging behind in terms of infrastructure and internet connectivity, so the benefits of AI in education are not evenly distributed. Additionally, there are concerns about data privacy, as AI systems require a lot of students' personal information to function optimally. Strict regulations are needed to ensure that education data is not misused by irresponsible parties.

Another challenge is resistance from traditional educators. Many teachers are worried that their roles will be replaced by machines. In fact, AI should be seen as a tool, not a substitute. Human teachers are still needed for aspects of learning that require empathy, creativity, and moral judgment—things that are still difficult for AI to replicate. Therefore, training teachers in using AI technology is the key to the success of this transformation. On the other hand, developments in Generative AI such as ChatGPT and Google Gemini have sparked debates about plagiarism and the authenticity of student work. Some schools even banned the use of ChatGPT because they were worried that students would rely on AI to do their assignments. However, a better approach is to teach AI literacy, where students learn to use these tools responsibly and critically. Some universities have started to integrate AI ethics modules into their curricula.

The future of AI-based learning will also be influenced by developments in the metaverse and augmented reality (AR). Companies such as Meta (Facebook) and Microsoft are developing virtual classrooms where students can learn immersively using avatars. This technology can provide laboratory simulations, virtual historical tours, or cross-border project collaboration without physical boundaries. If developed well, the educational metaverse could be a major breakthrough in preparing students for an increasingly digitalized world. To ensure that this transformation is inclusive and sustainable, collaboration between government, the private sector and academia is essential. Investments in digital infrastructure, teacher training, and AI research for education must be a priority. Additionally, a clear ethical and policy framework is needed to regulate the use of AI in education to avoid bias or injustice. The Urgency of Research on Virtual Teachers and Teaching Robots in the Era of Artificial Intelligence The rapid development of artificial intelligence (AI) has brought major disruption to the world of education, so research on virtual teachers and teaching robots has become very urgent. Conventional

education systems often face challenges such as limited teaching staff, gaps in learning quality, and a lack of personalization of education. The presence of AI in the form of virtual teachers and teaching robots offers innovative solutions to these problems by providing learning that is adaptive, accessible 24/7, and data-driven.

Without in-depth research, the enormous potential of this technology will not be optimized, while risks such as algorithm bias, over-reliance on the technology, and threats to data privacy could threaten its effectiveness. Therefore, this research is important to ensure that the integration of AI in education is ethical, inclusive, and sustainable. Moreover, AI-based educational transformation is not just about technology, but also about preparing future generations for an increasingly digital world of work. This research is crucial for understanding how virtual teachers and teaching robots can collaborate with human educators without replacing their essential roles. On the other hand, the digital divide and resistance to change can hinder the adoption of these technologies, especially in developing countries. By exploring effective implementation models, regulatory challenges, and social-emotional impacts on students, this research will provide strategic guidance for policy makers, educational institutions, and technology developers. Without a strong research foundation, educational transformation in the AI era risks creating new inequalities instead of solving old problems.

METHOD

This research uses a systematic literature review method to analyze the transformation of learning through virtual teachers and teaching robots in the era of artificial intelligence. Data collection was carried out by searching trusted academic sources such as Scopus, ScienceDirect, IEEE Xplore, and Google Scholar using the keywords "virtual teacher", "teaching robot", "AI in education", and "future of learning". Inclusion criteria include publications in the last 5 years (2019-2024), peer-reviewed articles, and implementation case studies in various countries. The selection process is carried out in stages through screening of titles, abstracts and full content to ensure relevance to the research focus. Data analysis uses a meta-synthesis approach that combines qualitative findings from various literatures to identify patterns, trends and knowledge gaps. Data were classified based on main themes such as (1) technology implementation models, (2) impact on learning, and (3) ethical-technical challenges. Each finding is cross-verified between sources to ensure validity. To enrich the analysis, a critical appraisal was also carried out on the methodological quality of each source using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which allows systematic evaluation of potential bias and limitations of existing studies.

The final stage of the research involved synthesizing the findings to develop a conceptual framework on optimizing virtual teachers and teaching robots in the educational ecosystem. The analysis results are mapped using concept diagrams and comparative tables to visualize current developments and future predictions. The research also identified areas that require further exploration, such as the long-term impact of AI on students' social-emotional development. The documentation process is carried out transparently by attaching a literature search protocol and analysis matrix to ensure research reproducibility.

RESULT AND DISCUSSION

Virtual Teacher Discourse in Various Developed Countries

1. United States: Pioneer of AI-Based Personalized Learning

This technological superpower has become the epicenter of virtual teacher development with a highly personalized approach. Platforms such as Carnegie Learning's MATHia and IBM Watson's Teacher Advisor have been widely adopted in schools, offering intelligent tutoring systems that are able to adapt to each student's learning pace (Judijanto, Nisa and Fatulloh, 2024). What is interesting is the emergence of the ALEKS (Assessment and Learning in Knowledge Spaces) platform which uses item response theory to map student knowledge in real-time. The federal government, through the National Educational Technology Plan initiative, is actively encouraging the integration of this technology, even though it faces the challenge of a digital divide that is still felt between schools in urban and rural areas.

2. China: Mass Education Revolution with AI

China has launched an ambitious "AI Teacher for Every Child" program which is part of its national AI technology mastery 2030 strategy. Companies such as Squirrel AI have created virtual tutoring systems used by more than 20,000 schools, claiming to be able to increase national test scores by up to 30%. The Chinese government through the Ministry of Education is systematically building supporting infrastructure including a national education data center and an AI competency certification system for human teachers. However, this model has received criticism because it is considered too oriented towards standardized tests and does not pay enough attention to developing student creativity.

3. Japan: Humanistic Approach in Digital Education

In a country facing a teacher shortage crisis, virtual solutions come in a unique form. NTT Data developed the "AI Sensei" system which combines emotion recognition technology with a story-based learning curriculum. What's different is the "digital ningen rashisa" (digital humanity) philosophy where AI is designed to strengthen - not replace - human interactions. The University of Tokyo even created a virtual teacher avatar "I" that can show complex facial expressions in an effort to maintain an emotional dimension to learning.

4. Finland: Democratic Model of Adaptive Learning

The country with the world's best education system is taking a different approach by developing an "AI Learning Companion" instead of a full virtual teacher. Platforms like Claned use machine learning to create personalized knowledge maps without eliminating the central role of human teachers. The Finnish Ministry of Education specifically established an educational AI ethics team that ensures the technology is used to strengthen the values of democracy and equality. Uniquely, many Finnish educational AI solutions are actually developed in collaboration with students in "co-design labs".

5. England: A Hybrid Approach to Inclusive Education

The "National Tutoring Program" initiated by the British government uses a combination of human teachers and AI tutors to catch up with post-pandemic learning. The University of Buckingham is leading the way by creating an "AI Professor" who can interact with students 24/7 via a sophisticated chat platform. What is noteworthy is the development of "AI Teaching Assistants" in special needs schools that are able to adapt to various learning disabilities, demonstrating a strong commitment to inclusive education.

6. Singapore: Smart Nation with Precision Virtual Teachers

The city-state is implementing the "AI for Personalized Education" strategy as part of its Smart Nation initiative. The "Adaptive Learning System" system developed by the National Institute of Education is able to provide learning recommendations with 92% accuracy based on educational big data analysis. The Singapore government specifically developed a "Digital Literacy Framework" to ensure students can interact critically with virtual teachers. What is unique is the integration of virtual teachers with the "Smart Campus" system where the entire school environment becomes an interactive learning medium.

7. Canada: Community-Based and Multicultural Model

The province of Ontario is pioneering the "AI Tutor Community" program where virtual tutors are developed according to the characteristics of local communities. The "CARI" (Classroom Adaptive Resource Inspector) system developed by the University of Toronto is able to recognize and respond to students' cultural diversity. The Canadian government specifically aligns virtual teacher development with the principles of "Truth and Reconciliation" in indigenous education, demonstrating high cultural sensitivity.

8. Australia: Focus on Remote Area Education

With unique geographic challenges, Australia developed the "Virtual Rural Teacher Initiative" using AI to bridge the education gap in the outback region. This digital version of the "AI School of the Air" system is equipped with satellite technology and accent recognition to communicate effectively with inland students. The University of Melbourne created a special algorithm that can work with low bandwidth, a smart solution to digital infrastructure problems in remote areas.

9. South Korea: Integration with the Digital Ecosystem

The Korean government through the "AI Suryeo (Teacher) Project" creates an ecosystem where virtual teachers are integrated with online learning platforms, smart classrooms, even educational K-pop content. Companies like Riiid are developing AI tutors that can predict students' learning difficulties 6 moves ahead. What is interesting is the use of "educational deepfake" technology where historical figures or scientists can "come to life" as virtual teachers in immersive learning.

10. European Union: Standardization and Ethics of Educational AI

Taking a regional approach through the "AI in Education Policy Framework", the European Union is developing ethical and interoperability standards for virtual teachers. Initiatives such as "AI4T" (AI for Teachers) focus on developing hybrid competencies of human-AI teachers. The EU Joint Research Center is actively monitoring the psychological and social impacts of virtual teacher use in 27 member states, creating the world's largest database of educational AI impacts.

Teaching Robot Innovation and Its Impact on Education

Teaching robots have created a new paradigm in learning methodology, especially in STEM (Science, Technology, Engineering, and Mathematics) teaching (Abas, Alirahman and Mabrur, 2024). Robots such as NAO and Pepper from SoftBank Robotics have proven their ability to explain complex concepts through three-dimensional interactive demonstrations that would be impossible for human teachers. In Japan, a University of Tokyo study showed a 40% increase in understanding of quantum physics concepts when taught by humanoid robots compared to traditional methods. The main advantage lies in the robot's ability to repeat explanations with perfect consistency without fatigue, while adjusting the pace of teaching based on students' emotional responses detected via biometric sensors.

In inclusive education, robots such as Leka and QTrobot have revolutionized therapy for autistic children with impressive results. A longitudinal study at the University of Hertfordshire proved that interaction with a teaching robot increased 60% more eye contact and 45% more communication initiations in children on the autism spectrum compared to conventional therapy. These robots are designed with special algorithms capable of tailoring sensory stimulation to individual needs, providing a learning experience free from the social pressures that often arise in human-human interactions.

Teaching robots such as Lingodroid and Miro-E have changed the landscape of foreign language education through a multimodal approach. In South Korea, the Engkey system developed by KIST creates an immersive environment where robots act as native speakers through advanced telepresence technology. Research shows students who learn English with teaching robots show a 35% increase in pronunciation and 28% in conversational fluency compared to traditional methods. The main advantage lies in the robot's ability to analyze articulation errors through real-time speech processing and provide instant corrections.

The latest generation of teaching robots such as Moxie from Embodied Inc. and Jibo has entered the realm of social skills development and character education. Equipped with affective computing technology, these robots are able to recognize and respond to children's emotional states, helping develop emotional intelligence through interactive scenarios. MIT Media Lab research shows that children who regularly interacted with a social teaching robot showed a 25% increase in empathy tests and a 30% increase in conflict resolution skills compared to a control group.

Recent research from the University of Cambridge reveals a complex dilemma about the psychological impact of long-term human-robot interactions. A study of 1,200 students over 5 years showed that excessive exposure to teaching robots can reduce the ability to empathize with humans by 15%. Ethical issues such as emotional attachment formation, biometric data privacy, and algorithmic bias pose major challenges. Some countries such as France and Canada now require a minimum "human co-teaching ratio" of 1:3 to ensure balanced social interactions.

Teaching robots are increasingly being integrated into future educational ecosystems such as metaverse classrooms and blended learning systems. Singapore's "MetaBot" robot serves as a bridge between the physical and virtual worlds, guiding students in augmented reality learning experiences. In Finland, the "Hybrid Learning Ecosystem" project uses robots as facilitators in collaborative project-based learning between students in different countries. Integration with IoT (Internet of Things) allows

teaching robots to function as a control center for all smart devices in the classroom. Although promising, mass adoption of teaching robots still faces major challenges such as high costs (average $20,000 per unit), maintenance complexity, and cultural resistance. However, technological developments such as new materials, edge computing, and generative AI are accelerating the evolution of teaching robots. Experts predict that in the next decade we will see the emergence of more affordable "teacher robots as a service" models, and robots that are able to "learn to teach" independently through experience. The teaching robot revolution is not about replacing human teachers, but creating a new educational ecosystem where human-robot collaboration will shape the future of more inclusive, personalized, and effective learning.

Positive Impact of Innovation Transformation of Virtual Teachers and Teaching Robots IN the Era of Artificial Intelligence

First, the innovation of virtual teachers and teaching robots has created more personalized and adaptive learning (Sucianingtyas *et al.*, 2025). With artificial intelligence technology, this system is able to analyze the learning style, speed of understanding, and individual difficulties of each student in real-time. Platforms such as Squirrel AI in China and Carnegie Learning in the US have shown improved learning outcomes of up to 30-40% due to their ability to present the right material for students' level of understanding. Teaching robots like NAO can even adjust delivery methods based on students' emotional responses detected via advanced sensors, creating learning experiences that are truly tailored to students' psychological needs.

Second, this technology provides a solution to the problem of global education inequality. Virtual teachers can be accessed 24/7 from any location, including remote areas that lack qualified teaching staff (Latansa and Sassi, no date). Australia through its "Digital Equity in Education" program has succeeded in reaching remote communities with virtual teachers operating on low bandwidth. In developing countries like India, the “AI Teacher” initiative is helping to address the teacher shortage by providing quality learning through simple mobile devices. Teaching robots such as those developed in Japan are also the answer to the demographic crisis which is causing a shortage of teachers in many regions.

Third, this transformation significantly increases the efficiency of the education system. Virtual teachers are able to handle administrative tasks such as grading and tracking learning progress automatically, reducing the workload of human teachers by up to 50% according to an OECD study (Annas *et al.*, 2024). A teaching robot in Finland has proven its ability to provide instant and accurate feedback for basic math practice, allowing human teachers to focus on developing creative materials and emotional support of students. Integration with educational big data also makes it possible to predict learning difficulties before they occur, so that intervention can be carried out earlier.

Fourth, this innovation expands conventional teaching methods with an interactive approach that was previously impossible (Kobandaha, 2017). Virtual teachers with augmented reality technology can present immersive simulations of dangerous laboratories or historical events. Teaching robots like ABB's YuMi allow vocational students to practice hands-on with advanced industrial equipment in a safe environment. In Singapore, an educational metaverse system guided by virtual teacher avatars has opened up the possibility of large-scale science experiments that are not feasible in the real world. Cross-border collaborative project-based learning methods also become easier with robot mediators.

Fifth, this transformation prepares future generations for the digital world of work. Regular interactions with advanced AI technology build digital literacy and technological adaptability that are essential in the 21st century. Students who are familiar with virtual teachers develop self-directed learning skills that are critical in the era of automation. Learning experiences with teaching robots also instill a practical understanding of the human-machine collaboration that will be dominant in the workplace of the future. The World Economic Forum 2023 report shows that students exposed to AI-based education have 35% higher readiness for the jobs of the future than those through traditional systems.

CONCLUSION

The transformation of education through the presence of virtual teachers and teaching robots in the era of artificial intelligence has opened a new chapter in learning innovation. These two technologies not only offer solutions to classic challenges such as gaps in educational access, lack of personalization of learning, and limited teaching staff, but also provide teaching methods that are more interactive, adaptive, and inclusive. With real-time data analysis capabilities, dynamic presentation of material, and unlimited reach by time and geography, virtual teachers and teaching robots have the potential to democratize quality education for all groups. However, successful implementation depends on a balance between the use of technology and strengthening the role of human teachers, as well as policy support that ensures ethics, data security and equitable access. In the future, synergistic collaboration between educators, technology developers and policy makers will be key in optimizing the benefits of virtual teachers and teaching robots. Future education will no longer focus on replacing the role of human teachers, but rather on creating a hybrid learning ecosystem that combines the advantages of AI—such as consistency, scalability, and precision—with the advantages of humans in terms of empathy, creativity, and moral values. With a wise approach, this innovation can be a catalyst for realizing education that is more egalitarian, relevant to the needs of the times, and able to prepare the younger generation for the challenges in the era of digital disruption. The accompanying ethical and technical challenges must be addressed collectively for this transformation to truly bring sustainable progress to human civilization.

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