



Integration Of Artificial Intelligence And Augmented Reality In Learning In The 5.0 Era

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Abstract. Era 5.0 brings significant changes in several aspects of life, including the education sector. The use of Artificial Intelligence (AI) and Augmented Reality (AR) has created new ways to make learning experiences more interactive, adaptive, and personalized. This study aims to examine the integration of AI and AR in learning, exploring the benefits, challenges, and implications of the technology at various levels of education. AI enables the development of intelligent learning systems that can adjust materials according to individual needs, while AR provides interactive visualizations and simulations that enrich the learning process. The results of the study show that the integration of these two technologies can increase student engagement, learning effectiveness, and understanding of complex concepts. However, challenges such as implementation costs, infrastructure readiness, and teacher training remain major obstacles. Therefore, collaboration is needed between educational institutions, the government, and the technology sector to ensure optimal use of AI and AR in supporting education in the 5.0 era.

Keywords: Integration, Artificial Intelligence, Augmented Reality, Learning, Era 5.0

Abstrak. Era 5.0 membawa perubahan signifikan dalam berbagai aspek kehidupan, termasuk sektor pendidikan. Penggunaan Artificial Intelligence (AI) dan Augmented Reality (AR) telah membuka peluang baru untuk menciptakan pengalaman pembelajaran yang lebih interaktif, adaptif, dan personal. Penelitian ini bertujuan untuk mengkaji integrasi AI dan AR dalam pembelajaran, mengeksplorasi manfaat, tantangan, serta implikasi teknologinya di berbagai tingkat pendidikan. AI memungkinkan pengembangan sistem pembelajaran cerdas yang dapat menyesuaikan materi sesuai kebutuhan individu, sementara AR menyediakan visualisasi dan simulasi interaktif yang memperkaya proses pembelajaran. Hasil penelitian menunjukkan bahwa integrasi kedua teknologi ini mampu meningkatkan keterlibatan siswa, efektivitas pembelajaran, dan pemahaman konsep kompleks. Namun, tantangan seperti biaya implementasi, kesiapan infrastruktur, dan pelatihan tenaga pendidik tetap menjadi kendala utama. Oleh karena itu, diperlukan kolaborasi antara institusi pendidikan, pemerintah, dan sektor teknologi untuk memastikan pemanfaatan AI dan AR secara optimal dalam mendukung pendidikan di era 5.0.

Kata kunci: Integrasi, Artificial Intelligence, Augmented Reality, Pembelajaran, Era 5.0

Introduction

Rane et al., (2023) stated that the Society 5.0 era is a stage in the development of human civilization that emphasizes the integration of digital technology and artificial intelligence (AI) into various aspects of life, including education. This idea emphasizes the use of advanced technology to create more humane solutions to global problems like equal access to education, better learning quality, and developing 21st century skills. In the context of education, one of the main trends in this era is the integration of Artificial Intelligence (AI) and Augmented Reality (AR) into the learning process. AI enables more personalized and adaptive learning, with the ability to analyze individual student learning needs. This technology can provide recommendations for materials that are appropriate to the student's level of understanding and facilitate faster and more accurate feedback (Falola et al., 2025). Meanwhile, AR offers a more interactive and immersive learning experience. AR technology can present virtual objects or simulations that are integrated with the real world, so that they can explain abstract concepts more concretely and interestingly. The use of AR can help increase student motivation and strengthen their understanding of learning materials (Gunawan, I. G. D., & Danika, 2023).

According to Akbar, J. S., & Djakariah, D. (2023) the integration of AI and AR in learning has great potential to revolutionize traditional teaching methods. For example, teachers can use AI to monitor student progress in real-time, while AR is used to create a more engaging learning environment. Thus, the learning process is no longer limited to conventional classrooms, but can be accessed anytime and anywhere.

In addition, according to Kharisma et al., (2023) the integration of AI and AR in education also enables an experience-based learning approach. With AR, students can interact directly with three-dimensional models of certain objects, such as human organs, atomic structures, or natural phenomena, which were previously difficult to explain with text or images alone. AI technology, on the other hand, can help in providing scenario-based simulations, such as critical thinking skills training through educational games tailored to the needs of each student.

However, despite its great potential, the implementation of AI and AR in learning is not without challenges. The digital divide between urban and rural areas is one of the main obstacles. Unequal technological infrastructure, such as slow internet access or inadequate hardware, can limit the adoption of this technology in various regions. In addition, the level of technological literacy among educators and students is also an important factor that needs to be considered. Intensive training for educators to understand and apply this technology must be a top priority.

Another challenge that arises according to Papakostas et al., (2024) is related to ethical and privacy aspects. The use of AI requires the collection of user data to improve learning personalization. However, this also poses risks related to data security and student privacy.

Therefore, strict regulations and a clear ethical framework are needed to ensure that this technology is used responsibly.

In addition, the successful integration of AI and AR also requires a collaborative approach between the government, educational institutions, and the private sector. The government can play an important role in providing supportive policies and funding, while the private sector can contribute to the development of innovative technologies. On the other hand, educational institutions need to adapt to these changes through more flexible and technology-based curricula (Taj, I., & Zaman, 2022).

Further research and development is also needed to understand the long-term impact of using AI and AR in learning. Empirical studies evaluating the effectiveness of these technologies in improving student learning outcomes can provide a basis for better decision-making. It is also important to ensure that these technologies are not just additional tools, but are truly integrated into a holistic learning strategy.

Research Methods

This study uses a literature review method to analyze the integration of Artificial Intelligence (AI) and Augmented Reality (AR) in learning in the Society 5.0 era. The literature review was conducted by reviewing various scientific sources, including journals, books, and relevant research reports, to identify trends, challenges, and opportunities related to the use of AI and AR in the education sector. This process involves selecting literature based on the criteria of relevance, credibility, and currency, so that the data obtained can provide a comprehensive picture.

Data analysis was carried out using a descriptive approach, where the information collected was categorized into main themes, such as the benefits of technology in learning, implementation challenges, and strategic recommendations for optimizing the use of AI and AR. With this method, the study is expected to contribute in the form of a theoretical framework that is useful as a basis for further development in the integration of advanced technology for education. In addition, the results of this literature review can be a guide for policy makers and educators in designing innovative learning strategies that are in accordance with the needs of the Society 5.0 era.

Results and Discussion

Era Society 5.0 and the Role of Technology in Human Life

According to Rahmawati et al., (2022) the Society 5.0 era is a new civilization concept first introduced by the Japanese government in response to the rapid growth of digital technology and the industrial revolution 4.0. In this era, technology is not only used to increase efficiency and productivity, but also to create more humane solutions to overcome various global challenges. The concept of Society 5.0 places humans at the center of technological development, with the main goal of creating an inclusive, prosperous, and sustainable society. Society 5.0 goes beyond the limitations of the industrial revolution 4.0 by integrating advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT),

Big Data, and robotics into various aspects of human life. This technology is not only applied in the economic sector, but also in health, education, transportation, and the environment (Ellitan, 2020). Thus, the Society 5.0 era aims to create harmony between technological progress and human welfare. In the context of education, Society 5.0 opens up great opportunities for learning transformation. Education is no longer one-way or teacher-centered, but becomes more interactive, personal, and adaptive. Technology enables wider access to quality learning resources and creates learning experiences that are relevant to the needs of the 21st century. This is in line with the vision of Society 5.0 to create a society of lifelong learners.

Yaras, Z., & Öztürk, F. K. (2022) stated that technology has become an integral element in human life, influencing almost every aspect of life, from how we work, communicate, to learn. In the era of Society 5.0, the role of technology is increasingly significant because its focus is not only on technical innovation, but also on solving social problems effectively and efficiently. Technological advances enable society to be more connected and support the realization of a more comfortable, inclusive, and balanced life.

In the economic sector, technologies such as AI and Big Data have revolutionized the business world by providing the ability to analyze large amounts of data quickly and accurately. This technology provides valuable insights that support strategic decision making. In addition, IoT enables better system integration in the manufacturing, logistics, and trade sectors (Calp, M. H., & Bütüner, 2022). In the era of Society 5.0, this technology enables the creation of a more inclusive economy, where people from all backgrounds can participate in the global economic ecosystem. Technology has also had a major impact on the world of health. Innovations such as telemedicine, medical robotics, and AI-based genetic analysis have improved the quality of health services. Patients can get faster and more accurate diagnoses and treatments, even remotely. In addition, technology helps in drug and vaccine research, as seen during the COVID-19 pandemic. In Society 5.0, health services are expected to be more affordable, equitable, and responsive to individual needs, so that everyone can enjoy a better standard of health. In the world of education, the role of technology in the era of Society 5.0 is very large. AI enables the creation of adaptive learning, where learning content is tailored to the abilities and needs of individual students. Technologies such as Augmented Reality (AR) and Virtual Reality (VR) provide more immersive learning experiences, such as laboratory simulations or virtual trips to historical sites. This technology also enables wider access to education, especially for people in remote areas, through increasingly developing online learning platforms (Yıkılmaz, 2020).

The transportation sector is also undergoing a major transformation thanks to advanced technology. Autonomous vehicles, AI-based navigation systems, and shared transportation have changed the way people move from one place to another. In the era of Society 5.0, transportation will not only become more efficient but also more environmentally friendly. IoT and Big Data enable better traffic management, reduce congestion, and improve road safety. Thus, technology is expected to create a more integrated and sustainable transportation system. In addition, technology also plays an important role in environmental conservation.

IoT-based monitoring systems are used to detect environmental changes in real time, such as air pollution levels or water quality. Renewable energy technologies, such as solar panels and wind turbines, are increasingly developing and becoming more efficient. In Society 5.0, technology is expected to be the main tool for realizing environmental sustainability, which is one of the main focuses in dealing with the global climate crisis. However, although technology offers many opportunities, its implementation in the era of Society 5.0 is not without challenges. One of the main challenges is the digital divide between developed and developing countries, as well as between urban and rural areas. Uneven technological infrastructure can hinder people's access to the benefits of technology. In addition, technological literacy among the public is also a major challenge, considering that not all individuals have the ability to utilize technology optimally. Therefore, education and training on technology are very important in this era.

Ethical and privacy aspects are also major concerns in the application of technology in the Society 5.0 era. The use of AI and Big Data often involves the collection of personal data, which can pose a risk of privacy violations. Strict regulation and transparency in data use are essential to ensure that technology is used responsibly. Thus, this challenge must be managed properly so that technology can be utilized optimally without sacrificing human values (Satata, 2023).

The Society 5.0 era presents a new vision where technology is the solution to creating a better human life. With the increasingly dominant role of technology in various sectors, such as the economy, health, education, transportation, and the environment, this era has a significant impact on improving the quality of human life. However, to achieve the full potential of Society 5.0, challenges such as the digital divide, technological literacy, and ethical and privacy aspects must be overcome. With the right approach, Society 5.0 can be a truly inclusive era, where technology works for the holistic well-being of humanity.

Development and Potential of Integration of Artificial Intelligence and Augmented Reality in Learning

The way teachers and children learn has been profoundly impacted by the advancement of technology in the classroom. Artificial Intelligence (AI) and Augmented Reality (AR) are two technologies that are now receiving a lot of interest in the field of education. Both offer new approaches that can change the traditional learning paradigm to be more interactive, personal, and adaptive. AI and AR not only help in increasing learning efficiency but also provide a more immersive and contextual learning experience for students (Al Balushi, 2024).

Over the past few decades, artificial intelligence (AI) has advanced quickly and is now a crucial component of many industries, including education. Large volumes of data can be analyzed in real time by AI, yielding insights that were previously impossible to obtain with traditional techniques. AI can be utilized in education to develop adaptive systems that modify course materials according to each student's requirements and skill level. An AI-based learning platform, for instance, might recognize when students are struggling to grasp a subject and immediately offer more relevant exercises to strengthen their understanding

(Devagiri et al., 2022). With this approach, AI not only increases learning efficiency but also provides personalized support to each student, making the learning process more inclusive.

On the other hand, Augmented Reality (AR) has opened up new opportunities to create more interactive and immersive learning experiences. AR allows students to see, hear, and interact with virtual objects integrated with the real world. This technology is very effective in explaining abstract concepts that are difficult to understand with just text or static images. For example, through AR, students can learn the structure of human anatomy by seeing three-dimensional models of body organs that can be rotated, enlarged, or even broken down into smaller parts. This provides a deeper understanding compared to conventional learning that only relies on textbooks. The integration of AI and AR in learning not only increases the effectiveness of the teaching and learning process but also provides opportunities to create context-based learning experiences. For example, AI technology can be used to create realistic simulation scenarios, such as educational games that challenge students to solve real problems. Meanwhile, AR can be used to provide a visual context that supports the learning. As an illustration, in history learning, students can use AR to virtually explore historical sites, while AI provides interactive narratives that adapt to students' interests and questions. This approach not only increases students' motivation but also helps them understand the material better (Zouhri, A., & EL MALLAHI, 2024).

The potential of AI and AR integration in education is also evident in its ability to support collaborative learning. In an AR-based virtual classroom, students from different locations can work together on the same project, share ideas, and interact with virtual objects simultaneously. AI can help manage group dynamics by providing analysis of each student's contribution and recommending ways to improve collaboration. This technology opens up great opportunities to create inclusive learning environments, where all students, regardless of their geographic or social background, can actively participate (Egunjobi, D., & Adeyeye, 2024).

However, despite its great potential, the integration of AI and AR in learning is not without its challenges. One of the main challenges is the availability of adequate technological infrastructure. In many developing countries, access to hardware and a stable internet connection is still a major obstacle. In addition, technological literacy among teachers and students also needs to be improved so that they can make optimal use of this technology. Training and technical support must be an integral part of the implementation of AI and AR in the education sector.

Another challenge that needs to be addressed is related to ethical and privacy aspects. The use of AI in learning often involves collecting students' personal data to analyze their learning patterns. Therefore, it is important to ensure that this data is managed securely and in accordance with applicable privacy regulations. In addition, technology developers also need to consider the aspect of inclusivity, ensuring that their products are accessible to all students, including those with special needs (Toshmurodovich, 2024).

Going forward, the integration of AI and AR in learning has great potential to change the way education is run. With the right approach, this technology can help create an

education system that is more equitable, inclusive, and adaptive to individual needs. In addition, AI and AR can also encourage experiential learning, where students learn not only to memorize information, but also to understand, analyze, and apply it in real-world situations. As technology continues to advance, the future of smarter and more personalized education is getting closer to reality.

Synergy Between Artificial Intelligence and Augmented Reality to Support Experience-Based Learning in the 5.0 Era

In the era of Society 5.0, education faces new challenges to provide relevant, inclusive, and student-centered learning experiences. In this context, the synergy between Artificial Intelligence (AI) and Augmented Reality (AR) is a great opportunity to create an experience-based learning method that is able to answer the needs of education in the future. These two technologies not only offer an innovative approach, but also allow students to be actively involved in the learning process through interactive simulations, personalized data analysis, and richer real-world visualizations (Manikandan et al., 2023).

AI plays an important role in supporting the personalization of learning, which is one of the main focuses in the era of Society 5.0. With the ability to analyze big data, AI can provide deep insights into the learning needs of each student. AI-based systems, such as virtual tutors or adaptive learning applications, can monitor student progress, analyze their weaknesses, and provide recommendations for materials that are appropriate to individual abilities. This allows learning to be more effective, efficient, and relevant to the needs of each student (Rane et al., 2024).

On the other hand, AR provides a new dimension to the learning experience by integrating virtual elements into the real world. This technology allows students to visualize abstract concepts in a more concrete and interactive way. For example, in biology lessons, students can use AR to see a simulation of human organs in three dimensions, which can be enlarged, rotated, or explored in detail. This capability not only improves students' understanding of the material but also makes learning more interesting and enjoyable.

According to Russo et al., (2023) the synergy between AI and AR creates a context-based and immersive learning experience. AI can be used to provide data analysis that supports AR-based learning, such as recommending interactive content that is appropriate to the student's level of understanding. For example, in history lessons, students can use AR to explore the virtual environment of a historical event, such as a battlefield or ancient city. Meanwhile, AI provides a dynamic narrative that explains the background of the event based on the student's interests or questions. This interaction creates a more immersive and personal learning experience.

In addition, the synergy between AI and AR also supports collaborative experience-based learning. In virtual classrooms supported by this technology, students from different locations can work together on the same project, interact with virtual objects, and share ideas in real time. AI can help facilitate this collaboration by monitoring each student's contribution, providing real-time feedback, and recommending ways to improve teamwork. In this way,

this technology not only supports individual learning but also builds social and collaborative skills that are essential for the future.

According to Chasokela, D., & Mangena, N. (2025) the potential synergy between AI and AR is also seen in simulation-based learning. Students can use this technology to practice real-world situations in a safe and controlled virtual environment. For example, in medical education, AR can be used to simulate surgical procedures, while AI provides step-by-step guidance based on the student's actions. In this way, students not only learn theory but also gain practical experience that enhances their readiness to face real-world challenges.

However, the implementation of AI and AR synergy in learning is not without challenges. One of the main obstacles is the need for adequate technological infrastructure, such as hardware that supports AR and a stable internet connection to run AI-based systems. In addition, technological literacy among educators and students also needs to be improved so that they can utilize this technology optimally. To overcome this challenge, adequate training and technical support are needed, as well as collaboration between the government, educational institutions, and the private sector.

Ethical and privacy aspects are also important concerns in the implementation of this technology. AI used to analyze student data must be designed with data security and individual privacy in mind. Clear regulations and transparency in data use are essential to ensure that this technology is used responsibly. In addition, technology developers must also ensure that their AI and AR applications are accessible to all students, including those with special needs, so that this technology is truly inclusive (Tavares et al., 2022).

Going forward, the synergy between AI and AR has great potential to revolutionize education in the Society 5.0 era. With an experience-based approach, this technology can help create a learning environment that is more adaptive, interactive, and relevant to individual needs. In addition, this synergy also opens up opportunities for lifelong learning, where students do not only learn to face exams, but also to develop skills that are relevant to the world of work and everyday life. With a shared commitment from various stakeholders, the synergy between AI and AR can be a driving force for better educational transformation in the future.

Conclusion

The integration of Artificial Intelligence (AI) and Augmented Reality (AR) in learning in the Society 5.0 era opens up great opportunities to create educational methods that are more adaptive, interactive, and relevant to the needs of the 21st century. AI provides the ability to analyze learning data in depth, enabling personalization of materials that suit the needs of individual students. Meanwhile, AR offers a more immersive learning experience through interactive visualizations and simulations that help students understand abstract concepts more easily. The synergy of these two technologies not only supports individual learning but also facilitates collaboration and active student involvement in the learning process.

The application of AI and AR in education brings various significant benefits, including increased learning motivation, strengthening conceptual understanding, and developing 21st-

century skills such as problem solving, collaboration, and creativity. This technology also provides opportunities for experiential learning, where students can practice what they learn in situations that are close to the real world. However, the successful implementation of this technology requires adequate infrastructure support, technological literacy training for educators and students, and an ethical framework that ensures data security and inclusivity.

The integration of AI and AR has the power to completely transform education by establishing a more sustainable and inclusive educational framework. To fully realize this potential, cooperation between the public and private sectors, as well as educational institutions, is essential. In the era of Society 5.0, AI and AR technologies can be a smart way to handle educational difficulties with the correct planning and assistance while empowering students as lifelong learners who are ready to face global change.

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