THE UTILISATION OF ARTIFICIAL INTELLIGENCE, INTERNET OF THINGS, AND VIRTUAL/AUGMENTED REALITY IN ENHANCING THE EFFECTIVENESS AND EFFICIENCY OF LEARNING: A LITERATURE REVIEW

Risqah Amaliah Kasman
Institut Teknologi dan Kesehatan Permata Ilmu Maros
risqahamaliahkasman@itkpi.ac.id

Al-Amin
Universitas Airlangga, Surabaya, Indonesia
al.amin-2024@feb.unair.ac.id

Abstract
The rapid development of digital technology has brought fundamental changes to the world of education, particularly through the use of Artificial Intelligence (AI), Internet of Things (IoT), and Virtual and Augmented Reality (VR/AR). This literature study aims to examine the role and impact of these three technologies in improving the effectiveness and efficiency of learning. The findings reveal that AI enables personalised learning materials, automated assessment, and real-time analysis of students' achievements, making the learning process more responsive and adaptive to individual needs. IoT creates an integrated learning environment, enabling monitoring of learning conditions, optimisation of resources, and improved access and inclusivity. Meanwhile, VR/AR provides immersive learning experiences that strengthen the understanding of abstract concepts, increase learning motivation, and support the development of students' practical skills without real risk. Despite their many potential benefits, the adoption of these three technologies also faces challenges related to infrastructure, digital literacy, data security, and human resource readiness. The integration of AI, IoT, and VR/AR has proven to be a key driver of educational innovation, but a comprehensive implementation strategy is necessary to maximise their impact on improving the quality of education in the digital age.
Keywords: Artificial Intelligence, Internet of Things, Virtual Reality, Augmented Reality, Learning Effectiveness, Learning Efficiency, Literature Study.

Introduction

The rapid advancement of technology has brought significant changes to various aspects of human life, including the field of education. Digitalisation and automation have become hallmarks of the modern world, creating new challenges and opportunities for educational institutions worldwide. This transformation is becoming increasingly evident with the emergence of cutting-edge technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and Virtual/Augmented Reality (VR/AR), which are beginning to integrate into learning systems. (Saputra, 2022) ; (Rokhmawati et al., 2025) .

The emergence of AI as one of the main innovations in educational technology has changed the paradigm of traditional learning. AI has the ability to analyse student learning behaviour data in depth and adjust teaching materials and methods according to individual needs. This provides opportunities for personalised learning that was previously difficult to achieve on a large scale through conventional methods (Khan, 2022) . Meanwhile, the Internet of Things (IoT) has had a significant impact with the emergence of devices connected in real-time to the internet. IoT enables data-driven management of learning environments, such as through sensors that monitor classroom conditions, student activities, and energy usage efficiently. With IoT, schools can create a safer, more comfortable, and adaptive learning ecosystem tailored to students' needs. (Jumani, 2022) .

Virtual Reality and Augmented Reality are the answer to the challenges of abstract and difficult-to-visualise learning. With the help of VR/AR, learning materials—especially technical and scientific concepts—can be realised in the form of interactive 3D simulations and visualisations, making the learning process more engaging, enjoyable, and in-depth. Students can interact directly with virtual objects and practise in a virtual environment without any real-world risks. (Nasrullah et al., 2024) .

The integration of advanced technologies above offers a major transformation in learning effectiveness. AI facilitates the creation of adaptive learning scenarios and automatic analysis of student performance, VR/AR stimulates engagement and motivation through immersive experiences, and IoT enhances operational efficiency in schools, including infrastructure management and monitoring of learning outcomes. (Aslan & Rasmita, 2025) ; (Revalina & Aslan, 2025) .

However, not all educational institutions are able to adopt these innovative technologies evenly. Infrastructure constraints, teacher skills, and cost aspects remain major obstacles in many areas. The adoption of high technology in education requires hardware readiness, a capable internet network, and human resources with adequate digital literacy.

However, recent studies show that the application of AI, IoT, and VR/AR in education can provide various advantages. These include a more adaptive learning process, increased student motivation and understanding, more intensive interaction with the material, and efficiency in terms of time and resources. This approach also supports the creation of a more inclusive and responsive education system that addresses individual needs (, 2022) . In addition to the above benefits, the integration of these technologies also brings new issues that need to be managed wisely. Issues such as student data privacy, potential biases in AI algorithms, and challenges in maintaining a balance in social interactions are of primary concern. Therefore, the development of policies, ethical guidelines, and ongoing training for teachers and students are essential to optimise the use of technology in education (Nasrullah et al., 2024) .

It is also important to note that innovation should not stop at technology. Curriculum development, instructional design, and learning evaluation models must transform in line with the integration of AI, IoT, and VR/AR. This aims to maximise the benefits of technology and have a direct impact on improving the quality of student learning outcomes (Rullyana & Triandari, 2024) .

In a global context, the application of advanced technology in education is a necessity to address the challenges of the Fourth Industrial Revolution and Society 5.0. Developed countries are competing to develop digital-oriented education systems to prepare future generations who are competent, creative, and adaptable to changes in the times (Meylani, 2024) .

Indonesia is also encouraged not to fall behind in this wave of transformation. Various initiatives, pilot projects, and policies have begun to be implemented. This is an important momentum for education stakeholders to further improve governance, competence, and collaboration in accelerating the utilisation of AI, IoT, and VR/AR in schools and universities (Putri et al., 2024) .

Finally, literature research on the utilisation of Artificial Intelligence, Internet of Things, and Virtual and Augmented Reality in enhancing the effectiveness and efficiency of learning has become highly relevant. This study aims to map trends, challenges, and strategic recommendations as a tangible contribution to the development of technology-driven education that is both advanced and highly competitive.

With this foundation, this study will focus on identifying and synthesising various findings related to the implementation of AI, IoT, and VR/AR in the education sector. Furthermore, it is hoped that the results of this study can serve as a reference and catalyst for paradigm shifts in learning in Indonesia towards a more innovative, inclusive, and adaptive system in line with technological advances.

Research

The research method used in this study is a systematic literature review, which involves identifying, selecting, and analysing relevant scientific articles that discuss the utilisation of Artificial Intelligence (AI), Internet of Things (IoT), and Virtual/Augmented Reality (VR/AR) to enhance the effectiveness and efficiency of learning (Eliyah & Aslan, 2025) . This process involves searching references through various electronic databases such as Scopus, Google Scholar, and DOAJ using specific keywords, establishing structured inclusion and exclusion criteria, and synthesising the obtained data to summarise trends, key findings, and implementation challenges of these technologies in (Green et al., 2006) .

Results and Discussion

The Role and Impact of AI, IoT, and VR/AR in Enhancing the Effectiveness and Efficiency of Learning

The development of information and communication technology has brought significant transformations to the world of education. Artificial Intelligence (AI), Internet of Things (IoT), and Virtual and Augmented Reality (VR/AR) technologies have become pioneers of innovation that contribute significantly to improving the effectiveness and efficiency of learning. These three technologies enable personalisation, interactivity, and better resource management in the teaching and learning process (Pramesti et al., 2022) .

AI plays a role in providing adaptive and personalised learning experiences. With its deep data analysis capabilities, AI can map the needs, learning styles, and learning speeds of each student so that teaching materials and methods can be automatically adjusted. This helps improve student focus and understanding, as well as maximise individual learning outcomes (Tariq et al., 2024) . In addition to personalisation, AI also accelerates learning efficiency through the automation of administrative tasks and evaluations. AI systems can manage automatic assessments, provide real-time feedback, and reduce teachers' workload on routine tasks, allowing educators to focus more on creative teaching aspects and interactions with students (Alkhairi et al., 2024).

The role of IoT in education is prominent in terms of smart learning environment management. By connecting various devices and sensors in real time, IoT enables monitoring of classroom conditions such as temperature, lighting, and cleanliness, which can be optimised for learning comfort. This creates an adaptive and conducive learning ecosystem (Afrita, 2023) .

IoT also improves accessibility and inclusivity in education. IoT devices support students with special needs through learning environments that are responsive to their needs, as well as providing access to various digital learning resources. This enables more equitable and inclusive learning across different student backgrounds. Operational efficiency in schools is also improved with IoT technology. IoT sensors can automatically monitor energy usage, learning equipment, and classroom safety, enabling more efficient and effective resource management without compromising the quality of the learning environment (Judijanto et al., 2024) .

VR and AR technologies provide highly interactive and immersive learning experiences. VR allows students to enter realistic learning environment simulations, while AR combines the real world with digital elements that can be seen directly. These experiences enrich the understanding of abstract concepts that are difficult to explain using conventional methods (Shiddiqi et al., 2020) .

The use of VR/AR not only increases student engagement and motivation, but also helps improve information retention. Visualisation and direct interaction with learning materials in 3D format make it easier for students to remember and understand

the topics being taught. Additionally, VR and AR support the development of practical skills, particularly in fields that require simulation, such as medicine and engineering. The safe learning experience without real physical risks allows students to practice and refine their skills effectively (Purnomo & Yuhana, 2018) .

The role of AI, IoT, and VR/AR in learning also contributes to improving the overall effectiveness of the teaching and learning process. With AI as an adaptive tutor, IoT providing a supportive environment, and VR/AR providing an immersive experience , learning becomes more focused, in-depth, and contextual according to the needs of students (Muzakki, 2018) .

Learning efficiency is supported by the speed of material delivery, more optimal time management, and easy access to learning materials anytime using integrated devices. AI and IoT enable flexible and responsive learning processes tailored to individual and group conditions. However, the implementation of these technologies faces challenges such as the need for adequate infrastructure, human resource readiness, and significant implementation costs. Additionally, the development of digital literacy among teachers and students is a crucial component to ensure that technology can be utilised to its fullest potential and optimally (Hanila & Alghaffaru, 2023) .

Ethical and data security issues also require serious attention. The use of AI and IoT involves the collection and analysis of students' personal data, making privacy protection and the prevention of algorithmic bias key priorities in the use of technology in education (Setiawan, 2018) .

The integration of AI, IoT, and VR/AR must also be accompanied by updates to the curriculum, teaching methods, and evaluation processes that are relevant to these technologies in order to produce educational outcomes that align with the demands of the times and the needs of the workforce. The experiences of several educational institutions indicate that the use of these technologies can enhance learning outcomes, student engagement, and their readiness to face the increasingly complex and digitally-driven dynamics of the workplace (Zhang et al., 2025) .

In conclusion, AI, IoT, and VR/AR have strategic roles and significant positive impacts in promoting learning effectiveness and efficiency. The development and utilisation of these technologies must be based on technical readiness and human resources so that the education system can move towards a more adaptive, inclusive, and highly competitive era of learning.

Thus, these three technologies are not merely tools, but representations of the future of education—smart, interactive, and efficient—that can address various learning challenges in the modern era.

Challenges & Obstacles of AI, IoT, and VR/AR in Enhancing the Effectiveness and Efficiency of Learning

The application of Artificial Intelligence (AI), Internet of Things (IoT), and Virtual/Augmented Reality (VR/AR) in education offers many potential benefits, but various technical and non-technical challenges still limit the optimal use of these technologies in schools and universities. AI in education faces challenges such as limited digital infrastructure, including the availability of hardware, high-speed internet, and adequate data storage. Many institutions, particularly in rural areas, still rely on conventional methods, making the access and integration of AI difficult to implement evenly. (Sudarmo et al., 2021) .

The lack of digital literacy among educators and students is one of the main obstacles. Many teachers and students are still unfamiliar with how AI works and how to use it effectively, making training and skill development an urgent need to support educational transformation. Additionally, the adoption of AI often faces high implementation costs. The development and maintenance of AI-based systems still require significant funding, including investments in hardware, infrastructure, and supporting software that are currently unaffordable for many educational institutions. (Zhao, 2023) .

Data security and privacy are crucial issues in the use of AI and IoT in education. The collection of large amounts of student data can pose risks of data leakage or misuse, making data protection regulations and standards an urgent requirement (Singh, 2022) . Ethical challenges also arise, such as the potential for algorithmic bias that could lead to unfair decisions in academic assessment or treatment of students from different backgrounds. Overreliance on AI can have negative effects on motivation, creativity, and critical thinking skills—students tend to seek instant solutions without engaging in comprehensive and reflective learning processes (Tlili et al., 2025) .

IoT promises an integrated and real-time learning ecosystem, but its implementation is still hampered by uneven internet connectivity, especially in 3T (underdeveloped, frontier, and outermost) regions. IoT device security is also vulnerable to unauthorised access or misuse by malicious actors, including data theft, hacking, and system sabotage, necessitating the implementation of high cybersecurity standards (, 2023) . The lack of local experts and intensive training is another obstacle in the utilisation and maintenance of IoT devices and systems in educational environments, both for administration and teaching. Additionally, the costs of building and maintaining an IoT ecosystem—from purchasing devices, maintenance, to system upgrades—are still relatively high for most public and private schools (Riduwan, 2006).

The use of VR and AR technology in education also faces challenges related to the high cost of devices and the need for high-quality infrastructure, such as computers, headsets, and high-speed internet networks. VR/AR learning content that is truly tailored to curriculum needs is also still limited. Content development requires

collaboration with education and technology experts as well as significant resources (Calvert, 2023) .

Health factors are a concern, such as eye fatigue and potential nausea from prolonged use of VR devices. In addition, social interaction between students may decrease if technology is used excessively. Not all educators are ready to use VR/AR due to a lack of training, minimal experience, and concerns about the effectiveness of technology-based learning compared to conventional methods (Muarif et al., 2022) .

In general, the challenges of implementing AI, IoT, and VR/AR include issues of digital divide, high costs, limited human resource readiness, data protection, content availability, and ethical and health aspects. A multidimensional solution encompassing training, regulation, incentives, and cross-sector collaboration is essential to ensure that technological innovations can truly enhance the effectiveness and efficiency of learning in a sustainable manner.

Conclusion

The use of Artificial Intelligence (AI), Internet of Things (IoT), and Virtual and Augmented Reality (VR/AR) has been proven to significantly improve the effectiveness and efficiency of learning. AI contributes through personalisation of learning materials, automation of assessment, and analysis of student data, making the learning process more targeted and adaptive to individual needs. Additionally, AI helps expand access to education, provides real-time feedback, and reduces administrative burdens on teachers, enabling them to focus more on interactive and creative learning processes.

IoT supports the creation of a smart and integrated learning ecosystem through connected devices that enable real-time monitoring, management, and optimisation of the learning environment. The presence of IoT promotes flexibility, accessibility, and operational efficiency—for example, in monitoring attendance, resource usage, and school environment safety. IoT also opens up opportunities for more inclusive learning, both for students with special needs and those in remote areas, while helping to reduce operational costs for educational institutions.

VR and AR technologies provide immersive, interactive, and contextual learning experiences, reinforcing understanding of abstract concepts through 3D visualisation, simulations, and virtual experiments. With this approach, student engagement and retention of material increase, enabling the development of practical skills in a safe and engaging manner. Overall, the literature review indicates that the integration of AI, IoT, and VR/AR is key to more creative, relevant, and competitive learning innovation in the digital age.

References

Abdullah, N. S. S., & Sahid, S. (2023). Determination in Education Development Towards the Improvement of Human Capital Productivity: Systematic Literature Review. *International Journal of Academic Research in Economics and Management Sciences*, 12(2), 252–266. https://doi.org/10.6007/IJAREMS/v12-i2/16649

Afrita, J. (2023). Peran Artificial Intelligence dalam Meningkatkan Efisiensi dan Efektifitas Sistem Pendidikan. *COMSERVA: Jurnal Penelitian Dan Pengabdian Masyarakat*, 2(12), 3181–3187.

Alkhairi, P., Windarto, A. P., & Wanto, A. (2024). Sosialisasi Pemanfaatan Tool AI dalam Literasi Digital Untuk Pengembangan Kompetensi Siswa. *Jurnal Warta Pengabdian Masyarakat Nusantara*, 2(1), 10–17.

Aslan, A., & Rasmita, R. (2025). EXPLORING CHALLENGES AND STRATEGIES IN TEACHING ENGLISH AS A SECOND LANGUAGE TO YOUNG LEARNERS. *International Journal of Teaching and Learning*, 2(11), Article 11.

Calvert, J. (2023). Improving Student Learning Outcomes Using Narrative Virtual Reality as Pre-Training. *Virtual Reality*, 27(3), 2633–2648.

Eliyah, E., & Aslan, A. (2025). STAKE'S EVALUATION MODEL: METODE PENELITIAN. *Prosiding Seminar Nasional Indonesia*, 3(2), Article 2.

Green, B. N., Johnson, C. D., & Adams, A. (2006). Writing Narrative Literature Reviews for Peer-Reviewed Journals. *Chiropractic & Manual Therapies*, 52–57.

Hanila, S., & Alghaffaru, M. A. (2023). Pelatihan Penggunaan Artificial Intelligence (AI) Terhadap Perkembangan Teknologi Pada Pembelajaran Siswa SMA 10 Sukarami Kota Bengkulu. *Jurnal Dehasen Mengabdi*, 2(2), 221–226.

Judijanto, L., Shodiqin, R., & Aslan. (2024). SOCIAL SOLIDARITY IN THE DIGITAL AGE: CHALLENGES AND OPPORTUNITIES. *Prosiding Seminar Nasional Indonesia*, 2(3), 357–368.

Jumani, A. K. (2022). Virtual Reality and Augmented Reality for Education. In *Virtual Reality and Augmented Reality for Education* (pp. 200–221). CRC Press. https://doi.org/10.1201/9781003196686-9

Khan, A. K. J. (2022). Virtual Reality and Augmented Reality for Education. In *Virtual Reality and Augmented Reality for Education* (pp. 200–221). CRC Press. https://doi.org/10.1201/9781003196686-9

Meylani, R. (2024). Transforming Education with the Internet of Things: A Journey into Smarter Learning Environments. *International Journal of Research in Education and Science*, 10(1), 161–178. https://doi.org/10.46328/ijres.3362

Muarif, J. A., Jihad, F. A., Alfadli, M. I., & Setiabudi, D. I. (2022). Hubungan Perkembangan Teknologi AI terhadap Pembelajaran Mahasiswa. *Seroja: Jurnal Pendidikan*, 1(2), 117–127.

Muzakki, M. N. (2018). *Pemanfaatan Augmented Reality Sebagai Media Pembelajaran pada Mata Pelajaran Penerapan Rangkaian Elektronika untuk Siswa Jurusan Teknik Elektronika Komunikasi SMK Negeri 1 Cimahi*. Universitas Pendidikan Indonesia.

Nasrullah, A., Noni, N., Basri, M., & Humaera, I. (2024). Virtual Reality (VR) Potential for Education in the Future: A Bibliometric Analysis. *International Journal of Integrative Sciences*, 3(9), 961–974. https://doi.org/10.55927/ijis.v3i9.11435

Pramesti, A. A., Sitompul, R. P., Sopiya, N., & Fitroh. (2022). Systematic Literature Review: Pemanfaatan Virtual Reality (VR) Sebagai Alternatif Media Pembelajaran. *Jurnal Pendidikan Teknologi Dan Kejuruan*, *19*(2), 105–117.

Purnomo, M. H., & Yuhana, U. L. (2018). Pengaruh Pendidikan, Informasi dan Komunikasi terhadap Internet of Things. *Jurnal Manajemen Pendidikan Dan Ilmu Sosial*, *3*(2), 573–582.

Putri, N. W. S., Agustini, K., Dantes, G. R., & Sudatha, I. G. W. (2024). Systematic Literature Review: Penerapan Teknologi Virtual Reality dalam Meningkatkan Pengalaman Belajar. *Indiktika: Jurnal Inovasi Pendidikan Matematika*, *7*(1), 47–57.

Revalina, A., & Aslan, A. (2025). PERUBAHAN NORMA ETIKA DALAM HUBUNGAN SOSIAL DI PLATFORM MEDIA SOSIAL. *Jurnal Komunikasi*, *3*(6), Article 6.

Riduwan. (2006). *Internet of Things (IoT)*. PERMENDIKNAS No. 23 Tahun 2006.

Rokhmawati, Z., Aslan, A., & Farchan, A. (2025). Inovasi Teknologi dalam Pendidikan Jarak Jauh: Kajian Literatur. *Jurnal Ilmiah Edukatif*, *11*(1), Article 1. https://doi.org/10.37567/jie.v11i1.3735

Rullyana, G., & Triandari, R. (2024). Trends and Research Issues of Augmented Reality in Education: A Bibliometric Study. *Jurnal Teknologi Pendidikan*, *1*(4). https://doi.org/10.47134/jtp.v1i4.907

Saputra, R. (2022). *Implementasi Mediasi Dalam Menyelesaikan Sengketa Perdata di Pengadilan Negeri Bulukumba*. Universitas Muslim Indonesia.

Setiawan, H. S. (2018). Pelatihan Guru dalam Penggunaan Internet of Things pada Madrasah Darussa'adah. *E-Dimas: Jurnal Pengabdian Kepada Masyarakat*.

Shiddiqi, A. M., Ijtihadie, R. M., Ahmad, T., Wibisono, W., Anggoro, R., & Santoso, B. J. (2020). Penggunaan Internet dan Teknologi IoT untuk Meningkatkan Kualitas Pendidikan. *Sewagati*, *4*(3), 235–240.

Singh, K. (2022). Investigating the impact of IoT-Based smart laboratories on students' academic performance in higher education. *Universal Access in the Information Society*. https://doi.org/10.1007/s10209-022-00944-1

Sudarmo, S., Arifin, A., Pattiasina, P. J., Wirawan, V., & Aslan, A. (2021). The future of instruction media in Indonesian education: Systematic review. *Al-Ishlah: Jurnal Pendidikan*, *13*(2), 1302–1311.

Tariq, R., Casillas-Muñoz, F. A., Hassan, S. T., & Ramírez-Montoya, M. S. (2024). Synergy of Internet of Things and Education: Cyber-physical Systems contributing towards Remote Laboratories, Improved Learning, and School Management. *Journal of Social Studies Education Research*, *15*(2), 305–352. https://doi.org/10.17499/jsser.603721

Tlili, A., Saqer, K., Salha, S., & Huang, R. (2025). Investigating the effect of artificial intelligence in education (AIEd) on learning achievement: A meta-analysis and research synthesis. *Information Development*. https://doi.org/10.1177/02666669241304407

Zhang, J., Jantakoon, T., & Laoha, R. (2025). Meta-Analysis of Artificial Intelligence in Education. *Higher Education Studies*, *15*(2), 189–204. https://doi.org/10.5539/hes.v15n2p189

Zhao, Y. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis From the Web of Science (2018–2022). *SAGE Open*. https://doi.org/10.1177/21582440231190821