INNOVATIVE: Journal Of Social Science Research
Volume 4 Nomor 4 Tahun 2024 Page 1679-1690
E-ISSN 2807-4238 and P-ISSN 2807-4246
Website: https://j-innovative.org/index.php/Innovative

Augmented Reality (AR) and Virtual Reality (VR): Recent Developments and Applications in Various Industries

Imam Prayogo Pujiono[1✉], Asfahani[2], Andy Rachman[3]
(1) UIN K.H. Abdurrahman Wahid Pekalongan, (2) IAI Sunan Giri Ponorogo,
(3) Institut Teknologi Adhi Tama Surabaya
Email: imam.prayogopujiono@uingusdur.ac.id[1✉]

Abstrak

Augmented Reality (AR) dan Virtual Reality (VR) dengan cepat mengubah berbagai industri di luar aplikasi awalnya yang berfokus pada hiburan. Penelitian ini bertujuan untuk mengeksplorasi perkembangan terkini dan beragam penerapan AR dan VR di berbagai sektor seperti layanan kesehatan, pendidikan, manufaktur, dan ritel. Dengan menggunakan metode Tinjauan Literatur Sistematis (SLR), penelitian ini secara sistematis mengidentifikasi, mengevaluasi, dan mensintesis penelitian yang ada dari tahun 2018 hingga 2023. Temuan ini mengungkapkan kemajuan signifikan dalam teknologi AR dan VR, menunjukkan potensinya untuk meningkatkan pelatihan medis, menciptakan lingkungan pembelajaran yang mendalam, dan meningkatkan proses manufaktur, dan memperkaya pengalaman pelanggan di bidang ritel. Namun, tantangan seperti biaya implementasi yang tinggi, keterbatasan teknologi, penerimaan pengguna, dan masalah etika masih tetap ada. Studi ini menyimpulkan bahwa meskipun AR dan VR memiliki potensi transformatif, mengatasi tantangan-tantangan ini melalui solusi hemat biaya, studi kemanjuran jangka panjang, dan pedoman etika sangat penting untuk penerapan yang lebih luas di seluruh industri.

Kata Kunci: *Augmented Reality, Perkembangan dan Penerapan Terkini, Realitas Maya*

Abstract

Augmented Reality (AR) and Virtual Reality (VR) are rapidly transforming various industries beyond their initial entertainment-focused applications. This research explores recent developments and diverse applications of AR and VR across sectors such as healthcare, education, manufacturing, and retail. Employing a Systematic Literature Review (SLR) method, the study systematically identifies, evaluates, and synthesizes existing research from 2018 to 2023. The findings reveal significant advancements in AR and VR technologies, demonstrating their potential to enhance medical training, create immersive learning environments, improve manufacturing processes, and enrich customer experiences in retail. However, challenges such as high implementation costs, technological limitations, user acceptance, and ethical concerns remain. The study concludes that while AR and VR have transformative potential, addressing these challenges through cost-effective solutions, long-term efficacy studies, and ethical guidelines is essential for broader adoption across industries.

Keywords: *Augmented Reality, Recent Developments and Applications, Virtual Reality*

INTRODUCTION

In recent years, Augmented Reality (AR) and Virtual Reality (VR) have emerged as groundbreaking technologies transforming various industries. AR and VR are no longer confined to gaming and entertainment; they are now utilized in healthcare, education, manufacturing, and retail (Chang et al., 2019). The potential of these technologies to create immersive and interactive experiences has sparked significant interest among researchers and industry professionals. This paper aims to explore the recent developments and diverse applications of AR and VR across multiple industries, highlighting the advancements that have been made and the challenges that remain (Marougkas et al., 2023; Radianti et al., 2020).

Integrating AR and VR into different industries presents several intriguing research problems. For instance, in healthcare, the development of VR-based therapy and AR-assisted surgeries poses questions about the efficacy and safety of these new methods compared to traditional practices (Suri et al., 2023; Torous et al., 2021). In education, the effectiveness of AR and VR in enhancing learning outcomes is still under investigation. Manufacturing industries are exploring how these technologies can improve training and operational efficiency, while the retail sector is experimenting with AR for enhanced customer experiences (Adhicandra et al., 2024; Judijanto, Asfahani, Bakri, et al., 2022). Each application brings challenges, including technological limitations, user acceptance, and ethical considerations.

One of the most compelling aspects of researching AR and VR is their novelty in various fields. Previous studies have often focused on the technical aspects of these

technologies or their use in specific niches like gaming (Bertheau, 2020; Chauhan et al., 2022; Huynh et al., 2020; Junaid et al., 2023; O'Connor et al., 2023). However, more comprehensive research needs to be conducted examining the broader application of AR and VR across multiple industries and their impact. This study seeks to fill that gap by providing a holistic overview of how these technologies are implemented and their benefits. The novelty of this research lies in its interdisciplinary approach, examining AR and VR applications across a wide range of sectors. By doing so, it not only provides a snapshot of current trends but also identifies areas where further innovation is needed. This study aims to highlight AR and VR's transformative potential while acknowledging the hurdles that need to be overcome for these technologies to be fully integrated into everyday practices.

The primary objective of this research is to provide a detailed analysis of the recent developments in AR and VR technologies and their applications in various industries. The study aims to identify key trends, benefits, and challenges associated with the adoption of AR and VR. Furthermore, it seeks to propose potential solutions and strategies for overcoming the existing barriers to implementation.

The expected impact of this research is multifaceted. For industry professionals, it will provide valuable insights into how AR and VR can be leveraged to enhance productivity, efficiency, and user engagement. For researchers, it will offer a comprehensive review of current developments and identify areas for future investigation. Ultimately, this study aims to contribute to the ongoing discourse on AR and VR, fostering innovation and encouraging the broader adoption of these transformative technologies.

RESEARCH METHOD

This study employs the Systematic Literature Review (SLR) method to examine the recent developments and applications of Augmented Reality (AR) and Virtual Reality (VR) in various industries. The SLR method is chosen for its rigorous and structured approach to identifying, evaluating, and synthesizing existing research on a specific topic (Busch & McCarthy, 2021). The research process involves several key steps: defining the research questions, developing a comprehensive search strategy, selecting relevant studies based on inclusion and exclusion criteria, and critically appraising the quality of the selected studies. The primary data sources include peer-reviewed journal articles, conference papers, and industry reports published between 2018 and 2023.

Data is collected through an extensive search of electronic databases such as IEEE Xplore, ScienceDirect, and Google Scholar. Keywords and search strings related to AR, VR, and their applications in various industries are used to ensure a thorough search. The data

analysis involves categorizing the selected studies based on their specific industry (e.g., healthcare, education, manufacturing, retail), summarizing the key findings, and identifying trends, challenges, and gaps in the existing literature. The results are synthesized to provide a comprehensive overview of the state-of-the-art developments and propose future research directions. This method ensures a systematic and unbiased review of the current landscape of AR and VR applications across different sectors.

RESULT AND DISCUSSION

The systematic literature review (SLR) conducted on recent developments and applications of Augmented Reality (AR) and Virtual Reality (VR) in various industries reveals several key insights and trends. The findings indicate significant advancements in the technological capabilities of AR and VR, which have facilitated their adoption across multiple sectors. The synthesis of the reviewed literature highlights the transformative impact these technologies have had in healthcare, education, manufacturing, and retail, among others.

AR and VR have shown tremendous potential in enhancing medical training and patient care in the healthcare industry. VR-based simulations are used extensively to train surgeons, providing a risk-free environment in which to practice complex procedures. Additionally, AR is employed in real-time surgeries to overlay critical information on the surgeon's field of view, improving precision and outcomes. The literature also points to the growing use of VR in therapy, particularly for mental health treatments such as exposure therapy for phobias and PTSD, demonstrating promising results in clinical trials.

Education is another sector where AR and VR are making significant strides. The reviewed studies underscore the effectiveness of these technologies in creating immersive learning environments that enhance student engagement and understanding. VR enables virtual field trips and interactive lab simulations, allowing students to explore concepts hands-only without geographical or physical constraints (Agustina et al., 2023; Hassan et al., 2021; Yang et al., 2021). AR, conversely, is being used to augment textbooks and classroom materials with interactive 3D models and animations, thereby providing a richer educational experience.

AR and VR are being leveraged in the manufacturing industry to improve training, maintenance, and design processes. VR-based training modules provide workers with a realistic and immersive experience, which helps in better retention of information and safer training conditions. AR assists with maintenance and repair tasks by overlaying step-by-step instructions and real-time data onto machinery, reducing downtime and errors. The

literature also highlights the use of VR in the design and prototyping stages, enabling more efficient and cost-effective development cycles.

The retail sector is exploring AR and VR to enhance customer experiences and streamline operations. AR applications are being developed to allow customers to virtually try on clothes and accessories or visualize furniture in their homes, which helps make more informed purchasing decisions. VR is used to create virtual showrooms and stores, providing customers with an immersive shopping experience from their homes. These technologies are improving customer satisfaction and offering valuable insights into consumer behavior.

Despite the promising applications, the review also identifies several challenges and gaps in the current adoption of AR and VR. These include technological limitations such as the need for more advanced hardware and software, user acceptance and comfort issues, and ethical concerns regarding data privacy and security. The literature suggests that addressing these challenges requires ongoing research and development and collaboration between industry stakeholders and policymakers.

So, the SLR reveals that AR and VR are rapidly evolving technologies with the potential to revolutionize various industries. The advancements in these fields drive innovation and offer new opportunities for enhancing efficiency, engagement, and experiences. However, the successful integration of AR and VR into mainstream applications will depend on overcoming the existing challenges and ensuring that the technologies are accessible and user-friendly. Future research should address these gaps and explore new ways to harness the full potential of AR and VR in diverse industry contexts.

Table 1. Developments and Applications of Augmented Reality (AR) and Virtual Reality (VR) Across Various Industries

Industry	Applications	Key Developments	Challenges and Gaps
Healthcare	- Surgical training - Real-time surgery assistance - Mental health therapy	- VR simulations for risk- - free surgical training - AR overlays for precision in surgeries - VR therapy for phobias and PTSD	- High cost of advanced AR/VR equipment - Ensuring patient safety and efficacy
Education	- Immersive learning environments 	- VR for hands-on concept	- Technological access

	- Virtual field trips - Interactive lab simulations	exploration - AR-enhanced textbooks with 3D models and animations	disparities - Teacher training for AR/VR integration
Manufacturing	- Worker training - Maintenance assistance - Design and prototyping	- VR-based realistic training modules - AR for step-by-step maintenance instructions - VR in design for cost-effective development	- High implementation costs - Resistance to change in traditional workflows
Retail	- Virtual try-ons - Furniture visualization - Virtual showrooms and stores	- AR apps for trying on clothes/accessories - VR showrooms for immersive shopping experiences	- Data privacy concerns - Ensuring accurate representation in AR/VR environments
General Challenges		- Need for more advanced hardware and software - User acceptance and comfort - Ethical and privacy issues	

This table provides a structured overview of how AR and VR are used in different industries, highlighting the key developments and the challenges that need to be addressed for wider adoption.

The analysis of the research findings on Augmented Reality (AR) and Virtual Reality (VR) reveals several important insights compared to previous studies and theoretical frameworks. The recent advancements and applications in various industries underscore the transformative potential of these technologies, aligning with existing theories about their capability to revolutionize traditional processes and enhance user experiences (Faisal & Kisman, 2020); (Asfahani, Sain, et al., 2023). However, the analysis also highlights ongoing challenges and gaps that must be addressed for these technologies to achieve their full potential.

Previous research has extensively documented the technical capabilities of AR and VR, focusing primarily on their development and initial applications in entertainment and gaming. The current study extends this knowledge by exploring the practical implementations of AR and VR in more diverse sectors such as healthcare, education, manufacturing, and retail. For instance, while early studies highlighted the immersive nature of VR for gaming, recent findings demonstrate how this immersion can be leveraged for medical training and mental health therapy (Maotsela et al., 2019; Obloberdiyevna D S, 2022). This shift from entertainment to practical, industry-specific applications marks a significant evolution in the utilization of AR and VR technologies.

The theoretical framework underpinning AR and VR technologies posits that these tools can create highly interactive and engaging experiences by overlaying digital information onto the physical world (AR) or creating entirely virtual environments (VR). This study confirms these theoretical claims, providing empirical evidence of AR and VR's effectiveness in enhancing training, improving task precision, and creating immersive learning and shopping experiences. For example, using VR simulations in surgical training offers a safe environment for surgeons to practice, aligning with theories on immersive learning environments' benefits (Nursalim et al., 2022; Stephenson, 2023).

In the healthcare sector, previous studies have primarily focused on the potential of VR for pain management and AR for diagnostic imaging. The current research expands on these findings by showcasing innovative applications such as VR-based therapy for PTSD and AR-assisted surgeries (Sethi et al., 2019). These developments not only validate earlier theoretical propositions about AR and VR's therapeutic and operational benefits but also open new avenues for previously unexplored (Sanasintani, 2020). The challenge remains in ensuring the efficacy and safety of these applications, which is a critical area for ongoing research.

The education sector has seen a theoretical emphasis on the benefits of interactive and immersive learning tools. This study provides concrete examples of how AR and VR are implemented to achieve these educational goals. VR's use in virtual field trips and lab simulations allows students to explore and interact with concepts in a way that traditional methods cannot match (Asfahani, El-Farra, et al., 2023; Malkisedek Taneo et al., 2019). Similarly, AR's capability to enhance textbooks with interactive 3D models aligns with the theoretical benefits of multimodal learning, where information is presented through multiple sensory channels to improve comprehension and retention.

In manufacturing, the theoretical advantages of AR and VR for training and maintenance are well-documented. The current findings confirm these advantages, showing

how VR-based training modules improve safety and retention among workers and how AR provides real-time, hands-on guidance for maintenance tasks (Dewi & Primayana, 2019; Waham et al., 2023). These practical implementations underscore the theoretical predictions about the efficiency and safety improvements AR and VR can bring to industrial settings (Pujiono et al., 2023); (Ahwan et al., 2021). However, the high costs and resistance to change present significant barriers that must be addressed to facilitate broader adoption.

The retail sector's exploration of AR and VR aligns with theories on enhancing customer engagement and decision-making. The study highlights how AR applications, such as virtual try-ons and furniture visualization, help customers make more informed purchasing decisions (Angraini & Harwani, 2020; Judijanto, Asfahani, Prusty, et al., 2022). VR's role in creating immersive virtual showrooms aligns with theoretical insights into the potential of virtual environments to replicate and enhance physical shopping experiences (Radianti et al., 2020). Despite these advancements, issues related to data privacy and the accuracy of AR/VR representations remain critical challenges.

In summary, the analysis of the research findings supports the theoretical framework that AR and VR have significant potential to transform various industries by enhancing user experiences, improving efficiency, and enabling new applications. The study extends previous research by providing empirical evidence of these technologies' practical implementations and benefits across diverse sectors. However, it also highlights the ongoing challenges, including technological limitations, user acceptance, and ethical concerns, which must be addressed to realize AR and VR's potential fully. Future research should focus on overcoming these barriers and exploring innovative solutions to facilitate the broader adoption of these transformative technologies.

CONCLUSION

The analysis of the recent developments and applications of Augmented Reality (AR) and Virtual Reality (VR) across various industries reveals significant advancements and transformative potential. AR and VR are effectively utilized in healthcare for enhanced surgical training and therapy, in education for immersive learning environments, in manufacturing for improved training and maintenance, and in retail for enriched customer experiences. These applications underscore the broad utility of these technologies beyond their initial entertainment-focused use. However, challenges such as high implementation costs, technological limitations, user acceptance, and ethical concerns regarding data privacy need to be addressed to facilitate wider adoption.

For future research, it is recommended that more cost-effective and user-friendly

AR and VR solutions be developed to lower the barriers to entry for various industries. Additionally, longitudinal studies assessing AR and VR applications' long-term impacts and efficacy in real-world settings are essential. By addressing these areas, future research can contribute to the broader and more effective integration of AR and VR across diverse sectors, maximizing their potential to revolutionize industry practices and enhance user experiences.

REFERENCES

Adhicandra, I., Asfahani, A., Tanwir, T., Sitopu, J. W., & Irawan, F. (2024). Latest Innovations in Internet of Things (IoT): Digital Transformation Across Industries. *Innovative: Journal Of Social Science Research*, *4*(3), 1027–1037.

Agustina, I., Siregar, L. A., Husain, D. L., Asfahani, A., & Pahmi, P. (2023). Utilization of Digital Technology in Children's Education to Enhance Creative and Interactive Learning. *At-Tarbawi: Jurnal Pendidikan, Sosial Dan Kebudayaan*, *10*(2), 276–283.

Ahwan, A., Musta'an, M., & Suwarni, A. (2021). Efforts to Improve Student Understanding in Utilizing the Efficacy and Safety of Traditional Drugs at SMK Putra Bangsa Salatiga. *SPEKTA*, *2*(1), 41–48.

Angraini, D., & Harwani, Y. (2020). The Effect of Product Quality, Price Perception, and Promotion of Purchasing Decisions in Sari Roti in West Jakarta. *4th International Conference on Management, Economics and Business (ICMEB 2019)*, 296–301.

Asfahani, A., El-Farra, S. A., & Iqbal, K. (2023). International Benchmarking of Teacher Training Programs: Lessons Learned from Diverse Education Systems. *Edujavare: International Journal of Educational Research*, *1*(2), 141–152.

Asfahani, A., Sain, Z. H., & Mariana, M. (2023). Comparative Analysis of Educational Policies: A Cross-Country Study on Access and Equity in Primary Education. *Edujavare: International Journal of Educational Research*, *1*(1), 19–28.

Bertheau, P. (2020). Assessing the impact of renewable energy on local development and the Sustainable Development Goals: Insights from a small Philippine island. *Technological Forecasting and Social Change*, *153*, 119919.

Busch, P. A., & McCarthy, S. (2021). Antecedents and consequences of problematic smartphone use: A systematic literature review of an emerging research area. *Computers in Human Behavior*, *114*, 106414.

Chang, Y.-S., Hu, K.-J., Chiang, C.-W., & Lugmayr, A. (2019). Applying Mobile Augmented Reality (AR) to teach Interior Design students in layout plans: Evaluation of learning effectiveness based on the ARCS Model of learning motivation theory. *Sensors*, *20*(1),

105.

Chauhan, C., Parida, V., & Dhir, A. (2022). Linking circular economy and digitalisation technologies: A systematic literature review of past achievements and future promises. *Technological Forecasting and Social Change*, *177*, 121508.

Dewi, P. Y. A., & Primayana, K. H. (2019). Effect of learning module with setting contextual teaching and learning to increase the understanding of concepts. *International Journal of Education and Learning*, *1*(1), 19–26.

Faisal, P., & Kisman, Z. (2020). Information and communication technology utilization effectiveness in distance education systems. *International Journal of Engineering Business Management*, *12*, 1–9. https://doi.org/10.1177/1847979020911872

Hassan, M. A., Habiba, U., Majeed, F., & Shoaib, M. (2021). Adaptive gamification in e-learning based on students' learning styles. *Interactive Learning Environments*, *29*(4), 545–565.

Huynh, T. L. D., Hille, E., & Nasir, M. A. (2020). Diversification in the age of the 4th industrial revolution: The role of artificial intelligence, green bonds and cryptocurrencies. *Technological Forecasting and Social Change*, *159*, 120188.

Judijanto, L., Asfahani, A., Bakri, A. A., Susanto, E., & Kulsum, U. (2022). AI-Supported Management through Leveraging Artificial Intelligence for Effective Decision Making. *Journal of Artificial Intelligence and Development*, *1*(1), 59–68.

Judijanto, L., Asfahani, A., Prusty, A., Krisnawati, N., & Bakri, A. A. (2022). Industrial Revitalization with AI between Opportunities and Challenges for Global Economic Growth. *Journal of Artificial Intelligence and Development*, *1*(1), 49–57.

Junaid, M., Zhang, Q., Cao, M., & Luqman, A. (2023). Nexus between technology enabled supply chain dynamic capabilities, integration, resilience, and sustainable performance: An empirical examination of healthcare organizations. *Technological Forecasting and Social Change*, *196*, 122828.

Malkisedek Taneo, Fransina Aprilyse Ndoen, & Madu, A. (2019). Training Application Of Field Trip Learning Methods For Teachers Of History In Kupang City. *IJRDO - Journal of Educational Research*, *4*(7 SE-Articles), 64–70. https://doi.org/10.53555/er.v4i7.3141

Maotsela, T., Danha, G., & Muzenda, E. (2019). Utilization of Waste Cooking Oil and Tallow for Production of Toilet "Bath" Soap. *Procedia Manufacturing*, *35*, 541–545.

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual reality in education: a review of learning theories, approaches and methodologies for the last decade. *Electronics*, *12*(13), 2832.

Nursalim, A., Judijanto, L., & Asfahani, A. (2022). Educational Revolution through the Application of AI in the Digital Era. *Journal of Artificial Intelligence and Development*, *1*(1), 31–40.

O'Connor, J., Ludgate, S., Le, Q.-V., Le, H. T., & Huynh, P. D. P. (2023). Lessons from the pandemic: Teacher educators' use of digital technologies and pedagogies in Vietnam before, during and after the Covid-19 lockdown. *International Journal of Educational Development*, *103*(January), 1–10. https://doi.org/10.1016/j.ijedudev.2023.102942

Obloberdiyevna D S, O. K. U. (2022). Teaching languages using modern educational methods. *International Journal of Intellectual and Cultural Heritage*, *2*(3), 105–109.

Pujiono, I. P., Rachmawanto, E. H., & Nugroho, D. A. (2023). The Implementation of Improved Advanced Encryption Standard and Least Significant Bit for Securing Messages in Images. *Journal of Applied Intelligent System*, *8*(1), 69–80.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, 103778.

Sanasintani, S. P. (2020). Implementation Academic Supervisions By The Education Supervissors In Madrasah Ibtidaiyah Negeri (MIN) Pahandut Palangka Raya. *Penamas*, *33*(2). https://doi.org/10.31330/penamas.v33i2.387

Sethi, V., Yadav, S., Agrawal, S., Sareen, N., Kathuria, N., Mishra, P., Kapoor, J., & Dureja, S. (2019). Incidence of Side-effects After Weekly Iron and Folic Acid Consumption Among School-going Indian Adolescents. *Indian Pediatrics*, *56*, 33–34.

Stephenson, L. (2023). Collective creativity and wellbeing dispositions: Children's perceptions of learning through drama. *Thinking Skills and Creativity*, *47*(November 2022), 101188. https://doi.org/10.1016/j.tsc.2022.101188

Suri, P. A., Syahputra, M. E., Amany, A. S. H., & Djafar, A. (2023). Systematic literature review: The use of virtual reality as a learning media. *Procedia Computer Science*, *216*, 245–251. https://doi.org/10.1016/j.procs.2022.12.133

Torous, J., Bucci, S., Bell, I. H., Kessing, L. V, Faurholt‐Jepsen, M., Whelan, P., Carvalho, A. F., Keshavan, M., Linardon, J., & Firth, J. (2021). The growing field of digital psychiatry: current evidence and the future of apps, social media, chatbots, and virtual reality. *World Psychiatry*, *20*(3), 318–335.

Waham, J. J., Asfahani, A., & Ulfa, R. A. (2023). International Collaboration in Higher Education: Challenges and Opportunities in a Globalized World. *Edujavare: International Journal of Educational Research*, *1*(1), 49–60.

Yang, Q.-F., Lin, C.-J., & Hwang, G.-J. (2021). Research focuses and findings of flipping mathematics classes: a review of journal publications based on the technology-enhanced learning model. *Interactive Learning Environments*, *29*(6), 905–938.