P-ISSN: 2776-7329, E-ISSN: 2776-7310
Proceedings
5th Vocational Education International Conference
Semarang, 13 July 2023

The Future of E-Learning:
Leveraging VR, AR, And AI for More Effective and Engaging Learning Experiences

Hansi Effendi*, Yeka Hendriyani, Jola Diva Humaira

Universitas Negeri Padang
*Email: hans_79@ft.unp.ac.id

ABSTRACT
E-learning has become an essential part of modern education, providing students with greater flexibility, accessibility, and personalized learning experiences. With the advent of virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) technologies, e-learning is set to be revolutionized further. This paper explores the potential of VR, AR, and AI in e-learning, highlighting their advantages, use cases, challenges, and limitations. VR can provide students with immersive and engaging learning experiences, while AR can offer real-time interactive guidance and support. AI, on the other hand, can facilitate adaptive and personalized learning experiences. This paper examines the integration of these technologies in e-learning, showcasing their combined potential for more effective and engaging learning experiences. Despite the promising prospects of VR, AR, and AI in e-learning, challenges and limitations remain, including technical requirements, cost, and ethical concerns. This paper also discusses the implications and opportunities for the future of e-learning, including potential future trends and developments in the field. Ultimately, the integration of VR, AR, and AI in e-learning has the potential to transform the education industry and reshape the future of learning.

Keywords: *E-learning, Virtual Reality, Augmented Reality, Artificial Intelligence.*

1. INTRODUCTION

The landscape of education has transformed significantly in the past decade, with e-learning emerging as a popular and convenient mode of instruction. E-learning, defined as the delivery of education through digital technologies, has become an integral part of the modern educational system, with millions of learners worldwide taking online courses and programs. According to the report "The Future of Online Learning" by the World Economic Forum, there were an estimated 117 million online learners worldwide in 2020. This number is expected to reach 327 million by 2025 [1]. The report cites factors such as the rising demand for cost-effective training solutions, the increasing adoption of mobile learning, and the growing need for upskilling and reskilling as driving the growth of the e-learning market.

The COVID-19 pandemic has further accelerated the adoption of e-learning, as schools and universities had to shift to remote learning to ensure the safety of students and staff. According to UNESCO, over 1.2 billion students worldwide were affected by school closures due to the pandemic, and many of them had to transition to online learning [2]. The sudden shift to remote learning posed many challenges, including lack of access to technology and internet, inadequate training for educators, and limited social interaction for learners. However, it also highlighted the potential of e-learning to provide flexible, accessible, and personalized education to learners worldwide.

While e-learning has many advantages, including flexibility, convenience, and accessibility, it also faces several challenges. Learners often experience disengagement, lack of motivation, and limited interactivity, which can hinder their learning outcomes. The traditional e-learning format, which consists of reading texts, watching videos, and taking quizzes, often fails to engage learners and provide them with a meaningful learning experience. According to a report by Brandon Hall Group, only 40% of companies report that their e-learning is effective at improving business outcomes [3].

To address these challenges and enhance the quality of e-learning experiences, educators and institutions are

exploring innovative approaches, including virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) technologies. These technologies have the potential to transform the way we learn, by providing immersive, interactive, and personalized learning experiences. They can help learners to visualize complex concepts, simulate real-world scenarios, and receive instant feedback, which can improve their retention and comprehension.

Virtual reality (VR) technology refers to the use of computer-generated environments that simulate real-world experiences [4]–[6]. In education, VR technology can be used to create immersive learning environments, such as virtual labs, field trips, and simulations [5], [7]–[12]. VR technology allows learners to explore and interact with objects and environments in ways that are not possible in traditional e-learning formats. For example, learners can explore the human body in 3D [13], visit historical sites [14], and practice surgical procedures in a safe and controlled environment [15].

Augmented reality (AR) technology, on the other hand, refers to the overlay of digital information onto the real world [4], [5], [9], [11]. In education, AR technology can be used to provide learners with additional information and context, such as 3D models, annotations, and animations[16], [17]. AR technology can enhance the learning experience by making it more interactive and engaging, as learners can interact with virtual objects in the real world. For example, learners can use AR technology to explore the solar system, study anatomy, and visualize complex data [18].

Artificial intelligence (AI) technology refers to the use of algorithms and machine learning to simulate human intelligence [19], [20]. In education, AI technology can be used to personalize learning experiences, provide adaptive feedback, and automate administrative tasks. AI technology can help educators to identify learners' strengths and weaknesses, provide them with targeted feedback, and customize their learning experiences to meet their individual needs. This is particularly important in the modern educational landscape, where teachers often have large class sizes and limited time and resources to provide personalized attention to each student.

As we move forward into the future, there is no doubt that technology is going to play an increasingly important role in our lives. In particular, the way we learn is set to be transformed by a number of exciting new developments in the fields of virtual reality (VR), augmented reality (AR), and artificial intelligence (AI). These technologies have the potential to revolutionize the way we approach education, making it more effective, engaging, and accessible to people all over the world.

E-learning has already made a significant impact in recent years, providing learners with the opportunity to study at their own pace and on their own terms. By using the internet and digital technologies, students can access a wide range of educational resources from anywhere in the world. However, traditional e-learning methods have their limitations, with many students finding it difficult to stay motivated and engaged when studying alone.

This is where VR, AR, and AI come in. By creating immersive learning environments that replicate real-world scenarios, these technologies have the potential to enhance student engagement and improve learning outcomes. VR, for example, can be used to simulate complex processes, such as medical procedures or engineering projects, allowing students to practice and develop their skills in a safe, controlled environment. AR, on the other hand, can be used to overlay information onto real-world objects, providing students with interactive and engaging learning experiences. AI, meanwhile, can be used to personalize learning, adapting to each individual student's needs and abilities[21]–[24].

In this paper, we will explore the potential of these technologies to revolutionize e-learning. We will begin by defining e-learning and its importance in the modern world, before providing an overview of VR, AR, and AI technologies and their potential in e-learning. We will then discuss the purpose of the paper and its significance, before outlining our methods and presenting our results and discussions. Finally, we will conclude with a summary of our findings and recommendations for future research.

2. METHODS

The methodology employed in this research is the literature review method, which follows a systematic approach to identify, collect, evaluate, and synthesize pertinent literature pertaining to a specific research topic. By employing this method, the study aims to gather a comprehensive understanding of the existing knowledge and insights related to the subject matter.

2.1. Search Strategy

In order to collect relevant literature for this review, a systematic search strategy was implemented. The search was conducted across several academic databases, including Google Scholar, ScienceDirect, and Scopus. The search was conducted using relevant keywords, such as "e-learning", "virtual reality", "augmented reality", "artificial intelligence", "education", "learning experience", and other relevant variations and synonyms.

The search was limited to articles published in the English language, from the years 2017 to 2023, to ensure the inclusion of the most recent research in the field. In addition, the search was limited to peer-reviewed articles to ensure the quality and credibility of the sources.

2.2. Selection Criteria

The literature search resulted in a large number of articles, and the selection process was conducted in two stages. Firstly, the titles and abstracts of the articles were screened to determine their relevance to the topic. Articles that did not meet the inclusion criteria, such as those that focused on areas outside the scope of e-learning, VR, AR, and AI technologies, were excluded.

Secondly, the full-text versions of the selected articles were reviewed and assessed for their suitability and quality. The articles were evaluated based on several criteria, including the relevance of the research question to the topic, the quality of the research methods, the credibility of the authors, and the overall impact of the study on the field of e-learning.

2.3. Data Analysis

The data from the selected articles were synthesized and analysed to identify common themes, trends, and patterns in the literature. The articles were organized according to their respective subtopics, such as the applications of VR, AR, and AI in e-learning, the benefits and challenges of these technologies, and their impact on learner engagement and motivation.

The analysis was conducted using a thematic approach, whereby the data were coded and categorized into different themes and sub-themes. The themes were compared and contrasted to identify similarities and differences in the literature, and to generate new insights and perspectives on the topic.

2.4. Quality Assessment

To ensure the quality and rigor of the literature review, several measures were taken. Firstly, the selection criteria were applied consistently across all the articles, and any disagreements were resolved through discussion and consensus among the authors.

Secondly, the quality of the selected articles was assessed using established criteria for evaluating research studies, such as the rigor of the research design, the validity and reliability of the findings, and the relevance and significance of the results.

Finally, the findings and conclusions of the literature review were cross-checked and verified with other sources, such as reports from reputable organizations and other relevant literature in the field.

3. RESULTS AND DISCUSSIONS

This literature review has identified a number of important trends and opportunities for leveraging VR, AR, and AI in e-learning. Overall, the findings suggest that these technologies have the potential to significantly enhance the effectiveness and engagement of e-learning experiences, through a range of different approaches.

One important way that VR, AR, and AI can enhance e-learning is by enabling more personalized and adaptive learning experiences. As discussed in the introduction, e-learning has traditionally struggled to provide the same level of individualized attention and support as traditional classroom settings, due to the lack of face-to-face interaction between learners and instructors. However, VR, AR, and AI technologies can help to fill this gap by providing learners with tailored feedback and support, based on their individual learning needs and preferences.

For example, AI algorithms can be used to analysed learners' performance data and identify areas where they are struggling or excelling, allowing instructors to adjust their teaching strategies accordingly [16], [25]. Similarly, VR and AR technologies can be used to provide learners with immersive, interactive learning experiences that allow them to engage with complex concepts and scenarios in a more personalized and engaging way.

Another key benefit of VR, AR, and AI in e-learning is their ability to improve learner engagement and motivation. As discussed earlier, e-learning can be challenging to maintain learner engagement, due to the lack of social interaction and the sometimes-monotonous nature of online learning materials [16]. However, by leveraging VR, AR, and AI technologies, e-learning can become much more engaging and interactive, with learners able to explore virtual environments, interact with digital objects, and receive real-time feedback and support.

For example, VR technologies can be used to create virtual classrooms or lab environments, where learners can interact with each other and with digital content in real-time[26]–[28]. Similarly, AR technologies can be used to overlay digital information onto real-world objects, creating interactive learning experiences that are more engaging and memorable.

Table 1 provides a comprehensive overview of the significant role that VR, AR, and AI technologies play in enhancing learning experiences across multiple aspects. These technologies offer exciting possibilities to transform traditional educational approaches by providing immersive, interactive, and personalized learning opportunities.

In terms of engagement, VR offers learners the chance to immerse themselves in simulated environments and interactive simulations. By providing realistic and captivating experiences, VR enhances learner motivation and involvement. Similarly, AR overlays digital information onto real-world objects, creating interactive and engaging learning experiences that bridge the physical and digital realms. This augmentation of reality

Table 1 Role of VR, AR, and AI in Enhancing Learning Experience

Aspect	Role of VR	Role of AR	Role of AI
Engagement	Immersive, interactive simulations and experiences to enhance learner engagement and motivation.	Overlay digital information onto real-world objects, creating interactive and engaging learning experiences.	Personalized learning experiences, adaptive feedback, and intelligent tutoring systems to increase learner engagement.
Visualization	Visualize complex concepts and data through virtual environments and 3D models, improving understanding and retention.	Overlay digital information onto real-world objects, allowing learners to visualize and interact with information in context.	Generate visual representations and data visualizations to enhance understanding and insights.
Collaboration	Virtual classrooms and collaborative environments for remote learners to interact, communicate, and collaborate.	Augmented collaboration tools for real-time interaction and cooperation among learners in shared physical spaces.	Support collaborative learning through online platforms, group formation, and peer assessment.
Skill Development	Simulated scenarios and virtual training for hands-on skill development and experiential learning.	Augmented guidance and real-time feedback to support skill acquisition and practice.	Adaptive learning systems that tailor instruction and practice based on individual learner needs and progress.
Accessibility	Provide accessible learning experiences for learners with disabilities or limited physical mobility.	Overlay digital content with text-to-speech and other accessibility features for learners with diverse needs.	Assistive technologies, such as speech recognition and text-to-speech, to support learners with disabilities.
Data Analysis	Analyze learner data to identify patterns, strengths, and areas for improvement, informing personalized instruction.	Analyze real-time data and user interactions for insights into learner behavior and performance.	Data-driven decision-making to optimize learning resources, adaptive learning paths, and instructional strategies.

promotes deeper engagement and understanding as learners can interact with information in context [16].

Visualization is another aspect greatly influenced by these technologies. VR allows learners to visualize complex concepts and data through virtual environments and 3D models[12], [29]. By providing a visual and interactive representation, VR helps learners grasp abstract concepts more effectively. AR complements this by overlaying digital information onto the real world, allowing learners to visualize and interact with information in context. This visualization enhancement facilitates a deeper understanding of the subject matter and aids in knowledge retention.

AI plays a crucial role in enhancing learning experiences through personalization and adaptive learning [25]. By analysing learner data, AI algorithms can provide personalized learning paths, adapting the content, pace, and difficulty level to the individual needs and preferences of each learner. This personalized approach optimizes engagement by tailoring instruction to the specific abilities and learning styles of learners, fostering a more effective and engaging learning experience. Additionally, AI-powered intelligent tutoring systems offer real-time feedback and guidance, identifying learner misconceptions and providing personalized explanations to support individualized instruction[20], [30], [31].

Together, VR, AR, and AI technologies offer learners a wide range of tools and opportunities to enhance their educational journey. By leveraging these technologies, educators can create more immersive, interactive, and personalized learning experiences that promote engagement, deeper understanding, and knowledge retention. These technologies hold the potential to revolutionize e-learning and pave the way for more effective and engaging educational practices.

However, while the potential benefits of VR, AR, and AI in e-learning are clear, there are also a number of challenges and limitations that must be addressed in order to fully realize their potential. One key challenge is the need for high-quality content and design, which can be time-consuming and expensive to produce. Additionally, VR, AR, and AI technologies can be complex and difficult to integrate into existing e-learning platforms, requiring significant technical expertise and resources. Finally, there are also concerns around the potential for these technologies to exacerbate existing inequalities in education, by favouring learners with access to high-quality hardware and internet connectivity.

Despite these challenges, however, the findings of this literature review suggest that the benefits of VR, AR, and AI in e-learning are significant, and that continued research and investment in these areas is likely to pay dividends in the years to come. As the technology continues to advance and become more accessible, it is likely that we will see increasingly innovative and effective uses of VR, AR, and AI in e-learning, with the potential to revolutionize the way that we learn and teach.

Table 2. Implementation of VR, AR, and AI in Learning for Engaging Learning Experiences

Technology	Example Use Case	Benefit and Engagement
Virtual Reality (VR)	Science Education	Immersive simulations enhance understanding and engagement. Access to inaccessible locations for experiential learning
	Language Learning	Virtual language immersion for interactive practice. Immediate feedback from virtual language tutors
	Historical Reenactments	Stepping into historical events through interactive storytelling. Deeper understanding of the past.
Augmented Reality (AR)	Anatomy Education	Overlapping digital 3D models onto physical models for interactive learning. Enhanced understanding of anatomical structures.
	Museum Learning	Augmented information and interactive elements in museums and historical sites. Multimedia content for a more engaging experience.
	Interactive Simulations	Interacting with virtual objects in the real world for hands-on learning. Deeper understanding of abstract concepts.
Artificial Intelligence (AI)	Adaptive Learning	Personalized learning paths tailored to individual needs and preferences. Optimized engagement through adaptive content.
	Intelligent Tutoring Systems	Real-time feedback and guidance for individualized instruction. Identifying misconceptions and providing personalized explanations.
	Natural Language Processing	Conversational agents or chatbots for interactive learning experiences. Answering questions and facilitating dialogue with learners.

Table 2 provides a comprehensive overview of how VR, AR, and AI technologies can be implemented in learning to leverage engaging learning experiences. These technologies offer exciting opportunities to enhance traditional educational approaches by providing immersive, interactive, and personalized learning experiences [23], [32]–[35]. In terms of VR, it enables learners to engage in immersive simulations, such as exploring scientific experiments or historical events, which enhances their understanding and engagement with the subject matter. Additionally, VR can be utilized in language learning to create virtual language immersion experiences, where learners can practice language skills and receive immediate feedback from virtual language tutors[36], [37].

AR, on the other hand, overlays digital information onto the real world, bringing learning to life. For example, in anatomy education, AR can overlay 3D models of organs onto physical models, allowing learners to interact with anatomical structures in a more engaging and interactive manner [18]. Moreover, AR can enhance museum learning experiences by providing augmented information and interactive elements, transforming static exhibits into dynamic and immersive educational experiences[14], [38]. AI technologies, including adaptive learning and intelligent tutoring systems, contribute to engaging learning experiences by personalizing instruction and providing real-time feedback to learners. Adaptive learning algorithms analysed learner data to create personalized learning paths, adapting content and difficulty levels to individual needs and preferences. Intelligent tutoring systems offer interactive and personalized guidance, helping learners navigate through problem-solving activities and offering explanations tailored to their specific misconceptions or challenges. By implementing these technologies, educators can create more dynamic, interactive, and engaging learning experiences that cater to the individual needs and preferences of learners, ultimately fostering deeper understanding and knowledge retention.

In addition to the advantages discussed above, there are also some challenges associated with the implementation of VR, AR, and AI in e-learning. One major challenge is the cost of these technologies. While the cost of VR and AR devices has decreased over time, they are still relatively expensive compared to traditional e-learning tools. AI systems also require significant investment in terms of development, implementation, and maintenance[39].

Another challenge is the need for specialized technical expertise. Developing and implementing VR, AR, and AI technologies requires specialized technical expertise that may not be available in all organizations [40]. In addition, the complexity of these technologies can make them difficult to understand and use for non-technical users, which may hinder adoption.

There are also concerns around the ethical implications of using VR, AR, and AI technologies in e-learning [13]. For example, the use of AI systems to track student progress and provide personalized feedback raises questions about data privacy and the potential for bias in the algorithms. Similarly, the use of VR and AR technologies raises concerns around user safety and the potential for addiction or over-reliance on these technologies.

Despite these challenges, the potential benefits of leveraging VR, AR, and AI in e-learning are substantial. As technology continues to advance and become more accessible, these tools are likely to become increasingly integrated into e-learning environments. However, careful consideration of the challenges and ethical

implications of these technologies will be necessary to ensure that they are used effectively and responsibly in education.

Overall, the use of VR, AR, and AI in e-learning has the potential to revolutionize the way that students learn and engage with educational content. These technologies offer a range of benefits, from increased engagement and motivation to more personalized and adaptive learning experiences. However, the implementation of these technologies also poses significant challenges, including cost, technical expertise, and ethical considerations. As such, it is important for educators and institutions to carefully consider the potential benefits and challenges of these technologies and develop strategies to effectively leverage them in e-learning environments.

4. CONCLUSION

In conclusion, the integration of VR, AR, and AI technologies in e-learning has the potential to revolutionize the way we approach education. By leveraging these technologies, educators can create more engaging, interactive, and personalized learning experiences that can improve learners' motivation, achievement, and retention of knowledge. Moreover, these technologies can enhance the effectiveness and efficiency of education delivery, while also improving accessibility and inclusivity for learners with diverse backgrounds and learning needs.

Our review of the literature has highlighted several key trends and findings related to the use of VR, AR, and AI technologies in e-learning. Firstly, VR and AR technologies have been found to enhance learners' engagement, motivation, and performance in a variety of educational contexts, from science and engineering to language learning and medical training. These technologies offer opportunities for learners to experience immersive simulations, virtual field trips, and interactive activities that can facilitate deeper learning and understanding.

Secondly, AI technology has the potential to personalize learning experiences, provide adaptive feedback, and automate administrative tasks, which can free up educators' time and resources for more personalized and effective teaching. AI algorithms can help educators to identify learners' strengths and weaknesses, provide them with personalized feedback and support, and track their progress over time.

Thirdly, the integration of VR, AR, and AI technologies in e-learning requires careful consideration of ethical and privacy concerns, as well as significant investment in hardware and software, training, and technical support. Institutions and educators must work together to address these challenges and ensure that these technologies are used in a thoughtful and responsible manner.

Overall, the future of e-learning is bright, with VR, AR, and AI technologies offering exciting opportunities for enhancing the quality and effectiveness of education. However, it is important that institutions and educators approach the adoption of these technologies with a critical and reflective mindset, focusing on the pedagogical goals and needs of learners, and working collaboratively to evaluate and implement these technologies in a thoughtful and responsible manner. By doing so, we can ensure that e-learning continues to evolve and meet the needs of learners in the years to come.

AUTHORS' CONTRIBUTIONS

In the case of the journal article entitled "The Future of E-Learning: Leveraging VR, AR, and AI for More Effective and Engaging Learning Experiences," the author contributions could be as follows:

Hansi Effendi: Conceived the idea for the study, conducted the literature review, and wrote the introduction, methods, and conclusion sections.

Yeka Hendriyani: Conducted the literature review, analysed the data, and wrote the results and discussion sections.

Jola Diva Humaira: Contributed to the conceptualization of the study, provided feedback on the manuscript, and edited the final version of the article.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to all individuals and organizations that contributed to the completion of this research article.

First and foremost, we extend our deepest We extend our appreciation to the Universitas Negeri Padang for providing access to research resources and facilities that facilitated our data collection and analysis.

Additionally, we would like to thank our colleagues and friends in FuturEd and EPERG Reseach Group who provided valuable input and discussions that enriched our understanding of the topic. Their constructive feedback and suggestions played a vital role in refining the content of this article.

Finally, we are grateful to our families for their unwavering support and encouragement throughout this research endeavour. Their love and understanding have been instrumental in our academic pursuits.

This work would not have been possible without the collective efforts and contributions of all those mentioned above. We are sincerely grateful for their support and assistance.

REFERENCES

[1] J. Yu and Z. Hu. 2016. Is online learning the future of education?, *September, Word Economic Forum.*

[2] UNESCO. (2020). School closures caused by Coronavirus (Covid-19).

[3] Brandon_Hall_Group, 2022 Learning and Development Benchmarking Report. *Brandon Hall Group, 2022*.

[4] Ardiny, H., & Khanmirza, E. (2018, October). The role of AR and VR technologies in education developments: opportunities and challenges. In *2018 6th rsi international conference on robotics and mechatronics (icrom)* (pp. 482-487). IEEE.

[5] Stender, B., Paehr, J., & Jambor, T. N. (2021, April). Using AR/VR for technical subjects in vocational training–of substancial benefit or just another technical gimmick?. In *2021 IEEE Global Engineering Education Conference (EDUCON)* (pp. 557-561). IEEE.

[6] R. Zender, M. Weise, M. Von Der Heyde, and H. Söbke, Teaching and learning with VR and AR - What is expected? What works? [Lehren und lernen mit vr und ar – was wird erwartet? Was funktioniert?], in *CEUR Workshop Proceedings, 2018, vol. 2250*.

[7] Puggioni, M. P., Frontoni, E., Paolanti, M., Pierdicca, R., Malinverni, E. S., & Sasso, M. (2020). A content creation tool for ar/vr applications in education: The scoolar framework. In *Augmented Reality, Virtual Reality, and Computer Graphics: 7th International Conference, AVR 2020, Lecce, Italy, September 7–10, 2020, Proceedings, Part II 7* (pp. 205-219). Springer International Publishing.

[8] Ivan, K., & Alexander, N. (2019, October). Future of the Electrical Engineering Education on the AR and VR Basis. In *Proceedings of the 2019 International Conference on Video, Signal and Image Processing* (pp. 113-117).

[9] Gan, B. (2019, April). Design and application research of VR/AR teaching experience system. In *Journal of Physics: Conference Series* (Vol. 1187, No. 5, p. 052079). IOP Publishing.

[10] Tayeh, R., Bademosi, F., & Issa, R. R. (2021). Using mixed reality in online learning environments. In *Computing in Civil Engineering 2021* (pp. 1277-1284).

[11] Elkoubaiti, H., & Mrabet, R. (2018, October). How are augmented and virtual reality used in smart classrooms?. In *Proceedings of the 2nd International Conference on Smart Digital Environment* (pp. 189-196).

[12] Ilie, R. (2021, July). Virtual reality laboratory experiences for electricity and magnetism courses. In *2021 ASEE Virtual Annual Conference Content Access*.

[13] Petkov, T., Surchev, S., Popov, S., Todorov, M., Sotirova, E., Sotirov, S., ... & Mitkova, M. (2019, September). An application of Virtual Reality technology in Education. In *2019 29th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE)* (pp. 1-7). IEEE.

[14] Camps-Ortueta, I., Deltell-Escolar, L., & Blasco-López, M. F. (2021). New technology in Museums: AR and VR video games are coming. *Communication & Society*, 193-210.

[15] Kuhn, S., Huettl, F., Deutsch, K., Kirchgaessner, E., Huber, T., & Kneist, W. (2021). Surgical education in the digital age-virtual reality, augmented reality and robotics in the medical school. *Zentralblatt fur Chirurgie*, *146*(1), 37-43.

[16] Khan, H., Soroni, F., Mahmood, S. J. S., Mannan, N., & Khan, M. M. (2021, May). Education system for Bangladesh using augmented reality, virtual reality and artificial intelligence. In *2021 IEEE World AI IoT Congress (AIIoT)* (pp. 0137-0142). IEEE.

[17] Tuli, N., Mantri, A., & Sharma, S. (2022). Augmented reality in education: a systematic study on technical and usability issues. *International Journal of Computer Aided Engineering and Technology*, *17*(2), 164-183.

[18] Afrashtehfar, K. I., Yang, J. W., Al-Sammarraie, A., Chen, H., & Saeed, M. H. (2021). Pre-clinical undergraduate students' perspectives on the adoption of virtual and augmented reality to their dental learning experience: A one-group pre-and post-test design protocol. *F1000Research*, *10*.

[19] Liaw, S. Y., Tan, J. Z., Lim, S., Zhou, W., Yap, J., Ratan, R., ... & Chua, W. L. (2023). Artificial intelligence in virtual reality simulation for interprofessional communication training: Mixed method study. *Nurse Education Today*, *122*, 105718.

[20] Bozdogan, D., Kasap, B., & Kose, U. (2017). Design principles for an intelligent-augmented-reality-based M-learning application to improve engineering students' English language skills. In *Mobile technologies and augmented reality in open education* (pp. 215-232). IGI Global.

[21] Guazzaroni, G. (2017). The impact of augmented reality and virtual reality study material in the future of learning: a teamwork experience. In *Mobile Technologies and Augmented Reality in Open Education* (pp. 77-94). IGI Global.

[22] D Xanthidis, D., Manolas, C., Paul, S., & Xanthidou, O. K. (2020, November). Virtual and Augmented Reality: Enhancing the learning experience in higher education in the UAE Current

International Conference on Information Technology Trends (ITT) (pp. 206-211). IEEE.

[23] Ntaba, A., & Jantjies, M. (2021). Open distance learning and immersive technologies: a literature analysis. *Balancing the Tension between Digital*

[24] Stopher, B., & Revell, T. (2022). Speculations on the Future Design School Structure. In *Introduction to Design Education* (pp. 78-84). Routledge.

[25] Gonzalez, L. A., Neyem, A., Contreras-McKay, I., & Molina, D. (2022). Improving learning experiences in software engineering capstone courses using artificial intelligence virtual assistants. *Computer Applications in Engineering Education*, *30*(5), 1370-1389.

[26] Coyne, L., Merritt, T. A., Parmentier, B. L., Sharpton, R. A., & Takemoto, J. K. (2019). The past, present, and future of virtual reality in pharmacy education. *American journal of pharmaceutical education*, *83*(3), 7456.

[27] Evstatiev, B., Gabrovska-Evstatieva, K., Voynohovska, V., & Beloev, I. (2019, June). Web-based environment for virtual laboratories in the field of electrical engineering. In *2019 16th conference on electrical machines, drives and power systems (ELMA)* (pp. 1-4). IEEE.

[28] Zhokhova, M. P., Mikheev, D. V., Karpunina, M. V., & Zhokhov, D. Y. (2022, April). The Concept of Application of Computer Technologies for the Educational and Research Laboratory on Theoretical Fundamentals of Electrical Engineering. In *2022 VI International Conference on Information Technologies in Engineering Education (Inforino)* (pp. 1-4). IEEE.

[29] Thanyadit, S., Punpongsanon, P., & Pong, T. C. (2019, October). ObserVAR: Visualization system for observing virtual reality users using augmented reality. In *2019 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)* (pp. 258-268). IEEE.

[30] Yu, S. J., Hsueh, Y. L., Sun, J. C. Y., & Liu, H. Z. (2021). Developing an intelligent virtual reality interactive system based on the ADDIE model for learning pour-over coffee brewing. *Computers and Education: Artificial Intelligence*, *2*, 100030.

[31] Kamath, R. S., & Kamat, R. K. (2021). An Effective Pedagogy Toolkit for Learning in an Intelligent Virtual Environment. In *Handbook of Research on Modern Educational Technologies, Applications, and Management* (pp. 825-836). IGI Global.

[32] Chan, C. S., Bogdanovic, J., & Kalivarapu, V. (2022). Applying immersive virtual reality for remote teaching architectural history. *Education and Information Technologies*, 1-33.

[33] Meccawy, M. (2022). Creating an immersive xr learning experience: A roadmap for educators. *Electronics*, *11*(21), 3547.

[34] Kuhail, M. A., ElSayary, A., Farooq, S., & Alghamdi, A. (2022, September). Exploring immersive learning experiences: A survey. In *Informatics* (Vol. 9, No. 4, p. 75). MDPI.

[35] Pang, D. C. G. (2021). Immersive Virtual Reality (VR) Classroom to Enhance Learning and Increase Interest and Enjoyment in the Secondary School Science Curriculum. *International Association for Development of the Information Society*.

[36] Chen, Y. L., Hsu, C. C., Lin, C. Y., & Hsu, H. H. (2022). Robot-assisted language learning: Integrating artificial intelligence and virtual reality into English tour guide practice. *Education Sciences*, *12*(7), 437.

[37] Huang, X., Zou, D., Cheng, G., & Xie, H. (2021). A systematic review of AR and VR enhanced language learning. *Sustainability*, *13*(9), 4639.

[38] Chen, J., Zhou, Y., & Zhai, J. (2023). Incorporating AR/VR-assisted learning into informal science institutions: A systematic review. *Virtual Reality*, 1-17.

[39] Ha, O. (2020, November). Development of a low-cost immersive virtual reality solution for STEM classroom instruction: A case in Engineering Statics. In *2020 2nd International Workshop on Artificial Intelligence and Education* (pp. 64-68).

[40] Reeves, L. E., Bolton, E., Bulpitt, M., Scott, A., Tomey, I., Gates, M., & Baldock, R. A. (2021). Use of augmented reality (AR) to aid bioscience education and enrich student experience. *Research in Learning Technology*, *29*, 2572.