*engineering proceedings*

MDPI

*Proceeding Paper*

# The Future of Artificial Intelligence in Interactive Learning: Trends, Challenges, Opportunities †

**Teguh Hidayat Iskandar Alam [1,2,*] and Ika Safitri Windiarti [1,3]**

[1] Faculty of Business Manajemen and Information Technology Perlis, Universiti Muhammadiyah Malaysia (UMAM), Padang Besar 02100, Malaysia; ika.windiarti@umam.edu.my
[2] Fakultas Teknik, Universitas Muhammadiyah Sorong, Sorong 98416, Indonesia
[3] Fakultas Keguruan dan Ilmu Pendidikanm Palangkaraya, Universiti Muhammadiyah Palangkaraya, Palangka Raya 73111, Indonesia
* Correspondence: teguhhidayat@um-sorong.ac.id or p5240019@student.umam.edu.my
† Presented at the 8th Mechanical Engineering, Science and Technology International Conference, Padang Besar, Perlis, Malaysia, 11–12 December 2024.

**Abstract:** This study explores how artificial intelligence (AI) will evolve and impact interactive learning models in the next two decades. Using a PRISMA-based Systematic Literature Review (SLR) approach, the study analyzes articles published in the last five years to identify trends, challenges, and opportunities for AI applications in education. The results show that AI has the potential to create adaptive, personalized, and immersive learning systems, while supporting the development of a more inclusive and multidisciplinary education ecosystem. The findings also show how AI can synergize with technologies such as virtual reality (VR) and augmented reality (AR), and contribute to sustainability, decision-making, and professional education. In addition, the study identifies the social, economic, and cultural impacts of AI adoption, and provides recommendations to mitigate challenges, such as data privacy and technology access. By providing new insights into future trends in AI in education, this study offers a basis for developing innovative and sustainable education policies and practices to meet global needs.

**Keywords:** artificial intelligence; interactive learning; future trends; systematic literature review

check for updates

Academic Editors: Noor Hanita Abdul Majid, Agus Dwi Anggono, Waluyo Adi Siswanto, Tri Widodo Besar Riyadi, Mohammad Sukri Mustapa, Nur Rahmawati Syamsiyah and Afif Faishal

Published: 8 April 2025

**Citation:** Alam, T.H.I.; Windiarti, I.S. The Future of Artificial Intelligence in Interactive Learning: Trends, Challenges, Opportunities. *Eng. Proc.* **2025**, *84*, 87. https://doi.org/10.3390/engproc2025084087

**Copyright:** © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

## 1. Introduction

In the past two decades, artificial intelligence (AI) technology has brought significant changes to various aspects of life, including the field of education [1,2]. The integration of AI in education has created new opportunities to improve interactive learning models, allowing for personalized education, increased student engagement, and the development of critical thinking skills [3,4]. With rapid advances in machine learning algorithms, natural language processing, and adaptive technologies, the potential of AI to revolutionize education is becoming more and more apparent [5]. Given the importance of education as the foundation of social and economic development, understanding how AI will continue to evolve and influence interactive learning models in the next 20 years is crucial. This research aims to explore the future trends of AI technology in education, as well as its broader impacts on society.

Previous research has shown that AI can significantly improve learning effectiveness through content adaptation and personalized instant feedback. For example, a study by [6,7] found that AI-based adaptive learning platforms can improve student performance by providing learning experiences tailored to individual needs. In addition, research

by [8,9] shows that the integration of AI and machine learning in education has great potential to personalize and improve the learning experience of students. On the other hand, research by [10–12] shows that AI-based education chatbots can provide effective real-time learning support, improve student engagement, and facilitate prompt and precise feedback. However, there are still significant challenges, such as data privacy and unequal access to technology, that need to be addressed in order to optimize the use of AI in education.

However, existing research generally focuses on the short term and specific aspects of AI implementation, such as content adaptation and instant feedback, without evaluating its long-term impact on interactive learning [13–15]. In addition, many studies are still limited to specific contexts or lack consideration of the social, economic, and cultural implications of the application of AI in education. This research offers novelty by evaluating the long-term impact of AI, as well as anticipating and mitigating the development process. Using data from scientific articles published in the last five years, the study provides a wider and more comprehensive coverage than previous studies.

This research will answer three key questions: (1) How will AI technology evolve and influence interactive learning models in the next 20 years? (2) How can interactive learning synergize with other topics such as virtual reality (VR), augmented reality (AR), and sustainability to create a more immersive and inclusive education ecosystem? (3) How can artificial intelligence (AI) integrate key topics such as decision-making, sustainability, and professional education to support innovation in education? The method used is Systematic Literature Review (SLR) with the PRISMA approach, which will identify, filter, and analyze articles from the Scopus database published in the last five years. The potential contribution of this research is to provide comprehensive insights into the future of AI in education, as well as recommendations for policies and practices that can help optimize the benefits of AI while reducing risks that may arise.

## 2. Literature Review

Artificial intelligence (AI) has become one of the key technologies adopted in education to improve various aspects of learning [16,17]. AI in education includes the use of machine learning algorithms, natural language processing, and adaptive systems that can tailor learning content to students' individual needs [18,19]. AI is also used in the development of educational chatbots that are able to provide real-time learning support and instant feedback [20,21]. This technology aims to create a more personalized, effective, and interactive learning experience.

The interactive learning model is a pedagogical approach that actively involves students in the teaching and learning process. Interactive technologies such as Virtual Reality (VR), Augmented Reality (AR), and gamification have been shown to increase student engagement and motivation in learning [5,22]. This model not only focuses on delivering material, but also on developing critical and collaborative thinking skills through immersive and interactive activities [23–25].

Game-based learning uses game elements and mechanisms to increase student motivation and engagement in the learning process. AI can be used to develop adaptive and interactive educational games, which can help students develop critical thinking and problem-solving skills [26]. Research shows that AI-powered game-based learning can significantly improve student learning outcomes [27,28].

### *2.1. Relevant Recent Research Findings*

Recent research shows that AI has a significant impact on various aspects of education. A study by [29,30] revealed that the use of AI tools can improve students' academic performance by providing in-depth analyses of learning data. Refs. [31,32] found that the

application of AI in English as a foreign language (EFL) education can improve students' academic writing skills by providing more structured and personalized feedback.

In addition, a study by [33] shows that AI-based adaptive learning can overcome academic inequality by adjusting learning content according to the needs of each student. [34,35] in its research on NajahniBot, an intelligent chatbot for adaptive learning, found that AI can provide more responsive and contextual learning support, increasing student engagement in the learning process.

Research by [36] highlighting the adoption of AI in the development of sustainable intelligent education systems, demonstrating that AI can help create a more flexible and adaptive education system to the changing needs of students and the learning environment. [37] emphasized the importance of AI adoption in higher education, noting that AI can improve student engagement and performance through more personalized and interactive learning.

Study by [38] identify challenges and opportunities related to the use of AI in education, including ethical and data privacy issues. [39] added that while AI has great potential in education, privacy and data protection issues should be top priorities to ensure responsible use of technology.

Furthermore, research by [40,41] shows that Android-based interactive multimedia powered by AI can improve students' critical thinking skills in science learning. [42] also revealed that personalization of learning in the AI era can improve student engagement by providing a more relevant and engaging learning experience.

Finally, research by [43–45] about the use of virtual reality (VR) in medical training indicates that AI-powered interactive technology can provide a more immersive and practical learning experience, helping students develop the necessary skills in a safe and controlled environment.

### *2.2. Research Framework and Filling Gaps in Previous Research*

Based on the existing literature, this research will develop a framework to explore how AI technology can evolve and affect interactive learning models in the next 20 years. This study will use the Systematic Literature Review (SLR) approach with the PRISMA method to identify, filter, and analyze relevant articles from the Scopus database in the last five years. The main focus is on the impact of AI on interactive learning. In addition, this research will examine the social, economic, and cultural impacts of the application of AI in education, as well as strategies to anticipate and mitigate its negative impacts.

The study will also continue to fill in the gaps in previous research by providing a more comprehensive and long-term analysis of the impact of AI in education. While many previous studies have focused on the short-term benefits and technical aspects of AI, this study will evaluate the long-term and multidisciplinary implications of using AI. This includes an assessment of how AI can contribute to the development of more inclusive, equitable, and effective learning in the future.

## 3. Methods

This study uses the SLR method with the PRISMA approach from various scientific articles sourced from the Scopus database published in the last 5 years between 2019 and 2024. This process includes the identification, screening, and inclusion of relevant studies based on predefined criteria, as well as the analysis of the resulting data to evaluate the impact of AI in the context studied. This study aims to conduct a comprehensive review of the latest AI technology developments and analyze its potential impact, both positive and negative, on future interactive learning models as well as examine how AI technology will change the way we learn and teach interactively.

Publication data was extracted from the Scopus database in June 2024 using the PRISMA Method, which was used to obtain relevant research journal articles. All data is processed using the Scopus database on its website in real-time and stored as data in RIS format. The PRISMA flow chart is presented in Figure 1.

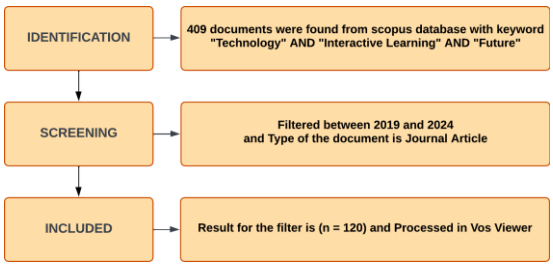



**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses Method.

Based on Figure 1, the PRISMA Method includes three main steps, namely Identification, Screening, and Selection. In the initial step, the author identified, as many as 409 documents were found through the Scopus database using the keywords "Technology" AND "Interactive Learning" AND "Future" published between 2019 and 2024, with searches by title and abstract so that a total of 206 documents were filtered. Then, in the screening step, the authors filter the documents based on the journal type, so that this number becomes 120 sample documents generated at the end of the screening. These samples were then analyzed using VOSviewer, an application to view a bibliometric map visualization of a collection of discussable research for research grouping and relationships between research topics in a particular field.

## 4. Analysis and Discussion

This study employs the PRISMA-based SLR approach to analyze articles from the Scopus databses (2019–2024), evaluating AI's impact on interactive learning methods.

### *4.1. Trends and Patterns Based on the Year*

Data from Scopus shows that the number of publications focusing on "Technology in Interactive Learning" has varied significantly over the past five years (2019–2024). In 2020, there were 9 publications that addressed this topic. This relatively low number is likely influenced by the COVID-19 pandemic, which has diverted many researchers to pandemic-related issues and disrupted technology-related research activities in general. In 2021, the number of publications increased to 15. This increase reflects the adaptation to pandemic conditions, where research was beginning to adapt to distance and digital learning methods, which are relevant to interactive technology and AI in education.

Figure 2 In 2022, the number of publications remained stable at 15, demonstrating a consistent and persistent interest in exploring interactive technologies and AI in the context of endidate. This consistency reflects further adjustments to learning methods that have undergone significant changes during the endidacies. However, in 2023, there was a significant surge with 37 publications. This surge is likely due to increased access and implementation of new technologies that are starting to receive wider attention from academics and quarantine practitioners. Innovations in AI and interactive learning technologies may have reached a more mature stage and are ready for wider adoption.

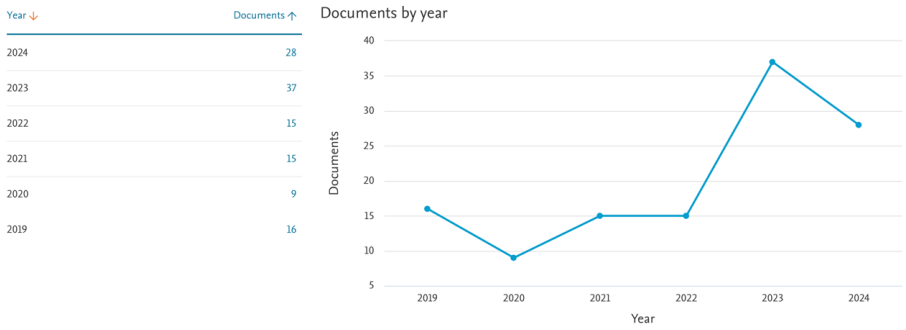



**Figure 2.** Publication Trends by Year.

Until the middle of 2024, there will be 28 publications, showing an increasing trend that continues, although it decreases slightly compared to the previous year. This may reflect the stabilization of interest after the peak of innovation and technology adoption that occurred in 2023. The pattern of increasing the number of publications from 2019 to 2024 shows a growing and growing interest in the use of AI and interactive technologies in encoding. The significant surge in 2023 can be interpreted as the peak of innovation and technology adoption, where many researchers and endemic practitioners are beginning to explore the full potential of AI technology. Some of the factors that can contribute to this trend include the COVID-19 endemic which accelerates the adoption of digital technologies and distance learning, technological advancements in AI, VR, AR, and gamification that reach maturity levels, as well as increased awareness of the importance of personalization in endidics that can be achieved through AI-powered adaptive technologies.

This trend incicates the significant potential of AI technology and interactive learning worldwide, especially in education, has great potential to continue to grow and be widely adopted in the coming years. However, it is still necessary to pay attention to existing challenges such as data privacy and technology access gaps to ensure fair and responsible adoption [46,47].

### *4.2. Trends and Patterns Based on the Country*

An analysis of data from Scopus shows the distribution of the number of publications focused on "Technology in Interactive Learning in the Future" by country. China topped the list with 23 publications, reflecting a huge investment in endemicization technology research and development. The Chinese government and endemic institutions in the country strongly support the adoption of new technologies in learning, including AI and interactive technologies.

Figure 3 the United States is second with 22 publications. The country has a strong research infrastructure and many leading educational institutions are active in exploring and implementing the latest educational technologies. AI and interactive technologies have become major focuses of many universities and research centers in the US. Taiwan has 10 publications, demonstrating a significant commitment to technological innovation in education. Taiwan has become a technology hub with many major tech companies investing in educational research. The UK has 7 publications, reflecting a strong interest in the integration of advanced technologies in the education system. Universities in the UK are active in the research and application of AI and interactive technologies in their curriculum. India, with 6 publications, shows progress, despite challenges such as unequal access to technology.

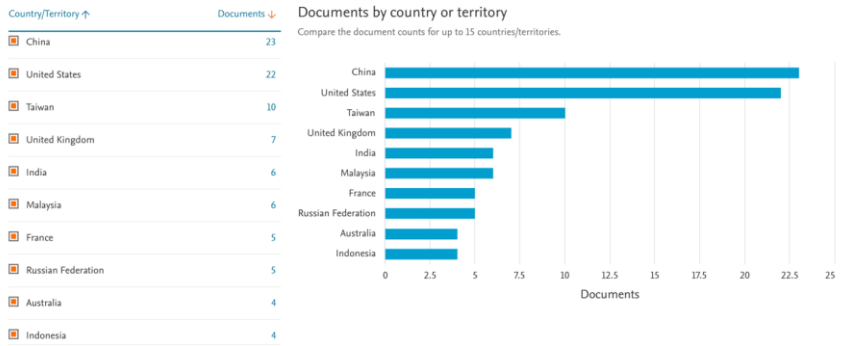



**Figure 3.** Publication Trends by Country.

The geographical distribution of these publications shows that countries with advanced technological infrastructure and strong government support tend to have a higher number of publications. China and the United States stand out as leaders in educational technology research, with a strong focus on AI and interactive technologies. These two countries not only have adequate resources for research and development, but also policies that encourage innovation in education.

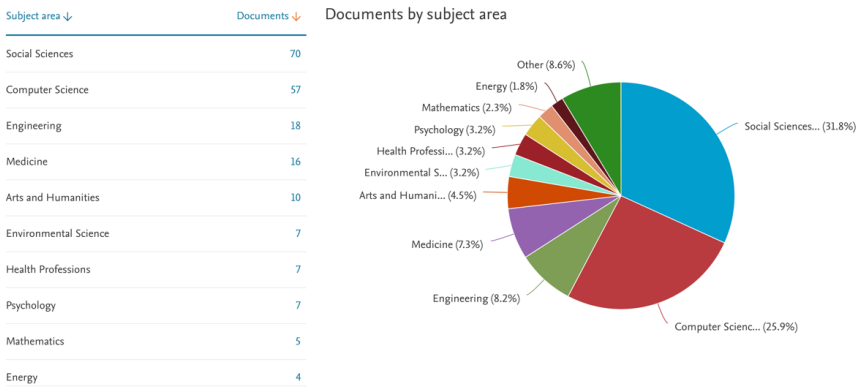
Overall, this trend shows that the adoption of AI technology and interactive learning in education is global, with countries in different parts of the world seeking to improve the quality of education through technological innovation. However, there needs to be more attention paid to challenges such as the technology access gap and the need for policies that support the fair and responsible use of technology.

### *4.3. Trends and Patterns Based on the Subject*

Data analysis from Scopus shows the distribution of the number of publications focusing on "Technology in Interactive Learning" by field of study or subject area. The field of social sciences has the highest number of publications with 70 publications. This reflects a great interest in understanding how interactive technology can affect learning dynamics, student engagement, and learning outcomes in social contexts. Research in this area often explores the impact of technology on human interaction, pedagogy, and the development of social skills.

Figure 4 computer science is second with 57 publications. The focus of research in this area is on the development and implementation of new technologies, such as AI, VR, AR, and gamification, in the context of education. Research in computer science also often includes the development of algorithms and adaptive systems for more personalized and effective learning. The engineering field has 18 publications, showing that there is an interest in the application of advanced technologies for technical and vocational education. Research in this area often focuses on the use of simulation, VR, and other interactive tools to enhance practical and technical learning [44,48,49].

The field of medicine has 16 publications, reflecting the use of interactive technologies such as VR and AR simulations for medical training. This technology allows medical students to practice in a safe and controlled environment, developing essential clinical skills without risking real patients. Arts and humanities has 10 publications, demonstrating interest in how interactive technologies can be used to enhance creative and critical learning. Research in this area often includes the use of technology to support immersive and interdisciplinary learning.



| Subject area | Documents |
|---|---|
| Social Sciences | 70 |
| Computer Science | 57 |
| Engineering | 18 |
| Medicine | 16 |
| Arts and Humanities | 10 |
| Environmental Science | 7 |
| Health Professions | 7 |
| Psychology | 7 |
| Mathematics | 5 |
| Energy | 4 |



**Figure 4.** Publication Trends by Subject.

The distribution of the number of publications by field of study shows that interactive technology in education has received wide attention from various disciplines. Overall, this trend suggests that interactive technology in education is a multidisciplinary field, with various disciplines contributing to research and development. This reflects the vast potential of interactive technology to enhance learning in a variety of educational contexts.

### *4.4. Cluster-Based Analysis from Network Visualization*

It can be seen in the following Figure 5 about the division of focus areas divided into several topic clusters, according to their relevance. The image shows the relationship between each cluster indicated by the colors and connecting lines between topics. Figure 5 is extracted from the data of 120 Scopus journal articles with fields corresponding to the topic "technology in interactive learning in the future".

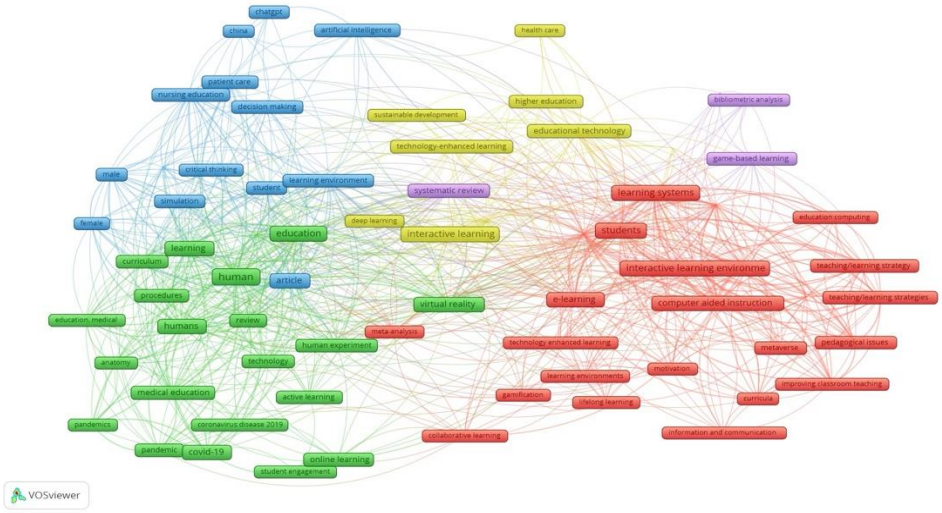



**Figure 5.** The results of the extraction of 120 documents with various discussion topics relevant to Technology in Interactive Learning.

Figure 5 From the image above, we can see the division, based on clusters with the color of each cluster having a different number of topics. We can also see the relationship between cluster topics is not always the same, and there is a relationship between the topics in each cluster and the research title. This information has been presented in Table 1:

**Table 1.** Discussion of cluster relationships, topics and titles related to technology and interactive learning.

| Cluster | Topic | Topic & Cluster Relationship | Title & Cluster Relationship |
|---|---|---|---|
| 1 (Red, 24 items) | learning systems, students, interactive learning environments, computer aided instruction, e-learning | Focus on technology integration in supporting an interactive and effective learning process. | Linking research titles on interactive learning systems and computer-aided instruction with a primary focus in clusters. |
| 2 (Green, 21 items) | education, learning, human, online learning, medical education | Exploring the use of technology to improve student learning and engagement in a variety of educational contexts. | Linking research titles on online education and learning with a primary focus in the cluster. |
| 3 (Blue, 14 items) | Artificial Intelligence, ChatGPT, Nursing Education, Critical Thinking, Simulation | The use of AI in education to improve learning and evaluation, particularly in simulation and the development of critical thinking skills | Linking research titles on AI and critical thinking skills development with a primary focus within the cluster. |
| 4 (Yellow, 10 items) | Interactive Learning, Educational Technology, Higher Education, Sustainable Development | Focus on educational technology in the context of higher education and sustainable development. | Linking research titles on educational technology in higher education and sustainable development with a primary focus in the cluster. |
| 5 (Purple, 4 items) | game-based learning, bibliometric analysis, systematic review | A meta-analytic approach to understanding the impact and trends in the use of games in an educational context. | Linking research titles on bibliometric analysis and game-based learning with a primary focus in clusters. |

Table 1 discussed how the topics in each cluster relate to each other. Each cluster shows a different focus area in educational technology research, ranging from interactive learning systems to bibliometric analysis and game-based learning. This analysis helps in understanding research trends and directions in the field of educational technology, as well as how these topics are interrelated and affect each other.

### *4.5. Analysis of the Potential of AI and Interactive Learning Topics in the Next 20 Years*

Figure 6 represents an analysis of the potential of artificial intelligence (AI) and interactive learning topics in the next 20 years, showcasing the close relationships between key topics such as adaptive learning systems, interactive learning environments, virtual reality (VR), and augmented reality (AR). This graph shows that AI has a central role in shaping future learning models, where this technology is projected to support the increasingly sophisticated personalization of learning. AI will function as a personal tutor based on big data that is able to provide adaptive recommendations in real-time, adapting learning materials to the individual needs of students [50,51]. In addition, this technology will also strengthen social interaction through more efficient management of group collaboration dynamics.

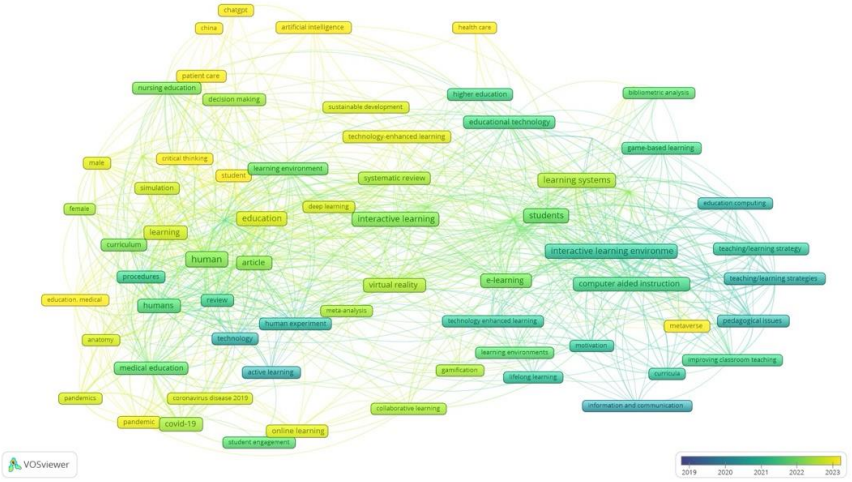



**Figure 6.** Analysis of the Potential of AI and Interactive Learning Topics in the Next 20 Years.

Figure 6 illustrates the categorization of topics based on years and color representation. The yellow shades indicate more recent topics that have gained attention in recent years, whereas the blue shades represent older topics that have been studied in previous years. This visualization helps in understanding the evolution and progression of research trends over time.

The interconnectedness of AI with immersive technologies such as VR and AR in this image suggests that the future of learning will increasingly rely on realistic and interactive simulations. In the next two decades, this technology is expected to allow students to practice in a real-world-like environment, especially in fields such as medicine and engineering. With the help of AI, real-time feedback will be available to support rapid and accurate mastery of the material, allowing for a more effective and efficient learning process.

Furthermore, this image also shows AI's strong connection to the topic of sustainability development and collaborative learning, illustrating its potential in supporting sustainable and collaboration-based education. AI is predicted to play an important role in the development of sustainability-based curricula, which not only instills environmentally friendly principles but also develops cross-disciplinary cooperation capabilities. In the next 20 years, game-based learning is also projected to grow rapidly, with AI creating more dynamic adaptive content to improve student motivation and learning outcomes.

Further, the potential analysis of interactive learning topics with other topics, as will be explained in Figure 7, highlights how interactive learning can synergize with technologies such as the metaverse and immersive reality to create collaborative virtual classrooms that support multidisciplinary learning experiences. In addition, the analysis of the potential topic of artificial intelligence with other topics, such as those that will be discussed in Figure 8, strengthens the role of AI as a key enabler in connecting various educational domains, including sustainability-based learning, adaptive technologies, and data analytics. With all of this potential, Figure 6 provides a solid foundation for understanding how AI and interactive learning will evolve, answering key research questions regarding the transformation of interactive learning models in the future.

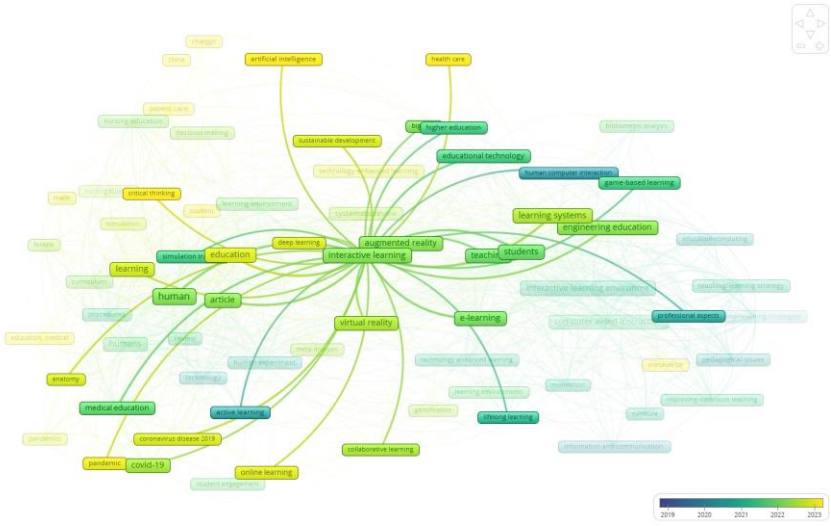



**Figure 7.** Potential Analysis of Interactive Learning Topics with Other Topics.

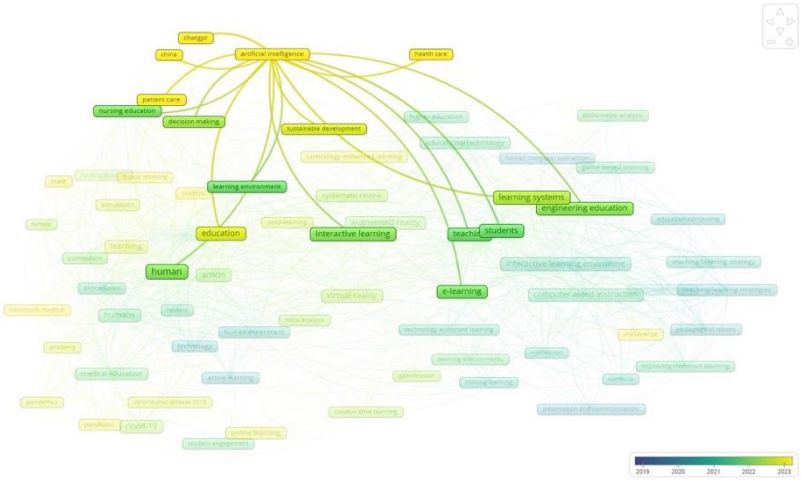



**Figure 8.** Potential Analysis of Artificial Intelligence Topics with Other Topics.

Based on the overlay visualization of the VOSviewer data, "interactive learning" emerged as the center of the node, demonstrating its importance in a wide network of topics related to educational technology. Here is an analysis of the potential interconnectedness between "interactive learning" and some other topics that may not currently show a direct relationship but have great potential to grow in the next 20 years:

Figure 7 illustrates the potential analysis of interactive learning topics with other topics, showing how interactive learning is central to the connectivity of various key concepts in technology-based education. The strong relationship between interactive learning and topics such as augmented reality (AR), virtual reality (VR), learning systems, and collaborative learning highlights the central role of interactive learning as a multidisciplinary liaison in the development of future educational models. The main focus of this chart is on the integration of these technologies to create a more immersive, personalized, and collaborative learning experience.

The relationship between interactive learning and augmented reality reflects how AR technology is being used to support deep learning simulations, especially in the fields of science, engineering, and medicine. AR technology allows students to visually interact with a more realistic learning environment, which ultimately improves comprehension of the material. Additionally, virtual reality is strongly connected in this graph, demonstrating

its potential to provide a simulated experience that allows students to practice in a virtual environment that approaches real conditions without physical risk.

Connectivity with learning systems and collaborative learning underscores the importance of adaptive technology in managing group dynamics and personalizing learning. Collaborative learning powered by AI and analytics technology can optimize interactions between students through smarter assignment and real-time feedback. This relationship supports the transformation of learning from conventional methods to a more active participation-based learning experience and cross-site collaboration.

Furthermore, this graph shows the relationship between interactive learning and educational technology and sustainability development, illustrating its potential in integrating continuing education into technology-based curricula. By linking interactive learning to these topics, Figure 7 emphasizes how technology-based learning can create learning environments that are not only more effective, but also support global goals such as sustainability and educational inclusion.

Overall, Figure 7 provides an in-depth picture of how interactive learning not only serves as a hub for innovation in education, but also as a strategic link with a variety of other key technology topics. This answers research questions related to how interactive learning topics can develop and have a significant impact on the transformation of education in the future.

Based on the overlay visualization of the VOSviewer data, "artificial intelligence" emerged as the center of the node, demonstrating its importance in a wide network of topics related to educational technology. Here is an analysis of the potential interconnectedness between "artificial intelligence" and some other topics that may not currently show a direct relationship but have great potential to grow in the next 20 years:

Figure 8 represents an analysis of the potential topic of artificial intelligence (AI) with other topics, highlighting the role of AI as a key link in the development of educational technology in the future. This graph shows the strong relationship between AI and various topics such as learning environments, sustainability development, decision-making, nursing education, as well as learning systems. This relationship pattern confirms that AI not only supports the development of learning technologies, but also contributes to creating innovative solutions to global educational challenges.

AI is seen to be closely related to learning environments, reflecting its potential in creating an adaptive learning ecosystem that can be tailored to the needs of students. AI can analyze learning data to provide personalized feedback in real time, accelerate the learning curve, and improve educational outcomes. The connection between AI and decision-making demonstrates the role of AI in supporting faster and more accurate decision-making in education, both for students and educators, through predictive analytics and data-driven learning.

The relationship with sustainability development indicates how AI can contribute to supporting sustainability goals through the development of environmentally friendly curricula and the optimization of educational resources. For example, AI can help design learning methods that reduce carbon footprints, while also promoting environmental awareness in education. This linkage becomes relevant to ensure that the development of educational technology is not only focused on innovation, but also on social and environmental impacts.

In addition, AI has a significant role in professional education, as seen in its relationship with nursing education. In this field, AI is used to create realistic medical simulations, enabling clinical training without risk for patients. The connection with learning systems and engineering education shows the role of AI in supporting the development

of technology-based learning systems, including engineering simulations and distance learning integrated with adaptive technology.

Overall, Figure 8 provides a comprehensive overview of how artificial intelligence is a catalyst in connecting different fields and topics of education. These findings answer research questions regarding how AI can impact interactive education in the next 20 years, demonstrating the great potential of AI in creating a more inclusive, adaptive, and sustainable education system.

The analysis results presented in Figures 6–8 provide a comprehensive overview of the potential of artificial intelligence (AI) and interactive learning in the next 20 years. Figure 6 shows that AI will play a key role in creating adaptive, personalized, and immersive technology-based learning models such as virtual reality (VR) and augmented reality (AR). These technologies not only support personalization of learning but also accelerate skill improvement through real-time feedback and realistic simulations. Figure 7 expands on this understanding by highlighting how interactive learning synergizes with other topics, such as sustainability, game-based learning, and collaboration, to create a more inclusive and multidisciplinary education ecosystem. Meanwhile, Figure 8 emphasizes the role of AI as a strategic connector that integrates various key topics, including decision-making and professional education, to support broader innovation in the world of education.

The benefits of this research are very significant for the future of education. First, this research provides insight into how AI and interactive learning technologies can be integrated to create a more inclusive, personalized, and adaptive education system. Second, these findings can help policymakers and education practitioners design strategies for implementing educational technology that not only improves the quality of learning but also addresses social and environmental challenges. Third, this study highlights the importance of multidisciplinary relationships in education, which can foster cross-disciplinary collaboration to deliver more innovative and relevant solutions to global needs.

For recommendations for future research, there are several things to consider. First, further research is needed to explore the application of AI technology in local and regional educational contexts, including solutions to challenges of technology access and data privacy. Second, other researchers are advised to develop longitudinal studies that evaluate the long-term impact of this technology on students' learning outcomes and social development. Third, cross-disciplinary collaboration should be strengthened to integrate AI with other topics such as sustainability and immersive technology to create a more holistic educational ecosystem. Finally, research also needs to focus on designing AI-based curricula that are not only technology-friendly but also support the development of 21st-century skills such as critical thinking, collaboration, and digital literacy.

With a sustainable and collaborative approach, future research can help realize the full potential of AI and interactive learning in creating a more inclusive, relevant, and impactful education for the global community.

## 5. Conclusions

The conclusion of this study confirms that artificial intelligence (AI) has enormous potential to revolutionize interactive learning models in the next two decades. With a focused approach to the development trends of AI technology, this study found that AI can drive the creation of more adaptive and personalized learning systems, allowing students to get learning experiences tailored to individual needs in real-time. In addition, the integration of AI with other topics, such as sustainability, decision-making, and professional education, shows the potential of AI in addressing global education challenges and supporting broader multidisciplinary innovation.

This study also provides important insights into the social, economic, and cultural impacts of AI applications in education. AI plays a role in creating more inclusive and sustainable curricula, as well as supporting equality in access to education. However, this study also highlights the importance of risk mitigation strategies, including data privacy protection and reducing technology access gaps, to ensure responsible AI adoption.

As recommendations for future research, focus can be directed at exploring AI applications in more specific local contexts, longitudinal studies to evaluate long-term impacts, and developing collaborative approaches across disciplines. Researchers are also advised to create AI-based solutions that support the development of 21st-century skills, such as critical thinking, creativity, and collaboration. With these ongoing efforts, future research can make significant contributions to maximizing the benefits of AI in education while reducing the risks that may arise.

**Author Contributions:** Conceptualization, T.H.I.A. and I.S.W.; methodology, T.H.I.A. and I.S.W.; investigation, T.H.I.A. and I.S.W.; writing—original draft preparation, T.H.I.A. and I.S.W.; writing—review and editing, T.H.I.A. and I.S.W.; visualization, T.H.I.A. and I.S.W.; supervision, T.H.I.A. and I.S.W.; project administration, T.H.I.A. and I.S.W. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** No new data were created or analyzed in this study. Data sharing is not applicable to this article.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Abbas, N.; Ali, I.; Manzoor, R.; Hussain, T.; AL Hussain, M.H. Role of Artificial Intelligence Tools in Enhancing Students' Educational Performance at Higher Levels. August–September 2023. Available online: https://api.semanticscholar.org/CorpusID:260999551 (accessed on 10 December 2024).
2. Aggarwal, D.; Sharma, D.; Saxena, A.B. Adoption of Artificial Intelligence (AI) For Development of Smart Education as the Future of a Sustainable Education System. *J. Artif. Intell. Mach. Learn. Neural Netw.* **2023**, *2023*, 23–28. [CrossRef]
3. Almousa, O.; Zhang, R.; Dimma, M.; Yao, J.; Allen, A.; Chen, L.; Heidari, P.; Qayumi, K.A. Virtual Reality Technology and Remote Digital Application for Tele-Simulation and Global Medical Education: An Innovative Hybrid System for Clinical Training. *Simul. Gaming* **2021**, *52*, 614–634. Available online: https://api.semanticscholar.org/CorpusID:235517731 (accessed on 10 December 2024). [CrossRef]
4. Amin, M.Y.M. AI and Chat GPT in Language Teaching: Enhancing EFL Classroom Support and Transforming Assessment Techniques. *Int. J. High. Educ. Pedagog.* **2023**, *4*, 1–15. Available online: https://api.semanticscholar.org/CorpusID:266555445 (accessed on 10 December 2024). [CrossRef]
5. Ansor, F.; Zulkifli, N.A.; Jannah, D.S.M.; Krisnaresanti, A. Adaptive Learning Based on Artificial Intelligence to Overcome Student Academic Inequalities. *J. Soc. Sci. Util. Technol.* **2023**, *1*, 112–123. Available online: https://api.semanticscholar.org/CorpusID:266556478 (accessed on 10 December 2024).
6. Bujdosó, G.; Novac, O.C.; Szimkovics, T. Developing cognitive processes for improving inventive thinking in system development using a collaborative virtual reality system. In Proceedings of the 2017 8th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Debrecen, Hungary, 11–14 September 2017; pp. 79–84. Available online: https://api.semanticscholar.org/CorpusID:22565943 (accessed on 7 December 2024).
7. Chang, D.H.; Lin, M.P.-C.; Hajian, S.; Wang, Q.Q. Educational Design Principles of Using AI Chatbot That Supports Self-Regulated Learning in Education: Goal Setting, Feedback, and Personalization. *Sustainability* **2023**, *15*, 12921. Available online: https://api.semanticscholar.org/CorpusID:261313757 (accessed on 10 December 2024). [CrossRef]
8. Chen, L.; Chen, P.; Lin, Z. Artificial Intelligence in Education: A Review. *IEEE Access* **2020**, *8*, 75264–75278. Available online: https://api.semanticscholar.org/CorpusID:218493891 (accessed on 9 December 2024). [CrossRef]

9. Cheng, Y.-H. Improving Students' Academic Performance with AI and Semantic Technologies. 2022. Available online: https://api.semanticscholar.org/CorpusID:249431920 (accessed on 10 December 2024).
10. Cristea, A.I.; Ghali, F. Towards adaptation in e-learning 2.0. *New Rev. Hypermedia Multimed.* **2011**, *17*, 199–238. Available online: https://api.semanticscholar.org/CorpusID:6856062 (accessed on 10 December 2024). [CrossRef]
11. du Boulay, J.B. Artificial Intelligence as an Effective Classroom Assistant. *IEEE Intell. Syst.* **2016**, *31*, 76–81. Available online: https://api.semanticscholar.org/CorpusID:5767346 (accessed on 10 December 2024). [CrossRef]
12. Essa, S.G.; Çelik, T.; Human-Hendricks, N. Personalized Adaptive Learning Technologies Based on Machine Learning Techniques to Identify Learning Styles: A Systematic Literature Review. *IEEE Access* **2023**, *11*, 48392–48409. Available online: https://api.semanticscholar.org/CorpusID:258733040 (accessed on 8 December 2024). [CrossRef]
13. Fidan, M.; Gencel, N. Supporting the Instructional Videos With Chatbot and Peer Feedback Mechanisms in Online Learning: The Effects on Learning Performance and Intrinsic Motivation. *J. Educ. Comput. Res.* **2022**, *60*, 1716–1741. [CrossRef]
14. Ghory, S.; Ghafory, H. The Impact of Modern Technology in the Teaching and Learning Process. 2021. Available online: https://api.semanticscholar.org/CorpusID:237379604 (accessed on 10 December 2024).
15. Gligorea, I.; Cioca, M.; Oancea, R.; Gorski, A.T.; Gorski, H.; Tudorache, P. Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. *Educ. Sci.* **2023**, *13*, 1216. Available online: https://api.semanticscholar.org/CorpusID:266076086 (accessed on 8 December 2024). [CrossRef]
16. Hamal, O.; El Faddouli, N.; Harouni, M.H.A.; Lu, J. Artificial Intelligent in Education. *Sustainability* **2022**. Available online: https://api.semanticscholar.org/CorpusID:247353273 (accessed on 10 December 2024).
17. Hamdani, S.A.; Prima, E.C.; Agustin, R.R.; Feranie, S.; Sugiana, A. Development of Android-based Interactive Multimedia to Enhance Critical Thinking Skills in Learning Matters. *J. Sci. Learn.* **2022**, *5*, 103–114. Available online: https://api.semanticscholar.org/CorpusID:247350913 (accessed on 10 December 2024).
18. Hashim SH, A.; Omar, M.K.; Jalil, H.A.; Sharef, N.M. Trends on Technologies and Artificial Intelligence in Education for Personalized Learning: Systematic Literature Review. *Int. J. Acad. Res. Progress. Educ. Dev.* **2022**, *11*, 884–903. Available online: https://api.semanticscholar.org/CorpusID:247333193 (accessed on 10 December 2024).
19. Hawanti, S.; Zubaydulloevna, K.M. AI chatbot-based learning: Alleviating students' anxiety in english writing classroom. *Bull. Soc. Inform. Theory Appl.* **2023**, *7*, 182–192. Available online: https://api.semanticscholar.org/CorpusID:265794128 (accessed on 7 December 2024).
20. Hodhod, R.A.; Fleenor, H.; Nabi, S. Adaptive Augmented Reality Serious Game to Foster Problem Solving Skills. In Proceedings of the Australasian Conference on Interactive Entertainment, Newcastle, NSW, Australia, 2–3 December 2014; Available online: https://api.semanticscholar.org/CorpusID:7409168 (accessed on 7 December 2024).
21. Hooshyar, D.; Pedaste, M.; Yang, Y.; Malva, L.; Hwang, G.; Wang, M.; Lim, H.; Delev, D. From Gaming to Computational Thinking: An Adaptive Educational Computer Game-Based Learning Approach. *J. Educ. Comput. Res.* **2020**, *59*, 383–409. Available online: https://api.semanticscholar.org/CorpusID:226333128 (accessed on 7 December 2024). [CrossRef]
22. Huang, L. Ethics of Artificial Intelligence in Education: Student Privacy and Data Protection. *Sci. Insights Educ. Front.* **2023**, *16*, 2577–2587. Available online: https://api.semanticscholar.org/CorpusID:259603639 (accessed on 7 December 2024).
23. Hyttinen, K. Human-centered design model in the development of online learning tools for international security training CASE IECEU New Media based Learning Application (NMLA). In Proceedings of the IC3K 2017-Proceedings of the 9th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, Funchal, Portugal, 1–3 November 2017; Volume 3, pp. 275–282. [CrossRef]
24. Ilieva, G.; Yankova, T.; Klisarova-Belcheva, S.; Dimitrov, A.; Bratkov, M.; Angelov, D. Effects of Generative Chatbots in Higher Education. *Information* **2023**, *14*, 492. Available online: https://api.semanticscholar.org/CorpusID:261644305 (accessed on 10 December 2024). [CrossRef]
25. Irfana, S.; Hardyanto, W.; Wahyuni, S. The Effectiveness of STEM-Based Android-Based Learning Media on Students' Critical Thinking Skills. *Phys. Commun.* **2022**, *6*, 12–17. Available online: https://api.semanticscholar.org/CorpusID:254318335 (accessed on 10 December 2024).
26. Shi, J.-J. Research on Control Model of Content Adaptation System. *IEEE Softw* **2013**. Available online: https://api.semanticscholar.org/CorpusID:58860666 (accessed on 10 December 2024).
27. Adnan, K.; Fahimullah, F.; Farrukh, U.; Askari, H.; Siddiqui, S.; Jameel, R.A. AI-enabled virtual reality systems for dental education. *Int. J. Health Sci.* **2023**, *7*, 1378–1392. Available online: https://api.semanticscholar.org/CorpusID:259391427 (accessed on 10 December 2024).
28. Kim, W.H.; Kim, J.-H. Individualized AI Tutor Based on Developmental Learning Networks. *IEEE Access* **2020**, *8*, 27927–27937. Available online: https://api.semanticscholar.org/CorpusID:211207842 (accessed on 10 December 2024).
29. Kiong, J.F. The Impact of Technology on Education: A Case Study of Schools. *J. Educ. Rev. Provis.* **2023**, *2*, 43–47. Available online: https://api.semanticscholar.org/CorpusID:257356151 (accessed on 10 December 2024).

30. Kyaw, B.M.; Saxena, N.; Posadzki, P.P.; Vseteckova, J.; Nikolaou, C.K.; George, P.P.; Divakar, U.; Masiello, I.; Kononowicz, A.A.; Zary, N.; et al. Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration. *J. Med. Internet Res.* **2019**, *21*, e12959. Available online: https://api.semanticscholar.org/CorpusID:58947061 (accessed on 10 December 2024). [PubMed]
31. Lampropoulos, G.; Keramopoulos, E.; Diamantaras, K.; Evangelidis, G. Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies. *Appl. Sci.* **2022**, *12*, 6809. Available online: https://api.semanticscholar.org/CorpusID:250322994 (accessed on 10 December 2024). [CrossRef]
32. Lin, Y.-S.; Chen, S.-Y.; Tsai, C.-W.; Lai, Y.-H. Exploring Computational Thinking Skills Training Through Augmented Reality and AIoT Learning. *Front. Psychol.* **2021**, *12*, 640115. Available online: https://api.semanticscholar.org/CorpusID:231991812 (accessed on 10 December 2024).
33. Luan, H.; Géczy, P.; Lai, H.; Gobert, J.D.; Yang, S.J.H.; Ogata, H.; Baltes, J.; da Silva Guerra, R.; Li, P.; Tsai, C.-C. Challenges and Future Directions of Big Data and Artificial Intelligence in Education. *Front. Psychol.* **2020**, *11*, 580820. Available online: https://api.semanticscholar.org/CorpusID:224274624 (accessed on 9 December 2024).
34. Mageira, K.; Pittou, D.; Papasalouros, A.; Kotis, K.I.; Zangogianni, P.; Daradoumis, A. Educational AI Chatbots for Content and Language Integrated Learning. *Appl. Sci.* **2022**, *12*, 3239. Available online: https://api.semanticscholar.org/CorpusID:247639609 (accessed on 9 December 2024). [CrossRef]
35. Mao, R.Q.; Lan, L.; Kay, J.; Lohre, R.; Ayeni, O.R.; Goel, D.P.; de Sa, D. Immersive Virtual Reality for Surgical Training: A Systematic Review. *J. Surg. Res.* **2021**, *268*, 40–58. Available online: https://api.semanticscholar.org/CorpusID:236158203 (accessed on 9 December 2024).
36. Marfuah, L.; Franita, Y.; Hendrastuti, Z.R. Development of flash-based learning media to improve critical thinking ability of grade VII middle school students. *Union Sci. J. Math. Educ.* **2023**, *11*, 191–199. Available online: https://api.semanticscholar.org/CorpusID:260402734 (accessed on 10 December 2024).
37. Mergen, M.; Junga, A.; Risse, B.; Valkov, D.; Graf, N.; Marschall, B. Immersive training of clinical decision making with AI driven virtual patients—A new VR platform called medical. *GMS J. Med. Educ.* **2023**, *40*, DOC18. Available online: https://api.semanticscholar.org/CorpusID:259231036 (accessed on 10 December 2024).
38. Neo, M. Developing a collaborative learning environment using a web-based design. *J. Comput. Assists. Learn.* **2003**, *19*, 462–473. Available online: https://api.semanticscholar.org/CorpusID:35978800 (accessed on 10 December 2024).
39. Papakostas, C.; Troussas, C.; Krouska, A.; Sgouropoulou, C. Personalization of the Learning Path within an Augmented Reality Spatial Ability Training Application Based on Fuzzy Weights. *Sensors* **2022**, *22*, 7059. [CrossRef]
40. Pardamean, B.; Suparyanto, T.; Cenggoro, T.W.; Sudigyo, D.; Anugrahana, A. AI-Based Learning Style Prediction in Online Learning for Primary Education. *IEEE Access* **2022**, *10*, 35725–35735. Available online: https://api.semanticscholar.org/CorpusID:247502527 (accessed on 10 December 2024).
41. Rourke, S. How does virtual reality simulation compare to simulated practice in the acquisition of clinical psychomotor skills for pre-registration student nurses? A systematic review. *Int. J. Nurs. Stud.* **2019**, *102*, 103466. Available online: https://api.semanticscholar.org/CorpusID:208498030 (accessed on 10 December 2024).
42. Saadé, R.G.; Morin, D.; Thomas, J.D.E. Critical thinking in E-learning environments. *Comput. Hum. Behav.* **2012**, *28*, 1608–1617. Available online: https://api.semanticscholar.org/CorpusID:18244543 (accessed on 10 December 2024).
43. Sethi, K.; Sharma, A.; Chauhan, S.S.; Jaiswal, V. Impact of Social and Cultural Challenges in Education Using AI. 2020. Available online: https://api.semanticscholar.org/CorpusID:204640695 (accessed on 10 December 2024).
44. Shankar, D.A.U.; Tewari, D.V.; Rahman, M.; Mishra, D.A.; Bajaj, M.K.K. Impact of Virtual Reality (Vr) and Augmented Reality (Ar) in Education. *Tuijin Jishu/J. Propuls. Technol.* 2023. Available online: https://api.semanticscholar.org/CorpusID:264444247 (accessed on 10 December 2024).
45. Shen, C.; Shi, P.; Guo, J.; Xu, S.; Tian, J. From process to product: Writing engagement and performance of EFL learners under computer-generated feedback instruction. *Front. Psychol.* **2023**, *14*. Available online: https://api.semanticscholar.org/CorpusID:264457555 (accessed on 7 December 2024).
46. Syawaludin, A.; Gunarhadi, G.; Rintayati, P. Development of Augmented Reality-Based Interactive Multimedia to Improve Critical Thinking Skills in Science Learning. *Int. J. Instr.* **2019**, *12*, 331–344. Available online: https://api.semanticscholar.org/CorpusID:202717562 (accessed on 7 December 2024).
47. Tapalova, O.; Zhiyenbayeva, N.; Gura, D. Artificial Intelligence in Education: AIEd for Personalised Learning Pathways. *Electron. J. E-Learn.* **2022**, *20*, 639–653. Available online: https://api.semanticscholar.org/CorpusID:254558139 (accessed on 10 December 2024).
48. Vemula, S. Leveraging VR/AR/MR and AI as Innovative Educational Practices for "iGeneration" Students. 2021. Available online: https://api.semanticscholar.org/CorpusID:228868478 (accessed on 10 December 2024).
49. Verner, I.; Cuperman, D.; Perez-Villalobos, H.; Polishuk, A.; Gamer, S. Augmented and Virtual Reality Experiences for Learning Robotics and Training Integrative Thinking Skills. *Robotics* **2022**, *11*, 90. [CrossRef]

50. Zafari, M.; Bazargani, J.S.; Sadeghi-Niaraki, A.; Choi, S.-M. Artificial Intelligence Applications in K-12 Education: A Systematic Literature Review. *IEEE Access* **2022**, *10*, 61905–61921. Available online: https://api.semanticscholar.org/CorpusID:249213347 (accessed on 10 December 2024).
51. Zeineddine, H.; Braendle, U.C.; Farah, A. Enhancing prediction of student success: Automated machine learning approach. *Comput. Electr. Eng.* **2021**, *89*, 106903. Available online: https://api.semanticscholar.org/CorpusID:229454854 (accessed on 10 December 2024).

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.