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Contribution of Artificial Intelligence to the Development of Metaverses: A Bibliometric Review Study on its Impact on Immersive Learning in Higher Education

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Abstract. In the current post-pandemic scenario, the integration of artificial intelligence (AI) and metaverses in higher education has gained significant relevance, transforming learning experiences towards more immersive and personalized approaches. Identifying the way in which these technologies impact university teaching-learning is essential to understanding their true contribution. This bibliometric review study focuses on analyzing the trend in scientific production, as well as the implications of its impact on higher education. Through a mixed and descriptive methodological approach, 63 scientific documents from the Scopus database were reviewed. The findings show that scientific production increased during the pandemic; however, in the post-pandemic context, research has maintained an upward trend. Furthermore, the implications of AI's contribution to metaverses—representing a positive impact on higher education—have been grouped into five categories, the most prominent of which is "Interactivity for improving student movement", which covers 42.86% with respect to the other categories identified in the reviewed studies. Therefore, it is concluded that the integration of AI in the development of metaverses presents a significant potential to transform higher education, offering personalized immersive learning experiences that are redefining the way in which students interact with knowledge. Nevertheless, gaps persist that require attention from the scientific community, especially in terms of evaluating the long-term impact of these technologies and their equitable adaptation in various educational contexts. Future research should be directed towards understanding the effectiveness of these environments in the development of specific competencies in higher education, as well as in the creation of strategies that promote inclusive accessibility.

Keywords: artificial intelligence; bibliometric review; higher education; immersive learning; metaverse

1. Introduction

In recent years, learning techniques have been evolving and innovative tools to support these new techniques have also emerged, such as immersive technology (Avalos-Pulcha et al., 2023). The concept of immersion consists of achieving the perception of being physically present in a non-physical world, whether it is a replica of a realistic context or a completely fictional virtual world (Pérez et al., 2021). Immersion refers to the perception of being fully integrated into an environment, beyond simply being present within it; it is not just about being superficially present, but becoming part of it (Valdés Godiness & Angel Rueda, 2023). As a result of the COVID-19 pandemic, universities were prompted to adapt their classes to the virtual modality, promoting flexible methods and the use of technological tools to create innovative learning environments (Márquez & Olmos, 2022). In this way, immersive learning emerged as an alternative to traditional teaching, offering a viable option when it was not possible to follow conventional educational methods (Prince Torres, 2022). Immersive learning takes advantage of the selectivity of memory, using it to immerse students in unique experiences through stories and interactive games, thereby improving understanding and enhancing the teaching-learning process (Pinedo Rios et al.,

2020). Furthermore, immersive learning offers students experiences that are close to reality in a safe environment, which increases their motivation and commitment and leaves a lasting mark that facilitates the retention of content (Véliz Vega et al., 2021). The application of metaverses in the university educational process has given rise to terms such as metaversity, encompassing the creation of a virtual meeting space that connects all members of the university community, including teachers, students, and researchers, among others (Chamorro-Atalaya, Duran-Herrera et al., 2023; Laurens-Arredondo, 2024). However, the design of immersive learning environments faces challenges, especially in the application of multimedia principles that ensure effective communication. Many suggest that this is due to poor graphical interfaces (Rojas et al., 2023); therefore, relying on AI tools could contribute to improving these learning environments.

The metaverse is defined as a digitally created parallel universe. In approaching its design, it is essential to consider both the virtual worlds and the interaction that occurs in these spaces (Rodríguez Acevedo et al., 2024). Metaverses are characterized by merging images with fantasy elements and multimedia technology, extending aspects of the real world to facilitate social interaction between users in different contexts without any restrictions of geographical location (Ruiz-Campo et al., 2023). The metaverse can be considered as the next evolution of the internet: a 3D virtual space in which people can live unique experiences, also known as extended reality, representing a fundamental concept at the intersection of digital technology and human experience (Iparraguirre-Bernaola & Huamán-Huillca, 2023). Such experiences can include virtual reality (VR) and augmented reality (AR) (Suaza Restrepo, 2023). VR immerses users in a three-dimensional environment in which their senses are stimulated; the focus is mainly on sight and hearing (del Castillo, 2022). Furthermore, VR requires accessible tools that allow the efficient transfer of skills and knowledge to students; these must optimize time and resources compared to traditional methods (Paz Balanta et al., 2021). However, its incorporation into the educational field faces limitations related to accessibility, teacher training, and the necessary resources (Salas et al., 2023); additionally, a restructuring of methodologies and pedagogical structures is needed (Donoso Gormaz & Correa Rojas, 2024).

One way to improve immersive experiences is to integrate artificial intelligence (AI) with the metaverse, offering personalized content and activities to students in collaborative and interactive virtual reality environments (Galíndez & Pérez, 2023). Such an integration should be understood as a digital, immersive and simulated environment that allows users to have synchronous interactions and virtual experiences, generating environments of unlimited size and conversing in real time with characters (Garcia-Pomareda, 2024). Together, the metaverse and AI are revolutionizing higher education by allowing more interactive, collaborative learning that is adapted to meet the educational needs of each student (Diez, 2023). However, while infrastructure and connection limitations must be overcome, existing technological resources, such as AI and the metaverse, should be leveraged. Teacher training should focus on a practical approach oriented towards application in the classroom (Galíndez & Pérez, 2024). However,

the implementation of AI and the metaverse in higher education poses considerable challenges. For example, technology accessibility and the digital divide are critical issues that must be addressed to ensure that all students have equal opportunities (Ruiz, 2024).

In this context, the aim of this study is to analyze the contribution of AI in the development of metaverses and to examine its impact on immersive learning in higher education. Through a bibliometric review, scientific documents extracted from the Scopus database will be analyzed, with a focus on the period from 2018 to 2024, which covers both the accelerated adoption of digital technologies during the COVID-19 pandemic and the growing interest in the post-pandemic stage. The Scopus database has been selected for its broad coverage and rigor in publishing only high-quality publications. The review will focus exclusively on scientific articles and conference papers, as these allow for an in-depth analysis and detailed discussion of research results, facilitating the identification of recent trends and developments in the field of AI and metaverses. The main contribution of this bibliometric review study is to identify existing knowledge gaps, thereby providing guidance for future researchers wishing to explore the effectiveness of AI in creating immersive environments. The rest of this study is organized into the following sections: first, the research methodology is explained; after this, the results are presented and discussed. Next, conclusions will be drawn from the results and future lines of research will be suggested. The research questions (RQ), based on the established objective of the study, are as follows:

- RQ1: What is the trend of scientific production on the contribution of AI in the development of metaverses in the field of higher education?
- RQ2: What are the most impactful research studies on the contribution of AI to the development of metaverses in higher education?
- RQ3: What is the impact on immersive learning of the metaverses developed under the contribution of AI in the field of higher education?

2. Research Methodology

2.1 Methodological Approach and Scope of the Study

This bibliometric review was based on a methodological framework defined by a mixed approach and descriptive scope. In this mixed approach, both quantitative and qualitative methods are integrated to provide a global view of the implications of the use of AI in the development of metaverses within the context of higher education. Thus, this approach facilitates a more holistic and in-depth perspective of the object of the study, by combining descriptive elements, resulting in a richer understanding of the phenomenon under investigation (Cueva Luza et al., 2023). The quantitative analysis focuses on identifying trend patterns in scientific production, addressing indicators such as the number of scientific documents published, the scientific documents with the highest number of citations per year, and the highest number of citations on average per number of years of publication. On the other hand, the qualitative analysis was aimed at interpreting the content of the selected documents, identifying impact categories and the specific implications of the integration of AI and metaverses in immersive learning. This approach allowed us to explore the depth of the studies and classify their contributions in different areas of higher education, aligning with the focus

of the research question with regard to the impact of this technology. Additionally, the scope of the research is also descriptive, as it seeks to characterize the trends and areas of impact without modifying the variables analyzed, providing an understanding of the current state of research in this field of study. Therefore, this approach allows us to capture and systematize the contributions and conclusions of various scientific works, providing a description of a human group or a specific phenomenon (Ramos-Galarza, 2020).

2.2 Selection Process for Scientific Documents

The selection of scientific papers on the contribution of AI in the development of metaverses and its impact on immersive learning began with the identification of keywords that would allow for an exhaustive and precise search. The selected keywords were "metaverse", "virtual world", "immersive environment", "virtual reality", "AI", "artificial intelligence", "higher education", "teaching" and "learning". Using these words, the search equation was constructed in the Scopus database, which was designed to cover the largest number of relevant studies in this field. In this case, the search equation was: TITLE ((metaverse* OR "virtual world*" OR "immersive environment*" OR "virtual reality") AND (ChatGPT OR "AI" OR "artificial intelligence") AND ("education" OR "higher education" OR "teaching" OR "learning")). This equation was structured to capture the most significant and relevant research that explores the intersection between AI, metaverses and their applications in higher education, using key terms in English to ensure the coverage of relevant studies. Furthermore, the Scopus database was selected due to its wide reach and prestige in the field indexing of peer-reviewed scientific literature, which ensures the quality of scientific documents. In addition, the Scopus database provides a set of filters that allow a better selection of publications according to the inclusion and exclusion criteria defined in the bibliometric review study (Chamorro-Atalaya, Morales-Romero et al., 2023). Scopus stores high-quality scientific manuscripts, covering various areas of knowledge and facilitating a comprehensive analysis of research trends (Livia et al., 2021). Table 1 shows the inclusion and exclusion criteria used to extract scientific documents in the present study.

Table 1: Inclusion and exclusion criteria used for the extraction of scientific documents in the present study

Inclusion criteria	Exclusion criteria
Scientific documents must be scientific articles and conference papers	Scientific documents such as theses, letters to the editor, notes, and editorials are excluded
Scientific articles and conference papers must be published between 2018 and 2024	Scientific articles and conference papers published prior to 2018 are excluded
Open access scientific articles and conference papers are included	Scientific articles and conference papers with restrictions to their total content are excluded

2.3 Phases for the Identification of Documents Included in the Bibliometric Review

The steps taken to identify documents for inclusion in the bibliometric review were organized into three main phases, as follows. Phase 1 was "Topic, identification, and Scope". In this first phase, the research focus was defined and relevant keywords related to the contribution of AI in the development of metaverses and its impact on immersive learning were identified. A search equation was employed in the Scopus database, considering terms in English, as indicated in the section on the document selection process. This initial phase identified 63 scientific documents, without taking into account the time frame of the study. Phase 2 involved "Screening". In this phase, inclusion and exclusion criteria were applied to refine the obtained results. The inclusion criteria included the types of studies, such as scientific articles and conference papers, in addition to those studies published between 2018 and 2024, and being open access. In this way, the number of documents was reduced from 63 to 46. Lastly, Phase 3, "Included", involved a detailed evaluation of the abstracts and content of the 46 documents selected in the previous phase. As a result, it was determined that four further documents should be excluded, as two documents were not strictly focused on the object of the study, one was not related to the higher education context and the fourth had been retracted by Scopus. Finally, it was determined that 42 documents met all the criteria established for inclusion in the bibliometric analysis, forming the basis for this study. Figure 1 shows the phases used for the identification of the scientific documents included in the bibliometric analysis.

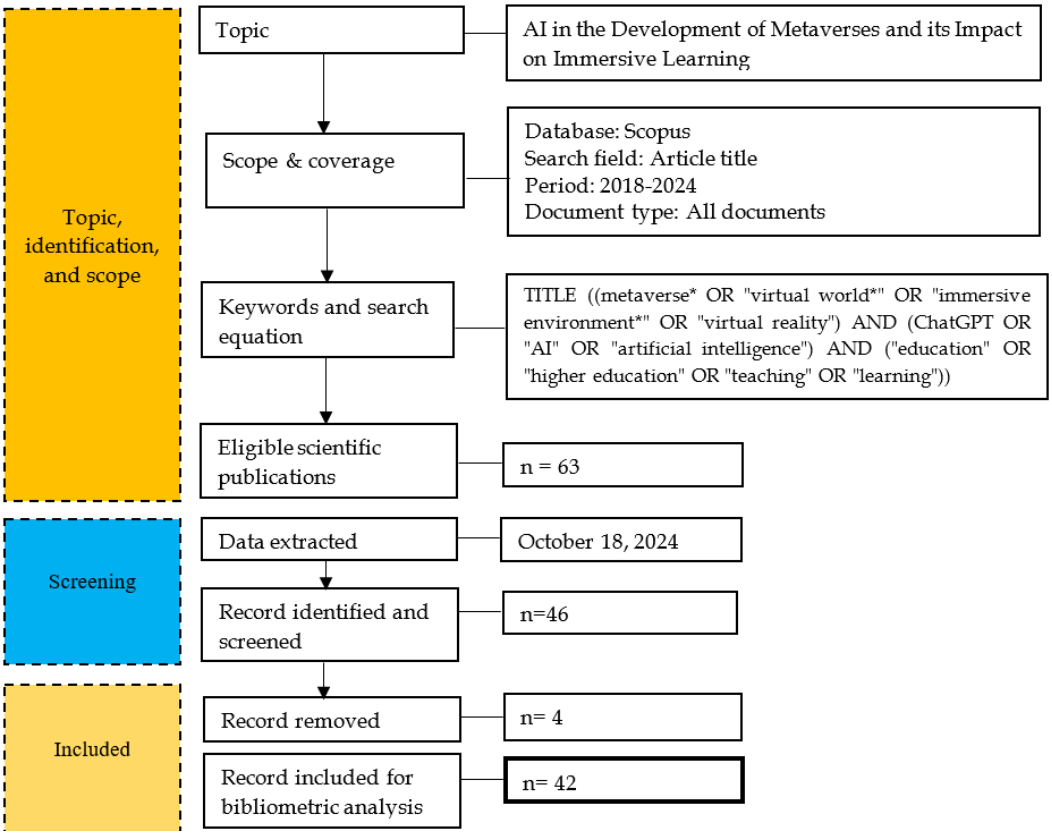

Figure 1: Phases used for the identification of scientific documents for inclusion in the bibliometric analysis

3. Results and Discussion

3.1 What is the Trend of Scientific Production on the Contribution of AI in the Development of Metaverses in the Field of Higher Education?

Regarding the trend of scientific production on the contribution of AI in the development of metaverses in the field of higher education, a significant growth over the last few years was identified. This evolution has been influenced by various factors, with the foremost among them being the COVID-19 pandemic, which boosted the adoption of digital technologies in the educational field. It was observed that between 2018 and 2019, the number of scientific documents was limited, with only 4.76% of the total manuscripts included in this bibliometric review study being produced. This period reflects an early stage of research, in which higher education institutions and the scientific community were still beginning to understand the possible applications of AI and VR in educational environments. On the other hand, in 2020, scientific production increased, surpassing that published from 2018 to 2019. This surge corresponds to the need to quickly adapt educational strategies during the pandemic. In 2022, research reached a peak of 10 scientific documents, representing 23.81% of the total manuscripts analyzed. Despite a slight reduction in 2023, when eight studies were published, in 2024 there has been an increase to fourteen publications to date, highlighting the fact that, even in a post-pandemic context, interest in AI and metaverses not only persists, but is strengthening, indicating a long-term interest in their impact and potential application in higher education. Figure 2 depicts the trend in scientific production on the use of AI in the development of metaverses for immersive learning.

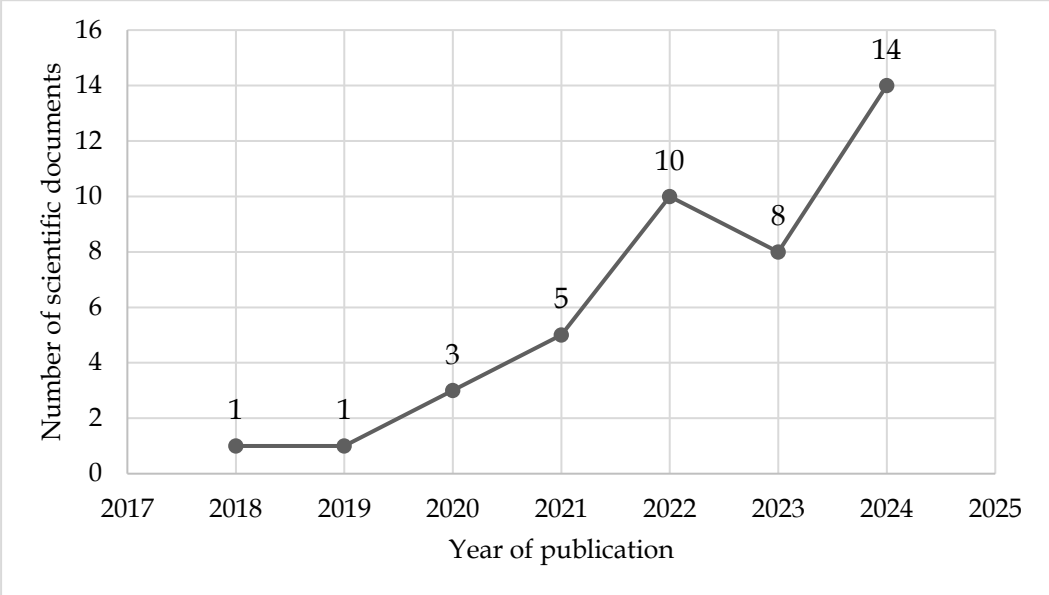

Figure 2: Trends in scientific production on the use of AI in the development of metaverses for immersive learning

The growing trend observed in the evolution of scientific production on the contribution of AI in the development of metaverses in higher education aligns with the conclusions of several recent studies, reflecting a growing and sustained interest, especially since the pandemic. Furthermore, Vo (2024) highlights the role

of AI and VR technologies in creating more interactive learning experiences, which coincides with the increase in research since 2021. Through their LearningverseVR platform, Song et al. (2024) demonstrated that the combination of AI and metaverses has enhanced student interaction and engagement, which is in line with the trend of increasing scientific production. Additionally, Liu (2024) highlighted the personalization of educational content through AI and VR, reflecting a significant aspect in the expansion of studies on metaverses in the educational field. Ebrahimi (2023) also underlines the relevance of using immersive environments to adapt teaching to individual needs, thereby highlighting the importance of AI in improving the educational experience. Together, these studies indicate the growing adoption of AI in the development of metaverses as an educational tool that not only improves the quality of learning, but also transforms higher education by adapting to modern demands, as reflected in the increase in the number of studies published in 2024.

3.2 What are the Most Impactful Research Studies on the Contribution of AI to the Development of Metaverses in Higher Education?

Regarding the research with the greatest impact on the field of study regarding the contributions of AI in the development of metaverses in the field of higher education, Table 2 presents the scientific documents with the highest total numbers of citations (TC) in the Scopus database. Among the most relevant studies, the work of Winkler-Schwartz et al. (2019) ranks highest, with a TC of 149, averaging 24.83 TC per year and with a normalization index of 1, making it one of the most influential studies in the area of medical education through AI-assisted virtual reality simulations. This study reflects the importance of AI in the evaluation and improvement of educational experiences in immersive simulation environments. In second place is the work of Ma (2021), with a TC of 58 citations, having an average 14.58 TC per year and a normalization index of 1.77; it explores the use of AI and machine learning techniques to improve the teaching of English through immersive environments. In general, the most cited studies address topics such as the integration of AI and VR in the development of digital skills, the creation of immersive learning environments and the improvement of educational experiences in various disciplines, demonstrating a continued interest in the convergence of these technologies with the improvement of higher education.

Table 2: Research with the highest numbers of citations and highest average numbers of citations per year

Author/s	Scientific document	TC	TC per year	Normalized TC
Winkler-Schwartz et al. (2019)	Artificial Intelligence in Medical Education: Best Practices Using Machine Learning to Assess Surgical Expertise in Virtual Reality Simulation	149	24.83	1.00
Ma (2021)	An Immersive Context Teaching Method for College English Based on Artificial Intelligence and Machine Learning in Virtual Reality Technology	58	14.50	1.77
Gong (2021)	Application of virtual reality teaching method and artificial intelligence technology in digital media art creation	57	14.25	1.74
Gandedkar et al. (2021)	Role of virtual reality (VR), augmented reality (AR) and artificial intelligence (AI) in tertiary education and research of orthodontics: An insight	40	10.00	1.22
Qian (2022)	Research on Artificial Intelligence Technology of Virtual Reality Teaching Method in Digital Media Art Creation	38	12.67	5.92
Stanica et al. (2018)	VR Job Interview Simulator: Where Virtual Reality Meets Artificial Intelligence for Education	31	4.43	1.00
Chen et al. (2022)	Robot-Assisted Language Learning: Integrating Artificial Intelligence and Virtual Reality into English Tour Guide Practice	19	6.33	2.96

The high citations of these studies reflect not only their influence, but also the relevance of their contributions in the construction of new educational practices. As higher education has increasingly adopted these new technologies, academic interest in the use of AI to enhance immersive and personalized learning has increased. Examples of this can be seen in the works of Gong (2021) and Gandedkar et al. (2021), which explore the application of AI in digital art teaching and orthodontic education, respectively, revealing the ways in which AI can improve teaching practice and student engagement in these fields. In addition, Stanica et al. (2018) and Qian (2022) highlight the importance of virtual environments and simulators as tools for professional training and the development of specific skills. Together with the work of Chen et al. (2022) on the

integration of robots and AI for teaching English, these investigations highlight the role of AI in creating adaptive and student-centered learning experiences, underlining the current trend of leveraging these technologies to transform the university education environment. Indeed, the discussion on these studies highlights the need to continue exploring the capabilities of AI in higher education, recognizing its potential to foster more meaningful learning and respond to the demands of an ever-evolving academic environment.

3.3 What is the Impact on Immersive Learning of the Metaverses Developed under the Contribution of AI in the Field of Higher Education?

By performing the content analysis of the 42 scientific documents composed of scientific articles and conference papers, we sought to identify the impact of AI on the development of metaverses in the field of higher education, as well as to categorize these impacts. Thus, Figure 3 presents the results of this categorization, from which five main categories have been identified as reflecting different aspects of the impact of AI-developed metaverses in higher education.

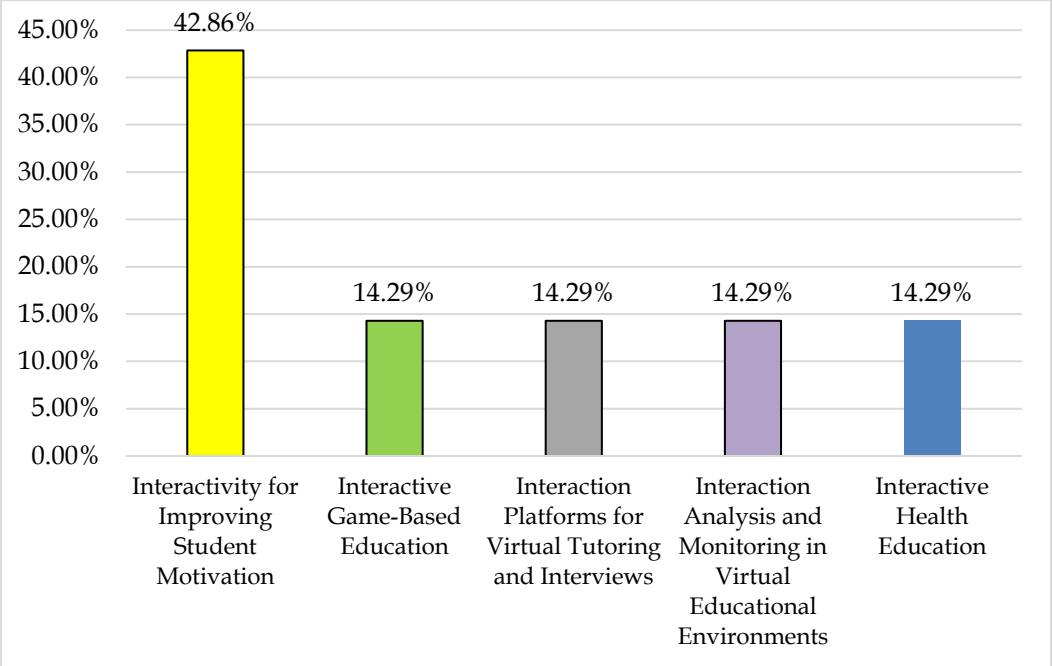

Figure 3: Categorizing the impacts of AI on immersive learning

The most significant category is "Interactivity for the improvement of student motivation", with 18 studies representing 42.86% of the total studies reviewed. This indicates that much of the research has focused on the ways in which AI-powered immersive environments can motivate students, thereby improving their engagement and willingness to learn. The other four categories, each with 14.29% of the studies, include "Game-based interactive education", "Interaction platforms for virtual tutoring and interviews", "Interaction analysis and monitoring in virtual educational environments" and "Interactive health education". These categories reflect a balanced interest in using metaverses to implement gamification in learning, facilitate tutoring and assessment, improve learning monitoring, and develop applications in the health field.

The implications of the impacts identified in the review of studies reflect the diversity of benefits that can be brought to the field of higher education by AI combined with immersive technologies, such as virtual reality. In the category of "Interactivity for improving student motivation", research highlights that the use of immersive environments allows students to experience more active and personalized learning, which, in turn, contributes to greater motivation and engagement with educational content. This suggests that the implementation of AI in metaverses not only facilitates the adaptation of content to individual needs, but also optimizes students' ability to interact with the environment in a meaningful way, promoting self-directed learning. In the case of -Game-based interactive education- it has been found that the integration of AI and metaverses goes beyond the simple inclusion of playful elements. AI allows for the creation of adaptive learning environments, adjusting the difficulty of activities in real time according to student progress, while metaverses provide immersive contexts that enrich the educational experience. The "Interaction platforms for virtual tutoring and interviews" and "Interaction analysis and monitoring" sections highlight AI's ability to provide continuous monitoring of student progress, facilitating immediate and tailored feedback for each student, which improves the learning experience and the effectiveness of educational processes. Finally, "Interactive health education" underlines the importance of simulating critical scenarios such as clinical training and patient education, highlighting the value of practical and safe learning that prepares students for real-life situations. Table 3 shows the implications of AI's impact on immersive learning.

Table 3: Implications of AI impact on immersive learning

Category	Author/s	Implications of the impact
Interactivity for improving student motivation	Vo (2024)	Using AI and VR in design projects allows students to explore and prototype their ideas more creatively and quickly, facilitating interactive learning.
	Cao and Yu (2024)	The application of VR in fitness training offers immersive and personalized experiences, improving training effectiveness and user interaction with the environment.
	Wang (2024)	Teaching ethical dilemmas in AI through VR fosters a deeper understanding of AI ethics, facilitating the transfer of knowledge to practical situations.
	Balushi et al. (2024)	Combining AI and VR/AR in teaching motivates students and improves their retention of complex concepts, creating a more effective learning experience.
	Liu (2024)	The use of deep learning techniques in smart classrooms with VR improves the adaptation of educational content to the needs of each student.

	Cavallaro et al. (2024)	VR voicebots enhance language teaching by reducing communication anxiety and providing a natural and fluid learning experience.
	Chen and Yao (2024)	The integration of IoT, VR and AI into an online education system improves the personalization and quality of teaching, offering tailored experiences.
	Hwang and Chien (2023)	The study of the metaverse in education highlights the need to understand how the integration of VR and AI facilitates interaction and collaboration in learning contexts.
	Ebrahimi (2023)	Virtual learning environments, supported by AI, improve personalization and user experience in educational platforms, facilitating adaptive learning.
	Qiu et al. (2023)	AI-based interactive VR software enhances the naturalness of interactions in virtual environments, providing a more satisfying user experience for learners.
	Li and Yu (2023)	The integration of AI and VR in aviation safety education improves the training of professionals by providing realistic simulations for critical situations.
	Li et al. (2022)	Teaching entrepreneurship in a distributed VR environment facilitates the interaction of shared experience, optimizing the design of educational environments.
	Yu (2022)	The AI and VR growth model in education fosters autonomous and collaborative learning, adapting content to the individual needs of students.
	Wang and Sun (2022)	Interaction with software products in VR, using deep learning algorithms, improves the student experience, offering more precise and efficient control of their learning.
	Ma (2021)	Immersive English teaching using AI and VR encourages active student participation, improving students' communication skills.
	Li et al. (2020)	Airport fire evacuation simulation with VR and AI improves students' preparedness and response in emergency situations.
	Lin (2020)	Combining VR with deep learning theory facilitates the creation of more dynamic and adaptive virtual spaces, improving the student experience.
Interactive	Song et al.	Learningverse VR uses generative AI and VR to

game-based education	(2024)	create immersive learning environments in which students interact with NPCs to enhance their learning experience.
	Wang (2022)	AI-powered VR sports simulation enables personalized training that optimizes students' physical performance.
	Lu (2022)	Integrating VR and AI into logistics education provides interactive simulations that incorporate gaming elements to enhance understanding of complex processes. This helps students to experience logistics challenges in a hands-on and dynamic way.
	Qian (2022)	Teaching digital art with VR and AI allows students to explore new forms of artistic expression and enhances visual creativity.
	Gong (2021)	Using AI and VR in digital art teaching fosters innovation and enriches the educational experience, overcoming the limitations of traditional methods.
	Hunvik and Lindseth (2021)	Using VR to teach AI concepts through a gamified escape room approach increases students' motivation and interest in complex topics.
Interaction platforms for virtual tutoring and interviews	Yun et al. (2024)	The AI-powered VR tutoring platform offers a personalized approach to teaching English, enhancing student learning through adaptive tutoring.
	Li (2023)	The AI-powered VR oral assessment system improves the accuracy and efficiency of English teaching, providing an alternative to traditional methods.
	Chen et al. (2022)	The use of robots and VR in teaching tourist guides improves student interaction and autonomy, providing a more active and dynamic learning environment.
	Luo (2022)	Personalizing English teaching through AI and VR enhances the learning experience by providing recommendations tailored to students' abilities.
	Khan et al. (2021)	The AR, VR and AI-based tutoring system facilitates autonomous learning without the need for external tutors, improving students' access to education.
	Stanica et al. (2018)	The VR and AI job interview simulator provides users with a practical tool to improve their communication skills and interview preparation.

Interaction analysis and monitoring in virtual educational environments	Chao et al. (2024)	Using eye-tracking technology in VR allows educators to monitor student engagement, improving learning monitoring and tracking.
	Marques (2024)	The metaverse and AI redefine post-pandemic teaching, promoting the use of virtual environments for dynamic and adaptive teaching to new technological realities.
	Kundu (2023)	Cyber-sickness detection using AI in VR improves user experience, facilitating the implementation of more user-friendly and comfortable virtual environments for students.
	de Carolis et al. (2023)	The AI-assisted VR experience in museums facilitates access to information and enhances understanding of cultural heritage through immersive environments.
	Chang et al. (2022)	A review of AI driving simulators in VR shows the potential of these systems to improve learning in road safety education.
	Palazzollo et al. (2020)	The DeepDive system uses AI and VR to explore submerged civilizations, generating new opportunities for archaeological research through pattern analysis.
Interactive health education	Teixeira et al. (2024)	Integrating VR and AI into nursing education enhances clinical training by allowing students to safely practice in simulated scenarios.
	Brucker-Kley et al. (2024)	The combination of VR and conversational agents improves the education of patients with chronic diseases, creating a more interactive and personalized learning environment.
	Chheang et al. (2024)	Generative virtual assistants in VR facilitate the teaching of anatomy by providing an immersive environment that improves the understanding of complex concepts.
	Seo et al. (2023)	SBIRT skills training in VR with virtual patients improves knowledge retention in nursing students by creating a safe and personalized learning environment.
	Gandedkar et al. (2021)	Implementing AI, VR, and AR in orthodontic teaching improves understanding of complex procedures and creates a collaborative learning environment.
	Winkler-Schwartz et al. (2019)	The use of machine learning algorithms in VR surgical simulators allows for the accurate assessment of surgical skills, improving academic training.

The results on the impact of metaverses developed with AI in higher education on immersive learning are closely aligned to the findings of previous studies, such as those by Chheang et al. (2024) and Wang (2024), which highlight the importance of using immersive environments with generative assistants and simulations to improve students' understanding of complex concepts. Furthermore, these studies align with the category of "Interactive Health Education", in which it is observed that AI facilitates the practice of skills in simulated virtual scenarios, providing more effective and safer training for students. In addition, Brucker-Kley et al. (2024) highlights the use of conversational agents for the personalization of the learning experience, which reinforces the relevance of "Interactivity for the improvement of student motivation", one of the most prominent categories. On the other hand, Vo (2024) and Song et al. (2024) note that AI in metaverses facilitates adaptive and playful learning experiences, which resonates with "Game-based interactive education". Ebrahimi (2023) and Liu (2024) also reinforce the notion that the personalization and adaptability provided by AI in immersive environments is key to meeting students' specific needs, enhancing their motivation and engagement.

4. Conclusion

Based on the findings, it was identified that there is a growing trend in the use of AI for the development of metaverses focused on improving immersive learning in higher education. During the pandemic period, this growth was accelerated due to the need to adopt alternative educational strategies; nevertheless, in the post-pandemic years, research on the topic has not only been maintained, but has continued to increase. Regarding the most relevant studies, it was found that these focus mainly on improving medical education through simulations in virtual environments and the use of machine learning techniques for language teaching, reflecting the interest in personalizing and optimizing the educational experience. Finally, in terms of the impact of AI on the development of metaverses in higher education, a positive impact was identified and grouped into five categories. Among these, the most prominent was "Interactivity to improve student movement", which comprises 42.86% of the studies reviewed. It is therefore concluded that the integration of AI in the development of metaverses has significant potential to transform higher education, offering personalized immersive learning experiences that are already redefining the way in which students interact with knowledge. However, gaps remain in the literature that require attention from the scientific community, especially in the evaluation of the long-term impact of these technologies and their equitable adaptation in diverse educational contexts.

5. Future Research

Future research should be directed towards a deeper understanding of the effectiveness of these environments in developing specific skills such as teamwork, leadership, communication, as well as creating strategies that promote inclusive accessibility. This will not only maximize the value of AI and metaverses in higher education, but will ensure that their impact contributes equitably to the advancement of learning in an increasingly digitalized world.

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