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Evaluating the Combined Use of Artificial Intelligence and Virtual Reality in Higher Education: A Bibliometric and Systematic Analysis

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Abstract: *In the study, which aims to determine the advantages and difficulties of using "artificial intelligence" and "virtual reality" applications in higher education, a systematic literature review and bibliometric analysis were used together to determine the trends in the studies conducted. Web of Science database was preferred to obtain the data in the study. "Artificial intelligence", "virtual reality", and "higher education" were used as keywords. Only English, open-access journals, literature reviews, and conference proceedings were included in the study. First, the abstracts of 61 studies that met these criteria were reviewed. Then, the documents to be included in the study were determined by the PRISMA steps. As a result of the PRISMA processes, ten studies were read in detail, and the study findings were obtained. According to the results obtained, it was determined that there were difficulties in motivation continuity and reflecting human emotions, in addition to the many positive effects of using "artificial intelligence" and "virtual reality" applications in higher education. In addition, as a result of the bibliometric mapping, it was determined that the most preferred keywords in studies containing these applications were "Virtual reality", "artificial intelligence", and "machine learning". Suggestions are given depending on the results obtained.*

Keywords: *artificial intelligence; virtual reality; machine learning; higher education*

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1. Introduction

Institutions are constantly changing due to digital transformation, defined as a change made by using digital technologies to make the work of institution employees or customers easier (Taşlıbeyaz, 2021). In the digital transformation process, artificial Intelligence, blockchain technology, computer vision, network infrastructure such as 5G/6G, edge computing, user, user interaction, virtual reality technology, internet of things, and robotic applications are technologies that interact with the real world (Damar, 2021). Digital transformation has affected many areas, including the economy, industry, tourism, health, and education.

This transformation is causing changes in the educational environment, from the role of teachers and students to teaching methods. Today, many countries face the great challenge of a shortage of highly qualified, expert, and skilled workers. Therefore, to renew higher education to meet the needs of the labor market, awareness about digital transformation needs to be raised, and educational programs need to be renewed (Tri, 2021). Today, traditional and e-learning are intertwined. The elements that form the infrastructure of e-learning have become a part of conventional education, making it very difficult to distinguish e-learning methods from other education methods (Demirkaya & Sarpel, 2018).

Research on digital transformation applications in learning institutions indicates that students' ability to interact with virtual learning environments, develop their self-learning skills and learn in their style has increased (Ma, 2021).

Researchers working on e-learning state that digital transformation in higher education affects two main areas of work (Spear, 2020). The first is that transformation involves creating new products and changing existing ones. For example, offering graduate programs in the form of distance education or switching to e-books. The second is about the complete digitization of processes. Examples of this include applying to university admissions or graduation procedures from digital platforms and registering for courses online at the beginning of each semester. Researchers have begun working on developing virtual campuses with virtual reality, metaverse, and augmented reality applications (Nagao, 2023).

One of the pioneers in virtual reality, Google Company, has enabled students to discover the learning experience at low costs by using mobile phones and virtual reality glasses designed from cardboard. Meta (Facebook) produces virtual reality devices with high-resolution screens and high-performance processors, offering hand movement tracking and offers them to all users with its investments and services. Using these devices, which are not expensive, is seen as an important development (Kahveci & Sondaş, 2023). Virtual reality has begun to be used for educational and evaluation purposes today. It has been determined that virtual reality (VR) applications positively affect achieving cognitive learning goals when used to increase student participation by transforming educational content (Cai, 2024).

There are many definitions in the literature regarding the explanation of Artificial Intelligence. Researchers generally define artificial Intelligence as the science and engineering of developing intelligent machines and intelligent computer software. Artificial intelligence applications, a theoretical framework, can perform tasks requiring human Intelligence, such as translation, environmental adaptation, decision-making, and speech. Artificial Intelligence is a field of study inspired by human Intelligence and aimed at solving and adapting cognitive problems. In the early days of the concept of Artificial Intelligence, it contributed to web-based and online intelligence systems. Today, it performs many different functions, such as evaluating students' homework more effectively and efficiently and giving grades by integrating with other technologies (Bülbül & Ersöz, 2022). In addition, artificial Intelligence is used in education for curriculum development, content development, virtual reality, augmented reality, web-based platforms, robotics, video conferencing, and audiovisual file development. Artificial Intelligence can change every aspect of social interactions and enable students to learn better. Today, artificial Intelligence has begun to produce new teaching and learning solutions that are being tested in different contexts

(Pedro et al., 2019). Thanks to its adaptability, artificial Intelligence contributes to personalized learning. A study on the use of Artificial Intelligence in higher education shows that students have positive beliefs that Artificial Intelligence will change the education process in the coming years (Ryzhova, 2024).

For the above reasons, this research aims to determine the advantages and difficulties of using virtual reality and artificial intelligence technologies in higher education institutions.

What is the distribution over time of the studies collected in the WoS that examine the use of AI and VR in higher education?

What are the advantages of combining AI and VR in higher educational settings, as indicated in the studies collected in WoS?

What are the challenges of combining AI and VR in higher educational settings, as indicated in the studies collected in WoS?

2. Method

The method of this study is literature review models Preferred Reporting Items and Systematic Reviews and Meta-Analysis and bibliometric analysis. Using the two models together increases the reliability of the study results (Moher et al., 2015). The Web of Science Database was preferred for systematic and bibliometric analyses. WoS, which has scientific research collections, was preferred because it is a rich database that adds high-impact journal articles, conference proceedings, and books to its collection (Web of Science Help, 2021).

Searches in the WoS database were performed using appropriate keywords, using AND, OR, and NOT Boolean combinations to ensure the topic's comprehensiveness.

2.1. Keywords Searches

The research keywords were determined according to the given criteria: "Artificial intelligence," "AI,"" Virtual Reality,"" higher education," and "University." The research conducted with these keywords includes those published open access and in English.

Formula:

((TS=("artificial intelligence" OR "AI")) AND TS=("higher education" OR "HEI")) AND TS=("virtual reality" OR "VR")

2.2. Searching Criteria and Variables

The inclusion and exclusion criteria were determined to ensure the study's reliability and validity. Table 1 presents the inclusion and exclusion criteria.

Table 1. Inclusion and exclusion criteria

Characteristic	Included	Excluded
Type	Journals Proceeding Papers Review Articles	Retracted Articles Editorial Letter
Language	English	Non-English
Availability	Open access	Access denied or chargeable

The inclusion and exclusion criteria were determined to ensure the study's reliability and validity. Table 1 presents the inclusion and exclusion criteria. The database search selection has commenced with 132 articles. Following PRISMA's examination process, many papers were excluded for several reasons, such as retracted articles, editorials, and letters. Also, only open-access articles are included. Articles published in languages other than English have been excluded from this study. In addition, after applying the inclusion and exclusion criteria specified in the table, 61 full texts were accessed from the database.

Another stage of the PRISMA technique, abstract-level screening, was performed, and 45 documents were excluded from the study's scope because it was determined that the keywords were not directly related to the subject, only included in the abstract, or only one of the subjects was used as a basis. Although keywords were included in the titles or abstracts of the studies, upon examination of the abstracts, it was understood that the keywords did not represent the main theme of the study and were not directly associated with the research topic. In the abstract screening phase, it was evaluated whether the main subject of the study was the combined use of virtual reality and artificial Intelligence and whether it discussed the integration of these two technologies and their effects on education.

In the full-text examination stage, it was determined that one study was carried out only to introduce the system in the country, and five studies did not research AI and VR applications together in higher education following the research purpose. As a result of the evaluations, ten documents were examined as full text.

In evaluating the documents, the authors created a forum to assess the risk of bias and applicability. The first and second authors examined the abstract and title by the inclusion and exclusion criteria. Cohen's Kappa Coefficient of the two authors was calculated as 0.93.

The VOSviewer tool was selected for the study's bibliometric analysis due to its advanced capabilities in datasets, mapping, visualization, and multidimensional analysis.

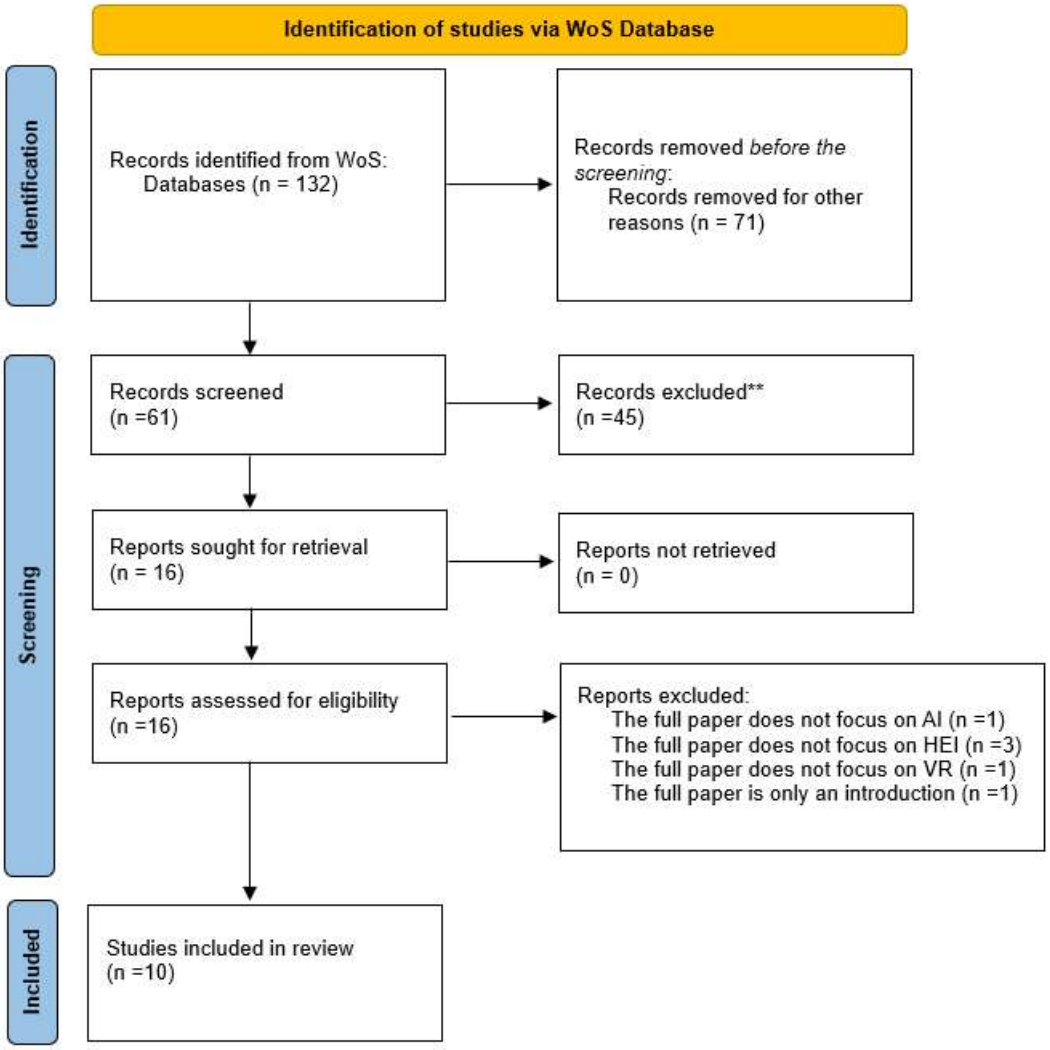

Figure 1. Prisma flow diagram
Source: (Page M.J., et al., 2021)

3. Results

The systematic and bibliometric study findings are presented under this heading. The study included ten studies scanned in the database on the use of “artificial intelligence” and “virtual reality” applications together in higher education.

3.1. Distribution of studies over time collected in the WoS

The distribution of the studies is presented in the figure below.

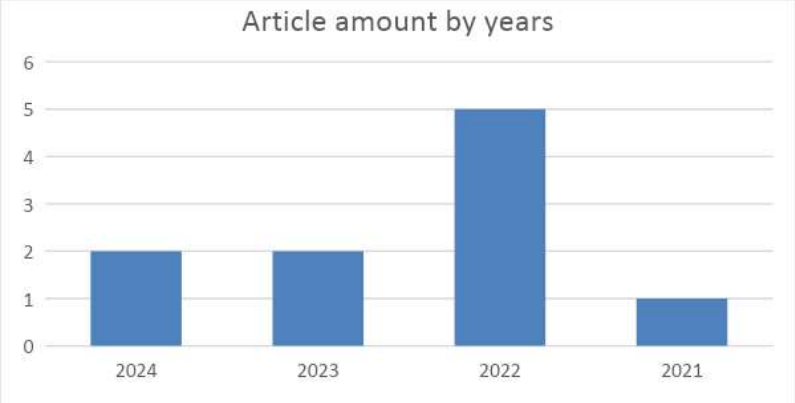

Figure 2: Distribution of articles according to years

This study was conducted without any specific year limitation in order to determine research trends in the use of artificial Intelligence and virtual reality applications together in higher education. In the systematic review process, suitable studies from all years were included. In this way, the general trends and changes in the literature on the subject were tried to be reflected over time. As can be seen in the given graph, the number of suitable studies after PRISMA in these years is only 10.

Although the beginning of artificial Intelligence and virtual reality studies dates back to earlier times, the studies in which both were used together in higher education started with two articles in 2021 and increased to five articles in 2023. This increase shows us that interest in the subject is growing daily. Since 2024 was not completed when the study was conducted, only one study was obtained. However, this number is expected to grow by the end of the year.

3.2. Advantages and challenges of combining AI and VR in higher educational settings

Table 2 presents the findings regarding the advantages and challenges of combining AI and VR in higher education.

According to the results obtained in this study, Virtual Reality helped students with dyslexia experience various sensory stimulation and feedback. For psychometric tests, they experienced as if they were real because they saw and heard real images and sounds of a certain environment (Yeguas-Bolivar et al., 2022).

In another study conducted to evaluate the competence and experience of nursing students in communicating with a medical doctor developed with artificial Intelligence, a virtual hospital, a patient and an AI doctor as an avatar were created in a 3D virtual environment. A medical doctor was placed in a virtual environment using human characteristics with Artificial Intelligence. According to the results obtained from the study, it was revealed that the communication skills of nursing students increased and there were also improvements in their interprofessional communication self-efficacy. It was determined that the "human-like" feature of the artificial

intelligence medical doctor was at a low level, indicating that the AI doctor's human-like expressions and gestures could not fully reflect human emotions. In addition, more than 90% of nursing students found the AI medical doctor interesting, and it was revealed that the application encouraged them to focus on relevant information. It was stated that virtual reality applications provided learners with the opportunity to repeat topics and were good prompts for practicing at the same time. Despite the clinical importance, it was stated that some participants noted that the lack of a sense of clinical urgency that could appropriately reflect real-world clinical practice with the AI doctor could cause differences that could be experienced in real life. The developed environment was determined to provide safe and quality patient care (Liaw et al., 2023).

Table 2. Advantages and challenges of combining AI and VR in HEI

	Opportunities	**Challenges**
(Yeguas-Bolivar et al., 2022)	● Contribute to the development of customized learning strategies ● Design of personalized learning processes through rapid acquisition and analysis of student data ● Instant feedback for learners	● Difficulty of access ● Large-scale adaptability ● Sustainability
(Liaw et al., 2023)	● Practicing in a virtual environment ● Safe environment ● Opportunity to correct mistakes through repetition ● Developing problem-solving skills	● AI's inability to reflect human emotions ● Educators need additional training
(Fan, 2023)	● Effective visual and environment ● Fast data processing ● Adaptable to different learning styles	● Personalized content development for different levels ● Accuracy and effectiveness of algorithms
(Nagao, 2023)	● Immersive learning experience ● Instant assessment ● Individualized feedback ● Increased concentration	● Optimizing user experiences ● Decrease in social skills
(Ryzheva et al., 2024)	● Practical and fast solution ● Integrated into different learning processes ● Improve creativity skills ● Decrease education costs	● Skepticism about AI use ● Impact on academic integrity
(Kumar et al., 2023)	● Ease of concretizing concepts ● Acquisition and analysis of real-time data ● Rich material support ● Safe environment	● Transferring skills to real life ● Technological deficiencies ● Sustainability
(Zingoni et al., 2021)	● Developing individual strategies ● Simulations enrich the learning process ● Customized solutions	● Measuring the real contribution of algorithms to achievement of students ● Inadequate technology acceptance levels of learners
(Ma, 2021)	● Immersive learning process ● Contextual learning strategies ● Offering effective learning method	● Technological challenges ● Uncertainties
(Wang et al., 2022)	● Improving problem-solving with simulation ● Support for comprehension processes ● Improving motivation and self-efficacy ● Decreasing anxiety	● Evaluation of the effectiveness of VR ● Educators' adaptation difficulties
(Pyae et al., 2023)	● Increased student performance ● Increased productivity ● Individualized learning opportunities ● Improving social interaction and communication skills	● Educators embracing AI ● Requires special equipment ● Measuring long-term effects ● Accessibility ● Cost constraints ● Lack of awareness

In the study aiming to investigate the effect of artificial Intelligence on art, the features of virtual reality technology were evaluated. It was determined that using these applications together, learners gained more information than traditional learning methods using visuals and pictures. In addition, the capacity to work faster on cellular and other devices with 5G is only one of its main advantages (Fan, 2023).

A digital campus was developed in the study, focusing on the potential value and future expectations of virtual reality (VR) technology. In the study where artificial intelligence (AI) systems based on body movements and biometric information that are difficult to collect in the real world were used, the contents were designed in which the avatar character developed with virtual reality served as a lecturer and used presentation slides as in a real lesson. According to the results obtained, it was stated as an advantage that the developed 3D materials and presentations could be recorded and later studied, analyzed and easily determined the problems experienced in detail. Since it was stated that it was impossible to determine whether the students were concentrated in the online education process, analyses were carried out using imaging devices and heart rate monitors to determine the concentration level. Effective learning is thought not to occur when the concentration level is low. The analysis of the concentration level showed a relationship between the exam results and the concentration level (Nagao, 2023).

In Ryzhova study, most university students have used AI at least once, and many stated that they had a positive interaction experience with AI. More than half of university students believe that AI will change the educational process in higher education. Some educators, on the other hand, are skeptical about AI applications. However, the teacher's avatar provides students with support and individual assistance when needed. AI and virtual reality applications can be used to create interactive classes. It has been revealed that the applications reduce the cost of education (Ryzheva et al., 2024).

Another study examined the effects of 3D gamification using integrated Artificial Intelligence implemented with virtual reality applications for biology and medical students to learn about the human brain. According to the results obtained from the study, it was shown that virtual reality increased learner motivation and positively affected the understanding of the process from concept to application. Another result of the study was that learners were enthusiastic at the beginning of the learning process with simulators, but in later lessons, interest decreased and problems such as not taking the studies seriously (Kumar et al., .

Zingoni developed software consisting of artificial Intelligence and virtual reality applications for students with dyslexia in their study. According to the results, study materials became more accessible and supported the lessons. In particular, choosing strategies suitable for each student's characteristics was one of the biggest advantages. Other advantages stated were the opportunity to repeat at any time, taking breaks during the lesson, accessible materials and appropriate strategies. Some students said that communicating with machines instead of real people did not work (Zingoni et al., 2021).

In the study, which aimed to develop learners' English language skills, virtual reality and artificial intelligence applications were used based on the constructivist approach. The study also showed that the learning process with virtual reality applications and the constructivist approach was successful. In addition, it was determined that immersive learning environments were provided, cooperation between learners increased, and feedback was provided instantly thanks to these technologies (Ma, 2021).

Pyae evaluated the usability and applicability of the software they developed with artificial Intelligence and virtual reality applications for computer science and engineering students. According to the results, the software developed with artificial Intelligence and virtual reality applications provides a user-friendly learning environment. In addition, according to the results obtained, it is emphasized that metaverse technologies have significant promise for advancing

higher education. The stated challenges are accessibility issues, cost constraints, lack of awareness and special equipment requirements (Pyae et al., 2023).

3.3. Co-occurrence of All Keywords

In studies on artificial Intelligence and virtual reality in higher education, the most used keyword by authors was determined as "virtual reality". Other keywords preferred most by authors in their articles were "artificial intelligence" and "machine learning", respectively. The strongest expressions in terms of total link strength were determined as "virtual reality", "artificial intelligence", and "machine learning" as a result of the analyses performed with 31 items that were seen at least one time and had relationships, a total of 5 clusters, 102 links and 104 total link strengths were determined.

Table 3. Most popular keywords used in 2020-2024 years

Keyword	Occurrences	Total Link Strength
Virtual reality	6	32
Artificial Intelligence	2	11
Machine learning	2	9
Heuristics	1	7
Human-computer interaction	1	7
Learning	1	7
Metaverse	1	7
System usability scale	1	7
Usability	1	7
User experience	1	7

Figure 3 shows the all-time trends of the most used keywords. After 2023, the most popular keywords in the field were "artificial intelligence" and "edutainment".

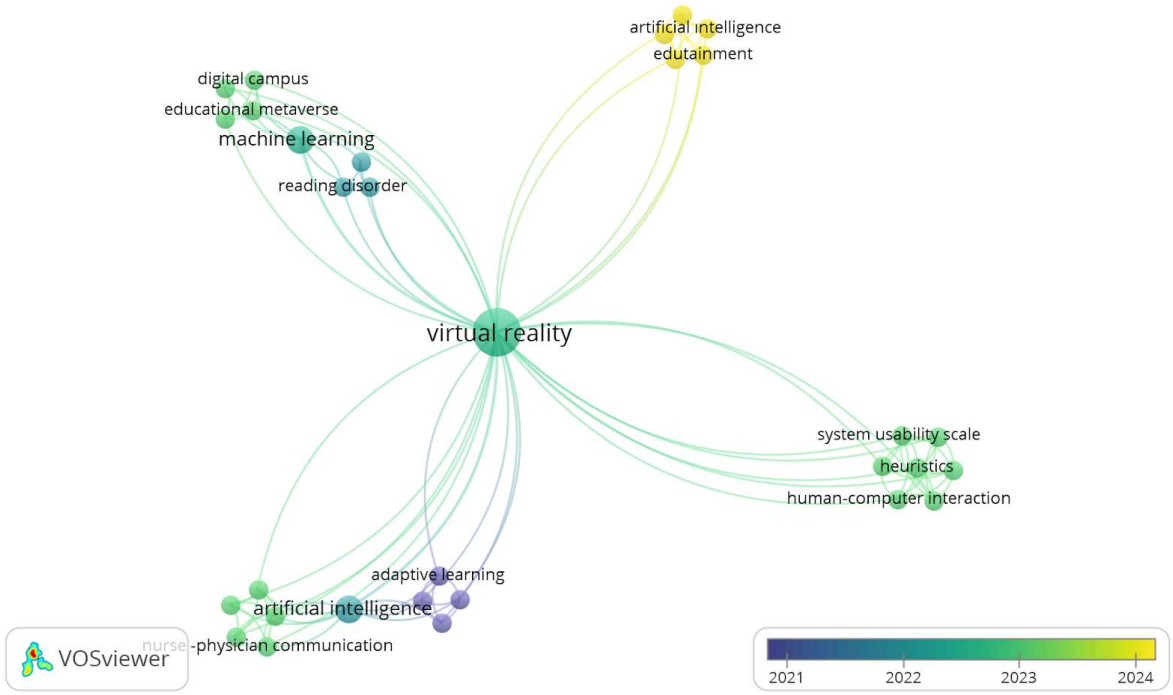

Figure 3. All-time trends of the most used keywords

Since 2022, the use of virtual reality and artificial Intelligence together has become more popular. Virtual reality has been preferred as a keyword in all studies. Although artificial intelligence applications have been used in all studies, they have not been selected as keywords.

3.4. Publications by country

Table 4 presents the distribution of studies by country on the use of virtual reality and artificial Intelligence in higher education.

Table 4. Most popular keywords used in 2020-2024 years

Keyword	Documents	Citations	Total Link Strength
Spain	3	23	205
Italy	2	21	115
Finland	1	2	90
Thailand	1	2	90
Peop. Rep. China	3	37	61
Taiwan	1	6	61
Saudi Arabia	1	5	37
India	1	5	37
Singapore	1	25	35
USA	1	25	35
Japan	1	2	0

Accordingly, researchers conducted studies from 11 different countries. Spain (3), Peop. Rep. China (3), and Italy (2) conducted the most studies on the subject. The other eight countries conducted one study on the subject.

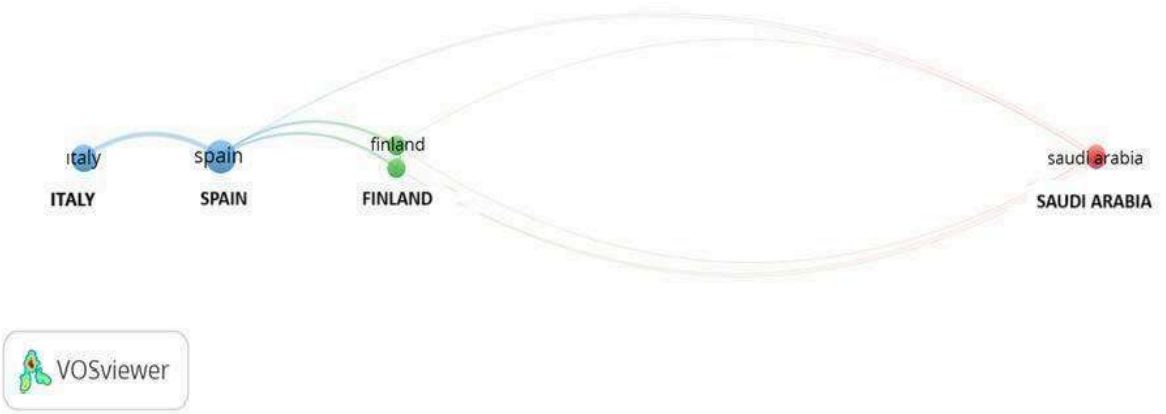

Figure 4: Number of publications by country

Using data collected from the WoS database, a mapping of the related publications of the countries was performed (Figure 4). In the mapping process, a minimum threshold of 1 document and 1 citation was limited for a country. Six countries out of twelve met the threshold. These 6 countries were divided into 3 clusters. In Figure 4, the size of each circle indicates the number of documents published by the country. The larger the circle, the more documents are published by the country. Spain has relations with all 5 other countries.

4. Discussion and Conclusion

The study used systematic literature analysis and bibliometric analysis to determine the advantages and difficulties of artificial Intelligence and virtual reality applications in higher education and to determine trends in these studies.

While searching the Web of Science database, the keywords “artificial intelligence”, “AI”, “higher education”, “HEI”, “Virtual reality”, and “VR” were used with the conjunctions “OR” and “AND” in the keywords, abstract and title. The inclusion criteria were English, open access, review papers, journals and proceeding papers. While 132 studies were accessed in the first search, 61 were found suitable after the inclusion and exclusive criteria. Later, after Prisma flow operations were performed, it was determined that only ten studies were ideal for the study.

When we look at the distribution of studies in which “Augmented reality” and “Virtual reality” applications are used together in higher education, we can see that studies on the subject started in 2021 and are gradually increasing. The interpretation was not considered since 2024 had not yet been completed when the study was conducted.

In a different study that developed a virtual campus, problems such as the need to monitor students' concentration levels and loss of motivation were identified. This situation reveals that gamification and VR applications have difficulties in creating sustainable motivation in the long term.

In the literature review on the impact of artificial Intelligence and virtual reality applications in higher education, "virtual reality," "artificial intelligence," and "machine learning" have emerged as the strongest keywords. The use of these two technologies together has increased, especially since 2022. This situation shows that the contribution of artificial Intelligence and virtual reality integration to higher education is increasingly accepted.

Further applications and research are needed to investigate VR and AI integration's long-term effectiveness and scalability in higher education. Studies should be conducted on algorithms that can better simulate emotional expressions to increase human-like interactions in avatars or other applications developed with artificial Intelligence and virtual reality. The educational use of artificial Intelligence and virtual reality applications is now inevitable, so it may be necessary to include emotional intelligence training in higher education curricula. Emotional intelligence levels can be increased by creating programs that help students identify, understand and manage their own emotions and the emotions of others.

Educators understanding the emotional states of their students, planning their lessons, and determining their methods accordingly are of great importance in increasing efficiency (Ozdamli et al., 2022). In this context, face readers ("Labeled Faces in the Wild," 2019), (Hadinejad et al., 2019) and X-press engines (Sun et al., 2017). These are important tools used for algorithms to determine learners' emotional states in the literature. Especially convolutional neural networks (CNN) provide successful results in emotion recognition and face detection processes in computer vision (Yang et al., 2020). CNN is one of the deep learning algorithms used for image recognition and classification and offers an effective method for identifying emotional changes in facial expressions with high accuracy ("Labeled Faces in the Wild," 2019). Deep learning algorithms are important since face detection and recognition processes require high precision. These technologies can make the learning process more effective and personalized by allowing instructors to better understand

students' emotional reactions and improve classroom interactions (Ozdamli et al., 2022), (Yang et al., 2020).

For this reason, these technologies can be used in learning processes where artificial Intelligence and virtual learning applications are combined. Motivation-enhancing elements such as gamification or learning models should be integrated to prevent students' motivation levels from decreasing using these applications. In addition, research on these applications in different disciplines should be expanded.

AI-supported data analytics offer a significant opportunity to monitor student performance and identify areas where they need support. In the future, it is expected that such analyses will be more widely applied and early intervention strategies will be developed. In addition, AI and virtual reality applications can increase student achievement and support management and planning activities by contributing to strategic decision-making processes in educational institutions. Therefore, it is recommended that researchers and education experts conduct more research in these areas and develop innovative strategies.

Open-source software can be encouraged to reduce license costs and hardware requirements. Educators could benefit from having experts provide training on using open-source VR content creation platforms and AI-based teaching tools.

Research shows that effective and sustainable use of artificial intelligence and virtual reality technologies in higher education can potentially transform future education systems. Integrating artificial intelligence and virtual reality applications into teaching-learning processes will enrich student success and learning experiences while also leading to the development of innovative and inclusive approaches in education.

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