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The use of immersive technologies in distance education: A systematic review

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Abstract
This study aims to conduct a systematic review that includes studies on the use of immersive technologies in distance education. For this purpose, 132 studies detected by searching Web of Science, Eric, Taylor & Francis and Education Full Text (EBSCO) databases were examined. The studies were analysed using the content analysis method. As a result of the analyses, it was observed that the first study investigating the subject was conducted in 2002, and the number of related studies increased over the years. In addition, these studies were primarily conducted quantitatively, were mainly journal articles, and originated mostly from China and the USA. Moreover, the sample groups of these studies consisted mostly of university students. Therefore, they mainly used academic performance and motivation variables. Furthermore, these studies were conducted primarily in the science and medical education disciplines. When the studies were evaluated in terms of publication journals, it was determined that they were published mostly in "Education Science" and "Computers & Education" journals. They were also included in the proceedings published within the scope of various conferences. When the application platforms in the studies were examined, it was determined that the UNITY and ARTUTOR platforms were mostly used. The findings of the studies revealed that the increase in academic performance and motivation was one of the most reported advantages of such technologies. On the other hand, the problems caused while using these technologies and the internet were the most reported difficulties in the studies. Finally, the review presented suggestions for future studies.

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1 Introduction

Technology has advanced by leaps and bounds. Additionally, the invention of Metaverse and the digital world has spurred educators to want to introduce virtual platforms in educational environments. In particular, virtual environments attract people's attention owing to the opportunities they offer in distance education, where students and teachers interact only on the internet. Moreover, the COVID-19 pandemic reminded us that we must transform distance education. Rather than merely "surviving" through a wave of crises, we must learn how to adapt to the new normal (Nesenbergs et al., 2021). Although distance learning environments offer various advantages, such as flexibility, affordability and unlimited repetition (Rodrigues et al., 2014), they also have several disadvantages. Distance education provides students with a more flexible learning environment when compared to face-to-face education; however, it is difficult to ensure that students participate in distance courses at the same level as regular education (Coyne et al., 2018). Pozdnyakova and Pozdnyakov (2017) stated that these difficulties might be mainly associated with the fact that the student and instructor are not physically present in the same environment. At this point, immersive technologies such as VR and AR can help overcome these difficulties. In this sense, innovative technologies such as Virtual Reality (VR) and Augmented Reality (AR) enable e-learning environments to have currently robust and flexible learning opportunities that offer learners enhanced dynamism and customisation opportunities (Alzahrani, 2020). Immersive technologies simulate the real world through the virtual world, allowing users to perceive virtual components as a part of the real world and have an immersive experience (Barrett et al., 2021; Wu et al., 2021). This study examined immersive technologies based on augmented and virtual reality technologies. In addition, in distance education, researchers have studied innovative instructional technologies and methods to increase the effectiveness of the teaching process. This has brought augmented reality and virtual reality technologies to the forefront.

Virtual reality and augmented reality technologies are attracting people's attention, mainly due to the commercial availability of new immersive VR/AR platforms and cost-effective standalone VR/AR platforms (Scavarelli et al., 2021). Although VR technology focuses on creating virtual environments by allowing the simulation of physical presence at a specific location in the real world, users can use this technology through several specialised devices that enable them to recreate hearing, seeing, hearing, and even smelling experiences (Guevara et al., 2020). In this sense, Lu et al. (2018) define VR technology as a computer-assisted simulation system that enables the formation of virtual environments to make real interactions. Also, VR technology can be used to overcome the difficulties of distance education (Liu et al., 2019). For example, in their study, Dunnagan and Gallardo-Williams (2020) designed a virtual laboratory to solve

the spatial problems experienced due to distance education in organic chemistry laboratory courses during the COVID-19 pandemic and stated that the students were satisfied with this laboratory.

Moreover, in an experimental study conducted by Valenti et al. (2020) to examine how the use of VR technology affected the orientations of students in distance education programs, they found that students using VR technology were more knowledgeable about evaluating their programs compared to the controls. In addition, their anxiety levels about the program decreased slightly, and they were satisfied with VR technology. Thus, it can be asserted that achieving deep and meaningful learning in e-learning environments and maintaining students' interests and motivation towards learning is more complicated when compared to face-to-face learning environments (Mystakidis et al., 2021). In addition, the high drop-out rates of students in e-learning environments are usually caused by students and their teachers logging in to the system from different locations, experiencing connection problems and lacking motivation (Paulus & Scherff, 2008). In this regard, virtual environments can offer opportunities for individuals to socialise and increase their motivation.

AR technology allows virtual objects to be viewed in real environments (Azuma et al., 2001). AR can be regarded as a virtual extension of people's reality in a system owing to three major features: real-time interaction, combined reality, and virtuality. Thus, AR has become a frequently studied technology in educational studies. Le and Nguyen (2020) state that AR offers cost-effective, easy-to-use solutions for academic settings. In this sense, in the study conducted by Çetin and Türkan (2022) with 15 third-grade students, they examined how the AR-based applications they developed for the science course affected the achievement and attitudes of the students who were taking science courses in distance education and found that students' achievement levels and attitudes changed positively through these applications. In another study, Altunpulluk et al. (2020) evaluated the use of AR technology in distance education by holding interviews with 14 field experts through the Delphi technique and stated that AR is an up-and-coming technology in the context of distance education and made positive contributions to disabled students as well as healthy students during distance education.

While VR and AR are similar in using many equivalent technologies, such as tracking sensors and displays, they represent two different approaches to blending real and virtual world realities (Scavarelli et al., 2021). While artificial environments do not interact with the real world in virtual reality-assisted environments, augmented reality-assisted applications offer users the opportunity to interact with both artificial and real worlds simultaneously (Carmigniani & Furht, 2011). VR is not a novel technology; however, due to advancements in visualisation and interaction possibilities, it has become more and more interesting for researchers, and head-mounted displays, especially HTC Vive and Oculus Rift, allow users to have a high level of immersion experience (Radianti et al., 2020).

Although there are systematic reviews examining the studies on the use of augmented reality and virtual reality technologies in education, there is no comprehensive systematic review examining the studies on using these two technologies in the context of distance education. For instance, Tang et al. (2022)

analysed 128 indexed articles on the Web of Science through a systematic review. The results show immersive technology is now widely used by physicians, medical students, and interns, primarily in surgery anatomy-related subjects. In addition, the authors discussed the evaluation methods and performance outcomes of immersive technology applications in medical education and practice. In their review, examining 54 studies on the state of immersive technology research in diverse settings, including education, marketing, business, and healthcare Suh and Prophet (2018) provide a comprehensive analysis of the existing literature on immersive technologies, including virtual reality, augmented reality, and mixed reality. The authors identified four main themes in the literature related to immersive technologies: (1) the impact of immersive technologies on learning outcomes, (2) the use of immersive technologies in training and simulations, (3) the effects of immersive technologies on user experience and engagement, and (4) the ethical and social implications of immersive technologies. In another study examining 30 studies on the use of AR and VR in distance education in the context of higher education, Nesenbergs et al. (2021) stated that these studies mainly focused on laboratory or practical skills and yielded positive findings. The present systematic review differs from existing studies since it is not limited to only the context of higher education and examines the related studies in more detail. Also, this study is thought to benefit researchers working on the subject and practitioners in this field. Distance education is spreading worldwide, and schools, universities and especially open education faculties and universities should reconsider their education processes with technological advancements. In this sense, it can be asserted that a detailed examination of the studies on immersive technologies in distance education will be useful in describing the current situation and providing guidance for future predictions. In addition, the findings of this study will be useful in closing the gaps in the literature. In this regard, the studies on the use of immersive technologies in distance education were assessed in this systematic review. The research questions are as follows:

Research Question 1 (RQ1). What are the trends in immersive technologies in the context of distance education studies?
Research Question 2 (RQ2): What are the application platforms, environments for presenting materials, variables, and types of teaching preferred in using immersive technologies in distance education?
Research Question 3 (RQ3): What are the advantages and disadvantages of using immersive technologies in distance education?

2 Method

In this study, the systematic literature review method was used. The systematic literature review includes the following stages; doing a comprehensive search for the studies published to create a solution to an application-related problem, evaluating the quality of the studies based on their inclusion and exclusion criteria, determining

studies to be included in the review, and synthesising the findings of the studies included in the review (Kowalczyk & Truluck, 2013). The method followed is the main difference between systematic and literature reviews. In the former, articles are accessed in a detailed, organised way through various databases. On the other hand, literature reviews are often done less systematically, and articles are obtained from only a few databases (Robinson & Lowe, 2015).

2.1 Data collection

The searching process of this systematic review was completed on April 9, 2022, through Web of Science, ERIC, Taylor & Francis and Education Full Text EBSCO databases. These databases were preferred because they contain a significant number of studies on education. Table 1 shows the individual keywords and their combinations. Both keywords and search strings were used to search.

2.2 Data analysis

The articles/proceedings included in the study were analysed by one of the researchers, and it was aimed to increase the reliability of the analyses through checking by another researcher. This study used content analysis as the data analysis method, a form was prepared using Microsoft Word program, and sections were included to answer the research questions. These sections in the form included the number of the article/proceeding, type of the article/proceeding, database of the article/proceeding, name of the article/proceeding, publication venue of the article/proceeding, the publication year of the article/proceeding, method of the article/proceeding, the sample of the article/proceeding, education level of the sample, the country where the article/proceeding was conducted, the application platforms used in the article/proceeding, the type of material used, the discipline in which the study was conducted; the variables examined in the study, the effect level of augmented/virtual reality in distance education, the advantages of using augmented/virtual reality in distance education, the disadvantages of using augmented/virtual reality in distance education, and the type of teaching preferred in the studies. Once the studies were carefully read, this form was filled out for each study. Then, the data in the form was converted into codes, categories, and graphics using the Microsoft Excel program. Table 2 details the examinations made within the scope of the research questions during the analysis process. In the present systematic review,

Table 1 Search terms

"Augmented Reality" OR "Mixed Reality" OR "Virtual Reality" OR "Virtual World" OR "Virtual Environments"
AND
"Distance Education" OR "Online Learning" OR "e-Learning" OR "Open Learning" OR "MOOC"

Table 2 Subcategories of the research questions

Research question	Subcategories
(RQ1)	Distribution of the studies by years: To ascertain the overall number of studies by years, the publication years of the studies were looked at.
	Research methods: The methods employed were determined by looking at the methods section of each study.
	Distribution of the study types: The publication types of studies on immersive technologies in distance education were examined.
	Countries of the studies: By looking at each study's abstract, method section, and author workplaces and locations, the nations in which the studies were carried out were identified.
	Study participants: Each study's method section contained information that helped identify the participant types.
	Disciplines examined: To identify the different forms of immersive technologies in distance education according to their domains, each study's abstract and method sections were carefully studied.
	Publication venues: The publication venues were revealed by examining each study's journals and conference proceedings.
(RQ2)	Application platforms: The applications were determined and used in studies examining immersive technologies in distance education.
	Environments for presenting materials: The settings shown were determined and used in studies examining immersive technologies in distance education.
	Variables: Each study was carefully examined to identify the variables by paying particular attention to the abstracts, research questions, and findings sections.
	Types of teaching: The preferred teaching types in studies evaluating immersive technology in remote education were identified by carefully analysing the method section of each study.
(RQ3)	Advantages and disadvantages of immersive technologies in distance education: The advantages and disadvantages of immersive technology were investigated by looking at each study's findings, discussion, and conclusion.

the data of the studies examined by the content analysis method were presented descriptively through figures and tables.

A total of 207 articles were accessed from four databases examined within the scope of the review (Fig. 1). After reviewing the titles and abstracts, 36 out of 207 articles were excluded because they were unrelated to AR, VR, and distance education. The remaining ten articles were excluded because they were not written in English. The remaining 161 articles were generally reviewed in terms of eligibility for the study, and it was determined that 29 of the articles did not comply with the scope of the review. Eight of these studies were not related to distance education, and the other ten studies did not focus on AR or VR applications in distance education; therefore, they were not included in the review. On the other hand, the remaining 11 articles were excluded from the consideration because they only contained descriptive information about AR or VR applications in distance education and were not scientific research studies. As a result, 132 studies were included.

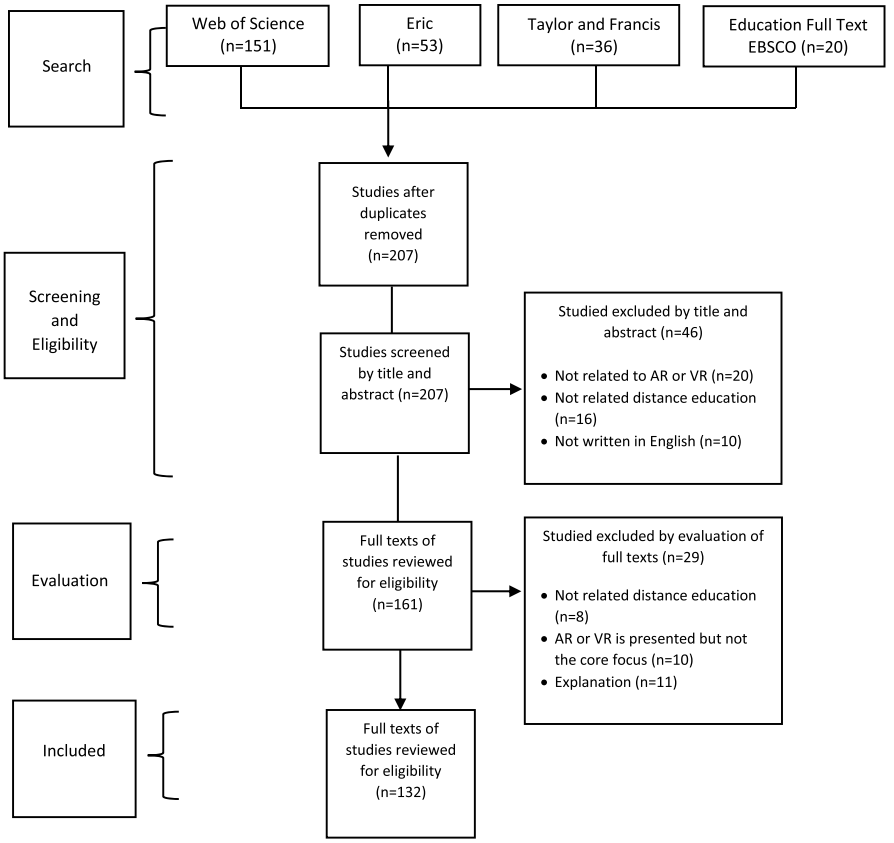
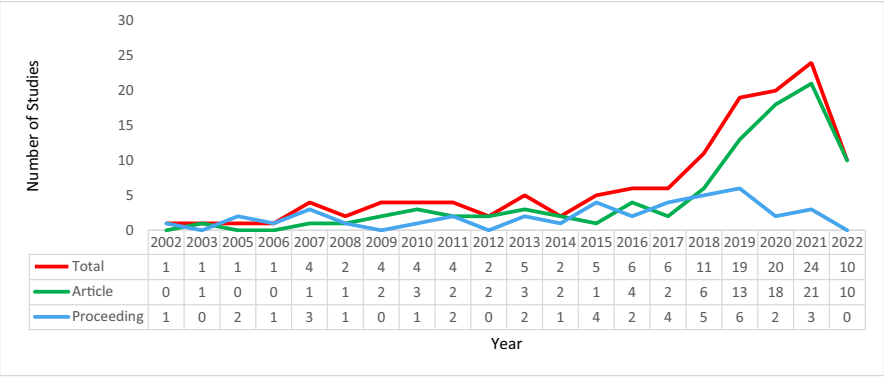


Fig. 1 Diagram of the systematic review process (adapted from Liberati et al., 2009)

First, two researchers coded twenty randomly selected articles separately to ensure inter-rater reliability. The Cohen's Kappa coefficient was then calculated to be 0.79 using SPSS for two codes. Values between 0.61 and 0.80 represent the ideal agreement level between the researchers, according to Viera and Garrett (2005).

3 Findings

The articles/proceedings determined from the search on the Web of Science, ERIC, Taylor & Francis and Education Full Text EBSCO databases for the studies on augmented/virtual reality used in distance education were analysed. The findings of the analysis are presented below based on the research questions.



	2002	2003	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Total	1	1	1	1	4	2	4	4	4	2	5	2	5	6	6	11	19	20	24	10
Article	0	1	0	0	1	1	2	3	2	2	3	2	1	4	2	6	13	18	21	10
Proceeding	1	0	2	1	3	1	0	1	2	0	2	1	4	2	4	5	6	2	3	0

Fig. 2 Distribution of the studies by years

3.1 Distribution of the studies by years

Figure 2 shows the distribution of studies using immersive technologies in distance education over the years. When Fig. 2 was examined, it was observed that the first of the studies were conducted in 2002, and the number of studies increased rapidly in the following years. In addition, as seen in Fig. 2, the articles and proceedings mainly belonged to 2021.

3.2 Distribution of the studies in terms of their research methods

Figure 3 shows the distribution of the methods used in the studies. Based on Fig. 3, quantitative ($n = 45$) and system development ($n = 38$) methods were used primarily in the studies. The least used method in the studies was the literature review ($n = 12$).

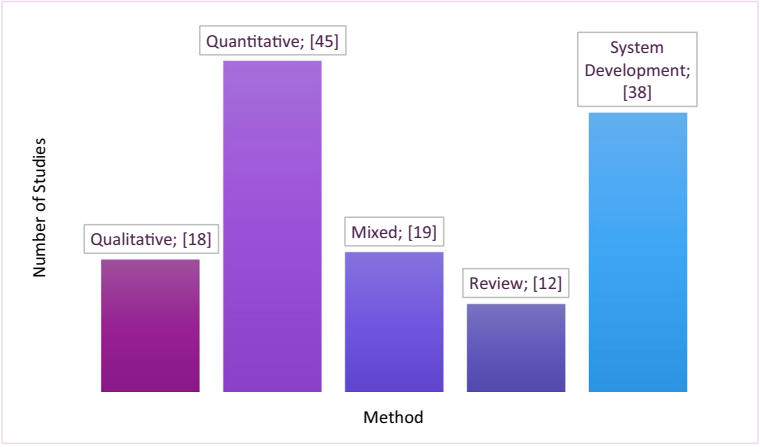


Fig. 3 Distribution of the methods used in the studies

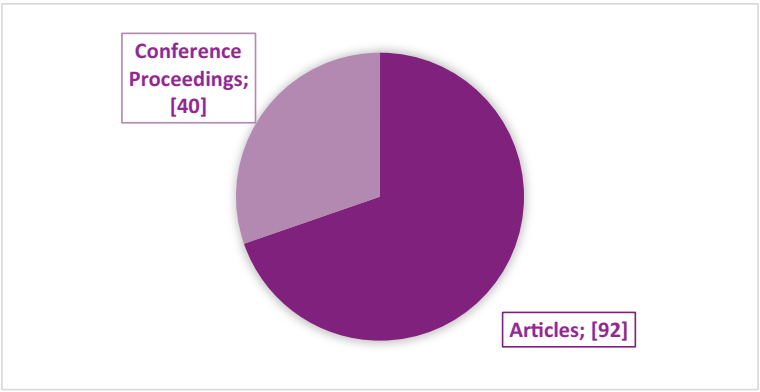


Fig. 4 Distribution of the studies in terms of their type

3.3 Distribution of the studies in terms of their type

Figure 4 shows the types of studies included in the review. Based on Fig. 4, these studies were mostly journal articles ($n = 92$) and proceedings ($n = 40$).

3.4 Distribution of the studies in terms of the country

Figure 5 shows the distribution of the studies included in the review by the countries where they were conducted. When Fig. 5 was analysed, it was determined that these studies were conducted mostly in China ($n = 16$) and the USA ($n = 15$).

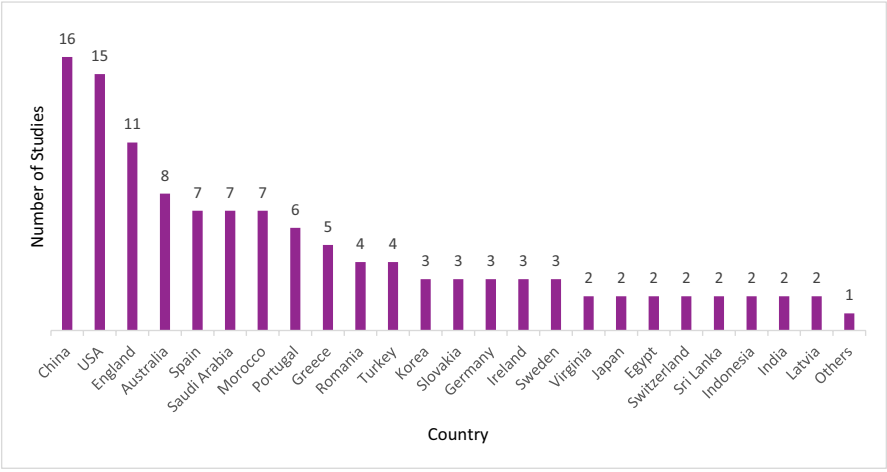


Fig. 5 Distribution of the studies in terms of the countries

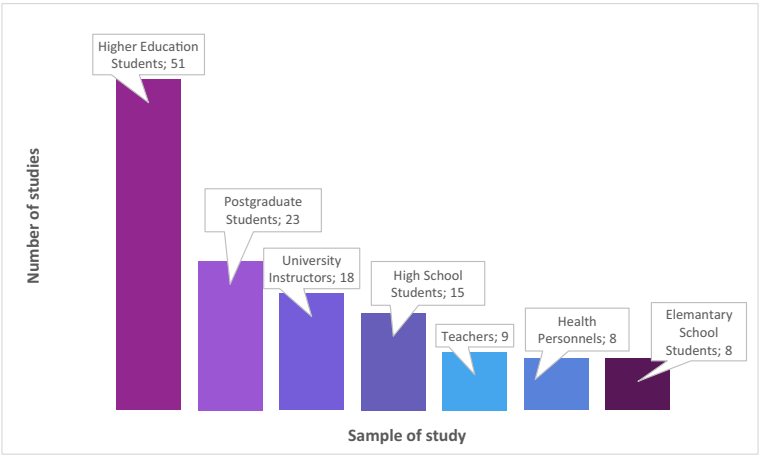


Fig. 6 Distribution of the studies in terms of the sample group

3.5 Distribution of the studies in terms of the sample group

Figure 6 shows the distribution of the studies in terms of the sample group. Based on Fig. 6, the studies were conducted mostly with higher education students ($n=51$). The other sample groups preferred in the studies consisted of postgraduate students ($n=23$) and university instructors ($n=18$). The least preferred sample groups in the studies were health personnel ($n=8$) and elementary students ($n=8$).

3.6 Distribution of the studies in terms of the discipline

Table 3 shows the distribution of the studies according to their disciplines. Accordingly, the studies included in the study were conducted mostly in the fields of Science Education ($n=24$), Medical Education ($n=20$), and Foreign Language Teaching ($n=17$).

3.7 Distribution of the studies in terms of journals/conference

Tables 4 and 5 show journals and conferences in which the related studies were published. As seen in Table 4, 92 articles were published mostly in the journals "Education Sciences" ($n=6$) and "Computers & Education" ($n=5$), respectively.

In addition, when Table 5 was examined, it was determined that 40 proceedings were presented in various conference organisations. In this sense, it was observed that the studies were published mostly in the following conferences: "International Conference on Virtual Learning", "International Conference Mobile Learning", "IEEE Serious Games and Applications for Health", "International Conference on

Table 3 Distribution of the studies in terms of the discipline

Field	Sub-Branches	Number of Studies (Sub-Branches)	Total
Science Education	Chemistry	9	24
	Biology	6	
	Physics	4	
	General	5	
Medical Education			20
Foreign Language Teaching			17
Information Technology			14
Engineering Education	Electrical-Engineering Education	4	12
	Computer Education	6	
	Industrial Engineering Education	2	
Mathematics Education			11
Computing and informatics			10
Instructional Technology			9
Architecture Education			5
Tourism			4
Clinical Psychology			2
Political Science			1
Unspecified			3
Total			*132*

Advances in Education and Management", "International Conference on Computers in Education", "International Conference on Computing and Applied Informatics", "WSEAS International Conference on E-ACTIVITIES", "International Conference on Virtual and Augmented Reality in Education", and "International Technology, Education and Development Conference".

3.8 Distribution of the studies in terms of application platform

Figure 7 shows the distribution of application platforms used in the studies. As seen in Fig. 7, UNITY ($n=36$) and ARTUTOR ($n=12$) application platforms were mostly used in these studies.

3.9 Distribution of the environments where materials are presented

Figure 8 shows the environments in which materials are presented in these studies. As can be seen in Fig. 8, it was observed that the environments in which the materials were presented in the studies were mostly computer (49%) and mobile (30%). In addition, some studies used computers and mobile (21%).

Table 4 Distribution of the publication journals of the studies

Journal Name	*f*	Journal Name	*f*
Education Sciences	6	Computer Assisted Language Learning	1
Computers & Education	5	Communications in Information Science and Management Engineering	1
Computer Applications in Engineering Education	4	Information Services & Use	1
International Journal of Emerging Technologies in Learning	4	Journal of Electronic Resources in Medical Libraries	1
Information & Communications Technology	3	I-Manager's Journal of Educational Technology	1
Applied Mechanics and Materials	3	IEEE Advancing Technology and Humanity	1
International Journal of Interactive Mobile Technologies	3	Australasian Journal of Educational Technology	1
Journal of Chemical Education	3	Open Praxis	1
Journal of Research on Technology in Education	3	Behavior & Information Technology	1
IEEE Transactions on Consumer Electronics	2	Technology, Pedagogy and Education	1
Journal of Universal Computer Science	2	Computer Assisted Language Learning	1
Interactive Learning Environments	2	Innovations in Education and Teaching International	1
Open Learning: The Journal of Open, Distance and e-Learning	2	World Journal of Engineering	1
The Electronic Journal of e-Learning	2	Interactive Learning Environments	1
Computers	2	Universal Access in the Information Society	1
Theory and Research in Education	2	Journal of Information Technology Education: Research	1
Journal of Engineering Science and Technology	2	Hindawi Journal of Mathematics	1
International Journal of Engineering Technologies	2	Engineer	1
International Journal of Web Information Systems	2	Contemporary Nurse	1
International Journal of Advanced Computer Science and Applications	2	*Total*	*92*
Journal of Political Science Education	2		
International Association of Online Engineering	2		
Biochemistry and Molecular Biology Education	2		

Table 4 (continued)

Journal Name	*f*	Journal Name	*f*
Higher Education Studies	2		
Educational and Information Technologies	2		
Educational Media International	2		
Applied Sciences	2		
Distance Education	1		
Croatian Journal of Education	1		
The Quarterly Review of Distance Education	1		

Table 5 Distribution of the conferences in which studies were published

Journal Name	*f*	Journal Name	*f*
International Conference on Virtual Learning	2	International Conference on Mobile Ad Hoc and Smart Systems	1
International Conference Mobile Learning	2	Convention and Workshop of the Network of Sport and Health Science	1
IEEE Serious Games and Applications for Health	2	Conference on Electrical and Computer Engineering	1
International Conference on Advances in Education and Management	2	Conference on Information Systems and Technologies	1
International Conference on Computers in Education	2	International Conference on Distance Education and Learning	1
International Conference on Computing and Applied Informatics	2	International Conference on Enterprise Information Systems	1
WSEAS International Conference on E-ACTIVITIES	2	International Conference on Education and New Learning Technologies	1
International Conference on Virtual and Augmented Reality in Education	2	*Total*	*40*
International Technology, Education and Development Conference	2		
International Conference on Agents and Artificial Intelligence	1		
International Conference on Systems, Signals and Image Processing	1		
International Technology, Education and Development Conference	1		
International Conference on Informatics, Health & Technology	1		
International Conf Human-Computer Interaction	1		
International Scientific Conference E-Learning And Software for Education	1		
In Proceedings Of The Combined European Concurrent Engineering Conference	1		
International Conference Educational Technologies	1		
IEEE International Conference on Advanced Learning Technologies	1		
IEEE Mediterranean Electrotechnical Conference	1		
IEEE Conference on Virtual Environments, Human-Computer Interfaces and Measurement Systems	1		
International Conference on Technologies for E-Learning and Digital Entertainment	1		
International Conference on Engineering & MIS	1		
International Conference of the Immersive Learning Research Network	1		
Teaching & Education Conference	1		

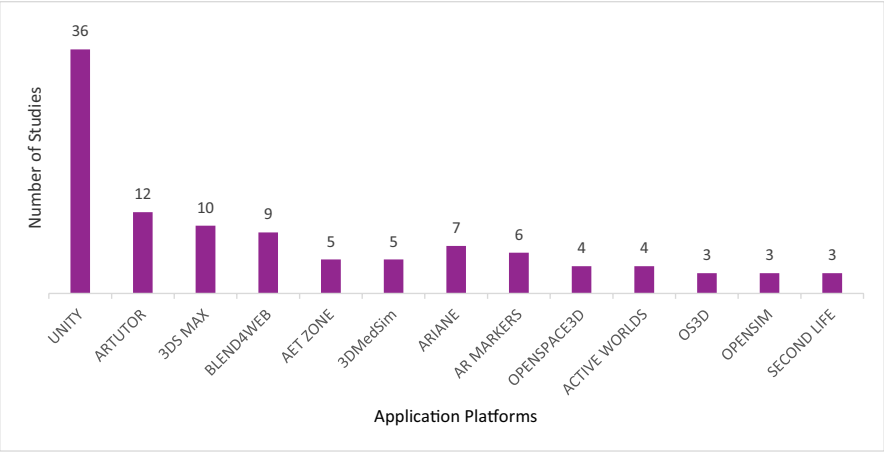


Fig. 7 Distribution of the application platforms used in studies

3.10 Distribution of the studies in terms of the examined variables

Table 6 shows the distributions of the variables examined in the studies. As seen in Table 6, it was determined that the variables examined in the studies were mostly achievement/performance ($n = 48$) and motivation ($n = 37$), and the least examined variables were cognitive affordances ($n = 3$) and recall ($n = 2$).

3.11 Distribution of the studies in terms of the type of teaching

Figure 9 shows the types of teaching preferred in the studies. As can be seen in Fig. 9, it was determined that the preferred teaching types in the studies were mostly distance education (77%), MOOC (16%), and Open University (7%), respectively.

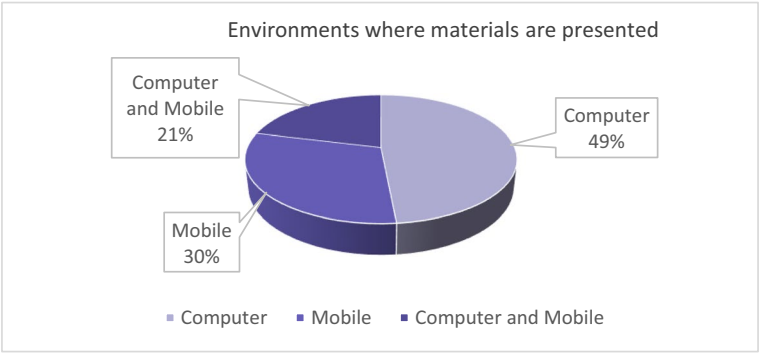


Fig. 8 Environments in which materials were presented in studies

Table 6 The variables examined in the studies

The Examined Variables	*f*	The Examined Variables	*f*
Achievement/ Performance	48	Excitement	7
Motivation	37	Attention	7
Attitude	32	Drop-out	6
Cooperation/Collaboration	21	Perceived behavioural control	6
Engagement	19	Behavioural intention	5
Feeling of reality	16	Self-regulation	5
Satisfaction	13	Critical thinking	4
Learning experience	12	Individual learning	4
Interaction	10	Cognitive Affordances	3
Enjoyment	9	Recall	2
Usability	9		
Flexibility	7		
Skills	7		

3.12 Advantages of the immersive technologies

Table 7 reveals the advantages of the use of immersive technologies in distance education. It was determined that the most reported advantages in the studies were increasing learning achievement/performance ($n = 48$), boosting learners' attention and motivation ($n = 37$), and enhancing the engagement of learners ($n = 19$), respectively.

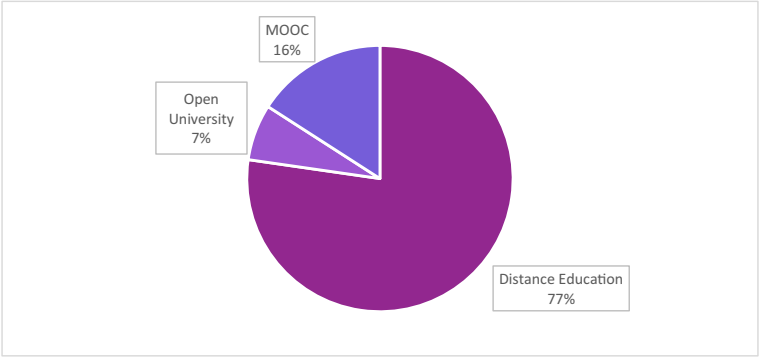


Fig. 9 Distribution of the variables examined in studies

Table 7 Advantages of using immersive technologies in distance education

Advantages	*f*	Sample Article
Increases learning achievement/performance	48	Eldokhny and Drwish (2021)
Boosting learner's attention and motivation	37	Alzahrani (2020)
Enhancing the engagement of learners	19	Luke et al. (2021)
Improving learning by experience skills of learners	14	Yildiz and Demiray (2022)
Boosting learner's satisfaction	13	Rozinaj et al. (2018)
Improving the online social collaboration experience	12	Yepez et al. (2020)
Visibility and variety of teaching methods and materials	10	Sitharan et al. (2020)
Enriching the learning environment	9	Rozinaj et al. (2018)
Enhancing peer interactions	5	Yilmaz et al. (2016)
Providing a learning environment at learners' own pace	5	Patil et al. (2016)
Improving procedural learning skills of learners	5	Valdez et al. (2013)
Providing a constructivist learning environment	4	Sood and Singh (2018)
Easy enhancement of existing learning material by teachers or learners	3	Lytridis et al. (2018)
Reducing the cognitive load of students	2	Holopainen et al. (2022)
Enhancing student-teacher interactions	2	Zhang and Lin (2020)
Improving the learning permanence of learners	1	Doumanis et al. (2019)
Enhancing the self-regulation of learners	1	Cabrera-Umpierrez et al. (2006)

3.13 Disadvantages of the immersive technologies

Table 8 reveals the disadvantages of using immersive technologies in distance education. It was determined that most of the studies mentioned technology/Internet-related problems ($n = 12$), the problem of adaptation to all platforms ($n = 9$), and disadvantages related to technological and pedagogical adaptation ($n = 8$).

Table 8 Disadvantages of using immersive technologies in distance education

Disadvantages	*f*	Sample Article
Technology/Internet-related problems	12	Rozinaj et al. (2018)
The problem of adaptation to all platforms	9	Birt et al. (2017)
Technological and pedagogical adaptation	8	Rogerson-Revell et al. (2012)
Increasing cost in terms of users	6	Lobo et al. (2020)
Learners' individual differences	4	Alkhattabi (2017)
The extra workload for teachers	3	Lee et al. (2009)
Lack of direct contact between teacher and trainee	3	El Kabtane et al. (2020)
Information security problem for learners	1	Zeide and Nissenbaum (2018)

4 Discussion

This study aims to systematically review the studies on the use of immersive technologies in distance education. In this sense, the general features, methodological features, and findings of the studies examined in the present systematic review were presented as the advantages and disadvantages of using immersive technologies in distance education. In this regard, it was observed that the first study on immersive technologies in distance education was conducted in 2002. When the studies conducted since 2002 were examined, it was determined that the number of related studies increased and were conducted mostly in 2021. This is associated with the increase in the number of studies and technological developments. Moreover, it can be asserted that studies on the Metaverse, which came to the fore after the COVID-19 pandemic, contributed to this increase. Additionally, the recent increase in studies due to the current conditions, especially after the COVID-19 pandemic, indicates that technological innovation in education systems has come to the fore more than before (Rashid et al., 2021). In addition, the number of studies, especially after 2019, shows that these technologies are used more in various contexts in distance education, and educators' interest in these technologies is increasing (Hincapie et al., 2021).

When the research methods used in the studies were examined, it was determined that quantitative and system development methods were most preferred. This finding can be associated with the interest in immersive technologies developing each day and the opportunity to reach many students in distance education. Additionally, since it is crucial to reach many people in quantitative research design and it is relatively easier to reach many people in distance education, the number of studies using this method may increase. Another reason for this finding on using quantitative methods in the studies stems from the researchers' concern about objectively testing AR technology's effects on students' learning (Hrastinski & Keller, 2007).

It was determined that the studies examined in this systematic review consisted of journal articles more than conference proceedings. This finding was because journal articles are more permanent than conference proceedings and are cited more by researchers (Lisée et al., 2008). In addition, many researchers tend to publish extended versions of the studies they presented at conferences as journal articles (González-Albo & Bordons, 2011). On the other hand, when the distribution of the studies examined in this systematic review was analysed according to the countries where they were conducted, it was found that the studies were conducted mostly in China and the USA, respectively. This finding can be associated with the fact that these countries are pioneers in technological development. Moreover, this situation can be handled by making immersive technologies more prevalent among countries, especially in applied studies. Rashid et al. (2021) state that the research and development processes are the main foci for researchers in high-income economies (developed countries).

On the other hand, scientists in developing countries use technology invented by those in developed countries. Moreover, access to mobile devices, the internet, software, and immersive technology applications is growing rapidly, particularly in

developing countries. As a result, the use of immersive technologies in educational environments and the number of studies investigating such technologies will likely increase (Akçayir & Akçayir, 2017).

When the sample groups included in the studies were examined, it was observed that the most preferred sample group was higher education students. This finding can be associated with university students receiving education through distance education at a higher rate. In addition, the fact that university students are easily accessible and their self-regulation skills are more advanced may be why the studies should include this sample group. The findings showed that the studies using immersive technologies were not limited to a specific discipline. Even though immersive technology requires a multidisciplinary nature, the studies in this review used this technology mostly in science and medical education. This may be because the complicated and high-cost application or experimental studies, which can attract the attention of students studying at higher education levels, can be easily supported with immersive technologies (Agbo et al., 2021). On the other hand, this finding can be explained by the fact that immersive technologies allow us to embody abstract concepts and simulate potentially dangerous situations (Cakiroglu, 2014; Klopfer & Squire, 2008). These immersive technologies' features allow students receiving surgical education to conduct trials without harming the patient (Yoon et al., 2018).

It was determined that the examined studies were published mostly in "Education Sciences" and "Computers & Education" journals and included in different conferences' proceedings. Therefore, this finding can be associated with these prominent and well-known journals. Furthermore, the studies revealed that Unity was mainly used as the application platform since it is open-source and easy to use.

Technology plays a vital role in immersive technologies (Wu et al., 2013); today, advances in PCs, mobile devices, hardware, and sophisticated head-mounted displays (HMD) give people more access to immersive technologies. On the other hand, other immersive technologies have different properties in terms of cost, accessibility and usability in educational environments. Desktop computers, for instance, can run AR apps, but they are not portable due to hardware restrictions (Chiang et al., 2014). Furthermore, mobile devices offer several benefits, including portability, promotion of high social interaction, and independent operation (Hwang et al., 2012). However, it can be thought that immersive technologies are generally presented in the classroom environment under the instructor's control; therefore, they are used in the computer environment more.

It was observed that the studies mainly investigated academic performance, motivation, and attitude variables. The reason behind investigating these variables is that there are limited studies on immersive technologies in distance education. Therefore, these variables, especially academic performance, are essential in evaluating the effectiveness of technology in learning environments. Moreover, Arici et al. (2019), in their systematic review study on AR technologies, reported that the variables examined in the studies were mostly "learning/academic success", "motivation", and "attitude", and these results support the findings of the present review. Therefore, it is logical that these factors are considered in conjunction with the examined studies because motivation and attitude significantly affect academic accomplishment (Lu & Liu, 2015; Wojciechowski & Cellary, 2013). Furthermore,

as AR is a newly-emerging technology, it is essential to understand attitudes towards it. In addition, motivation and attitude play a significant role in determining one's desire to use new technologies (Baydas & Goktas, 2016; Hsiao et al., 2012).

When the contexts of the studies included in the systematic review were examined, it was observed that they examined mostly distance education contexts but Open Universities and MOOCs, albeit less. The reason for this finding is that the concept of "distance education" is an inclusive term and practice. Furthermore, it was determined that the advantage of using immersive technologies in distance education was the increased academic performance and motivation in the studies. This finding is consistent with the results of studies in the literature (Nesenbergs et al., 2021; Rizov & Rizova, 2015). Furthermore, Mayer's spatial and continuity principles can also explain the increased academic performance associated with using immersive technologies (2009). In this sense, it can be asserted that well-designed immersive environments can reduce students' cognitive load and thus increase their performance. On the other hand, it was observed that the most mentioned disadvantage in studies on the use of immersive technologies in distance education was a technology/Internet-related problems. This finding can be associated with the fact that immersive technologies are high cost and there is not enough internet speed to access the environments developed with this technology, as stated in the literature (Ellaway et al., 2003; Saleem et al., 2017).

5 Conclusion and recommendations

Consequently, it was observed that studies investigating immersive technologies in the context of distance education were primarily published as journal articles, the number of related studies increased over the years, and the studies were mainly conducted using the quantitative method. In addition, using immersive technologies in distance education had many positive learning outcomes. Still, using these technologies in distance education also brought several disadvantages, especially technological/internet-related problems. In light of this study, the following recommendations for future studies can be presented:

- It was observed that the studies examined in this review were conducted mostly using the quantitative method. Therefore, It is recommended to conduct further studies using the qualitative approach to examine students' interactions with the environment in depth by using immersive technologies in the context of distance education.
- It was determined that the studies mainly included university students. Therefore, it is recommended to analyse the effects of immersive technologies in distance education of high and secondary school students.
- Investigating how immersive technologies in distance education affect attention, self-regulation and drop-out variables is recommended.

- It is recommended to examine quantitatively the effect of immersive technologies on learning in distance education environments using the meta-analysis method.

Declarations

Conflict of interest None.

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