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A BIBLIOMETRIC ANALYSIS OF AUGMENTED REALITY IN HIGHER EDUCATION

NISAUDZAKIAH UTAMI, AGUS SETIAWAN*, IDA HAMIDAH

Universitas Pendidikan Indonesia
*Corresponding Author: agus_setiawan@upi.edu

Abstract

Augmented reality (AR) is a technology that can enrich the learning and teaching experience in higher education. In recent years, the development of AR in higher education has become increasingly popular. This study report on overall research trends regarding research progress in the field of AR in higher education. The research method used is bibliometric analysis using VOSviewer. The data is taken from the Scopus database. The findings show an increasing trend of citations and publications indicating concern in AR use has been seen over the last decade. AR research in higher education started in 2006 until now. The most productive year was in 2021 producing as many as 91 articles and the most citations in 2017 amounting to 639 documents. Analysis of the data revealed that the top three ranking researchers (Marques, Moreira, and Osadchyi), countries (Spain, United States, United Kingdom), Organization (Universidad de la Laguna and Universiti Utara Malaysia), Journal (Ceur Workshop Proceedings, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics, ACM International Conference Proceeding Series). Furthermore, the main finding of this research is that the subject area that uses the most AR technology is the subject of computer science. Overall, this research that AR is no longer a technology that makes users feel in an unreal world but is accompanied by a real world that makes users feel real things. This technology is very practical in today's needs. The area of AR still has a lot of room for investigation, comprehension, and testing.

Keywords: Augmented reality, Bibliometric, Higher education, VOSviewer.

1. Introduction

In the last decade, augmented reality (AR), which enables the mixing of real-world components captured by a camera, has come to be as one of the most exciting technologies [1]. The implementation of AR is increasing in the area of education. [2]. AR applications are successfully used at different educational levels, in different educational settings, and in different environments, offering users many possibilities and many benefits [3]. The use of AR in education has the potential to enhance students' conceptual knowledge and understanding as well as crucial abilities like problem-solving, cooperation, and communication. [4]. AR is a technology that combines the virtual world with the real world [5]. Through digital blending, it enhances the real environment in certain aspects. [6]. In this way, AR enhances the user's sensory experience through real-time interaction with digital content [7]. This virtual technology is assisted by the help of technological devices (e.g., portable, handheld devices, glasses) [8]. AR technology enhances the feeling of reality by showing virtual objects, information, and cues (text, audio, images, videos, 3D objects) in the real world [9-11]. The development tools for virtual worlds in education are some of the most innovative virtual education tools utilized in higher education. [12].

Advances in digital technology, such as AR, are presently having a direct impact on higher education. As a result, instructional approaches offered by higher education institutions should take the level of development of these technologies into account. [13, 14]. Students have to utilize their own smartphones to record attendance in higher education settings where AR technology has been installed, as well as to interact with the classroom using online tools and other teaching and learning resources like virtual learning environments. [15]. Some AR experiences have been used in higher education, but instead haven't produced any didactic materials that can be used indefinitely. Only a few studies on collaborative learning have been conducted in the fields of land and urban planning. [16, 17]. This experience concludes that AR technology can enhance the design of student projects as well as their academic achievement. Other studies have also reported that AR technology produces positive impacts on learning such as resulting in increased achievement, motivation, increased perception, self-confidence, increased independence and daily life skills, spatial ability, interest, engagement, and satisfaction [18-20].

Many studies on bibliometric analysis have been conducted, including several points:

(i) bibliometric research on trends in research over the last six years using a content analysis and reviewing the results of bibliometric articles related to the use of AR in science education. [21].

(ii) Identification of publications relating to AR in education from 1999-2018 [22].

(iii) AR bibliometric analysis with Business Administration Researchers [23].

(iv) Analysis of articles that publish augmented or virtual reality in physics education [24].

(v) Analysis of the bibliometric characteristics of 100 AR applications after testing [25].

(vi) A systematic understanding of how AR contributes to education still lacks studies on the types of content and their effects on learning outcomes [26].

(vii) Researching the deployment of AR in the physics laboratory by bibliometric analysis so that future research prospects might be offered [27].

(viii) Exploring worldwide trends in the field of global surgical research [28].

(ix) Reviewing trends and bibliometric studies focusing on AR in education over the past five years based on the Web of Science (WOS) database and provides experimental results on the application of AR technology to improve visualization skills among engineering students [29].

A lot of research related to bibliometrics has been done on AR in education. However, from an educational standpoint, all bibliometric studies carried out in the AR domain concentrate on a single, varied aspect of the educational setting (such as primary, elementary, and higher education).

This study only emphases on presenting broad research trends regarding advancements in AR research in higher education, including an examination of research output, global collaborations, top universities, authors, journal citations, impact, keywords, and the thematic evolution of research. AR in higher education over the past 17 years (2006–2022). The research method used is bibliometric analysis (BA) using the VOSviewer tool. Therefore, the research questions are as follows in this study:

(i) What is the most published and cited articles relating to AR from 2006 to 2022?

(ii) Which countries and authors have most influenced AR research globally?

(iii) The most influential journals on AR research in higher education?

(iv) The most cited publication in AR research?

(v) Analysis (keywords and themes) related to AR research in higher education?

(vi) The highest number of publications based on AR in higher education.

The remaining text is organized into three main sections: methodology, results and discussion, and conclusions. methodology emphasizes the inclusion, exclusion, and keyword selection criteria. results and discussion summarizes the study findings.

2.Method

The bibliometric analysis of this research is about AR in higher education. Bibliometric analysis is a method of quantitative analysis used to measure performance, influence, and trends in scientific publications or academic literature. This method involves collecting bibliographic data, such as the title of the article, the name of the author, the source of the journal, the publication year, and the number of citations from a particular article or research. Bibliometric analysis is used to study patterns and trends in scientific literature, such as developments in research topics, relationships between authors, most published journals, and trends in citations in the literature. The aim is to provide insight into scientific and technological developments, as well as assist in decision-making in various fields such as education, social sciences, and science. The database used in this research is Scopus. Scopus is a well-known database that has grown to become one of the world's largest data repositories for peer-reviewed scientific publications [30]. Moreover, Scopus indexes items of up to 75 million. It makes updating the data daily. Social science literature accounts for 32% of all indexed content on Scopus. Therefore, the Scopus database was utilized in this study.

Data collection was carried out on Thursday, 21 April 2022, at 11:54 am. The data was retrieved automatically by entering keywords related to AR and higher education. Data were collected based on abstract titles, and keywords from each term related to AR in higher education, namely ("augmented reality") AND ("higher education"). The AND operator is used to search for keywords related to the topic that you want to associate with the previous or following keywords.

In Fig. 1, the data selection process was developed by four stages. The first stage is identification. This is based on keyword searches in Scopus data as many as 363 documents. Screening stage, with inclusion and exclusion criteria (document stage filter: final and document language filter: English). This criterion helped exclude 31 documents. Finally, 332 documents were eligible for access and each document was checked by the three authors who read the title and abstract to include data accuracy. Articles that have been filtered according to the research criteria are then exported into a file type (.csv).

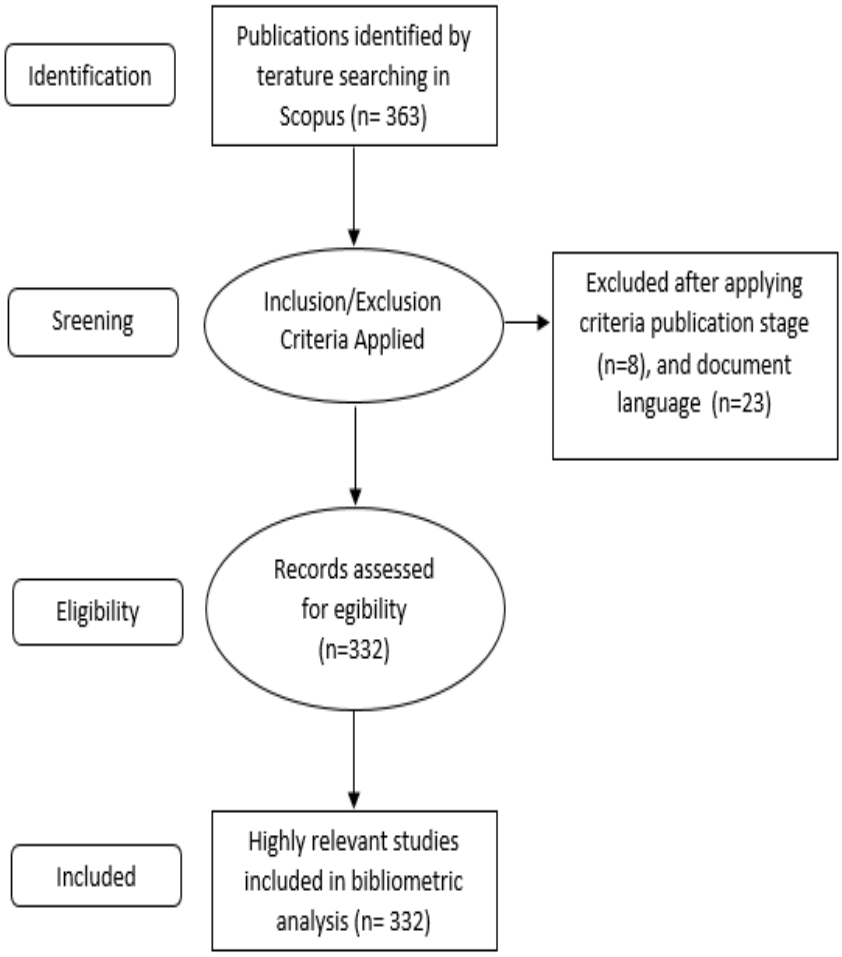

Fig. 1. Flowchart of the four-phase data extraction and filtration process.

3. Results and Discussion

3.1. Publication and citation trends

Figure 2 shows in general the total number of publications and citations regarding the use of AR in higher education over the last 17 years from 2006 to 2022. It is known that the development of research relating to AR in higher education has grown since 2006. In the first year, 2006 only one document was produced. then from 2007 to 2009 none of them even produced publications in the field of higher education. Regarding citations from 2006 to 2010, there are no citations at all. Publications and citations began to grow rapidly from 2011 to 2022. The highest peak of publications and citations in 2021 was 80 publications and 1183 citations. But in 2022 publications and citations as many as 11 publications and 154 citations have decreased because 2022 is running.

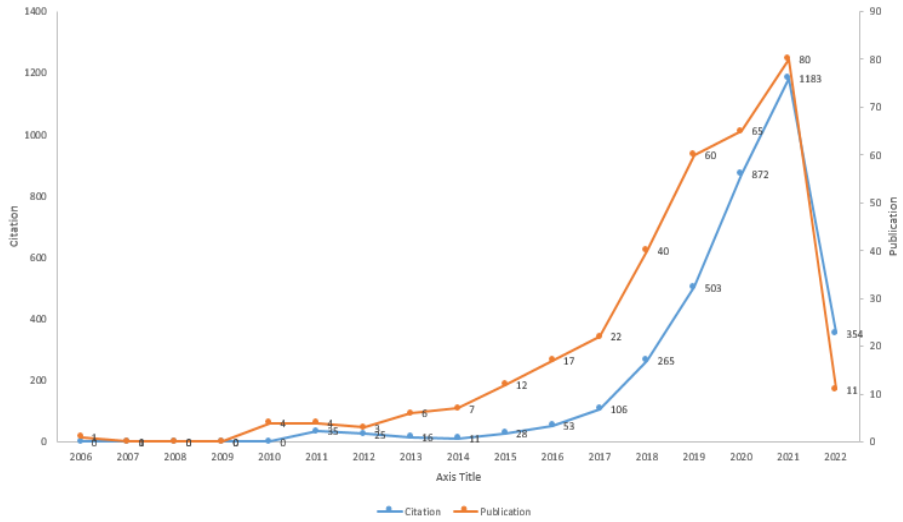

Fig. 2. Trends in the Publications and Citation Relating to AR from 2006 to 2022.

3.2. Country productivity

Table 1 displays the top 10 countries. Table 2 presents the top 10 organizations that issued the number of AR-related documents, along with the number of items and the citations. Spain emerged as the most productive country in terms of implementing AR in higher education. Based on Fig. 2, Spain appeared as the most productive country regarding AR implementation in higher education over the last decade. Spanish researchers contributed 37 articles or 11.1% and 852 citations of the total analysed documents. The country that publishes the fewest documents in Turkey. However, in terms of citations, Turkey is the country with the most. Meanwhile, the most productive organization, namely Tecnologico de Monterrey, produced 16 documents 4.8% and the least, Universidad de Almerla produced 4 documents 1.2%. Based on citations, the organization with the highest number of citations was Universidad de la Laguna with 277 citations, and the least Rheinisch-Westfalische Technische Hochschule Aachen with 7 citations.

Table 1. Most productive countries.

Rank	Country	Number of documents	Number of citations
1	Spain	37	852
2	United States	24	193
3	United Kingdom	23	186
4	Ukraine	21	282
5	Australia	16	202
6	Mexico	16	94
7	Malaysia	15	56
8	Germany	13	42
9	Portugal	12	118
10	Turkey	9	974

Table 2. Most productive institutions.

Rank	Organization	Number of documents	Number of citations
1	Tecnologico de Monterrey	16	74
2	Universidade de Aveiro	8	57
3	Kryvyi Rih National University	7	178
4	Bogdan Khmelnitsky Melitopol State Pedagodical University	6	48
5	Kryvyi Rih State Pedagogical University	6	145
6	Universidad de la Laguna	5	277
7	Universidad de Seville	5	83
8	Universiti Utara Malaysia	4	22
9	Rheinisch-Westfalische Technische Hochschule Aachen	4	7
10	Universidad de Almerla	4	66

3.3. Productivity of authors

Table 3 shows the ten most prolific authors in producing articles on AR in higher education or authors who are widely cited in the AR scientific literature. The most prolific first author was Marques from Portugal with 4 documents, 26 citations, and an H-Index 3 followed by Moreira et al. with each producing 4 documents. However, Osadchyi obtained a relatively higher number of citations, reaching 43. In particular, Birt has generated 3 documents with the highest number of citations of 72 citations. Cochrane has the highest H-Index of 3. Ferreira, Klamma, Mintii, and Modelski are at the bottom of the list with the number of documents (3 papers) and citations of 16, 5, 43, and 0, respectively.

3.4. Productivity of research journals

Table 4 shows the top 10 most published journals in AR research in higher education. These top ten journals published 100 documents in total from 2006 to

2022 and all journals have good reputations in their fields. The top 5 journals produced 72 documents with 490 citations. The Journal of Ceur Workshop Proceedings with a total of 25 documents and a total of 250 citations is in the highest order respectively. Followed by Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics with a total of 19 documents and a total of 17 citations. Journal of Communications in Computer And Information Science is at the bottom with 5 documents and 0 citations.

Table 3. The most prolific author in AR.

1st Author	Affiliation, Country	Number of Documents	Number of Citation	H-Index
Marques	University of Aveiro, Portugal	4	26	3
Moreira	Universidade de Aveiro, Portugal	4	31	3
Osadchyi	Bogdan Khmelnitsky Melitopol State Pedagogical University, Ukraine	4	43	3
Pombo	University of Aveiro, Portugal	4	26	3
Birt	Bond University, Australia	3	72	2
Cochrane	Auckland University of Technology, New Zealand	3	25	3
Ferreira	Universidade Portucalense, Portugal	3	16	2
Klama	RWTH Aachen University, Germany	3	5	1
Mintii	Kryvyi Rih State Pedagogical University, Ukraine	3	43	3
Modelski	Warsaw University of Technology, Poland	3	0	3

Table 4. The most influential journals in the field of AR.

Source	Number of Documents	Number of Citation
Ceur Workshop Proceedings	25	250
Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	19	17
ACM International Conference Proceeding Series	13	13
Advances In Intelligent Systems And Computing	8	26
Procedia Computer Science	7	184
Education Sciences	6	50
IEEE Global Engineering Education Conference Educon	6	7
Interactive Learning Environments	6	37
Sustainability Switzerland	6	89
Communications In Computer And Information Science	5	0

3.5. Most trending and cited AR publications

Table 5 shows the top ten most cited articles on AR in higher education. Based on Table 5, there are no articles under 2012 that are included. Two articles published

in the journal Computer in Human Behavior. The other eight articles were published respectively in Educational Research Review, Proceedings-12th International Conference on Signal Image Technology and Internet-Based System, SITIS, Procedia Computer Science, Journal of Science Education and Technology, BMC Medical Education, Eurasia Journal of Mathematics, Science and Technology Education, Journal of Enterprising Communities, and Ceur Woorkshop Proceedings. The article Advantages and challenges associated with AR for education: A systematic review of the literature written by Akcayir and Akcayir in 2017 topped the list with 639 citations. This article presents a SLR on AR used in education considering factors such as year of publication, type of learner (e.g., K-12, higher education, and adults), AR technology, and the advantages and challenges of using AR in educational settings. The findings highlight the most commonly cited benefit of AR, which is that it encourages higher learning attainment, as well as the benefits and obstacles of adopting AR in educational contexts. The findings highlight the most commonly cited benefit of AR, which is that it encourages higher learning attainment, as well as the benefits and obstacles of adopting AR in educational contexts. According to the research, the most often mentioned benefit of AR is that it promotes greater learning accomplishment. [18].

Table 5. Most trending and cited publications in AR.

Title	Author	year	Source	Cited by
Advantages and challenges associated with augmented reality for education: A systematic review of the literature	Akcayir and Akcayir	2017	Educational Research Review 20, pp. 1-11	639
Augmented reality in science laboratories: The effect of augmented reality on university students' laboratory skills and attitudes toward science laboratories	Akcayir et al.	2016	Computer in Human Behavior 57, pp. 334-342	220
Augmented reality to premote collaborative and autonomous learning in higher education	Martin-Gutierrez et al.	2015	Computer in Human Behavior 51, pp. 752-761	206
The Effect of the Internet of Things (IoT) on Education Business Model	Bagheri and Movahed	2017	Proceedings-12th International Conference on Signal Image Technology and Internet-Based System, SITIS 2016 7907501, pp. 435-441	77

Title	Author	year	Source	Cited by
Mobile Augmented Reality in Vocational Education and Training	Bacca et al.	2015	Procedia Computer Science 75, pp. 49-58	65
A Pilot Study of the Effectiveness of Augmented Reality to Enhance the Use of Remote Labs in Electrical Engineering Education	Mejlas Borrero and Andujar Marquez	2012	Journal of Science Education and Technology 21(5), pp. 540-557	61
Distance learning ects and flipped classroom in the anatomy learning: Comparative study of the use of augmented reality, video and notes	Ferrer-Torregrosa et al.	2016	BMC Medical Education 16(1), 230	60
The use of augmented reality in formal education: A Scoping review	Saltan and Arslan	2017	Euresia Journal of Mathematics, Science and Technology Education 13(2), pp. 503-520	58
Coronavirus (Covid-19) and the entrepreneurship education community	Ratten	2020	Journal of Enterprising Communities 14(5), pp. 753-764	54
Development and implementation of educational resources in chemistry with elements of augmented reality	Nechypurenko et al.	2020	Ceur Woorkshop Proceedings 2547, pp. 156-167	53

3.6. Keyword analysis

Figure 3 reveals the concurrence analysis, obtained using the VOSviewer software. The selected minimum co-occurrence scale for keywords was set at 3. Out of 781 keywords, only 62 met the criteria. The spacing and size of the bubbles determine the number of occurrences of keywords and association links. These 62 keywords are related to the four main clusters. To describe this, we classified into each colour, representing a cluster with association links between keywords.

Based on Fig. 3, the largest cluster (in red) represents research related to AR in higher education, in which this study discusses topics related to AR, higher education, authentic learning, bim, blended learning, chemistry education, computer science, curriculum, design-based research, didactic resources, digital technologies, distance learning, e-learning, innovation, educational technology, game-based learning, gamification, ICT, information and communication, learning, mixed reality, mobile applications, mobile AR, mobile devices, MOOC,

motivation, pedagogy, professors, Saudi Arabia, science education, sustainability, teacher training, teaching, technology, ubiquitous learning, university innovation, user experience, virtual reality, and XR.

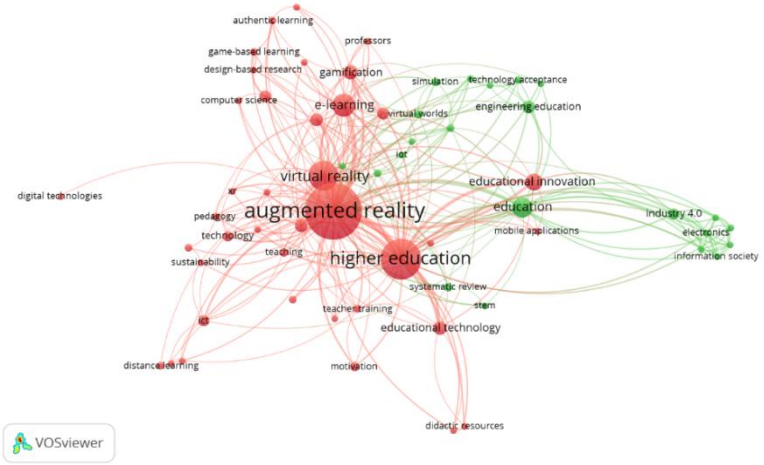

Fig. 3. Shows Keyword Analysis by VOSviewer software.

3.7. Research productivity by subject area

Based on Fig. 4, 332 papers appeared on the keyword AR in higher education. At this stage, the classification of papers is filtered based on the title, abstract, and keywords. However, it is hard to consider articles in a particular field since the articles cover interdisciplinary issues in AR topics in higher education. The top 10 fields in AR research in higher education from 2006 to 2022, among which are shown the three fields of publication that have the greatest number of publications, namely computer science with 220 papers (66.2% of the total papers screened) followed by social science, and engineering.

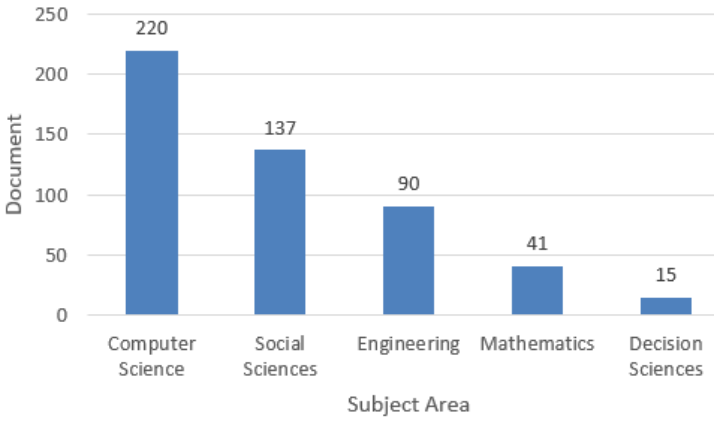

Fig. 4. The number of documents by subject area.

In terms of application, publishing, and citation, the overall findings indicate that of AR research. This is demonstrated by the growing number of publications and citations in the field of AR in higher education (in diverse subjects) during the

previous decade. The study's principal findings revealed the top publications and citations, researchers, nations, organizations, journals, and keywords in AR research, as well as productive articles by topic area.

This study can bring new ideas and suggestions regarding analysis using the bibliometric method. This can patch current studies in the bibliometric that have been done in the literature [31-50].

4. Conclusion

This study aims to report on overall research trends on research progress in AR in higher education related to productivity, international collaboration, leading universities, authors, the impact of citations and journals, and AR keywords in higher education.

The research method used is a bibliometric analysis using the VoSviewer tool. The data is taken from the Scopus database. This bibliometric research aids in the examination of publishing trends and patterns in order to determine the level of productivity of the subject area and to assist researchers in deciding what to publish and where to publish it, while keeping the productivity of the subject, highly relevant journals, authors, and so on in mind.

Over the last decade, the number of publications and citations has gradually increased. The fundamental advantage of AR research is that it is being studied not only by computer scientists but also by researchers from other fields like as engineering, education, medical, marketing, and psychology. The use of technology in all industries and spheres of life may be the primary motivation for doing research.

This study's findings reveal an upward trend in the number of citations and publications suggesting interest in AR usage over the previous decade. AR research in higher education began in 2006 until now, the most productive year was in 2021 producing as many as 91 articles and the most citations in 2017 amounting to 639 documents. Data analysis revealed that the top three ranking researchers (Marques, Moreira, and Osadchyi), countries (Spain, United States, United Kingdom), Organizations (Universidad de la Laguna and Universiti Utara Malaysia), Journals (Ceur Workshop Proceedings, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics, ACM International Conference Proceeding Series).

Furthermore, the main finding of this research is that the subject area of AR technology is the field of computer science. Overall, this study concludes with the argument that AR is no longer a technology that makes users feel in an unreal world but is accompanied by a real world that makes users feel real things. This technology is very practical for today's needs. There is still great potential in the AR field for exploration, understanding, and testing.

References

1. Martín-Gutiérrez, J.; Fabiani, P.; Benesova, W.; Meneses, M.D.; and Mora, C.E. (2015). Augmented reality to promote collaborative and autonomous learning in higher education. *Computers in Human Behavior*, 51, 752-761.

2. Wyss, C.; Degonda, A.; Bührer, W.; and Furrer, F. (2022). The impact of student characteristics for working with ar technologies in higher education - findings from an exploratory study with microsoft hololens. *Information*, 13(3), 1-16.
3. Garzón, J. (2021). An overview of twenty-five years of augmented reality in education. *Multimodal Technologies and Interaction*, 5(7), 1-14.
4. Ke, F.; and Hsu, Y.C. (2015). Mobile augmented-reality artifact creation as a component of mobile computer-supported collaborative learning. *The Internet and Higher Education*, 26, 33-41.
5. Bangkerd, P.; and Sangsawang, T. (2021). Development of augmented reality application for exercise to promote health among elderly. *Indonesian Journal of Educational Research and Technology*, 1(3), 77-80.
6. Ibáñez, M.B.; Di Serio, Á.; Villarán, D.; and Kloos, C.D. (2014). Experimenting with electromagnetism using augmented reality: impact on flow student experience and educational effectiveness. *Computers and Education*, 71, 1-13.
7. Azuma, R.; Baillot, Y.; Behringer, R.; Feiner, S.; Julier, S.; and MacIntyre, B. (2001). Recent advances in augmented reality. *IEEE Computer Graphics and Applications*, 21(6), 34-47.
8. Riegler, A.; Wintersberger, P.; Riener, A.; and Holzmann, C. (2019). Augmented reality windshield displays and their potential to enhance user experience in automated driving. *I-com*, 18(2), 127-149.
9. Tzima, S.; Styliaras, G.; and Bassounas, A. (2019). Augmented reality applications in education: teachers point of view. *Education Sciences*, 9(2), 1-18.
10. Bower, M.; Howe, C.; McCredie, N.; Robinson, A.; and Grover, D. (2014). Augmented reality in education–cases, places and potentials. *Educational Media International*, 51(1), 1-15.
11. Kesim, M.; and Ozarslan, Y. (2012). Augmented reality in education: current technologies and the potential for education. *Procedia-Social and Behavioral Sciences*, 47, 297-302.
12. Lucke, U.; and Zender, R. (2011). 3D interactions between virtual worlds and real life in an e-learning community. *Advances in Human-Computer Interaction*, 2011, 1-11.
13. Kyza, E.A.; and Georgiou, Y. (2019). Scaffolding augmented reality inquiry learning: the design and investigation of the tracereaders location-based, augmented reality platform. *Interactive Learning Environments*, 27(2), 211-225.
14. Sırakaya, M.; and Alsancak Sırakaya, D. (2020). Augmented reality in sains, technology, engineering and Mathematic (STEM) education: a systematic review. *Interactive Learning Environments*, 11, 1-14.
15. Jdaitawi, M.T.; and Kan'an, A.F. (2022). A decade of research on the effectiveness of augmented reality on students with special disability in higher education. *Contemporary Educational Technology*, 14(1), 1-16.
16. Chen, R.; and Wang, X. (2008). An empirical study on tangible augmented reality learning space for design skill transfer. *Tsinghua Science and Technology*, 13(S1), 13-18.

17. Fonseca, D.; Martí, N.; Redondo, E.; Navarro, I.; and Sánchez, A. (2014). Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models. *Computers in Human Behavior*, 31, 434-445.
18. Akçayır, M.; and Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, 20, 1-11.
19. Bridges, S. A.; Robinson, O.P.; Stewart, E.W.; Kwon, D.; and Mutua, K. (2020). Augmented reality: teaching daily living skills to adults with intellectual disabilities. *Journal of Special Education Technology*, 35(1), 3-14.
20. McMahon, D.; Cihak, D.F.; and Wright, R. (2015). Augmented reality as a navigation tool to employment opportunities for postsecondary education students with intellectual disabilities and autism. *Journal of Research on Technology in Education*, 47(3), 157-172.
21. Arici, F.; Yildirim, P.; Caliklar, Ş.; and Yilmaz, R.M. (2019). Research trends in the use of augmented reality in science education: content and bibliometric mapping analysis. *Computers and Education*, 142, 1-23.
22. Karakus, M.; Ersozlu, A.; and Clark, A.C. (2019). Augmented reality research in education: a bibliometric study. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(10), 1-12.
23. Marin, A.A.; Vergara, M.C.; and González, C.G. (2017). Análisis bibliométrico de la realidad aumentada y su relación con la administración de negocios. *Información Tecnológica*, 28(4), 57-66.
24. Moreno, F.C.; Serrano, M.H.G.; Fombona, J.; and Tascón, M.G. (2020). The emergence of technology in physical education: a general bibliometric analysis with a focus on virtual and augmented reality. *Sustainability*, 12(7), 1-16.
25. Cadavieco, J.F.; Pascual, M.Á.; and Cano, E.V. (2020). Augmented reality: a new way to build knowledge. Bibliometric analysis and apps testing. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, 15(1), 17-25.
26. Hincapie, M.; Diaz, C.; Valencia, A.; Contero, M.; and Castorena, D.G. (2021). Educational applications of augmented reality: a bibliometric study. *Computers and Electrical Engineering*, 93, 1-12.
27. Putri, C.R.; Soleh, S.M.; Saregar, A.; Anugrah, A.; and Susilowati, N.E. (2021). Bibliometric analysis: augmented reality-based physics laboratory with VOSviewer software. In Journal of Physics: Conference Series. *IOP Publishing*, 1796(1),1-12.
28. Zhang, J.; Yu, N.; Wang, B.; and Lv, X. (2022). Trends in the use of augmented reality, virtual reality, and mixed reality in surgical research: a global bibliometric and visualized analysis. *Indian Journal of Surgery*, 82, 52-69.
29. Ali, D.F.; Omar, M.; Abdullah, A.H.; Hasniza, N.; Ibrahim, M.M.; Zaid, N.M.; and Johari, N. 5 years into augmented reality technology in education: research trends, bibliometric study and its application to enhance visualization skills. *Wseas Transactions On Systems And Control*, 16, 253-260.
30. Baas, J.; Schotten, M.; Plume, A.; Côté, G.; and Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, 1(1), 377-386.

31. Nordin, N.A.H.M. (2022). Correlation between process engineering and special needs from bibliometric analysis perspectives. *ASEAN Journal of Community and Special Needs Education*, 1(1), 9-16.
32. Bilad, M.R. (2022). Bibliometric analysis for understanding the correlation between chemistry and special needs education using VOSviewer indexed by Google. *ASEAN Journal of Community and Special Needs Education*, 1(2), 61-68.
33. Ruzmetov, A.; and Ibragimov, A. (2023). Past, current and future trends of salicylic acid and its derivatives: A bibliometric review of papers from the Scopus database published from 2000 to 2021. *ASEAN Journal for Science and Engineering in Materials*, 2(1), 53-68.
34. Al Husaeni, D.F.; and Munir, M. (2023). Literature review and bibliometric mapping analysis: Philosophy of science and technology education. *Indonesian Journal of Multidiciplinary Research*, 3(2), 219-234.
35. Al Husaeni, D.F.; and Al Husaeni, D.N. (2022). Computational bibliometric analysis of research on science and Islam with VOSviewer: Scopus database in 2012 to 2022. *ASEAN Journal of Religion, Education, and Society*, 1(1), 39-48.
36. Al Husaeni, D.N. (2022). Development analysis research on physics education by mapping keywords using the VOSviewer application. *ASEAN Journal of Physical Education and Sport Science*, 1(1), 9-18
37. Firdaus, I.R.; Febrianty, M.F.; Awwaludin, P.N.; Ilsya, M.N.F.; Nurcahya, Y.; and Sultoni, K. (2023). Nutritional research mapping for endurance sports: A bibliometric analysis. *ASEAN Journal of Physical Education and Sport Science*, 2(1), 23-38.
38. Santoso, B.; Hikmawan, T.; and Imaniyati, N. (2022). Management information systems: Bibliometric analysis and its effect on decision making. *Indonesian Journal of Science and Technology*, 7(3), 583-602.
39. Utama, D.M.; Santoso, I.; Hendrawan, Y.; and Dania, W.A.P. (2023). Sustainable Production-inventory model with multi-material, quality degradation, and probabilistic demand: From bibliometric analysis to a robust model. *Indonesian Journal of Science and Technology*, 8(2), 171-196.
40. Husain, S.S.; Kadhim, M.Q.; Al-Obaidi, A.S.M.; Hasan, A.F.; Humaidi, A.J.; and Al Husaeni, D.N. (2023). Design of robust control for vehicle steer-by-wire system. *Indonesian Journal of Science and Technology*, 8(2), 197-216
41. Sahidin, I.; Nohong, N.; Manggau, M.A.; Arfan, A.; Wahyuni, W.; Meylani, I.; Malaka, M.H.; Rahmatika, N.S.; Yodha, A.W.M.; Masrika, N.U.E.; Kamaluddin, A.; Sundowo, A.; Fajriah, S.; Asasutjarit, R.; Fristiohady, A.; Maryanti, R.; Rahayu, N.I.; and Muktiarni, M. (2023). Phytochemical profile and biological activities of ethylacetate extract of peanut (Arachis hypogaea L.) stems: In-vitro and in-silico studies with bibliometric analysis. *Indonesian Journal of Science and Technology*, 8(2), 217-242.
42. Wirzal, M.D.H.; and Putra, Z.A. (2022). What is the correlation between chemical engineering and special needs education from the perspective of bibliometric analysis using vosviewer indexed by google scholar?. *Indonesian Journal of Community and Special Needs Education*, 2(2), 103-110.
43. Soegoto, H.; Soegoto, E.S.; Luckyardi, S.; and Rafdhi, A.A. (2022). A bibliometric analysis of management bioenergy research using vosviewer application. *Indonesian Journal of Science and Technology*, 7(1), 89-104.

44. Sudarjat, H. (2023). Computing bibliometric analysis with mapping visualization using VOSviewer on "Pharmacy" and "Special Needs" research data in 2017-2021. *ASEAN Journal of Community and Special Needs Education*, 2(1), 1-8
45. Setiyo, M.; Yuvenda, D.; and Samue, O.D. (2021). The concise latest report on the advantages and disadvantages of pure biodiesel (B100) on engine performance: Literature review and bibliometric analysis. *Indonesian Journal of Science and Technology*, 6(3), 469-490.
46. Nordin, N.A.H.M. (2022). A bibliometric analysis of computational mapping on publishing teaching science engineering using VOSviewer application and correlation. *Indonesian Journal of Teaching in Science*, 2(2), 127-138.
47. Nordin, N.A.H.M. (2022). Correlation between process engineering and special needs from bibliometric analysis perspectives. *ASEAN Journal of Community and Special Needs Education*, 1(1), 9-16.
48. Mudzakir, A.; Rizky, K.M.; Munawaroh, H.S.H.; and Puspitasari, D. (2022) Oil palm empty fruit bunch waste pretreatment with benzotriazolium-based ionic liquids for cellulose conversion to glucose: Experiments with computational bibliometric analysis. *Indonesian Journal of Science and Technology*, 7(2), 291-310.
49. Mulyawati, I.B.; and Ramadhan, D.F. (2021). Bibliometric and visualized analysis of scientific publications on geotechnics fields. *ASEAN Journal of Science and Engineering Education*, 1(1), 37-46.
50. Hamidah, I.; Sriyono, S.; and Hudha, M.N. (2020). A bibliometric analysis of covid-19 research using VOSviewer. *Indonesian Journal of Science and Technology*, 5(2), 209-216.