Nusantara Journal of Education and Social Science
E-ISSN: 3047-8472
Vol. 1 No. 2, Juli 2024, hal. 62-68
https://ejurnal.unukase.ac.id/index.php/nujess
Universitas Nahdlatul Ulama Kalimantan Selatan

Augmented Reality for Education: A Bibliometric Analysis Using VOSviewer

Augmented Reality untuk Pendidikan: Analisis Bibliometrik Menggunakan VOSviewer

Rina Astuti*

Universitas Muhammadiyah Surakarta, Jl. Ahmad Yani, Pabelan, Kartasura, Sukoharjo 57169, Jawa Tengah, Indonesia
rina.astuti@ums.ac.id

Format Kutipan: Astuti, R. (2024). Augmented Reality for Education: A Bibliometric Analysis Using VOSviewer. *Nusantara Journal of Education and Social Science*, 1(2), hal. 62-68. https://doi.org/10.69959/nujess.v1n2.57

RIWAYAT ARTIKEL
Dikirim: 28 Juli 2024
Revisi Akhir: 30 Juli 2024
Diterbitkan: Juli 2024
Tersedia Daring Sejak: 31 Juli 2024

KEYWORDS
Augmented Reality
Educational Technology
VOSviewer

KATA KUNCI
Augmented Reality
Teknologi Pendidikan
VOSviewer

ABSTRACT
This review aims to present a comprehensive knowledge mapping and analysis of Augmented Reality in education by conducting bibliometric analysis. This study will provide insight into the scope of research, the most frequently emerging research trends, and other areas in education. The use of AR in education has become an interesting topic for researchers over the past few years, presenting significant progress and transformation in educational technology that can improve students' understanding in the learning process. The data was taken from the Scopus database which discusses the use of Augmented Reality in the field of education and found 1396 journal articles. Based on the results of VOSviewer data processing with the topic of augmented reality in education, 4,2561 keywords were found. and related keywords were limited to 9 keywords. and 103 related keywords were found. Bibliometrics can improve the understanding of augmented reality and provide many contributions by discussing keywords used in the literature and grouping research trends and providing directions for further research.

ABSTRAK
Tinjauan ini bertujuan untuk menyajikan pemetaan pengetahuan dan analisis yang komprehensif tentang Augmented Reality dalam pendidikan dengan melakukan analisis bibliometrik. Studi ini akan memberikan wawasan tentang ruang lingkup penelitian, tren penelitian yang paling sering muncul, dan bidang lain dalam pendidikan. Penggunaan AR dalam pendidikan telah menjadi topik yang menarik bagi para peneliti selama beberapa tahun terakhir, menyajikan kemajuan dan transformasi yang signifikan dalam teknologi pendidikan yang dapat meningkatkan pemahaman siswa dalam proses pembelajaran. Data diambil dari database Scopus yang membahas tentang penggunaan Augmented Reality dalam bidang pendidikan dan ditemukan 1396 artikel jurnal. Berdasarkan hasil olah data VOSviewer dengan topik augmented reality dalam pendidikan, ditemukan 4.2561 kata kunci. dan kata kunci terkait dibatasi pada 9 kata kunci. dan ditemukan 103 kata kunci terkait. Bibliometrik dapat meningkatkan pemahaman tentang augmented reality dan memberikan banyak kontribusi dengan membahas kata kunci yang digunakan dalam literatur dan mengelompokkan tren penelitian dan memberikan arahan untuk penelitian lebih lanjut.

INTRODUCTION

Augmented reality (AR) can be defined as a means of approach to enhance natural feedback to users by using simulated cues. AR is created as an integration between virtual objects and real environments. Interaction between two three-dimensional objects in mixed reality This is a phenomenon that is impossible to obtain in the real world. Information generated by the computer is considered as if it were a world that coexists with real objects (Azuma, 1997). Augmented reality is a computer technology based on the interaction between humans and modern computers, artificial intelligence, and intelligent sensing using Virtual reality (VR) (Zhang et al., 2022). This technology uses 3D virtual objects generated by fast information system computers, and object view information can be seen as if with real views so that it can improve psychological perception of the real world. This technology can be integrated with other intelligent technologies such as big data and mobile. Especially in the field of education, it can be used for various teaching methods with learning methods combined with technology and educational philosophy in carrying out innovation. Psychological aspects in teaching include mental skills, instructional design, and motor skills as well as psychological learning aspects based on cognitive strategies (Sweller et al., 2019).

AR was created to bridge the virtual world and the real world (Bronack, 2011; Klopfer & Squire, 2008). Teaching and learning provided by AR allows learners to visualize complex relationships with abstract concepts. AR is widely used in various fields ranging from advertising, health services, military, to the entertainment sector. AR in education Not only how to use technology but also related to AR design, AR

implementation, and AR integration in formal and informal learning. AR can be used to develop other important practices and literacies in the learning environment so that AR is considered one of the main technologies in education. AR in the classroom can be applied as an alignment between the design of learning approach technology and learning experiences (Mulawarman et al., 2024). AR technology can be applied to two parts of learning psychology that aim to exploit the rules of the learning process and teaching psychology that can be used to explore classroom learning (Chen et al., 2017). The application of AR learning has begun to be widely used lately. Based on data, the application of AR is widely used at the elementary and junior high school levels, namely 31.6%, while the use of AR in infants is 7.9% (Cai et al., 2012). 3D virtual information can produce schematic structures that can not only be touched by abstract abilities but also become visualized and easy to understand with real-time experimental feedback and interactive technology. Perception and tracking of learning situations that are always changing in real time and can be used as a source of situational learning and increase students' sense of control over learning (Boekaerts & Corno, 2005).

AR technology can be used as a medium for changing situations with the guidance of situational learning theory, learning can be implemented from traditional classes to certain situations so that it can support situational learning with the characteristics of mobile AR to diversify the form of learning. Students can use smartphones as a medium to complete knowledge construction through inspection, verification, collaboration, interaction, and other flexible ways. The potential and challenges of collaboration using AR in an immersive virtual learning environment can be used as motivation to propose AR in education. The most important goal of an educational environment is to encourage social interaction between users in the same environment (Ruossos et al., 1999).

virtual reality (VR) creates an artificial world that can be experienced interactively by someone either through sight or through audio, touch and other senses. AR also provides an interactive experience with the aim of complementing the real world rather than creating a completely artificial environment (Höllerer & Feiner, 2004). AR collaboration in education can be used in various physical spaces and communicate with each other. Research shows that the high level of interaction provided by AR can improve kinesthetic and visual spatial skills in students while improving problem-solving skills and increasing motivation (Billinghurst & Dünser, 2012). Other studies state that AR can develop literacy skills and facilitate the development of spatial understanding skills in people with low literacy skills (Carrera & Asensio, 2017). AR can also be used as a medium in various educational disciplines to contribute to the learning experience (Pellas et al., 2019).

This study uses a study in bibliometrics. This study allows the use of statistical techniques in analyzing indicators that allow us to determine the impact of citations, network origins, publication keywords in a time period indicating the relevance of the publication so that it produces interest in the proposed discipline and future research. This study was conducted to analyze bibliometrics and understand research trends and the dissemination of knowledge in the context of AR in education. This study analyzes the number of publications, and collaboration networks so that an overview of researchers, institutions, and research topics that have a significant influence is obtained. The resulting analysis can provide a quantitative overview in the form of overall research results, identify influential authors, affiliations, and journals, and can map the network of collaborative relationships between researchers, identify authors, author institutions, and influential journals, and map the collaboration network between researchers in the field of AR in education. The resulting decision depends on the data obtained from the scientific database. although this tool provides information on the direction of future research, in general this tool has limitations that need to be improved.

The research question is: What is the role of research on the use of augmented reality in education? Based on the number of publications, what are the topics that are often discussed in research on the use of AR in education? How is the collaboration between authors and affiliates in AR research in education? This review aims to present a comprehensive knowledge mapping and analyze AR in education by conducting bibliometric analysis. This study will provide insight into the scope of research, the most frequently emerging research trends, and other areas in education. The use of am in education has become an interesting topic for researchers over the past few years, presenting significant progress and transformation in educational technology that can improve students' understanding in the learning process.

METHOD

Bibliometric Analysis

The method used is descriptive with the development of bibliometric analysis, which is a process that starts from selecting and defining articulated concepts to analyze with comprehensive assumptions. Biometric analysis is carried out by identifying the most influential articles, authors, institutions, journals, and countries that have the most impact and are prominent in the number of publications and citations on augmented reality in education. This study adopts previous bibliometric research (Astuti, 2023; Sulistyowati et al., 2024).

Data Collection

Data was taken on January 6, 2024 from the Scopus database. Scopus is the largest and most reputable research database considered the most complete data source in bibliometric analysis. Article selection To be more specific, it is limited to articles published since 2010-2024, only types of journal articles indexed by Scopus, using English, and all articles that are Open Access. So that the TITLE-ABS-KEY link (augmented AND reality AND for AND education) AND (LIMIT-TO (DOCTYPE, "AR") AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (OA, "all") is obtained. Based on the search, 1,396 documents were obtained. Then the metadata was exported in RIS form. The criteria for the metadata taken include information about citations, information about bibliographical, and information about abstracts and keywords. Furthermore, the metadata is selected according to the topic and completed using Mendeley. Next, the data is input into the publish or perish and VOSviewer applications.

Data Analysis

Bibliometric analysis was conducted using VOSviewer software. The VOSviewer mapping tool stands for visualizing similarity. This tool can be used to create co-occurrence mapping based on collected publication metadata. In addition, it can also map keywords based on co-occurrence data, and journal authors based on co-citations.

RESULTS AND DISCUSSION

Results

Number of Publications

based on the analysis of Research on the Scopus database that discusses the use of Augment reality in education and has found as many as 1396 journal articles that have been published and registered and analyzed on January 6, 2024. Bibliometrics is a method used to measure and evaluate scientific performance by considering factors such as citations, patents, publications and other more complex indicators. Several stages in bibliometric analysis include identifying the background of the research, collecting the database to be used, and determining the leading indicators used in the research.

Keyword and citation analysis can be applied to identify the content of research on in this section bibliometrics are applied in combination to visualize network maps regarding the appearance of keywords and citation analysis Used by authors to obtain general research content so that it can be used to identify as mathematics of a particular research subject based on keywords

The number of publications on the topic of augmented reality in education in the period 2010 to 2024 taken through the Scopus database shows a very significant development. The development of publications occurred in 2023, which was 341 articles (24.7%), while the lowest publication occurred in 2010 with a number of publications of 3 articles (0.2%). Furthermore, in 2012 there was a decrease in the number of publications of 5 articles (0.4%). However, in the following year there was a significant continuous increase.

Table 1. Number of Publications by Year of Publication

Year of publication	Number of articles	Percentage (%)
2010	4	0,2
2011	7	0,5
2012	5	0,4
2013	19	1,4
2014	23	1,4
2015	23	1,4
2016	24	1,8
2017	54	4,1
2018	76	5,6
2019	117	8,5
2020	161	11,6
2021	218	15,9
2022	305	22,0
2023	357	24,7
2024	7	0,5

Research on augmented reality has become a popular research topic. The number of publications on it has shown a significant increase since 2010. Here are some authors who discuss augmented reality.

Table 2. Authors of Research on Augmented Reality

No.	Author	Number of articles	Affiliation
1	Moro, C.	8	Bond University
2	Vahabzadeh, A.	8	Massachusetts General Hospital, Boston, USA
3	Keshav, N.U.	7	Department of Psychology, Harvard University, Cambridge
4	Sahin, N.T.	7	Department of Radiology, University of California–San Diego, La Jolla,USA
5	Andrade-Arenas, L.	6	Facultad de Ciencias e Ingeniería, Universidad de Ciencias y Humanidades, Lima, Peru
6	Birt, J.	6	Bond University
7	Huwer, J.	7	University of Saarland, Saarbrücken, Germany
8	Keramopoulos, E.	6	International Hellenic University, Thessaloniki, Greece
9	Salisbury, J.P.	6	Riverside Research, Cambridge, USA
10	Abriata, L.A.	5	University of Florence, Scientific Campus, Sesto Fiorentino, Florence, Italy
11	Cabanillas-Carbonell, M.	5	Universidad Autónoma del Perú, Lima, Perú
12	Cabero-Almenara, J.	5	Universidad De Sevilla, Spanyol
13	Christopoulos, A.	5	Monash University, Australia
14	Kinross, J.	5	Imperial College London,UK
15	Lavicza, Z.	5	Johannes Kepler University, Austria

Publication by Publisher

This analysis is to obtain j articles published by a publisher in a particular research field. In addition, this analysis is to determine the ranking of publishers based on the number of publications that indicate the most productive publishers in the field of augmented reality.

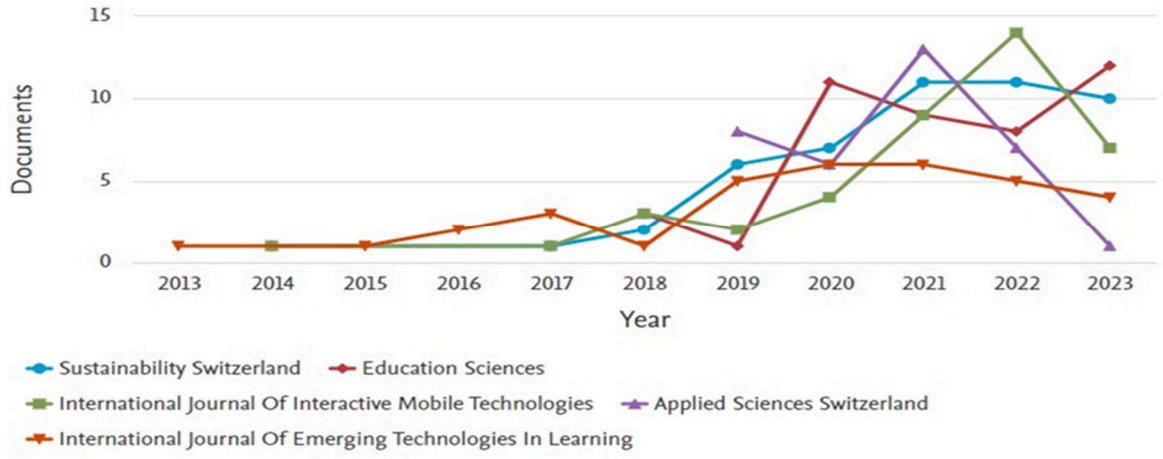

Figure 1. Graph of the Number of Documents Based on Publisher

Based on the search, there are 5 publishers that publish the most articles about augmented reality, including Sustainability Switzerland with 49 articles, Education Sciences with 44 articles, International Journal of Interactive Mobile Technologies with 41 articles, Applied Sciences Switzerland with 35 articles, International Journal of Emerging Technologies in Learning with 34 articles.

Citation Metrics

A comprehensive bibliometric review was conducted on augmented reality. This study contributes to the existing literature by identifying research gaps and informing future research. This study was conducted by means of data collection, data extraction, and data analysis to provide a transparent and accountable framework. The results of the citation metrics data processing from publish or perish are as follows:

Table 3. Citation Metrics

Publication years	2010-2024
Citation years	34(2010-2024)
Papers	1396
Citations	27508
Cites/year	809.06
Cites/paper	19.70
Cites/author	8716.42
Papers/authors	447.67
Authors/paper	4.25
h-index	75
G index	128
Hi,norm	39
Hi annual	1.15
Ha index	27
Papers with ACC>=1,2,5,10,20:982,751,339,128,46	

VOSviewer Visualization

Bibliometric analysis is done by creating visualization in the form of Network overlay and density which aims to find out the bibliometric network between published articles originating from downloaded Meta data. The bibliometric network consists of nodes in the form of circles or circles that represent keywords while Edge or network nodes represent the relationship between pairs of nodes. Mapping and clustering in bibliometric analysis through VOSviewer are complementary, meaning they complement each other (Waltman et al., 2010).

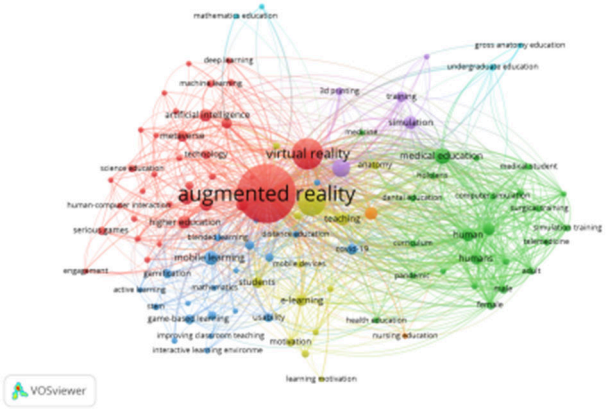

Figure 2. Network Visualization

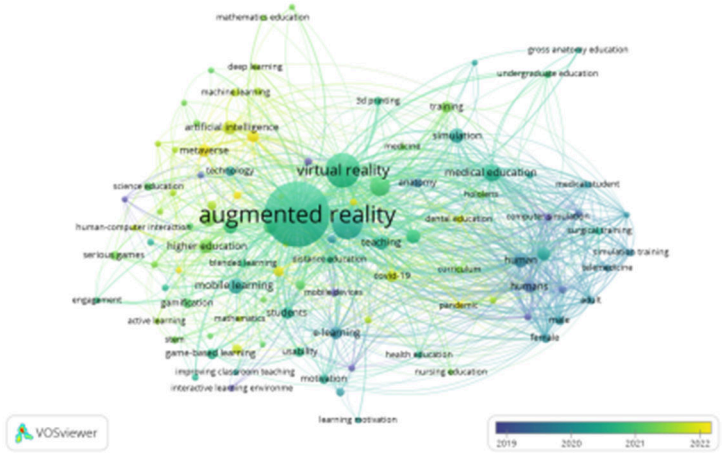

Figure 3. Overlay Visualization

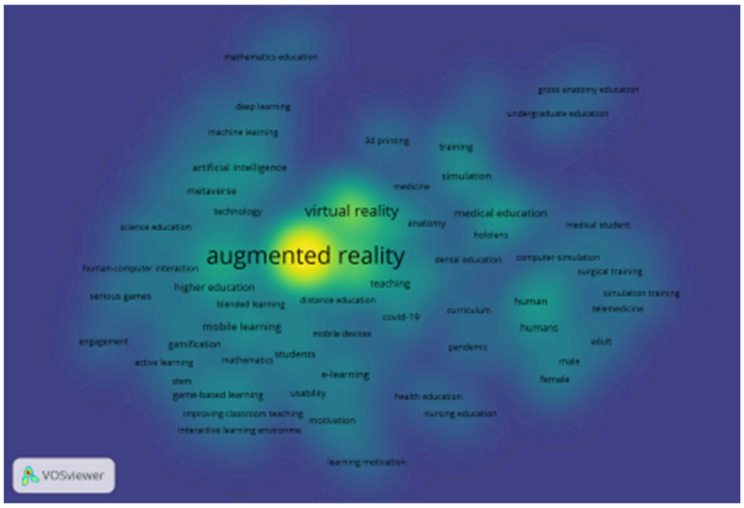

Figure 4. Density Visualization

Based on the results of VOSviewer data processing with the topic of augmented reality in education, 4,2561 keywords were found. and related keywords are limited to 9 keywords. and 103 related keywords were found.

Network visualization on co-occurrence which explains the network or relationship of one term to another in research in the field of augmented reality in the period 2010-2024. from 103 articles can be grouped into 7 clusters that can be identified through the color of the nodes of each keyword. Cluster 1 is symbolized in red including terms related to augmented reality, Cluster 2 is symbolized in green which contains medical education, in class 3 it is symbolized in blue which is related to mobile learning, Cluster 4 is symbolized in yellow, Cluster 5 is symbolized in purple, Cluster 6 is symbolized in blue, while Cluster 7 is dark orange. The clusters can be described as follows:

Table 4. Cluster Division Based on Keywords

Cluster	Keyword
Cluster 1 (34 items)	AR, Artificial Intelligence, Augmented reality(AR), autism, Bibliometric analysis, Chemistry education, Collaborative learning, deep learning, education 4.0, educational innovation, educational technology, emerging technologies, engagement, engineering education, extended reality, higher education, human computer interaction, ICT, Immersive technology, Industry 4.0, Learning media, Machine learning, Metaverse, Science education, Serious games, Teacher education, Teacher training, Technology, Technology acceptance model, User experience, Virtual and augmented reality, Virtual reality (VR).
Cluster 2 (24 items)	Adult, article, clinical competence, computer simulation, controlled study, curriculum, dental education, female, health education, HoloLens, human, humans, knowledge, male, medical education, medical student, medicine, pandemic, procedures, simulation training, telemedicine, user-computer interface
Cluster 3 (21 items)	Active learning, augmented and virtual reality, blended learning, covid-19, distance education, game-based learning, games, gamification, improving classroom teaching, interactive learning environment, mathematics, mobile application, mobile learning, online learning, primary education, secondary education, stem, stem education, systematic review, technology-enhanced learning, usability
Cluster 4 (13 items)	Anatomy, augmented reality technology, computer aided instruction, e-learning, education, learning motivation, mobile augmented reality, mobile devices, motivation, self-efficacy, students, teaching, visualization,
Cluster 5 (5 items)	3D printing, mixed reality, neurosurgery, simulation, training
Cluster 6 (4 items)	Gross anatomy education, mathematics education, spatial ability, undergraduate education
Cluster 7 (2 items)	Learning, nursing education

Discussion

Some studies relevant to this topic include Li et al. (2023). This study Reforms the traditional wushu education model by applying virtual technology. The purpose of this study is to analyze Exploring effective pathways and challenges of implementing virtual reality technology in the teaching process to obtain innovative breakthroughs and long-term development. Other studies, Kron et al. (2017) Assess advanced communication skills in computer simulations featuring virtual humans or multimedia computer-based learning models to understand learning experiences and preferences. Students trained with virtual reality can improve their interprofessional communication performance and can also improve higher grades compared to computer-based learning. students can provide direct feedback, teach non-verbal communication skills and prepare to deal with emotional patients

further research by Czok et al. (2023). This study determines and distinguishes the impact of implementing AR technology in a game-based science learning environment. The purpose of this study is to Investigate the impact of learning using a game-based augmented reality learning environment. The use of bibliometrics helps in distinguishing and categorizing the Scientific efforts of a particular journal which serves as a tool to ascertain important research topics in various specific sciences. Bibliometric research on augmented reality in education provides a comprehensive view of the research landscape, thus helping to direct further research efforts and support evidence-based decision-making in the development of the application of augmented reality technology to improve the quality of learning.

CONCLUSION AND RECOMMENDATION

Conclusion

By using bibliometrics can improve understanding of augmented reality and provide many contributions by discussing keywords used in the literature and grouping research trends and providing directions for further research so that learning using AR can be felt intuitively through various experimental activities. Research on the use of augmented reality (AR) in education plays a role in identifying innovative ways in which AR can enhance the teaching-learning process, as empirical studies assess the impact of AR on students' understanding, motivation, and learning outcomes, help find the best strategies for integrating AR into the curriculum, develop effective and appropriate AR-based learning materials. Topics frequently discussed in research on the use of AR in education is Artificial Intelligence, Augmented reality (AR), Virtual reality (VR), Metaverse, Teacher training. while collaboration between authors and affiliates in AR research in education includes Moro, C. from Bond University, Vahabzadeh, A from Massachusetts General Hospital, Boston, USA and Keshav, N.U. from the Department of Psychology, Harvard University, Cambridge

Recommendation

Suggestions for further research related to augmented reality include the need to conduct longitudinal studies to assess the impact of AR use on long-term learning outcomes, the need to explore the combination of AR with artificial intelligence or the Internet of Things to improve the learning experience, the need to develop and test assessment methods using AR technology.

REFERENCES

Astuti, R. (2023). Analisis Bibliometrik Model Pembelajaran Kontekstual Teaching and Learning (CTL). *Jurnal Pendidikan Tambusai*, *7*(2), 17656–17662.

Azuma, R. T. (1997). A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments*, *6*(4), 355–385. http://www.cs.unc.edu/~azumaW:

Billinghurst, M., & Dünser, A. (2012). Augmented Reality in the Classroom. *Computer*, *45*(7), 56–63. www.youtube.com/

Boekaerts, M., & Corno, L. (2005). Self-Regulation in the Classroom: A Perspective on Assessment and Intervention. *Applied Psychology: An International Review*, *54*(2), 199–231.

Bronack, S. C. (2011). The Role of Immersive Media in Online Education. *The Journal of Continuing Higher Education*, *59*(2), 113–117. https://doi.org/10.1080/07377363.2011.583186

Cai, S., Wang, X., Gao, M., & Yu, S. (2012). Simulation Teaching in 3D Augmented Reality Environment. *Proceedings of the 2012 IIAI International Conference on Advanced Applied Informatics, IIAIAAI 2012*, 83–88. https://doi.org/10.1109/IIAI-AAI.2012.25

Carrera, C. C., & Asensio, L. A. B. (2017). Augmented Reality as a Digital Teaching Environment to Develop Spatial Thinking. *Cartography and Geographic Information Science*, *44*(3), 259–270. https://doi.org/10.1080/15230406.2016.1145556

Chen, B., Wan, J., Shu, L., Li, P., Mukherjee, M., & Yin, B. (2017). Smart Factory of Industry 4.0: Key Technologies, Application Case, and Challenges. *IEEE Access*, *6*, 6505–6519. https://doi.org/10.1109/ACCESS.2017.2783682

Czok, V., Krug, M., Müller, S., Huwer, J., Kruse, S., Müller, W., & Weitzel, H. (2023). A Framework for Analysis and Development of Augmented Reality Applications in Science and Engineering Teaching. *Education Sciences*, *13*(926), 1–22. https://doi.org/10.3390/educsci13090926

Höllerer, T. H., & Feiner, S. K. (2004). Mobile Augmented Reality. In H. Karimi & A. Hammad (Eds.), *Telegeoinformatics: Location-Based Computing and Services* (pp. 1–39). Taylor & Francis Books Ltd.

Klopfer, E., & Squire, K. (2008). Environmental Detectives-The Development of an Augmented Reality Platform for Environmental Simulations. *Educational Technology Research and Development*, *56*(2), 203–228. https://doi.org/10.1007/s11423-007-9037-6

Kron, F. W., Fetters, M. D., Scerbo, M. W., White, C. B., Lypson, M. L., Padilla, M. A., Gliva-McConvey, G. A., Belfore, L. A., West, T., Wallace, A. M., Guetterman, T. C., Schleicher, L. S., Kennedy, R. A., Mangrulkar, R. S., Cleary, J. F., Marsella, S. C., & Becker, D. M. (2017). Using a Computer Simulation for Teaching Communication Skills: A Blinded Multisite Mixed Methods Randomized Controlled Trial. *Patient Education and Counseling*, *100*(4), 748–759. https://doi.org/10.1016/j.pec.2016.10.024

Li, W., Yang, L., Leng, X., Liu, W., & Dai, G. (2023). RETRACTED: Application of Virtual Reality Technology in Wushu Education. *International Journal of Electrical Engineering and Education*, *0*(0), 644–653. https://doi.org/10.1177/0020720920940583

Mulawarman, W. G., Kundori, K., Tubagus, M., Judijanto, L., & Susilawati, M. (2024). Character Education Management in Improving Students' Spiritual Intelligence. *Nidhomul Haq: Jurnal Manajemen Pendidikan Islam*, *9*(1), 79–90. https://doi.org/10.31538/ndh.v9i1.4550

Pellas, N., Fotaris, P., Kazanidis, I., & Wells, D. (2019). Augmenting the Learning Experience in Primary and Secondary School Education: A Systematic Review of Recent Trends in Augmented Reality Game-Based Learning. *Virtual Reality*, *23*(4), 329–346. https://doi.org/10.1007/s10055-018-0347-2

Ruossos, M., Johnson, A., Moher, T., Leigh, J., Vasilakis, C., & Barnes, C. (1999). Learning and Building Together in an Immersive Virtual World. *Presence*, *8*(3), 247–263. www.ice.eecs.uic.edu/nice

Sulistyowati, E., Indriyani, K. A., Nurhidayati, I., & Kundori, K. (2024). VOSviewer Software as a Tool in Analyzing the Bibliometric of Watchkeeping Onboard Ships. *Jurnal Saintek Maritim*, *24*(2), 131–140. https://doi.org/10.33556/jstm.v24i2.397

Sweller, J., van Merriënboer, J. J. G., & Paas, F. (2019). Cognitive Architecture and Instructional Design: 20 Years Later. *Educational Psychology Review*, *31*(2), 261–292. https://doi.org/10.1007/s10648-019-09465-5

Waltman, L., van Eck, N. J., & Noyons, E. C. M. (2010). A Unified Approach to Mapping and Clustering of Bibliometric Networks. *Journal of Informetrics*, *4*(4), 629–635.

Zhang, Z., Wen, F., Sun, Z., Guo, X., He, T., & Lee, C. (2022). Artificial Intelligence-Enabled Sensing Technologies in the 5G/Internet of Things Era: From Virtual Reality/Augmented Reality to the Digital Twin. *Advanced Intelligent Systems*, *4*(2100228), 1–23. https://doi.org/10.1002/aisy.202100228