



Bibliometric analysis of scientific publication on AR/VR in education: a case study in Universitas Negeri Yogyakarta, Indonesia and Russian State Vocational Pedagogical University, Rusia

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Abstract

The purposes of this research to find out the mapping and direction of future Augmented Reality and Virtual Reality development particularly in the education field in both Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University. The method used in this study consists of five steps: defining search keywords, initializing search results, refining search results, compiling preliminary data statistics, and analyzing data. The result shows that as many as 84 documents were refined from Scopus databases and visualized using Vosview-er. The cluster analysis shows the main research topics in the augmented reality and virtual re-ality field based on its unique association of the set of keywords within the cluster. Based on a review of keywords with less frequent occurrence, the report also suggests possible research areas for the future.

Keywords: augmented reality, virtual reality, education technology development

1. INTRODUCTION

Lecturers are professional educators who work in certain higher education. Lecturers are often referred to as scientists because of their knowledge capacity. The main task of a lecturer is to develop and disseminate science, technology, and art through the Tri Dharma Perguruan Ting-gi. This is in accordance with Law No. 15/2005 article 1 paragraph 2, lecturers are professional educators and scientists with the main task of transforming, developing, and disseminating sci-ence, technology, and art through education, research, and community service. Lecturers play a vital and

strategic role in improving the quality of human resources. In their duties, lecturers must continue to adapt to the trend of developing science and technology. Therefore, lecturers must have knowledge and skills in reviewing books, articles, and publications. This is very important so that lecturers can adapt to the latest developments in science and technology so that they can transfer to students and the community.

The publication of scientific papers is one form of tangible evidence of the dedication of lecturers in the world of education. Lecturer publications in the form of books and journals indicate that lecturers have contributed to the development of the world of education and science for the wider community. On the other hand, there is a technology that has been developed that can assist lecturers in publishing scientific papers, namely bibliometric analysis. Bibliometrics is a statistical analysis that can be performed on books, articles, or other publications.

Bibliometric analysis can also be used to quantitatively assess the academic quality of articles, authors, analyze bibliographic data in articles/journals, and analyze publication content, references, citations, and (co)authors. Bibliometric analysis is a popular and rigorous method for exploring and analyzing large amounts of scientific data. This allows us to dismantle the evolutionary nuances of a particular field while highlighting emerging areas in that field. However, its application in research is still relatively new and undeveloped. Therefore, researchers are trying to conduct a bibliometric study, with a special focus on publications related to Augmented Reality (AR) or Virtual Reality (VR) in education. We chose this focus with the consideration that AR/VR technology in education is a technology that is currently developing rapidly. The implementation of AR/VR technology in education is in accordance with the development of the millennial generation which cannot be separated from the use of smartphones. Several studies also mention that the use of AR/VR in the world of education can increase students' learning motivation.

Bibliometrics is defined as the use of statistical methods to analyze data for bibliometric publications such as peer-reviewed journal articles, books, conference proceedings, magazines, reviews, reports, and related documents. This method has been widely used to present the relationship between research domains with quantitative methods. The results of this bibliometric analysis will also provide benefits for Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University, as follows: (1) providing bibliometric analysis guidelines, (2) making it easier for lecturers to track relevant scientific publications, (3) giving an insight for new topic research related to AR/VR that were not previously studied yet.

Bibliometrics is an analytical approach that produces an integrative view and profile of quantitative parameters of an entire field of research or a particular area of scientific application (Yeung, et al., 2019). Scholars use bibliometric analysis to spot new trends in research, track collaboration patterns, and understand the key elements of a field (Donthu, et al., 2021). The bibliometric method provides many advantages, one of which is objectivity and quantity, and helps to avoid subjective bias (Muritala,

et al., 2019). The development of bibliometric analysis related to Augmented Reality (AR) and Virtual Reality (VR) from 2013 to 2021 can be seen in Figure 1.

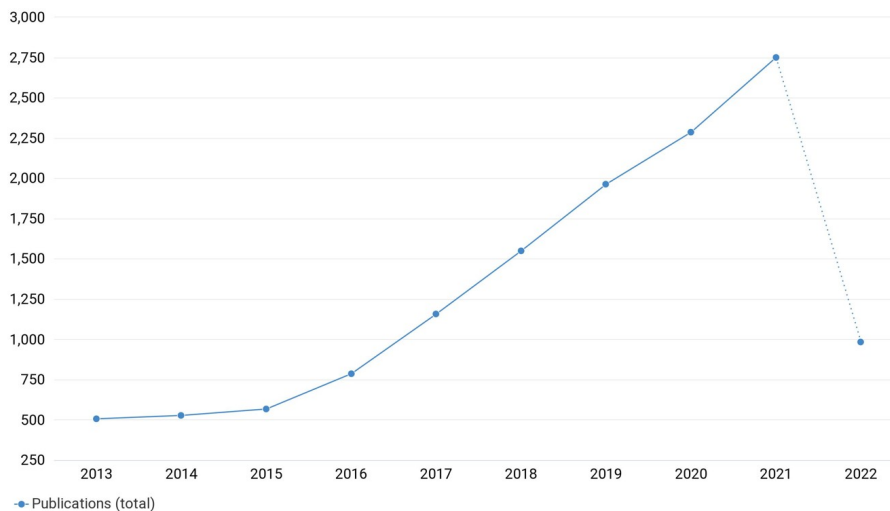


Figure 1. Scientific Publications related to AR/VR (2013-2021)

Some research related to bibliometric analysis can be explained as follows. Research by López-Belmonte, et al., (2023) entitled augmented reality in education. This study is a scientific mapping in Web of Science that focuses to find out the performance and scientific production of augmented reality in an education field using a bibliometric perspective approach. Documentary analysis technique based on scientific mapping and word analysis of 777 publications reported from the Web of Science. The research results reveal the languages, fields of knowledge, document types, institutions, authors, sources of origin, countries, and the most cited articles on augmented reality in education fields.

In line with previous research, research conducted by Abad-Segura, et al., (2020), examines the evolution of global research on the topic of augmented reality (AR) in the period 2005 to 2019. The bibliometric analysis was carried out in the 1977 paper. The research result indicates a growing interest in studying AR sustainability in higher education. Five lines of research were identified, among which those oriented to the topics of technological resources, computers, simulation, education, and learning stand out.

Research from Yeung, et al., (2021) entitled Virtual and Augmented Reality Applications in Medicine: Analysis of the Scientific Literature is based on data from 8399 papers. Overall, the literature contributions are distributed globally with the heaviest contributions from the United States and the United Kingdom. This study concludes that the bibliometric analysis carried out clearly reveals that VR and AR applications have high utility in medicine.

Research from Belmonte, et al., (2019), focuses on performance analysis and scientific production of augmented reality in bibliometric higher education. Data were taken from 552 scientific publications on the Web of Science (WoS) for scientific mapping, based on the process of estimation, quantification, analytical, and scientific evaluation research. The results of this research indicate that research on augmented reality in Higher Education (ARHE) was most productive starting in 2015. The studies that mostly involved were communication and articles, with a wide thematic variation in which the bibliometric indicators of "higher education" and "higher education" were the most important stand out. The main limitation of this study is that the results only reveal the status of the problem in the WoS database.

One of the studies related to bibliometric analysis of scientific publications was carried out by Yılmaz, et al., (2017). This research aims to evaluate the high-quality scientific productivity of Turkish anesthesia clinics in the last 10 years. The databases were retrieved from journals listed under the medical subject categories "anaesthesiology" and "critical care using" using the 'Thomson Reuters InCites' and PubMed databases. From the inclusion criteria of this study, 630 papers were found that met the criteria. The results of this study indicate that the high impact scientific productivity of Turkish anesthesia clinics is on a downward trend in the past 10 years, and the average number of citations is lower than the global average.

Research related to bibliometric was also conducted by Simolina, et al., (2020). In this study, the researcher analyzed Russian publications on sports science indexed in the Scopus database from 2008 to 2018. During the period, 2622 articles were published in 69 journals. The data analyzed consisted of the year of publication, journal title, institution, citation, type of publication, and international cooperation. The results of this study indicate that the scientific product of Russian sports science shows the progressive development and strengthening of this field with a clear focus on international cooperation.

In addition to several relevant studies that have been described above, other studies related to AR/VR have been conducted by this research team member. Several studies that have been conducted by the research team previously strongly relate to AR/VR. One example of research that has been completed entitles **"Augmented Reality in Basic Electrical and Electronic Engineering Subjects in Vocational High Schools"**. Other scientific publications owned by researchers also relate to AR/VR. Nurhening Yuniarti in 2019 published an article in the international journal entitled **"Augmented Reality as Android Based Learning Media for Wood Field Laboratory Work"** (Wulandari, et al., 2019). In the following year, Nurhening Yuniarti also published an article entitled **"A New Way of Teaching Business Ethics: The Evaluation of Virtual Reality-Based Learning Media"** in the International Journal of Management Education indexed by Scopus (Sholihin, et al., 2020). Other research member in this study, Didik Hariyanto, published a scientific publication in 2021 with the title **"The Design of Sensor and Transducer Learning**

Media based on Augmented Reality" in the Journal of Physics: Conference Series indexed by Scopus (Hariyanto, et al., 2021). In summary

Based on the results of research and publications that have been carried out by the researcher's member in this study in the previous year, then a research related to bibliometric analysis related to the scientific publications on AR/VR was conducted with the title "**Bibliometric Analysis of Scientific Publication on AR/VR a Case Study in UNY and RSVPU**". This study aims to find out the mapping and direction of future AR/VR development particularly in the education field. In the future, after knowing the direction and mapping of AR/VR research based on bibliometric analysis, researchers will obtain an insightful to the potential topic that related to AR/VR for the future research.

2. METHODS

The bibliometric analysis was conducted by following the sequential five stages method adopt-ed from Garza-Reyes, (2015) as seen in Figure 2 below. Those steps are 1) defining search keywords, 2) initial search results, 3) refinement of the search results, 4) compiling the initial data statistics, and 5) data analysis. The five stages were performed to obtain comprehensive data and evaluations toward research in the augmented reality or virtual reality field.

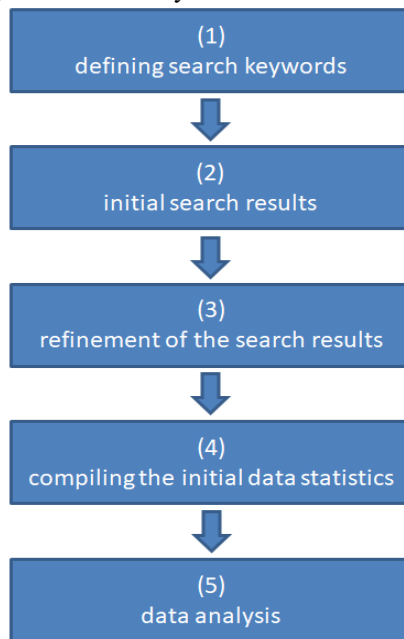


Figure 2. Five-Step of Bibliometric Analysis Method

2.1 *Defining the Search Keywords*

Literature search was conducted in November 2022, using search strings that contained key-words related to “Augmented Reality” or “Virtual Reality” and were based on the article’s title, keywords, and abstract as follows:

(TITLE-ABS-KEY ("augmented reality" OR "virtual reality" OR "AR" OR "VR" OR "aug-mented" OR "virtual") AND AFFIL ("Universitas Negeri Yogyakarta" OR "State University of Yogyakarta" OR "Yogyakarta State University" OR "UNY" OR "Russian State Professional Pedagogical University" OR "Russian State Vocational Pedagogical University"))

The process of searching articles in an electronics database was used as a source of information based on the defined keywords. Then Scopus was chosen as the electronic database for this research. Since Scopus is the largest trustworthy scientific database currently available and offers a variety of peer reviewed journal articles, the quality of the articles collected can be guaranteed.

2.2 Initial Search Result

The initial search results with the keywords returned 97 Scopus documents. Since this research aims (1) to identify scientific publications on AR/VR development in education, (2) to identify knowledge gaps and derive ideas for future research, (3) to provide bibliometric analysis guide-lines, for both Universitas Negeri Yogyakarta, Indonesia and Russian State Vocational Pedagogical University, Russia, the affiliation is restricted to Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University.

2.3 Refinement of Search Result

After obtaining the initial results, since Scopus databases are not created solely for bibliometric research, data cleaning is needed. Then a screening of all articles based on the inclusion criteria was conducted in this research. The screening of the articles was performed by excluding some articles that not related to augmented reality and virtual reality based on specific key-words and name of the authors. Total number of articles obtained following the refining procedure is summarized in Table 1.

Table 1. Refinement of Search Result

Search Keyword	Number of Scopus documents
(TITLE-ABS-KEY ("augmented reality" OR "virtual reality" OR "AR" OR "VR" OR "augmented" OR "virtual") AND AFFIL ("Universitas Negeri Yogyakarta" OR "State University of Yogyakarta" OR "Yogyakarta State University" OR "UNY" OR "Russian State Professional Pedagogical University" OR "Russian State Vocational Pedagogical University")) AND (EXCLUDE (PREFNAMEAUID,"Nurhaida#57204207408") OR EXCLUDE (PREFNAMEAUID,"Anoshina,	84

O.V.#6507831471")) AND (EXCLUDE (EXACTKEYWORD,"Phenomenology Study") OR EXCLUDE (EXACTKEYWORD,"Innovative Learning") OR EXCLUDE (EXACTKEYWORD,"Physical Education") OR EXCLUDE (EXACTKEYWORD,"Face To Face Learning") OR EXCLUDE (EXACTKEYWORD,"Sociodrama Techniques") OR EXCLUDE (EXACTKEYWORD,"Beksan Nir Corona") OR EXCLUDE (EXACTKEYWORD,"Gender") OR EXCLUDE (EXACTKEYWORD,"Physics Outreach") OR EXCLUDE (EXACTKEYWORD,"Marketing Mix") OR EXCLUDE (EXACTKEYWORD,"Essential Oil") OR EXCLUDE (EXACTKEYWORD,"Information-educational Sphere"))	
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2.4 Compile Preliminary Data Statistics.

In this step, RIS file was used to keep the data that was gathered after the refinement search re-sults. The file is then processed using the reference manager software (RMS) Mendeley to complete the metadata of the articles retrieved, including the author's name, title, keywords, abstract, and journal description. When in.

Trend of research on augmented reality and virtual reality based on number of publi-cations per year in Universitas Negeri Yogyakarta and Russian State Vocational Pedagog-ical University.

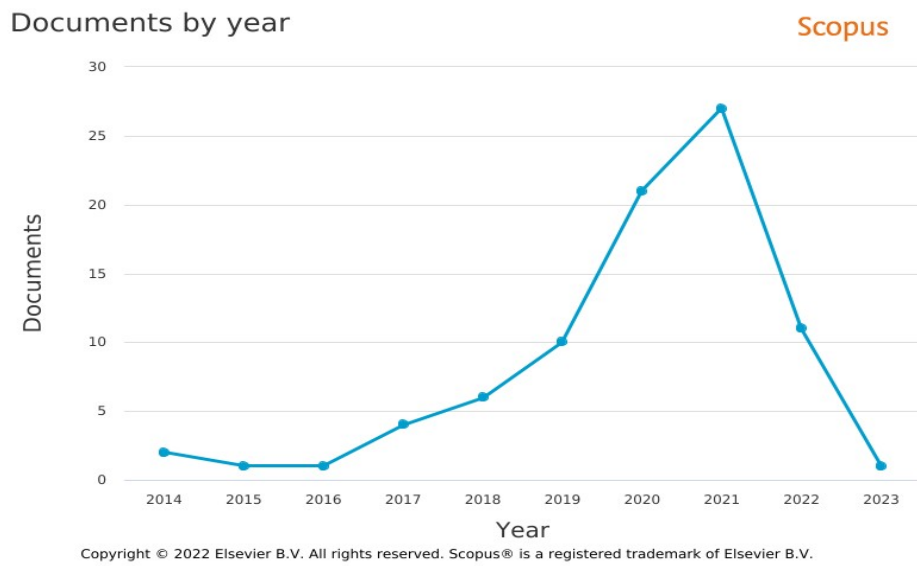


Figure 3. Trend Research of Augmented Reality and Virtual Reality in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University

Figure 3 shows the trend of research on augmented reality and virtual reality in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University based on the number of articles published per year. As can be seen from Figure 3, in general, augmented reality and virtual reality research in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University started to grow since 2016. The total number of articles was reached the peak in 2021 with 27 articles have been published.

Journals and proceedings that have most papers published in area of augmented reality and virtual reality by the authors who affiliated with Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University.

Figure 4 shows top five journals and proceedings have most papers published in area of augmented reality and virtual reality by the authors who affiliated with Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University which contributing roughly 65 % (55 articles) out of total data (84 articles) over approximately 9 years (2014-2023). The Journal of Physics Conference Series is the leader based on the publication numbers which has a total of 40 articles. This journal was published by Institute of Physics Publishing, one of the reputable publishers in scientific publications.

Documents per year by source

Compare the document counts for up to 10 sources. Compare sources and view CiteScore, SJR, and SNIP data

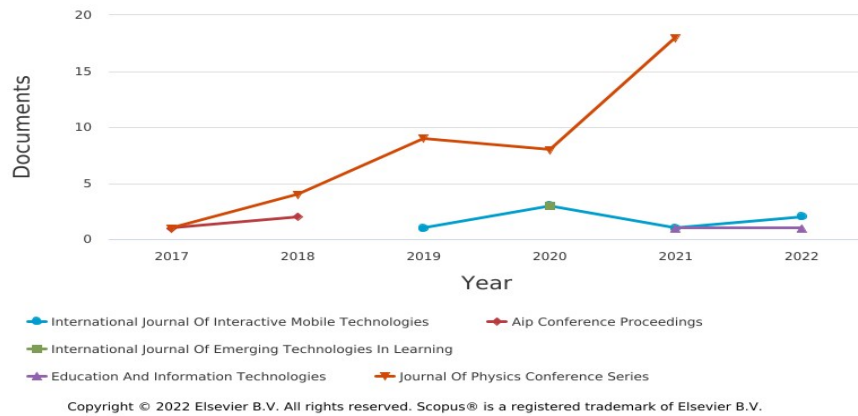


Figure 4. Top Five Journals and Proceedings Have Most Papers Published in Area of Augmented Reality and Virtual Reality.

The most productive authors in publication of augmented reality and virtual reality re-search in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University.

Documents by author

Compare the document counts for up to 15 authors.

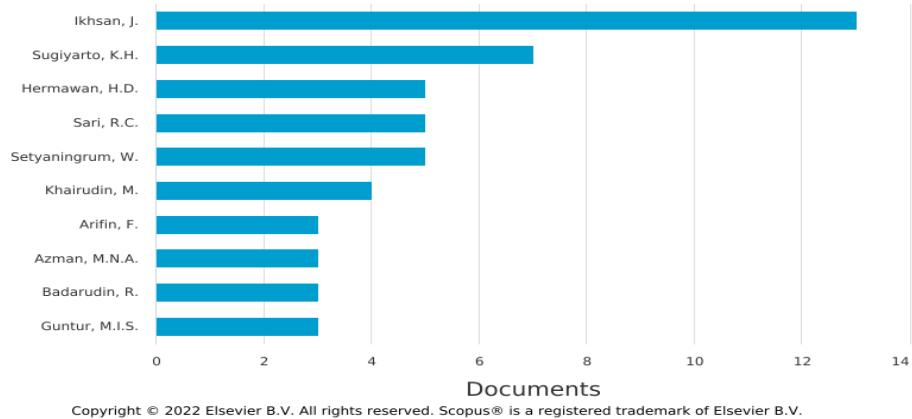


Figure 5. Top Ten Contributing Authors in Area of Augmented Reality and Virtual Reality Research in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University

Figure 5 shows the top ten contributing authors with published articles in area of augmented reality and virtual reality research in Universitas Negeri Yogyakarta and

Russian State Vocational Pedagogical University. Ikhsan J has become the most productive author in the list who has authored 13 articles followed by Sugiyarto who authored 7 articles. Both authors are affiliated with Universitas Negeri Yogyakarta. However, there is no author from Russian State Vocational Pedagogical University who in the top ten list of the most productive author in area of augmented reality and virtual reality research.

The subject areas or disciplines that contribute to augmented reality and virtual reality research in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University.

Figure 6 shows the publications in augmented reality and virtual reality field originate from several subjects or disciplines where physics and astronomy have dominated the publications with 43 articles (36.4%), followed by social sciences with 22 articles (18.6%), computer science with 16 articles (13.6%). The rest of the subject areas contribute to the area of augmented reality and virtual reality.

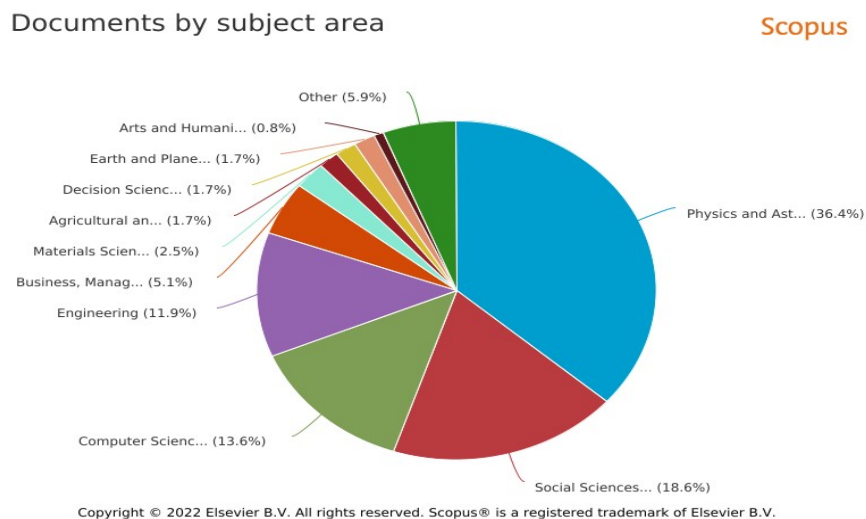


Figure 6. Subject Area of Augmented Reality and Virtual Reality Research Based on Publications

2.5 Data Analysis

To analyze and visualize bibliometric networks, VOSviewer software will be used. VOSviewer was used because of its ability to work efficiently with large data sets and provide a variety of interesting visuals, analyzes, and investigations (Eck & Waltman, 2010). This software can handle substantial amounts of data and deliver high-quality network data visualization (Bukar, et al., 2023). VOSviewer can also create publication maps, author maps, or journal maps based on co-citation networks or to build keyword maps based on shared networks. In this research, 3 different data: 1) co-occurrence, 2) co-authorship, and 3) citation-document were analyzed.

3. RESULTS AND DISCUSSION

3.1 Co-occurrence

3.1.1 Topic Area Visualization Using Vosviewer

The bibliometric analysis was carried out in this section to visualize the result based on key-words that were commonly used in area of augmented reality and virtual reality research. The Vosviewer is useful since it can reveal topics that has been studied for about 9 years (2014-2023). Additionally, Vosviewer offers cluster analysis, which shows the connections between various topics, particularly in the field of augmented reality and virtual reality research.

In this research, three distinct visuals have been used to map the bibliometric analysis: data network visualizations, overlay views, and density visualizations.

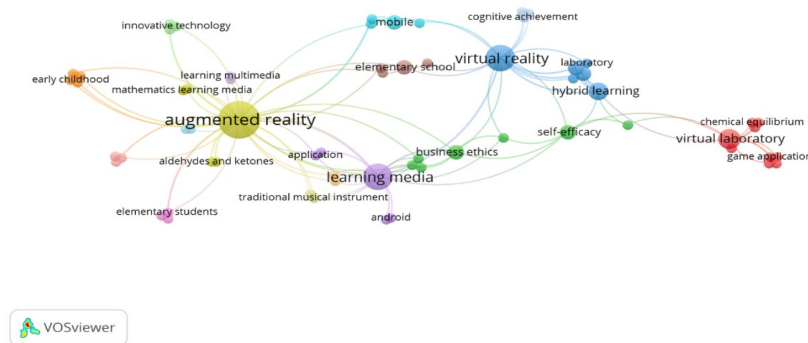


Figure 7. Network Visualization for Co-occurrence Type Analysis

Figure 7 shows how Vosviewer by default labels and symbols objects (keywords) linked to augmented reality and virtual reality research themes as circles. An object or keyword becomes more significant as it appears more frequently since the circle will be larger. The size of the items depends on how frequently they occur. Since it occurs the most frequently, it seems sense that the keyword "augmented reality" was chosen as the primary research topic. Each circle's cluster is colored differently when the elements are given a color when the color is assigned (Eck & Waltman, 2010).

Using Vosviewer and bibliographic data, the result was derived from the frequency of occurrence of author keywords. The minimum number of occurrences of keyword was set to 1. Then, 157 keywords have been obtained with all the keywords met the threshold. Several keywords that have similar meaning were used while dropping the others. After evaluating the data, we were able to identify 16 clusters that represent different study areas of augmented reality and virtual reality trends.

3.1.2 The Main Topics and Research Stream in area of Augmented Reality and Virtual Reality Research

The 16 clusters and their relationships within the research topic areas are shown in network visualization in Figure 7. The keywords in each cluster are in a strong agreement with one another in the map's structure. High frequency occurrences of keywords corresponding to the research emphasis of prior studies are present for each cluster. For example, the first cluster has the terms "virtual laboratory" (4) as its most frequent term. The third and fourth clusters with "virtual reality" (7) and "augmented reality" (14) as the highest common terms, respectively. For simplicity of this research, frequency of the top keywords with the most of occurrence was limited to 1 keyword as reported in Table 2.

Table 2. Cluster Analysis based on Keywords

No	Cluster	Most Frequent Keywords	Keywords
1	Cluster 1 - 9 items	virtual laboratory	Chemical equilibrium, game application, higher order thinking skills, mobile learning, motivation, science learning, self regulated learning, semi second life, virtual laboratory
2	Cluster 2 – 7 items	Business ethics	Accounting ethics, business ethics, electrochemistry, ethical efficacy, mobile application, self-efficacy, technology acceptance
3	Cluster 3 – 6 items	virtual reality	3d visualization, critical thinking skills, hybrid learning, laboratory, scientific attitude, virtual reality
4	Cluster 4 – 5 items	Augmented reality	Aldehydes and ketones, augmented reality, chemical learning, mathematics learning media, spatial reasoning
5	Cluster 5 – 5 items	Learning media	Android, application, batik, geography, learning media
6	Cluster 6 – 4 items	mobile	Digital engineering, electrical lighting installation, mobile,

No	Cluster	Most Frequent Keywords	Keywords
			virtual trainer
7	Cluster 7 – 4 items	Early childhood	Early childhood, executive functions, financial literacy, storybook
8	Cluster 8 – 4 items	anxiety	Anxiety, elementary school, learning management system, mathematics learning
9	Cluster 9 – 3 items	Elementary students	Elementary students, financial socialization, sharia financial literacy
10	Cluster 10 – 3 items	Gyroscope sensor	Gyroscope sensor, oriented fast rotated brief, pose estimation
11	Cluster 11 – 3 items	Innovative technology	Innovative technology, moral imagination, simulation based
12	Cluster 12 – 3 items	Cognitive achievement	Cognitive achievement, titration, virtual reality laboratory
13	Cluster 13 – 2 items	Instagram	Instagram, traditional musical instruments
14	Cluster 14 – 2 items	Learning multimedia	Learning multimedia, pencak silat
15	Cluster 15 – 2 items	Problem-solving skills	Problem-solving skills, spatial skills
16	Cluster 16 – 2 items	Javanese wedding make up	Javanese wedding make up, smartphone application

The keywords on each cluster reflect the research stream, and each cluster describes a specific (primary) topic as a study direction in the augmented reality or virtual reality field based on its special association of the collection of keywords within the cluster.

From the third and fourth clusters, it is clear that the augmented reality and virtual reality are the primary research subjects. Addressing the aim of this research, the mapping and direction of future AR/VR development particularly in the education field may be possible with the help of these types of data. The following are the results of material and media expert validation detailed in the table below.

3.1.3 The Potential Topics in area of Augmented Reality and Virtual Reality Research for Future Study

Table 2 also shows some fewer common keywords that could be investigated as prospective research topics in the future such as “spatial skills”, “virtual reality laboratory”, and “smartphone application”.

Figure 8 displays a research topic by year, it can be seen that the most occurrence keywords of augmented reality and virtual reality appear from 2020 until 2021.

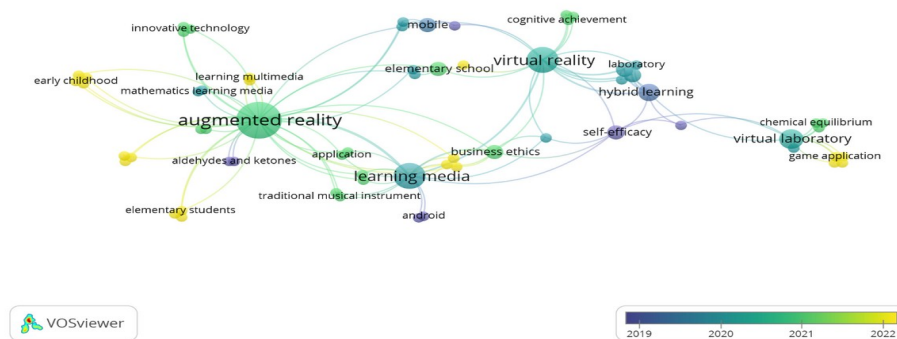


Figure 8. Overlay Visualization of Scopus using Vosviewer Displaying Research Topic

Figure 9 shows density visualization using Vosviewer, which indicates the depth of research studied in certain areas of augmented reality and virtual reality. The appearance of keywords in the number indicated by the color depends on the item density. The colors that are more concentrated show that the research has grown significantly. As a result, the unconcentrated color of the keyword with less frequent occurrence indicates that the research topic is still limited and requires further exploration for future study (potential topic). Some samples of these key-words are android, innovative technology, and elementary students. Thus, these results provide opportunities for researchers to identify the potential topic as a novel contribution to work in the area of augmented reality or virtual reality research. Furthermore, based on the interrelationship of keywords, a particular keyword is not related to other keywords. For example, the augmented reality and cognitive achievement keywords

have never been studied together. It provides the chance of new trend of research arise. Those potential topics in area of augmented reality and virtual reality research need more investigation in the future.

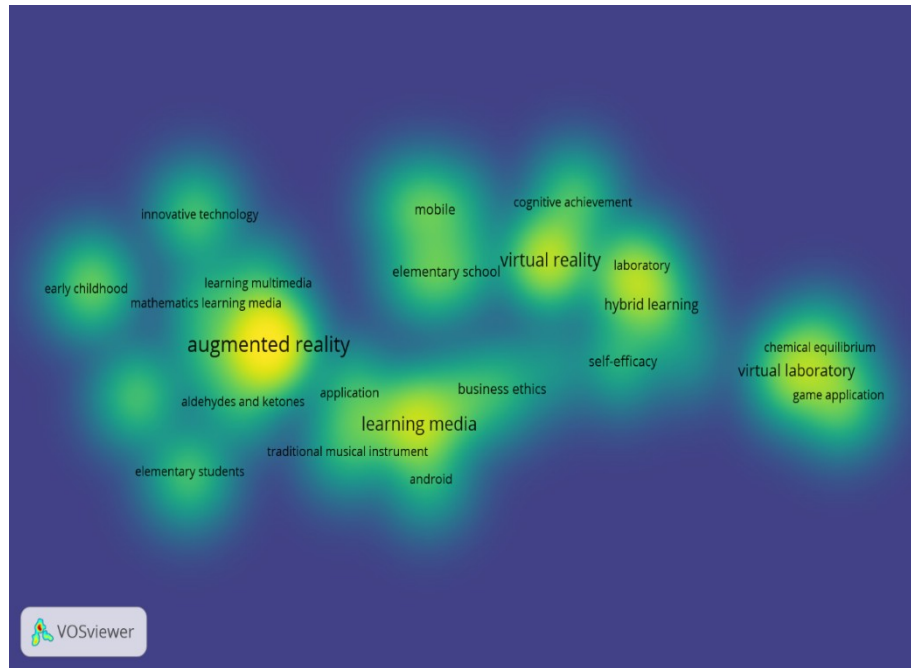


Figure 9. Density Visualization using Vosviewer Displaying the Depth of Research Studied in certain areas of Augmented Reality and Virtual Reality

Based on the results of the media expert validation instrument for the children's storybook, the book shows very high quality with a total score of 52 out of a maximum of 55, resulting in an assessment percentage of 94.5%. This indicates that this book is highly suitable for the target children's age, using simple and easily understood language, and is very attractive to fourth-grade elementary school students.

3.2 Co-authorship

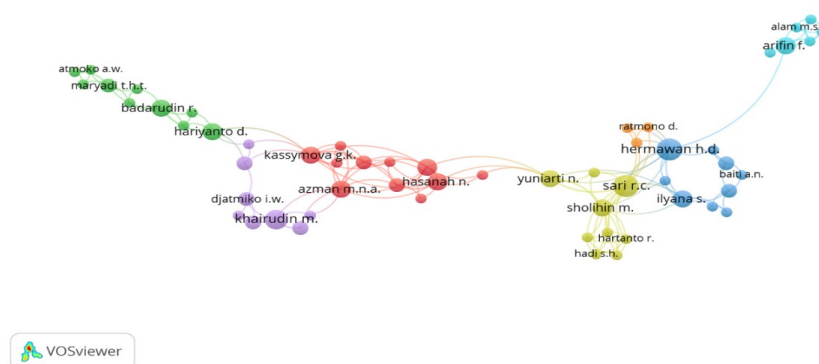


Figure 10. Network Visualization for Co-authorship Type Analysis

Figure 10 shows the interactions among authors from Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University with other authors who into augmented reality and virtual reality research topic. As can be seen from Figure 9, there are 7 clusters, Haryanto D from Universitas Negeri Yogyakarta has made collaboration in publishing paper with Kassymova g.k from Abai Kazakh National Pedagogical University, Almaty, Kazakhstan. In addition, Kassymova g.k also made collaboration with Pratama G., N.I.P who also has collaboration with Yuniarti N. In the future it is probable that Kassimova G.K and Yuniarti N can make collaboration directly to explore research themes related to augmented reality and virtual reality. Unfortunately, there is no direct collaboration between author from Universitas Negeri Yogyakarta and Russian State Vocational Pedagogical University yet during 2014-2022.

3.3 Citation

Figure 11 shows the density visualization of citation documents. It can be seen from the Figur 11 that the article entitled “Design and Development E-Learning System by Learning Man-agement System (LMS) in Vocational Education” written by Rabiman R has the highest num-ber of citations followed by “Digital Literacy and Digital Didactics as the Basis for New Learning Models Development” written by Liu Zhi-Jiang. Noteworthyly, augmented reality or virtual reality appear to play a secondary role in the documents that have been retrieved from Scopus database. However, using filtration on articles on “augmented reality” or “virtual reali-ty”, the article entitled “Mobile virtual reality to develop a virtual laboratorium for the subject of digital engineering” written by Khairudin M has the highest number of citations followed by “Effect of 3D Visualization on Students’ Critical Thinking Skills and Scientific Attitude in Chemistry” written by Astuti T N.

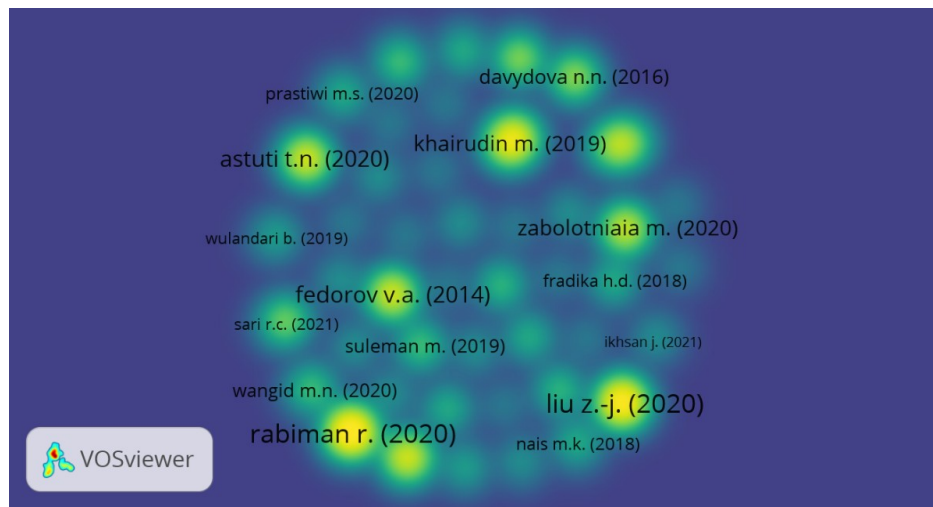


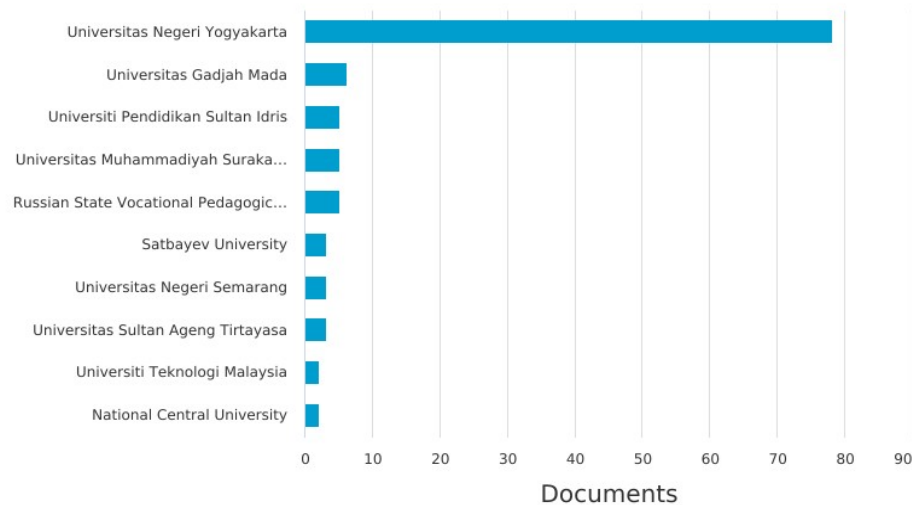
Figure 11. Density Visualization

3.3.1 Affiliations of author that contribute most publication in augmented reality and virtual reality research and their collaboration

Documents by affiliation

Compare the document counts for up to 15 affiliations.

Scopus



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Figure 12. Top Ten Affiliations of Author based on Publication Number

Figure 12 shows a comparison of the number of publications produced by Universitas Negeri Yogyakarta and Russian State Vocational Pedagogic University. It

appears that Universitas Negeri Yogyakarta has higher publication productivity than Russian State Vocational Pedagogic University in the fields of VR and AR. Universitas Negeri Yogyakarta produced 78 publications while Russian State Vocational Pedagogic University only produced 5 publications in the 2014-2022 period.

4. CONCLUSION

This research uses bibliometric analysis to review journal and proceedings papers by authors from Universitas Negeri Yogyakarta and Russian State Vocational Pedagogic University through Scopus database in augmented reality and virtual reality areas. There has been an increase in the amount of writing about augmented reality and virtual reality in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogic University during 2014 – 2023. The data retrieved from the scopus database at the initial result stage totaled up to 97 documents but following refining in accordance with the defined inclusion criteria, this number dropped to 84 documents. The results of this research highlight the trends in augmented reality and virtual reality areas in Universitas Negeri Yogyakarta and Russian State Vocational Pedagogic University, peer-reviewed journals and proceedings, authors who contributed, subject areas or disciplines, and most significant articles. Additionally, cluster analysis identifies the primary research areas in the field of augmented reality and virtual reality based on the distinctive associations between the set of keywords within the cluster, while analysis of keywords with less frequent occurrence identifies potential areas of future research as a contribution of this research. This research also intended to update and enrich the bibliometric analysis because there has been a significant increase in virtual reality and augmented reality research after 2014 in both Universitas Negeri Yogyakarta and Russian State Vocational Pedagogic University. The mapping and displaying of the bibliometric data using the Vosviewer program has been successfully demonstrated.

Based on the findings of this bibliometric analysis, it is recommended that future research on Augmented Reality (AR) and Virtual Reality (VR) in education should focus on addressing the identified research gaps and exploring emerging topics with less frequent occurrence, such as "spatial skills" and "virtual reality laboratories." Additionally, researchers should aim to diversify their publication platforms and engage in interdisciplinary studies to address the evolving needs of the educational landscape and maximize the potential of AR/VR technologies.

REFERENCES

- [1] N. J. v. Eck and L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, no. 2, pp. 523-538, 2010.
- [2] A. W. K. Yeung, N. T. Tzvetkov, A. Jóźwik, O. K. Horbanczuk, T. Polgar, M. D. Pieczynska, S. Sampino, F. Nicoletti, I. Berindan-Neagoe, M. Battino and

- A. G. Atanasov, "Food toxicology: quantitative analysis of the research field literature," *Int J Food Sci Nutr*, vol. 71, no. 1, pp. 13-21, 2019.
- [3] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey and W. M. Lim, "How to
] conduct a bibliometric analysis: An overview and guidelines," *Journal of Business Research*, vol. 133, pp. 285-296, 2021.
- [4] B. A. Muritala, M.-V. Sánchez-Rebull and A.-B. Hernández-Lara, "A
] Bibliometric Analysis of Online Reviews Research in Tourism and Hospitality," *Sustainability*, vol. 12, no. 23, p. 9977, 2019.
- [5] B. Wulandari, G. N. I. P. Pratama, N. Hasanah and N. Yuniarti, "Augmented
] Reality As Android Based Learning Media for Wood Field Laboratory Work," *Journal of Physics: Conference Series*, vol. 1413, no. 1, 2019.
- [6] M. Sholihin, R. C. Sari, N. Yuniarti and S. I. a, "A new way of teaching
] business ethics: The evaluation of virtual reality-based learning media," *The International Journal of Management Education*, vol. 18, no. 3, p. 100428, 2020.
- [7] D. Hariyanto, Zamtinah, T. Triasih, M. S. Wati and G. K. Kassymova, "The
] Design of Sensor and Transducer Learning Media based on Augmented Reality," *Journal of Physics: Conference Series, Volume 2111, 4th International Conference on Electrical, Electronics, Informatics, and Vocational Education (ICE-ELINVO 2021)*, vol. 2111, no. 1, 2021.
- [8] J. López-Belmonte, A.-J. Moreno-Guerrero, J.-A. López-Núñez and F.-J.
] Hinojo-Lucena, "Augmented reality in education. A scientific mapping in Web of Science," *Interactive Learning Environments*, vol. 31, no. 4, pp. 1-15, 2023.
- [9] E. Abad-Segura, M.-D. González-Zamar, M.-D. González-Zamar and M.-D.
] González-Zamar, "Sustainability of Educational Technologies: An Approach to Augmented Reality Research," *Sustainability*, vol. 12, no. 10, p. 4091, 2020.
- [1] A. W. K. Yeung, A. Tosevska, E. Klager, F. Eibensteiner, D. Laxar, J.
0] Stoyanov, M. Glisic, S. Zeiner, S. T. Klunik, R. Crutzen, O. Kimberger, M. Kletecka-Pulker, A. G. Atanasov and H. Willschke, "Virtual and augmented reality applications in medicine: analysis of the scientific literature," *Journal of Medical Internet Research*, vol. 23, no. 2, p. e2549, 2021.
- [1] J. L. Belmonte, A.-J. Moreno-Guerrero, J. A. L. Núñez and J. A. L. Núñez,
1] "Analysis of the Productive, Structural, and Dynamic Development of Augmented Reality in Higher Education Research on the Web of Science," *Appl. Sci.*, vol. 9, no. 24, p. 5306, 2019.
- [1] H. O. Yılmaz, R. Babazade, O. A. Turan, B. Babazade, O. Koyuncu and A.
2] Turan, "Scientific Publication Performance of Turkish Anaesthesia Clinics in High Impact Factor International Journals Between 2005 and 2014: A Bibliometric Analysis," *Turk J Anaesthesiol Reanim*, vol. 45, no. 1, pp. 16-25, 2017.
- [1] S. G. Simolina, D. M. Khafizov and V. V. Erlikh, "Bibliometric analysis of the
3] publication activity of Russian scientific institutions in sports science for 2008-2018," *Journal of Physical Education and Sport*, vol. 20, no. 2, pp. 783-790, 2020.
- [1] J. A. Garza-Reyes, "Lean and green – a systematic review of the state of the art
4] literature," *Journal of Cleaner Production*, vol. 102, pp. 18-29, 2015.
- [1] U. A. Bukar, M. S. Sayeed, S. F. A. Razak, S. Yogarayan, O. A. Amodu and R.

- 5] A. R. Mahmood, "A method for analyzing text using VOSviewer," *MethodsX*, vol. 11, 2023.

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