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Bibliometric Analysis: Research Trends in The Use of Augmented Reality-Based Learning Media in Elementary Schools

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Abstract

In the digital era, the use of digital learning media is increasingly popular among educators. The use of this media makes the trend of research on the use of digital learning media is increasing, including the use of Augmented reality which facilitates learning to be more real. This study aims to present data on the significance of bibliometric trends on Augmented reality as a learning media in elementary schools. The research method uses bibliometric analysis. Data analysis was carried out with the help of the VOSviewer application and biblioshiny with a total of 195 pieces of literature processed from the Scopus database from 2006-2024. The research results show that there was a significant increase in 2017 with 8 publications to a peak in 2020 with 24 publications but there was a decline again in 2021 with 15 publications. In 2021, the research discussion on this trend has decreased due to the fact that learning is no longer carried out by distance learning. Indonesia has contributed to this research although it is not dominant. Indonesia is one of the countries that has contributed research publications on this topic. China is the country with the most research citations. However, Indonesia should be more productive in writing on this topic, in order to make this trend increase.

Keywords: augmented reality; bibliometric, learning media; primary school

Introduction

Education must adapt to the development and advancement of technology. Technological development has an impact on many areas of life including education that can i ncrease human knowledge and activities. This acceleration will create new learning spaces needed for teaching and learning activities. Currently, there are many e-learning and online platforms for learning, but technological advancement is not limited to that (Nistrina, 2021), but there are various platforms that can be utilised directly in the learning process (Alzahrani, 2020); (Lo, J. H., Lai, Y. F., & Hsu, 2021); (Bih, 2022).

Transformation technology in the form of Augmented Reality bridges digital information with the real world (Castañeda, M. A., Guerra, A. M., & Ferro, 2018); (Chandra, S., & Kumar, 2018); (Muhammad, I., Marchy, F., Rusyid, H. K., & Dasari, 2022). Augmented Reality makes abstract objects into two-way interactive media (Dutta,

R., Mantri, A., & Singh, 2022); (Hsu-Wen, H., King, J.-T., & Lee, 2020); (Nayyar, A., Mahapatra, B., Le, D. N., & Suseendran, 2018).

Learning will become more effective by not depending on the time and place. Through AR-integrated learning, learning can take place anywhere and anytime (Adedokun-Shittu, N. A., Ajani, A. H., Nuhu, K. M., & Shittu, 2020); (Ahsan, M. G. K., Miftahudin, & Cahyono, 2020); (Alalwan, N., Cheng, L., Al-Samarraie, H., Yousef, R., Ibrahim Alzahrani, A., & Sarsam, 2020). Augmented Reality is a technology that combines two-dimensional and/or three-dimensional virtual objects into a real environment and then projects these objects in reality into the real world (Al, 2018). AR-integrated learning is a realistic interaction. Learning is structurally designed to integrate virtual objects that are made real to create interaction with students in learning. The main component contained in Augmented Reality is a 3D object that is animated with the help of software, which will be scanned, and an animated object will appear (Sungkono, S., Apiati, V., & Santika, 2022).

Communication can be established between teachers and students with the help of AR technology. This technology is also able to make the model structure in learning more contextual and directed to achieve learning objectives (Perrotta, C., & Selwyn, 2020); (Salmiyanti, Erita, Y., Putri, R. S., 2023); (Saputra, D. S., Mulyati, T., & Susilo, 2022). The marker will be detected by a calibrated camera. After the process of analyzing and marking, the webcam will sort it according to its database. If there is no suitable information, then the marker cannot be processed, but if it is suitable, the marker information will be used to render and display 3D objects or animations that have been created previously (Mario, 2013). Augmented Reality is different from Virtual Reality, which adds real objects to virtual images; AR adds virtual objects to real objects at the same time. Based on research, it is known that Augmented Reality was first used in 1957-1962 by a cinematographer named Norton Heilig, who was named Sensorama (Raajan N.R . Et, 2014).

Augmented Reality in elementary schools began to be widely used during the COVID-19 pandemic when students could not carry out face-to-face learning in class. Research conducted by Baarizky shows that AR is a bridge to introduce musical instruments to elementary school students' arts learning in Nambo 01. This AR-based learning is an alternative due to the Covid-19 pandemic, which requires elementary school

students to do online learning (Baarizky, 2023). Nowadays, AR is still connected as a learning medium in elementary schools because it is still felt to be effective in its use even though it is not as massive as when COVID-19 hit (Arrum, 2021).

Research by (Zhao, Y., Pugh, K., Sheldon, S., & Byers, 2002) shows that learning facilitated by the use of learning media will make motivation higher. In line with the research above, research by (Lim, C. P., Pek, M. S., & Chai, 2020) found that the key to effective learning is a more varied presentation of materials. Along with the abundant technological resources in the learning process, teachers are expected to be able to integrate technology into their teaching (Sari, F. F. K., & Atmojo, 2021). Integrating media in learning means providing transformative learning for students (Wahiddah, S. A. N., Lathipah, L., Indaryanti, D., Fadilah, Z. P., & Aeni, 2022).

The trend of this research topic has contributed to increasing insight and knowledge about the world of research using Augmented Reality (Alamäki, A., Dirin, A., & Suomala, 2021); (Chen, Y., Wang, Q., Chen, H., Song, X., Tang, H., & Tian, 2019). Augmented reality is a technology that has a relatively high percentage of users (Belda-Medina, J., & Calvo-Ferrer, 2022) that can improve the effectiveness of classroom learning or mobile (Hadi, S., Haryanto, H., AM, M. A., Marlina, M., & Rahim, 2022). In addition, Augmented Reality has a role in learning that can arouse students' enthusiasm for learning (Almenara, J. C., & Vila, 2019). The benefits obtained by implementing AR include AR making students' cognitive, psychomotor, and visualization levels more active and encouraging cooperation with other individuals (Fuchsova, M., & Korenova, 2019); (Sarkar, P., Kadam, K., & Pillai, 2020).

Publications on the use of digital media as teaching aids need to be controlled and evaluated through bibliometric studies. Given the importance of the study and interpretation of trends as an indicator of the realm of authorship and integration of existing media. Digital media, especially Augmented Reality, must continue to be used and connected to learning, especially for elementary school students. Augmented Reality helps visualize various learning materials that cannot be directly observed by students around them so that their cognitive development stages, which are still in the concrete operational stage, can be fulfilled. There are 1030 documents with the keywords searched. Then, the researchers carried out screening with various exclusions such as year and

document type. After that, 205 documents were obtained, and the researchers carried out manual screening, obtaining the final results of 189 articles that met the criteria.

This study looks at the significance of trends in Augmented reality in the primary school education environment. Bibliometric analysis is widely used in the field of education. Researchers study and scrutinize to present data and reveal details of specific sectors and areas of study (Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, 2021).

Research Methods

This research identifies publications using Augmented Reality as a teaching aid in primary schools and visualizes them using a qualitative descriptive method. This research also applied bibliometric analysis. Bibliometric analysis is the main method used to examine the trend and amount of data on the research concerned, where the hope is to find research gaps and novelty that will be the basis for further research (Herdianto R., Windyaningrum N., Masruroh B., 2021). Searching and researching data from the Scopus database to collect the required scientific publications. This database will be used in the bibliometric analysis to assist in the collection, analysis, interpretation, and visualization of the required bibliometric data. (Saputro, D. R. S., Prasetyo, H., Wibowo, A., Khairina, F., Sidiq, K., Wibowo, 2023); (Supriyadi, E., Turmudi, T., Dahlan, J. A., Juandi, 2023).

The researcher searched for research documents on the topic of Augmented Reality implementation in Primary Schools. Journals and documents in the form of articles are the types of data sources with search keywords entered: learning, media, digital media, augmented reality, AR, 3D, Primary School, Elementary School, and School Children, which are limited to the title, abstract, and keywords. The collected data was compiled using the RIS type and processed using the VOSviewer application. This application is for citation analysis, coincidence analysis, and author collaboration analysis (Arsi Prabaningtias, D., Istiyono, E., Mahmuda, D., Arman, D., Arifiyanti, 2022).

A search of scientific publications matching the keywords yielded 189 articles published over 18 years, from 2006 to 2024. Bibliometric analyses were conducted using quantitative research methods to assess the content of bibliographies (Sjuchro, 2023). Bibliometric analysis method using quantitative study of library data (Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, 2021).

Hierarchical clustering is done as a grouping effort; in this case, visualization analysis is done using the network, overlay, and density visualization. (Al Husaeni, D. F., & Nandiyanto, 2021). According to Setyaningsih, there are five steps in bibliometric analysis, as shown in Figure 1

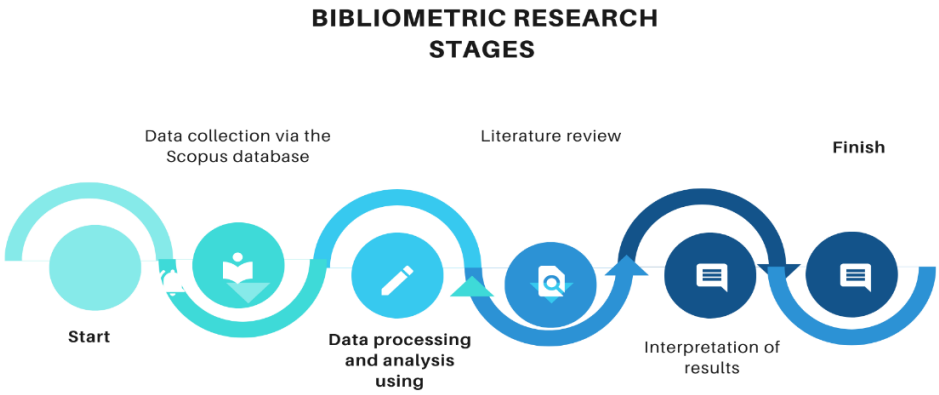

Figure 1
Bibliometric Research Map
Source: Personal Document

At the initial search results stage, the results of the data source summary and selection include several items, as in Table 1

Table 1
Summary of Data Sources and Selection

Type	Standard khusus
Bank Data	Academic Database
Periode	18 years (2006-2024)
Languange	Inggris
Keyword	learning, media, digital media, augmented reality, AR, 3D, Primary School, Elementary School, School Children
Document Type	Article
Sample	189

Source: Data Processed by Researchers

Data were collected through article review and application of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method, which uses inclusion and exclusion indicators to select articles (Prilatama, A., 2022). There are 1030 documents with the keywords searched. Then, the researchers carried out screening with various exclusions such as year and document type. After that, 205 documents were

obtained, and the researchers carried out manual screening, obtaining the final results of 189 articles that met the criteria.

The inclusion criteria include publications published within the last 18 years, titles that match the keywords, and topics that are relevant to the research being conducted. On the other hand, action standards include publications older than 18 years, irrelevant titles, and topics that are not related to the research being conducted. The steps of the PRISMA method are attached in Figure 2.

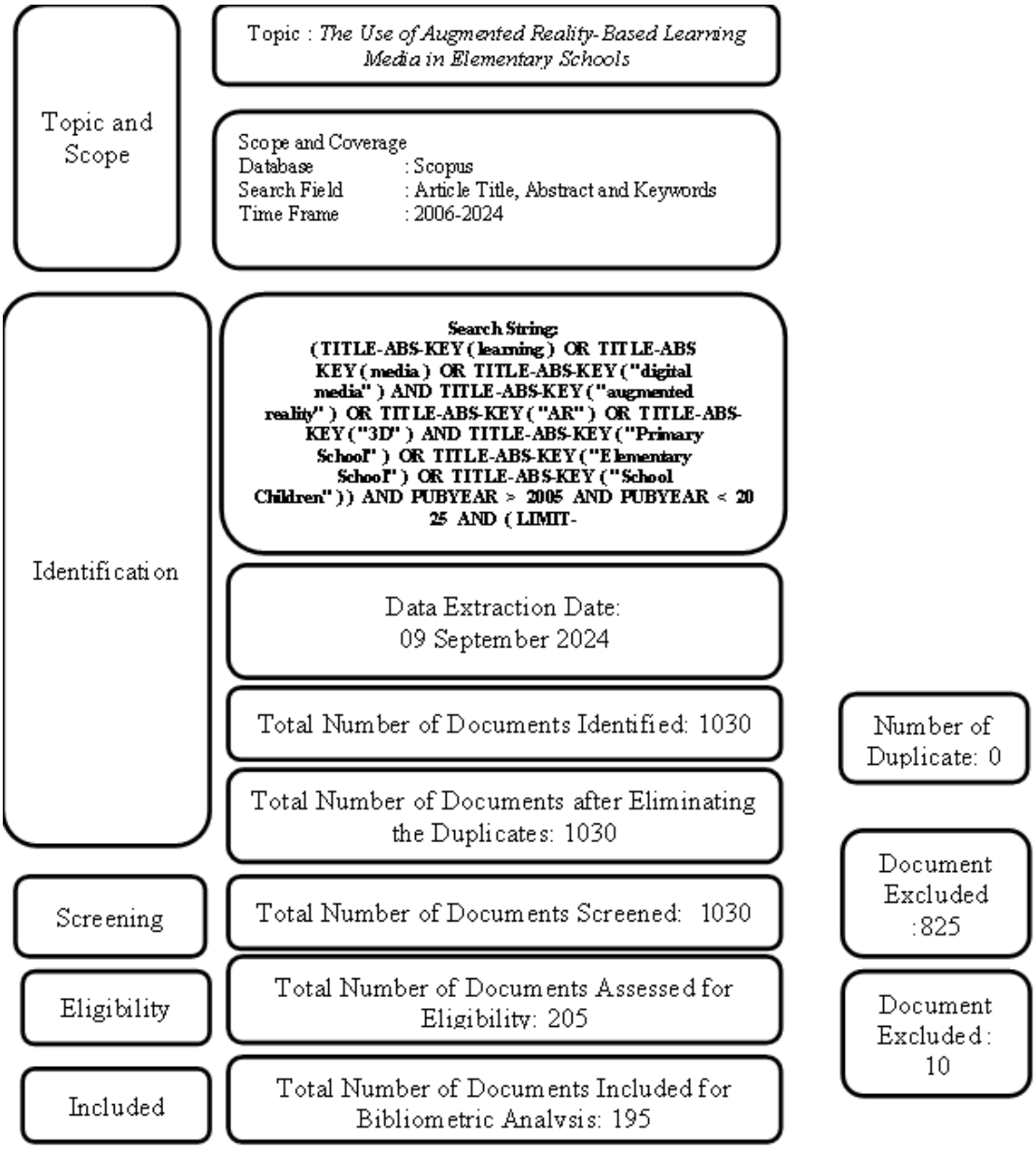

Figure 2
PRISMA stages
Source: Data Processed by Researchers

The first step taken by the researcher is to identify keywords that match the specific research title. The researcher then collected articles that matched the keywords and year of publication using the Scopus database. The results of the search were then filtered by year, namely the last 18 years (2006-2024). The researcher limited the number of articles in the search process, namely 195 articles that match the keywords and year of publication. Articles retrieved from Scopus were then saved in RIS and CSV formats. The RIS file format was then processed using VOSvieswer and Rstudio. The use of Rstudio is used to find out data such as the most productive authors, the origin of institutions, the origin of countries, and the number of citations. Besides that, the study is also used to extract the data obtained, while the use of VOSviewer aims to describe the data obtained in the form of visual graphics. From the various journal articles found, these articles were selected according to the theme that the researcher had determined.

Result

The researcher applied the deductive method to present the results of the analysis. In presenting the results of bibliometric analysis, data obtained from as many as 185 publications related to the use of Augmented reality as a teaching aid in primary education published in Scopus between 2006-2024 have been published in the Scopus database. Analysis of publication and citation trends from 2006 to 2024 shows that the development of publications experienced the highest growth in 2020. This is because in 2020, there was an outbreak of the COVID-19 disease, which requires learning to rely more on digital media, including the use of Augmented reality. This is also in accordance with the results of research(Fuada, 2021), which found that online learning using Augmented reality helped students develop a sense of fun and interest in learning during the COVID-19 pandemic. However, this research trend has decreased in 2022 after the end of the COVID-19 pandemic. Data regarding the analysis of publication and citation trends are presented in Figure 3 below.

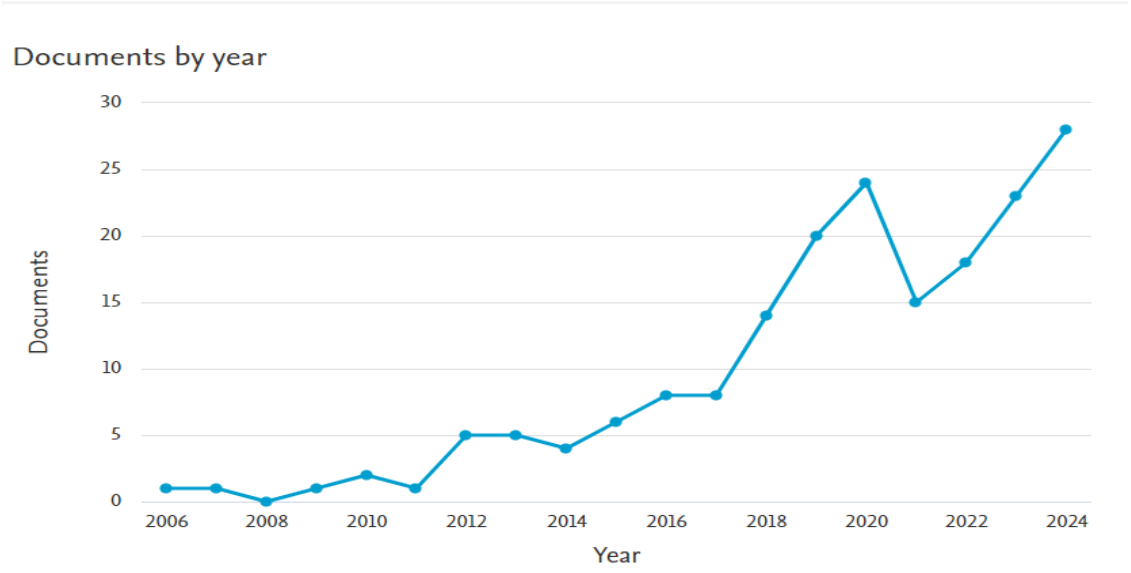

Figure 3
Research Trend in Augmented Reality Publications
Source : Data Processed by Researchers in VosViewer

The figure above shows the growth of publications related to the use of AR every year. This can be seen from the graph, which has continued to grow since 2018 and reached its peak in 2020. Although it experienced a fairly sharp decline until 2021, the research trend of using AR as a learning media in elementary schools rose sharply again starting in 2022 and continuing until now. 2017 there were 8 articles, and the peak was in 2020 with 24 articles. Then, in 2021, there was a decline in publications, with only 15 publications, but this trend increased again from 2022 until now, in 2024, at 29 articles.

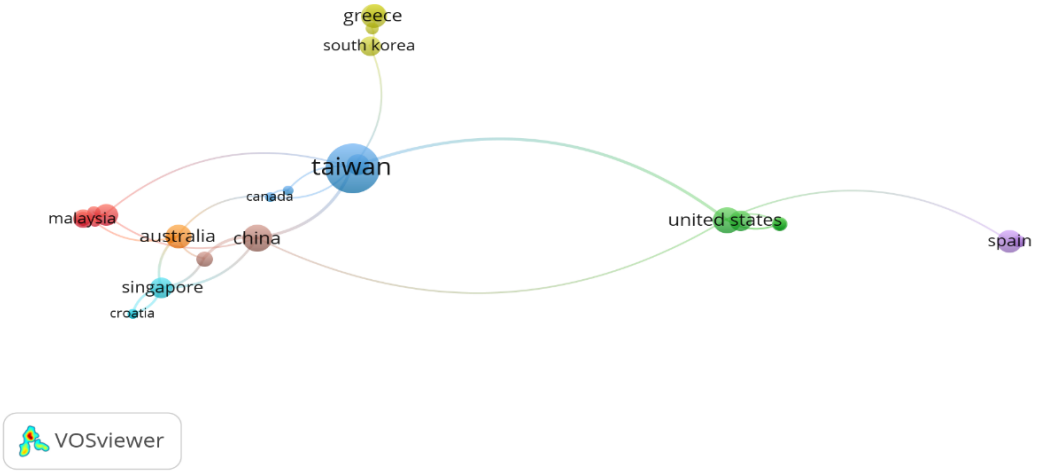

Figure 4
Bibliographic network visualization
Source : Data Processed by Researchers in VosViewer

Country Bibliography

The cross-country bibliographic pairs illustrated above show the use of network visualization. The researcher applied a threshold of at least five publications from a country. Out of 52 countries, 14 met this criterion. In terms of overall link strength, China ranked first with a total link strength of 10, 15 publications, and 100 citations. Taiwan ranked second with a link strength of 9, 50 publications, and 2,501 citations. The United States ranked third with a link strength of 7, 14 publications, and 947 citations. Hong Kong is fourth, with a link strength of 6, 5 publications, and 21 citations. The fifth is Singapore with six link strengths, 9 publications and 331 citations. Sixth place is Australia, with 3 link strengths, 12 publications, and 325 citations. The seventh place is the UK, with 3 link strengths, 10 publications, and 331 citations. The eighth place is occupied by Turkey, with 2 link strengths, 9 publications, and 143 citations. Followed by the ninth country is Cyprus (1,6,272). The tenth place is Greece, followed by Indonesia, Malaysia, South Korea and Spain.

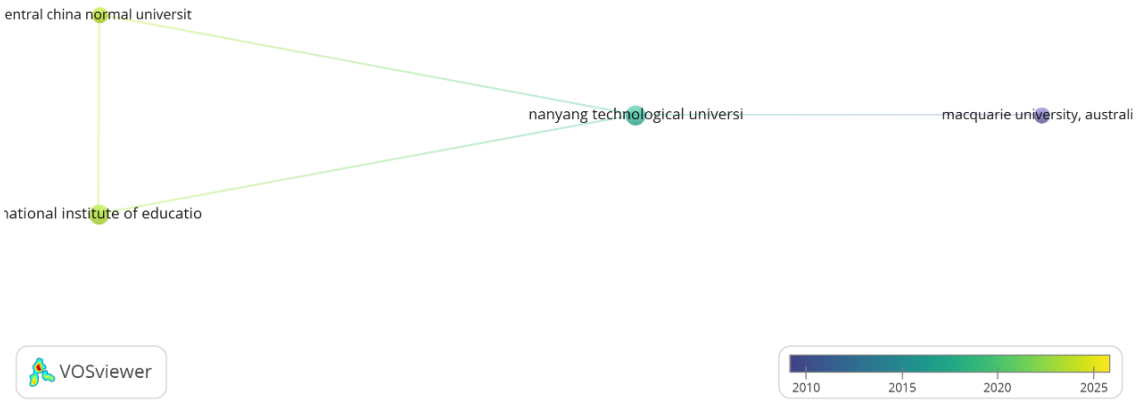

Figure 5
Visualization overlay for the Society's bibliography
Source: Data Processed by Researchers in VosViewer

Bibliographic pair of institutions

Paired institutional bibliographies are shown in Figure 4 and presented with an overlay visualization. In this step, researchers apply a threshold value, namely, the minimum number of publications per institution is 2 publications. From the 413 institutions, at least 16 institutions met the threshold value. Researchers ranked institutions based on overall citation strength, where Nanyang Technological University, Singapore, ranked first with a citation strength of 5, 3 publications, and 186 citations. Additionally, the overall publication strength is displayed sequentially, with the first

number indicating the number of publications, the second number indicating the number of publications, and the third number indicating the number of citations. Central China Normal University (4,2,11), National Institute of Education Nanyang Technological University, Singapore (4,3,19), department of Mathematics and Information Education, National Taipei (3,3,298), Graduate Institute of digital learning and Education, National Taiwan University (3,3,298), Macquarie university, Australia (1,2,188), department of digital technology design, national taipei university of education (0,2,220), department of information and computer engineering, ajou university (0,2,120), department of primary education, university of western macedonia, florina, greece (0,2,12), department of software engineering, engineering faculty, ataturk university (0,2,26), faculty of philosophy, university of novi sad, serbia (0,3,25), national taipei university of education, taiwan (0,2,17),national university of tainan, taiwan (0,2,12), teacher training and education faculty, eleven march university, Indonesia (0,2,86).

In the world of education in Indonesia, especially basic education, Augmented Reality technology has been widely used as a tool for learning. This is reinforced by the research carried out by Setyawan by developing Unity-based Augmented Reality on solar system material in elementary schools with the result that AR received a very good response in validity and attractiveness tests, and is suitable for use as a learning medium (Setyawan, 2019).

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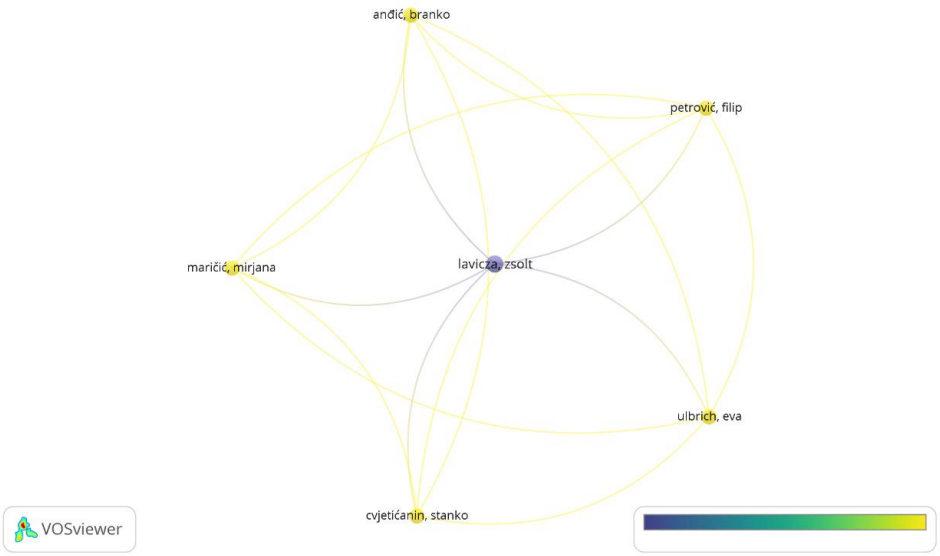

Figure 6
Overlay time of publication of the article and its author
Source: Data processed by researchers in VosViewer

The image above displays the data using an overlay visualization consisting of several colors, such as blue, green, and yellow. The colors indicate the publication time of the article and its author.

The image above displays the data using an overlay visualization consisting of various colors, including blue, green, and yellow. These colors represent the time and author of the article that was published. The greenish-yellow color shows articles that were recently published around 2023. The blue color shows articles published in 2022, and the purple color shows articles published in 2021. Ulbrich, Eva is the author in yellow; originally, Ulbrich, Eva wrote several articles and publications in 2023. Then Lavicza and Zsolt are purple writers, so Lavicza and Zsolt are writers who published articles in 2021. There are 6 items in 1 cluster, namely (Andie, Branko), (cvjeticanin, Stanko), (lavicza, Zsolt),(matrices, Mirjana), (Petrovic, Filip) and (Ulbrich, Eva).

Discussion

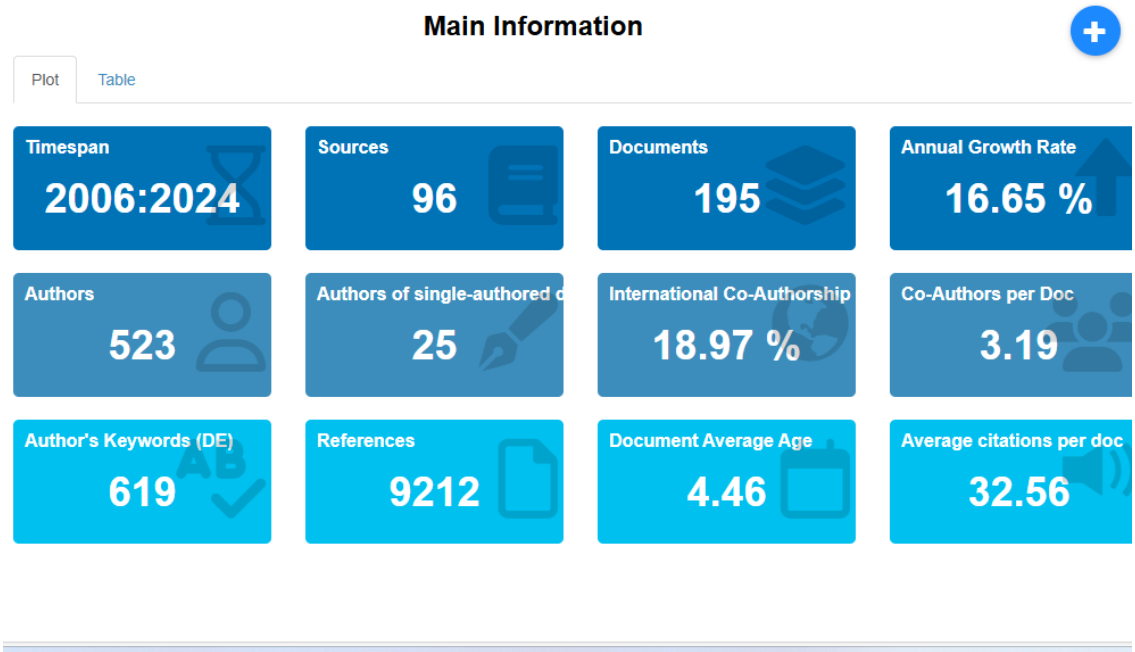

Figure 7
Main Information
Source : Data Processed by Researchers in Biblioshiny

Based on the main information data, it was found that 195 studies had been conducted on the use of augmented reality as a learning medium in elementary schools between 2006 and 2024. The growth in this research was 16.65%, which indicates that this research is experiencing an increasing trend. 523 authors joined this research. There

were 25 single authors included in this research. The growth of articles on an international scale reached a growth of 18.97%. The average citation rate for an article is 32.56, and the average collaboration rate between authors is 3.19

Table 2
Top Ten Authors

No.	Writer	Affiliate	Article	Citations	Average Citations
1	Hwang G.J	Nanyang Technological University	16	9	8
2	Wen Y	Beijing Normal University	15	5	4
3	Lavicza z	Macquarie University	15	4	3
4	Andic B	Maastricht University	14	3	3
5	Chen C-H	National Taiwan University of Science and Technology	11	3	3
6	Cvjeticanin S	Ataturk University	10	3	3
7	Darmi R	Cyprus University of Technology	9	3	3
8	Fokides E	Johannes Kepler University Linz	9	3	3
9	Ismail L	National Taiwan Normal University	9	3	3
10	Jalaludin I	Southern Taiwan University of Science and Technology	8	3	3

Source: Researcher Data Using Biblioshiny

The top ten authors who use AR as a learning medium in elementary schools are shown in Table 3. The table contains a detailed list of the top 10 authors who have contributed in the last 18 years. From this table, it can be seen that information about the names of authors who actively contribute, their home universities, and the number of publications they have produced. Based on the data above, Hwang G.J from Nanyang Technological University is known to have the author with the highest number of scientific publications, namely 16 publications, 9 total citations, and an average citation of 8. Second place is author Wen Y from Beijing Normal University, who has 15 scientific publications, a total of citations of 5, and an average number of citations of 4. The third place is occupied by author Lavicza Z from Macquarie University, who has 15 publications, a total of 4 citations, and an average of 3 citations.

The following is data on scientific publications with the most citations from 2006 to 2024, which are presented in the table below. Citations for each article are calculated based on the keywords used in this research. The following are the top 10 publications that received the most citations overall.

Table 3
Corresponding Author's Countries

COUNTRY	MCP	SCP
China	40	3
Greece	9	1
Australia	6	2
Usa	6	1
Cyprus	5	1
Korea	5	1
Singapore	3	3
Turkey	5	1
United Kingdom	6	0
Spain	3	2
Austria	1	3
Hongkong	1	3
Saudia Arabia	3	1
Chile	2	1
Indonesia	2	1
Malaysia	3	0
Egypt	2	0
Germany	2	0
India	1	1
Luxembourg	0	2

Source: Data processed by researchers from Biblioshiny

From this table, it can be concluded that SCP shows collaboration within one country, while MCP shows collaboration between countries. China is the country with the largest number of collaborations between countries in Augmented Reality research. Indonesia is at level 15, with the number of AR research collaborations as a learning media in elementary schools in the country being 1 collaboration and collaborations abroad totaling 2. The large role of researchers in the scope of applying AR as a learning media in elementary schools proves that AR as a learning media is still relevant today. In the field of AR applications, researchers contribute to applications of learning media in elementary schools, and the citations in each article show research trends in AR as a learning media that are relevant to date.

Table 4
Most Local Cited Documents

Document	DOI	Year	Local Citations	Global Citations
Radu I, 2014, Pers Ubiquitous Comp	10.1007/s00779-013-0747-y	2014	12	561
Chiang Thc, 2014, Educational Technology And Society		2014	6	408
Wen Y, 2021, Educ Technol Res Dev	10.1007/s11423-020-09893-z	2021	4	66
Laine Th, 2016, Educ Technol Res Dev	10.1007/s11423-015-9419-0	2016	4	74
Liu T-Y, 2009, Educational Technology And Society		2009	4	155
Efstathiou I, 2018, Interact Learn Environ	10.1080/10494820.2016.1276076	2018	4	70
Yousef Amf, 2021, J Comput Assisted Learn	10.1111/jcal.12536	2021	3	42
Solak E, 2016, Croat J Educ	10.15516/cje.v18i4.1729	2016	3	40
Gecu-Parmaksiz Z, 2019, Br J Educ Technol	10.1111/bjet.12740	2019	3	42
Fuchsova M, 2019, Eur J Contemp Educ	10.13187/ejced.2019.1.92	2019	3	59

Source: Personal Document

The table above shows that the writer who has the most international citations is Radu I, who published his article in 2014 regarding the use of augmented reality as a learning medium. The second author is Chiang Thc, with the article titled An Augmented Reality-based Mobile Learning System to Improve Students' Learning Achievements and

Motivations in Natural Science Inquiry Activities, which was published at the International Forum of Educational Technology & Society, National Taiwan Normal University, Taiwan. Wen Y is the third author who has the most citations with the article titled Augmented Reality Enhanced Cognitive Engagement: Designing Classroom-based Collaborative Learning Activities for Young Language Learners, which discusses an AR-supported Chinese character learning game designed for young students and investigates its effect on cognitive engagement students in classroom learning. Laine Th is ranked as the fourth author who has the highest number of international citations with the publication title Science Spots AR: a platform for science learning games with augmented reality which focuses on creating learning in a real-world context and by bridging virtual and real-world content with augmented reality (AR). This publication combines these ideas into the Science Spots AR platform, where context-sensitive storytelling science learning games are created.

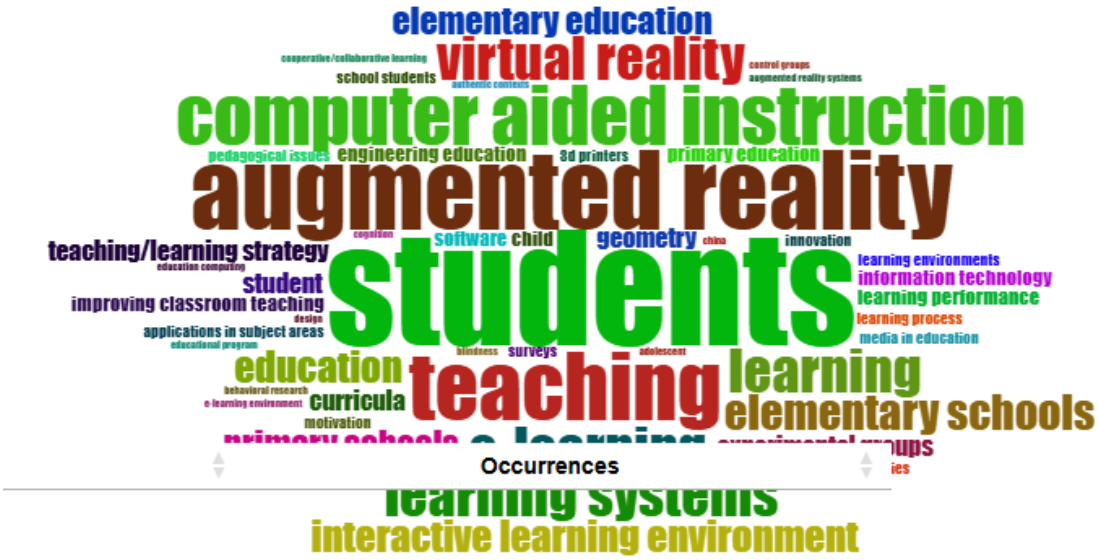

Figure 8
Visualization of the most keywords
Source : Data processed by researchers in Biblioshiny

The keywords analyzed using bibliophily resulted in the word student being the most frequently encountered word, namely 29, followed by the word Augmented Reality, with a total of 20. Teaching was the word that appeared third most often, with a total of 17. Followed by the word Computer-aided instruction with a total of 20. 15, and e-learning, learning, learning systems, and virtual reality are as many as 11. Then, it will be followed by the keywords elementary school and education. Based on clustering data,

students said augmented reality, teaching, computer-aided instruction, e-learning, learning systems, virtual reality, elementary school, and interactive learning environments. Then, in the second cluster, learning, information technology, software, and innovation are involved. Then, the third, fourth, and fifth clusters, respectively, consist of the keywords education, cognitive, and control group.

Conclusion

Based on the discussion, it was concluded that China and Taiwan are two countries with high levels of productivity, and this has earned them the title of influential country in the publication of the scope of Augmented Reality media use in elementary schools. This research trend experienced a significant increase when the disease outbreak in 2022 hit and had an impact, one of which was on the field of teaching. Students and Augmented Reality are the keywords that appear most often. However, based on the author's interpretation, the keywords used in the research still do not relate to other variables. Research regarding the use of augmented reality as a learning medium in elementary schools needs to be developed by connecting various additional variables such as motivation and students' level of thinking, or it can even extend to real learning.

This gap is a trigger for future researchers to carry out more in-depth research. Indonesia, specifically Sebelas Maret State University, has been included as an organization or institution that writes publications regarding this trend, but the number is still very limited. Various institutions, both universities and other organizations in Indonesia, must be more productive in exploring and conducting studies, especially in this discussion, because digital innovation will continue to develop rapidly, and we must not be left behind by technology. Technology must go hand in hand with humans and become the greatest benefit in education.

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Sisca Rahmadonna -
Ruqoyyah Amilia Andan -

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