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From Theory to Immersion on Ten Years of Augmented Reality in Physics Learning: A Comprehensive Bibliometric Analysis

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ABSTRACT

The increasing use of Augmented Reality (AR) in physics learning has led to a growing body of research, yet studies systematically mapping its development remain limited. This study aims to examine the publication trends and research patterns of AR-based physics learning from 2013 to 2023 using a bibliometric approach. A total of 260 documents were retrieved from the Scopus database and analyzed using VOSviewer and Microsoft Excel. The analysis covered annual publication growth, document types, publication language, leading countries, institutions, authors, and research networks. The results show that research on AR-based physics learning has increased steadily, reaching its peak in 2022. Most of the publications are conference papers, and all documents were published in English. Indonesia appears as the most productive country, with Jakarta State University and Bakri identified as the leading institution and author, respectively. Network visualization reveals eight interconnected research clusters, indicating strong collaboration and thematic linkages in this field. These findings provide an overview of the global development of AR-based physics learning research and may serve as a reference for future studies in identifying research directions and collaboration opportunities.

INTRODUCTION

From 2001 to the present, the world has entered the 21st century, a time of rapid technological and information development (Kristiani et al., 2017). The development of science and technology in the era of the Industrial Revolution 4.0 presents a major challenge for humanity and can help develop world education in Indonesia. Education in the era 4.0 is one way to use the phenomenon of digitalization in everyday life, where in education 4.0, there is interaction between humans and machines in solving problems and finding new innovations (Susanti, 2019; Badu & Ikbal, 2020). Based on the Republic of Indonesia Law No. 20 of 2003, it states that Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have spiritual and religious strength, self-control, personality, intelligence, noble morals, and skills needed by themselves, society, nation, and state. According to Ki Hajar Dewantara, education is an effort to advance the growth of children's character (inner strength and character), mind, and body. Education, as a process of developing human resources to acquire optimal social skills and individual development, establishes a strong relationship among the individual, the public, and the cultural environment (Abraham, 2013).

One of the uses of technology in education is the use of Augmented Reality technology in learning. Augmented Reality (AR) is a technology that visually enhances the real-world environment by projecting computer-generated information into the eye. With Augmented Reality technology, users can see the real world around them with the addition of virtual objects generated by a computer or its supporting devices. Augmented Reality can be used on mobile phones running the Android operating system because the Android system supports the digital-era learning strategies used by teachers today. The use of AR as a learning medium can enhance the learning process by making it more interactive and interesting, thereby improving students' critical thinking skills (Retnaningtiyas et al., 2021). The use of Augmented Reality technology in the learning process has advantages and disadvantages. Ilmawan Mustaqim et al. (2017) stated that Augmented Reality (AR) offers several key advantages, including enhanced interactivity, high

operational efficiency, and broad cross-media implementation. Additionally, it features simplified object modeling, minimal asset requirements, cost-effective production, and user-friendly operation. Meanwhile, according to Mustaqim et al. (2017), Augmented Reality has several drawbacks, including sensitivity to viewing angles, a limited number of developers, and high memory requirements on the host device.

Physics is a science that discusses and studies the basic principles of the universe and can also be said to be a science that discusses the most fundamental world (Serway, 2014). Physics is one of the fundamental sciences because it is needed to study other fields. However, physics is still considered difficult to understand. In learning physics, students are required to engage in experimental activities to develop their thought processes because, in essence, they do not study the finished product or final result (Hikmah & Jauhariyah, 2021; Nadiya et al., 2016). Based on the description above, Augmented Reality can be utilized in the learning process because it supports more interactive learning, one example being Physics Learning. Augmented Reality is one technology currently under development; teachers must be able to adapt to these developments.

Based on several relevant studies, it was found that the development of Augmented Reality-based Physics Learning can improve conceptual understanding (Ismail, 2021; Chaeranti et al., 2018; Sumardani et al., 2013), improve the flow of student experience (Jie Chao et al., 2015). Several studies also show that Augmented Reality-based physics learning can improve learning outcomes (Maria, 2014; Tzung-Jin Lin et al., 2013; Hsin-Yi Chang et al., 2014; Su Cai et al., 2013), increase learning motivation (Anabel et al., 2015; Kusniati et al., 2021; Budiarti et al., 2021), and improve performance assessment (Murat, 2016; Ibisono et al., 2020; Socrates & Mufit, 2021; Cai et al., 2017). Several studies have shown that Augmented Reality-based physics learning positively influences the learning process. This study conducts a bibliometric analysis of the implementation of Augmented Reality (AR)-based physics learning, aiming to provide a comprehensive description of global developments from 2013 to 2023, using VOSviewer to map distributions and present statistical data. The research is guided by several key questions: (a) how the development of publications in this field is characterized in terms of document quantity, types, and language; (b) which countries, institutions, and researchers rank within the top ten publications both globally and specifically in Indonesia; (c) how the thematic development map is visualized through VOSviewer ; and (d) how the author-based visualization maps the collaboration and contribution networks within the field.

RESEARCH METHOD

This research is a literature review that analyzes the implementation of Augmented Reality-based physics learning from 2013 to 2023 using a bibliometric method with a qualitative approach. Bibliometrics refers to the analysis of scientific literature using statistical and mathematical techniques (Desiriah & Setyarsih, 2021; Ningsari et al., 2021; Yanuarti & Suprapto, 2021). The term “bibliometrics” was first introduced by Alan Pritchard in 1969 to describe studies that quantitatively analyze written communication in science (Pritchard, 1969; Parra-González et al., 2020).

This study used secondary data retrieved from the Scopus database. The data were collected using the following search string: TITLE-ABS-KEY (“augmented reality” AND “learning”) AND (PUBYEAR > 2013 AND PUBYEAR < 2023), which was used to identify publications on the use of augmented reality in learning during 2013–2023. The retrieved records were exported from Scopus in CSV format for further processing. Microsoft Excel was used to organize the data into tables and graphs, while VOSviewer was employed to visualize bibliometric networks and publication maps. The following flowchart summarizes the bibliometric research procedure.

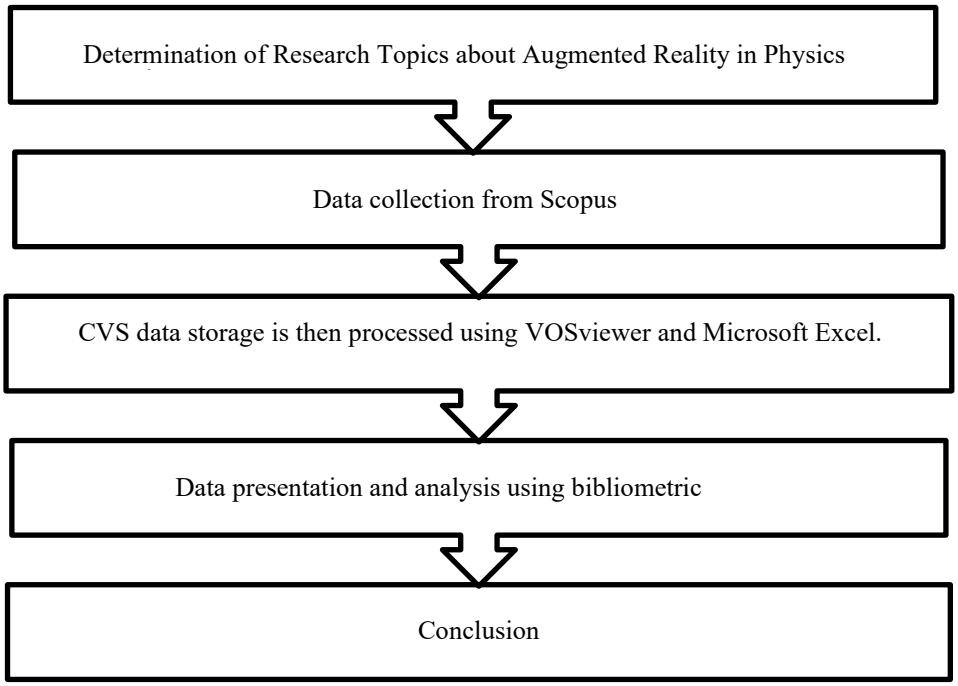


Figure 1. Flowchart Bibliometric Analysis

Data were obtained from Scopus using the keyword "Augmented Reality in Learning" for the period 2013-2023, reflecting the technology development era in learning. According to Moed et al. (2016), Scopus provides more consistent, curated, and easily exported data, making it more suitable for bibliometric analysis and mapping using VOSviewer. The period 2013–2023 was selected because it represents a complete and stable ten-year publication window. Data for 2024 and later years were not fully indexed in Scopus at the time of data collection, potentially leading to incomplete and biased bibliometric results. The data obtained from Scopus were saved in CSV format and analyzed using Microsoft Excel and VOSviewer to generate tables, graphs, and bibliometric maps (Desiriah & Setyarsih, 2021; Yanuarti & Suprapto, 2021). Data mapping was employed to review the literature statistically. The data obtained were mapped into several categories, namely: (a) the development of publications on the implementation of Augmented Reality-based physics learning in terms of the number, type, and language of published documents; (b) Countries, institutions, and researchers included in the top ten publications on the implementation of Augmented Reality-based physics learning in the world and Indonesia; (c) VOSviewer visualization of the publication development map; (d) VOSviewer visualization of the publication development map based on authors.

RESULTS AND DISCUSSION

Results Publication, Source Language, and Document Type

Based on the Scopus database with the keyword "Augmented Reality in Physics Learning", there are 260 documents found related to research on Augmented Reality-based physics learning in the period 2013-2023. The graph of the development of publications on Augmented Reality-based physics learning research is shown in Figure 2. From the figure, it is evident that research on Augmented Reality-based physics learning is increasing. Starting in 2013, there were 3 research publications, and this number increased twofold in 2015. The graph continues to increase every year, until in 2022, research on Augmented Reality-based physics learning is at its highest position with 52 publications. According to the Scopus database, which amounts to 260 documents on Augmented Reality-based physics learning publications, all publications use English

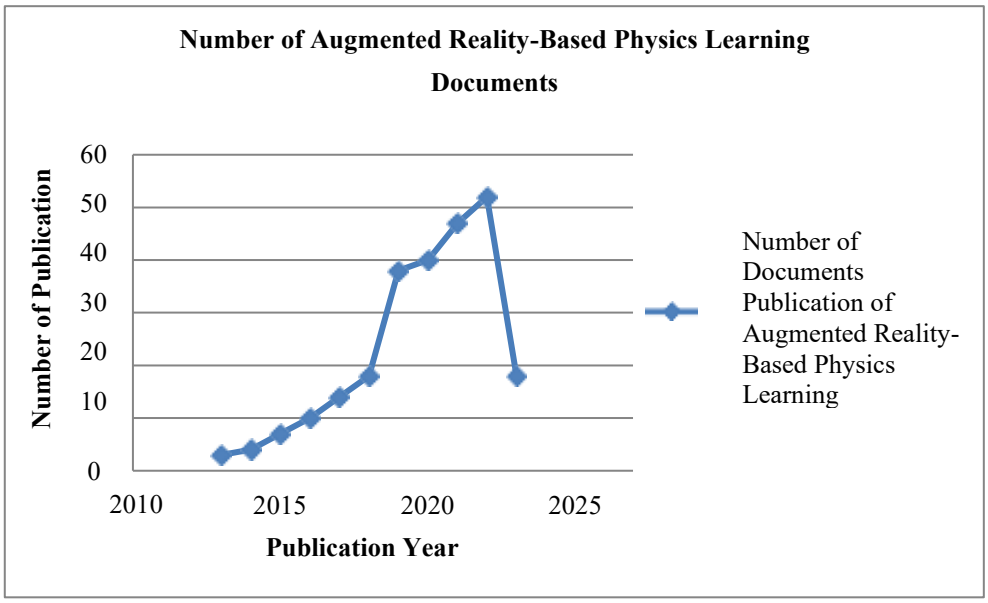


Figure 2. Amount Document Publication Learning Physics Based Augmented Reality in 2013-2023 in Scopus

The number of publications by publication type is shown in Figure 3. The publication document type is dominated by *conference papers* with 158 documents. This is followed by articles, *conference reviews*, and *book chapters,* which are the least published documents.

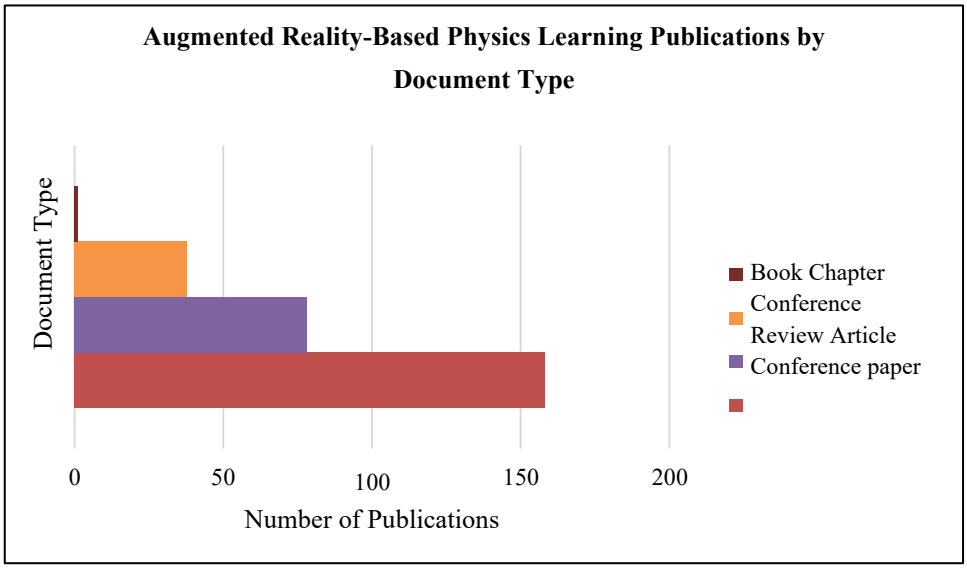


Figure 3. Publication Learning Physics Based Augmented Reality from 2013 to 2023 Based on Publication Document Type in Scopus

According to the Scopus database, Indonesia is the country with the most publications on Augmented Reality-based physics learning, with 61 publications during 2013-2023. This is followed by the United States with 36 published documents. The top ten countries that published publications on Augmented Reality-based physics learning are shown in Figure 4. Indonesia has the most publications. Position first globally, with two institutions in Indonesia ranked first and fifth in the top ten institutions publishing research on Augmented Reality-based physics learning. The number of published documents from the top ten institutions conducting research on Augmented Reality-based physics learning during 2013-2022 is shown in Figure 5. Jakarta State University is in first place with 32 publications, and Surabaya State University is in fifth position with 5 publications.

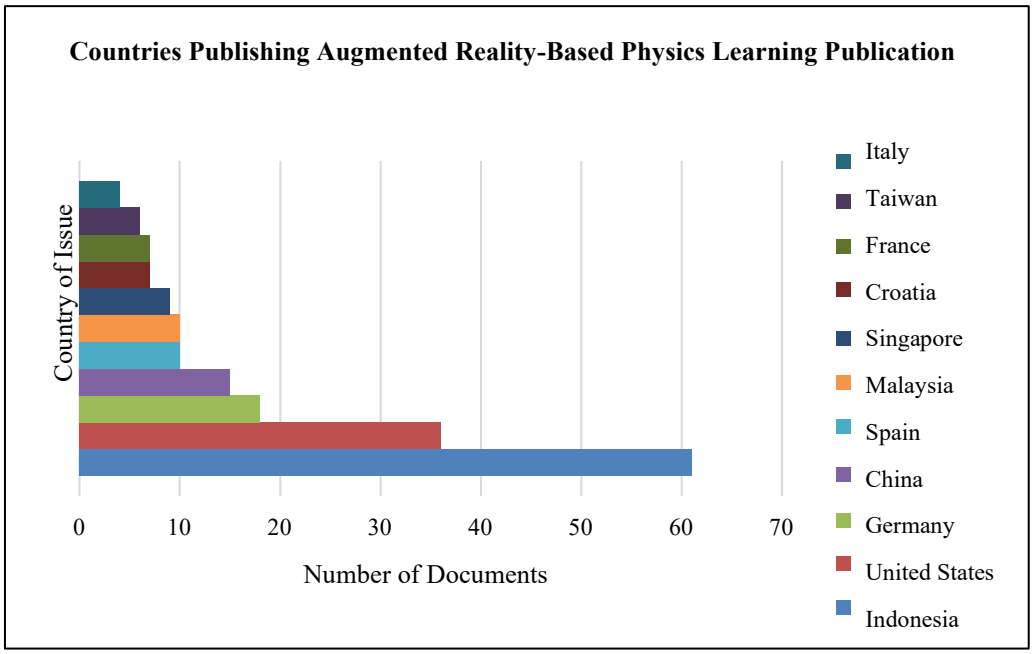


Figure 4. Country Publisher Publication Learning Physics Based Augmented Reality Scopus Indexed 2013-2023

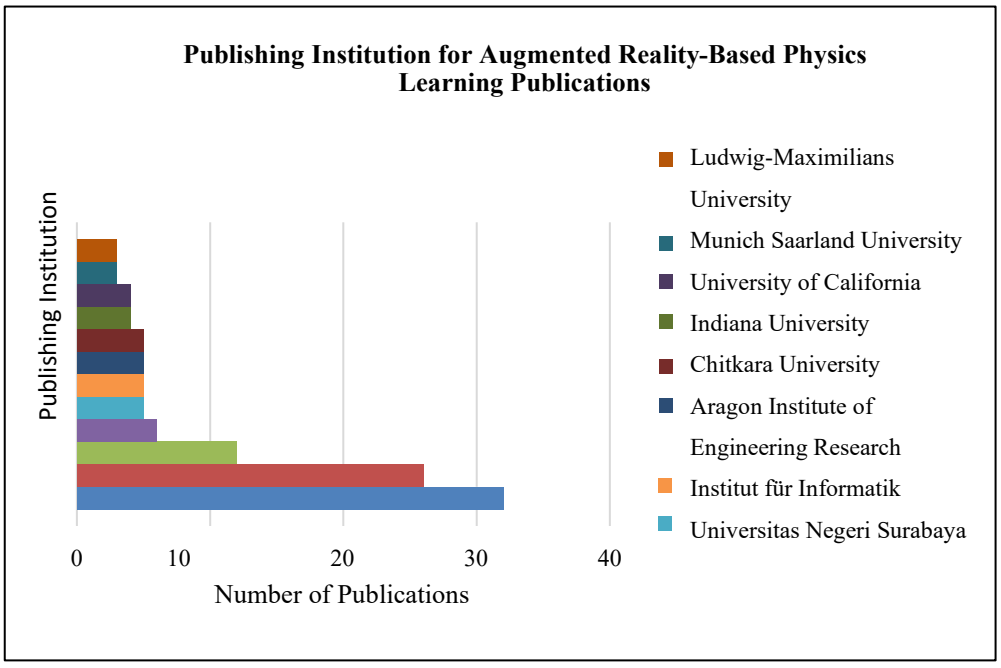


Figure 5. Institution Publisher Publication Learning Physics Based Augmented Reality Scopus Indexed 2013-2023

The productivity of the top ten researchers in Augmented Reality-based physics learning in the period 2013-2023 indexed by Scopus is shown in Figure 6. Researchers from Indonesia, including Bakri, have published 14 documents and ranked first in research productivity. Followed by writer Muliyati, Kuhn, Kapp, Thees, Radu, Schneider, Vidak, Suprapto, and Permana.

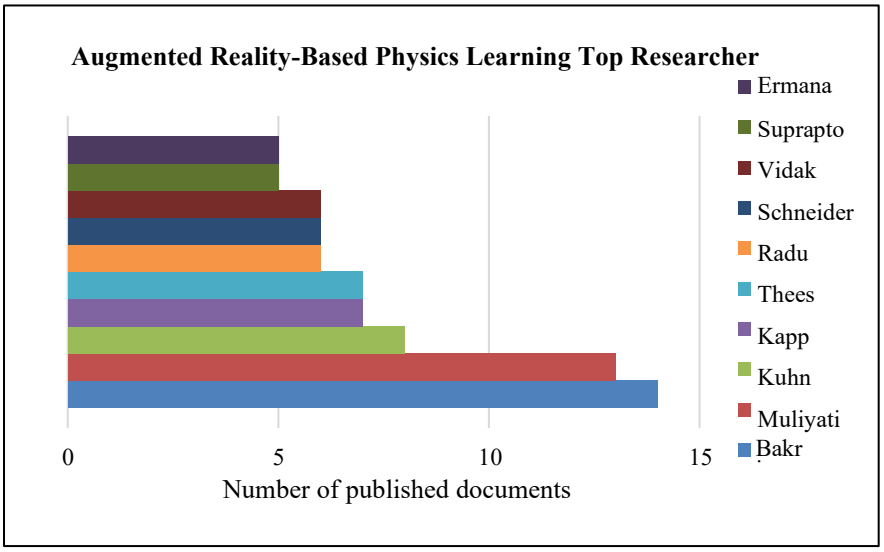


Figure 6. Productivity Researchers Learning Physics-Based Augmented Reality Year 2013-2023 Scopus Indexed

Visualization Trends Study Learning Physics Based Augmented Reality Assisted by VOSviewer Software Indonesia

Figure 7 is a visualization of research trends in Augmented Reality-based physics learning assisted by VOSviewer software using the Scopus database of 260 documents related to research in Augmented Reality-based physics learning in 2013-2023. Based on visualization found a number of parameter or relatedness between subject on learning variables physics Augmented-based Reality, In picture It is known that Augmented Reality-based physics learning in the world indexed by Scopus has produced four color clusters, namely the first cluster is red, the second is green, the third is blue and the fourth is yellow, with the dominant color clusters being red, yellow and blue.

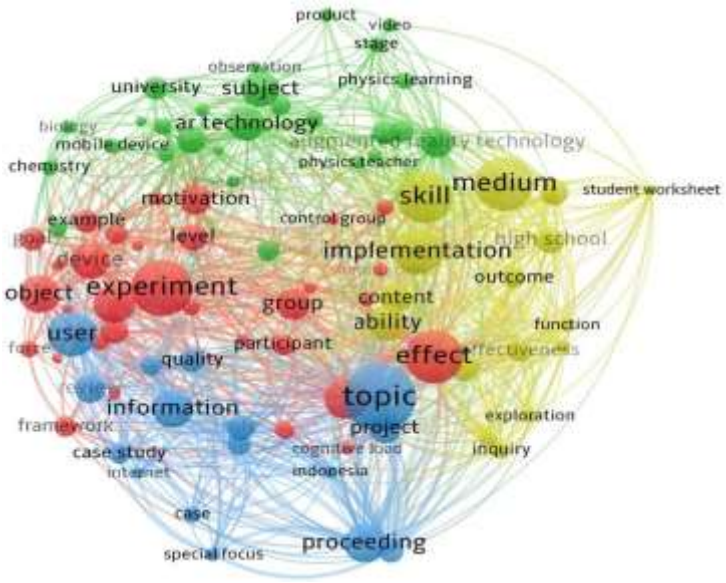


Figure 7. Visualization VOSviewer Map Development Publication Learning Physics Augmented Reality-Based Research in 2013-2023 in Scopus

Based on the image, the green cluster represents a subject classification of issues encountered in Augmented Reality-based physics learning. This is reinforced by the presence of the subjects of mobile devices, Pandemic, Physics Teacher, and so on. Meanwhile, the yellow cluster classifies subjects for developing Augmented Reality-based physics learning in the school environment. Matter. This can be

proven with existing subjects, such as high school, implementation, effectiveness, ability, student worksheet, and so on. The blue cluster classification is based on the development of Augmented Reality-based physics learning in the community. This opinion can be strengthened by the discovery of the words Indonesia and user in the analysis. VOSviewer . On classification cluster red found subject experiment, group, and interactions that can be concluded from the implementation of Augmented Reality are used to train students' science process abilities.

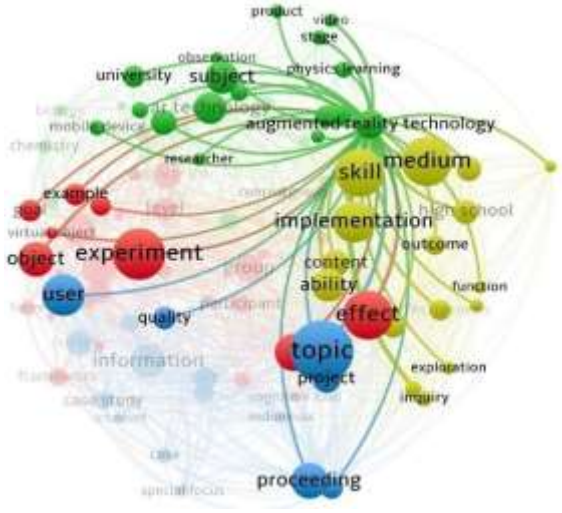
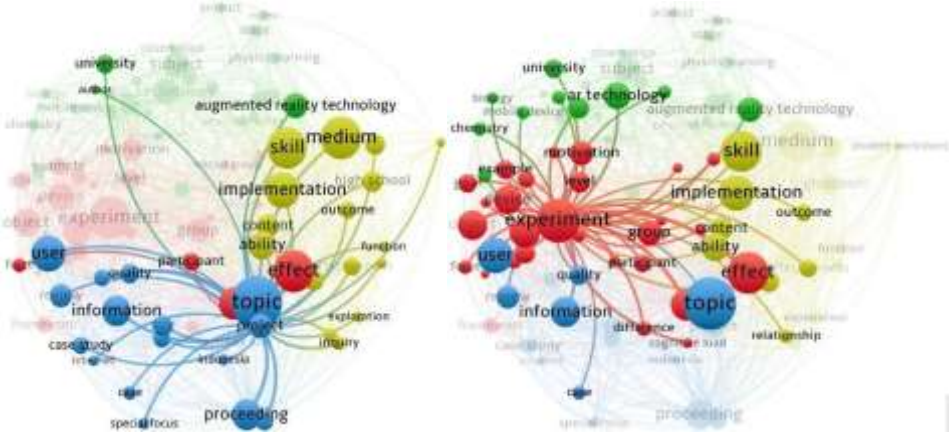


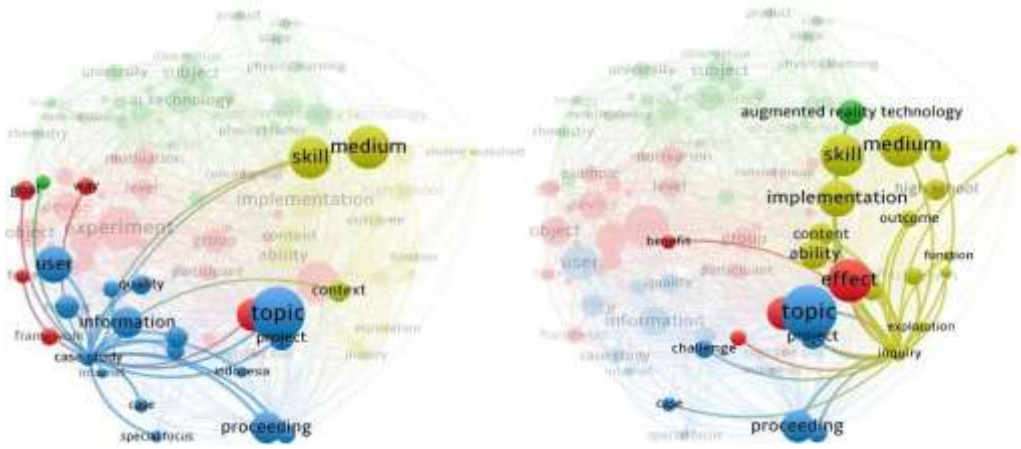
Figure 8. Visualization VOSviewer Augmented Reality Technology in Learning Physics

Based on Figure 8, Augmented Reality Technology is related to physics learning, the learning process, and mobile devices. Augmented reality technology has been applied in education, especially in physics instruction. AR technology is utilized in Android-based learning media (Ambarwulan & Muliyati, 2016).

Based on a visualization of Augmented Reality-based physics learning trends, the author found that the Augmented Reality approach is implemented through various models in physics learning. Figure 9 is a VOSviewer visualization of several learning models: project models, experiments, case studies, and inquiry. Research conducted by Rosida in 2019 shows that implementing a guided inquiry learning model enriched with augmented reality enhances learning. Reality is effective for increasing results. Study participants are educated. Then, in the year 2021, there is Bramastia, which found that implementation technology, Augmented Reality, can train students' thinking skills.



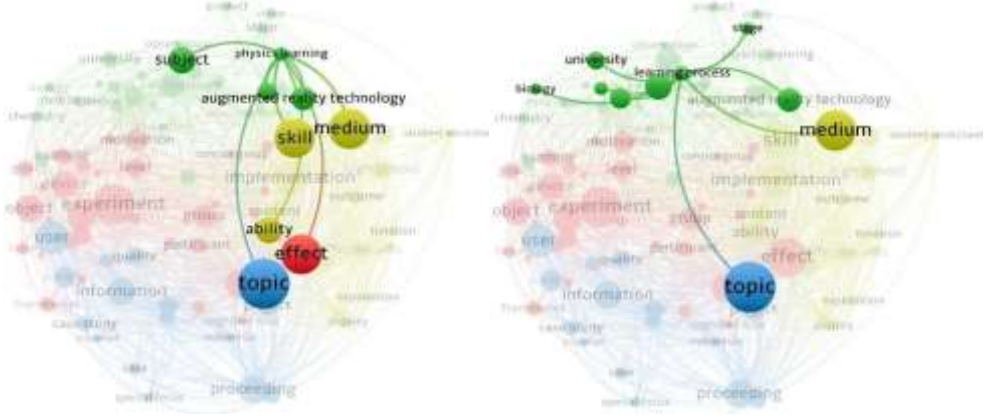
(a) (c)



(b) (d)

Figure 9. Visualization VOSviewer with Model (a) Project (b) Experiment (c) Studies Case (d) Inquiry

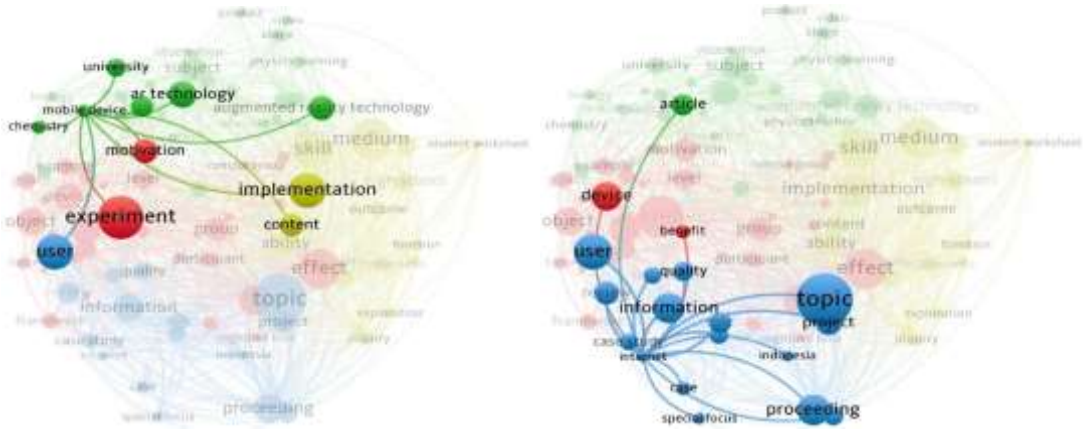
Based on Figure 10, Augmented Reality-based physics learning at the school level (both the learning content and the learning process) is also used as a preparation for students to go to college. Based on the VOSviewer visualization, both physics course subjects and the learning process are in the less complex category, as evidenced by the minimal relationships between the subjects. However, Augmented Reality-based physics learning is used to improve the skills of science. As shown in the picture, it is known that physics learning has a relationship with skills, or in some sources, the implementation of Augmented Reality is used to train each student to apply their knowledge in everyday life or the world of work.



(a) (b)

Figure 10. Visualization on VOSviewer (a) Subject Physics Learning (b) Learning Process

Based on the VOSviewer subject analysis shown in Figure 11, AR technology relies on multiple connection methods, including Wi-Fi and the internet. However, learning that relies on an internet connection can only be optimally utilized in urban areas or areas with good internet access. Matter. This, of course, is not valid for regions with poor internet connectivity. Augmented Reality (AR) technology is an animation technology that can make learning more fun when used with a smartphone. The use of AR technology is expected to shape children's tendency toward direction-based activity learning, with a positive impact. Maximizing the role of smartphones as a learning medium is an excellent way to manage children's playfulness and transform it into a fun, independent learning activity.



(a) (b)

Figure 11. Visualizations on VOSviewer (a) Mobile Device Subject (b) Subject Internet

Visualization of Augmented Reality-Based Physics Learning Research Trends Assisted by VOSviewer Software Based on the Author

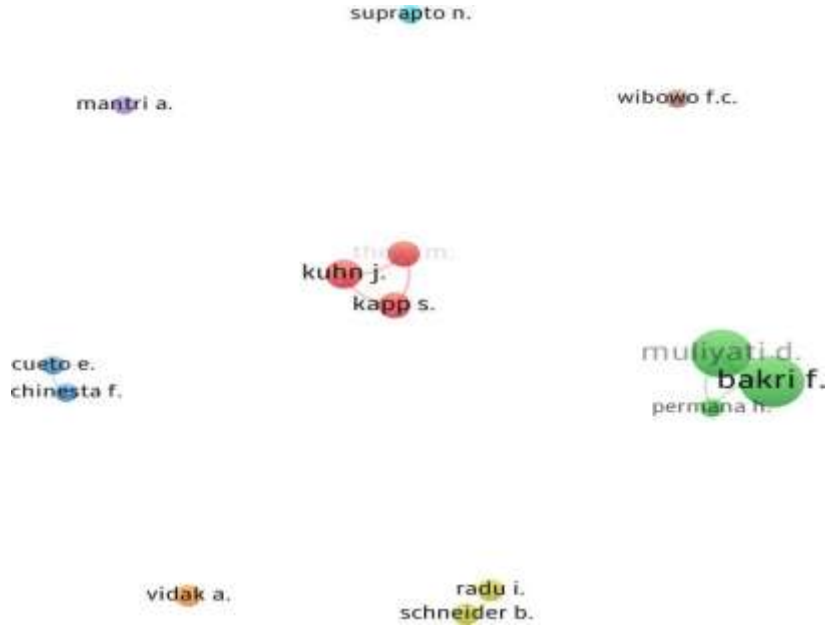


Figure 12. Visualization VOSviewer Map Development Publication Learning Physics Augmented Reality-Based Research in 2013-2023 in Scopus

Figure 12 shows a visualization of the development map of Augmented Reality–based physics learning research publications based on researchers. The figure presents leading researchers and their clusters, provided that each researcher has published at least five documents. The visualization shows that Bakri, Muliyati, and Kapp are the most dominant researchers. Bakri has published 14 documents with a link strength of 18, while Muliyati has also published 14 documents with the same link strength. Huang has published 13 documents with a link strength of 17, whereas Kapp has published 7 documents with a link strength of 14. These results indicate that the research conducted by Bakri, Muliyati, and Kapp is closely related.

Based on data from VOSviewer, the visualization of the development map for Augmented Reality–based physics learning publications shows eight clusters. These clusters are presented in Table 1, which shows the Augmented Reality–based physics learning research clusters published in Scopus from 2013 to 2023, organized by researchers.

Table 1. Cluster Study Physics Learning Based Augmented Reality in Scopus.

Cluster	Researcher Name
1	Kapp
2	Bakri
3	China
4	Radu
5	Minister
6	Suprapto
7	Vidak
8	Wibowo

CONCLUSION

This bibliometric study investigated the development of Augmented Reality (AR)–based physics learning research from 2013 to 2023, addressing four research questions. First, in terms of publication trends, document types, and language, the results show that research on AR-based physics learning has grown significantly over the last decade, reaching its peak in 2022 with the highest number of publications indexed in Scopus. The dominant document types were conference papers, followed by journal articles, conference reviews, and book chapters, and all publications were written in English.

Second, regarding the top contributing countries, institutions, and researchers, Indonesia emerged as the most productive country in AR-based physics learning research. Jakarta State University ranked as the most productive institution, while Bakri was identified as the most prolific researcher, indicating Indonesia's strong contribution to this field of research.

Third, the VOSviewer visualization of the publication development map revealed that AR-based physics learning research is clustered into several thematic groups: physics learning, learning processes, mobile devices, and educational applications. This indicates that AR technology has been widely applied in education, particularly in physics learning, using various instructional models such as project-based learning, experiments, case studies, and inquiry-based learning.

Fourth, the VOSviewer author-based visualization showed that researchers such as Bakri, Muliyati, and Kapp play central roles in the research network. The existence of eight interconnected clusters indicates a strong collaboration structure and thematic linkage among researchers in AR-based physics learning.

Overall, this study demonstrates that AR-based physics learning is a rapidly developing research area with strong international and national contributions, especially from Indonesia. These findings provide important implications for future researchers to further explore and develop AR-based physics learning to enhance learning effectiveness and innovation in physics education.

REFERENCES

Afifah, S. N., Liliawati, W., & Purwana, U. (2020). Kelayakan konten dan tampilan bahan ajar augmented reality pada materi teori kinetik gas. *WaPFi (Wahana Pendidikan Fisika)*, 5(1), 130–134. https://doi.org/10.17509/wapfi.v5i1.23448

Agustina, M., Yushardi, & Lesmono, A. D. (2018). Analisis penguasaan konsep-konsep teori kinetik gas menggunakan taksonomi bloom berbasis hots pada siswa kelas XI IPA di MAN Jember. *Jurnal Pembelajaran Fisika*, 7(4), 334–340. https://doi.org/10.19184/jpf.v7i4.9654

Akib, E., & Muhsin, M. A. (2019). Assessment of teaching in 21st century. *Journal of Physics: Conference Series,* 1179 (1). https://doi.org/10.1088/1742- 6596/1179/1/012065

Cai, S., Chiang, F.-K., Sun, Y., Lin, C., & Lee, J. J. (2016). Applications of augmented reality-based natural interactive learning in magnetic field instruction. *Interactive Learning Environments*, 25(6), 778–791. https://doi.org/10.1080/10494820.2016.1181094

Chaeranti, S. N., Bakri, auzi, & Permana, A. H. (2018). Modul yang dilengkapi dengan teknologi augmented reality: cara mudah belajar fisika untuk konsep dan fenomena kuantum di SMA Kelas XII.

Prosiding Seminar Nasional Fisika (E-Journal) SNF2018 UNJ, SNF2018-PE-118-SNF2018-PE-128. https://doi.org/10.21009/03.snf2018.01.pe.16

Chen, C., & Wang, C.-H. (2015). Employing augmented-reality-embedded instruction to disperse the imparities of individual differences in earth science learning. *Journal of Science Education and Technology*, 24(6), 835–847. https://doi.org/10.1007/s10956-015-9567-3

Datur, I. S., Yuliati, L., & Mufti, N. (2017). Kemampuan pemecahan masalah materi fluida statis melalui pembelajaran berbasis masalah berbantuan thinking map. *Jurnal Inspirasi Pendidikan*, 7(2), 118–127. https://doi.org/10.21067/jip.v7i2.1746

Destianingsih, E., Pasaribu, A., & Ismet. (2013). Pengaruh model problem-based learning terhadap kemampuan pemecahan masalah siswa pada pembelajaran fisika kelas XI di SMA Negeri 1 Tanjung Lubuk. *Jurnal Inovasi Dan Pembelajaran Fisika*, 1–6. https://doi.org/10.36706/JIPF.V3I1.3423

Badu, T. K., & Ikbal, M. S. (2020). Differences in students' understanding of physics concepts through the problem-based learning model and concept-based interactive learning). *Uniqbu Journal of Exact Sciences*, *1*(2), 23–30. https://doi.org/10.47323/ujes.v1i2.27

Fauziah, R., Abdullah, A. G., & Hakim, D. L. (2017). pembelajaran saintifik elektronika dasar berorientasi pembelajaran berbasis masalah. *Innovation of Vocational Technology Education*, 9(2). https://doi.org/10.17509/invotec.v9i2.4878

Gok, T. (2010). The general assessment of problem-solving processes and metacognition in physics education. *EJPCE - Eurasian Journal of Physics and Chemistry Education*, 2(2), 110–122. https://doi.org/10.51724/ijpce.v2i2.186

Hegde, B., & Meera, B. N. (2012). How do they solve it? An insight into the learner's approach to the mechanism of physics problem solving. *Physical Review Special Topics - Physics Education Research*, 8(1). https://doi.org/10.1103/physrevstper.8.010109

Hidayah, S. N., Pujani, N. M., & Sujanem, R. (2018). Implementasi model problem-based learning untuk meningkatkan aktivitas belajar dan kemampuan pemecahan masalah fisika siswa kelas X MIPA 2 MAN. *Jurnal Penelitian Pendidikan Fisika,* 8(1). https://doi.org/10.23887/jjpf.v8i1.20575

Hudha, M. N., Aji, S., & Rismawati, A. (2017). Pengembangan modul pembelajaran fisika berbasis problem based learning untuk meningkatkan kemampuan pemecahan masalah fisika. *SEJ (Science Education Journal)*, 1(1), 36–51. https://doi.org/10.21070/sej.v1i1.830

Kristiani, K. D., Mayasari, T., & Kurniadi, E. (2017). Pengembangan asesmen keterampilan berpikir kreatif siswa SMP Negeri 5 Madiun pada materi cahaya dan alat optik. *Prosiding SNFA (Seminar Nasional Fisika Dan Aplikasinya)*, 2, 102. https://doi.org/10.20961/prosidingsnfa.v2i0.16374

Ismail, A. 2021. Penerapan model pembelajaran problem solving berbantuan augmented reality untuk meningkatkan pemahaman konsep mahasiswa pada mata kuliah fisika umum. *Jurnal Petik*, 7(2), 87–92. https://doi.org/10.31980/jpetik.v7i2.1017

Kusniati, et al. 2021. Efektivitas penggunaan aplikasi edumu pada pembelajaran fisika terhadap motivasi belajar peserta didik kelas XI IPA di SMA Muhammadiyah 1 Unismuh Makassar. 10(1), 114–122. http://dx.doi.org/10.24127/jpf.v10i1.4915

Muntahanah, M., Toyib, R., & Ansyori, M. (2017). Penerapan teknologi augmented reality pada katalog rumah berbasis android (studi kasus PT. Jashando Han Saputra). *Pseudocode,* 4(1), 81–89. https://doi.org/10.33369/pseudocode.4.1.81-89

Mustaqim, I. (2016). Pemanfaatan augmented reality sebagai media pembelajaran. *Jurnal Pendidikan Teknologi Dan Kejuruan,* 13(2), 174. https://doi.org/10.23887/jptk.v13i2.8525

Mustaqim, I., & Kurniawan, N. (2017). Pengembangan media pembelajaran berbasis augmented reality. *Jurnal Edukasi Elektro*, 1(1), 36–48. https://doi.org/10.21831/jee.v1i1.13267

Socrates, T. P., & Mufit, F. (2022). The Effectivenes of applocation of physics learning media based on augmented reality: Literature study. *EduFisika: Jurnal Pendidikan Fisika*, *7*(1), 96–101. https://doi.org/10.59052/edufisika.v7i1.19219

Periera, S. (2017). Culture recognition through sociology learning for Timor Leste students. *ISLLAC. ISLLAC: Journal of Intensive Studies on Language, Literature, Art, and Culture,* 1(1), 119–139. https://doi.org/10.17977/um006v1i12017p119

Pistanty, M.A., Sunarno, W., & M. (2015). Pengembangan modul IPA berbasis problem based learning untuk meningkatkan kemampuan memecahkan masalah pada materi polusi serta dampaknya pada manusia dan lingkungan siswa kelas XI SMK Pancaila Purwodadi. *Jurnal FKIP UNS* 4(2). https://doi.org/10.20961/inkuiri.v4i2.9574

Siahaan, A. D., Medriati, R., & Risdianto, E. (2019). Pengembangan penuntun praktikum fisika dasar II menggunakan teknologi augmented reality pada materi rangkaian listrik dan optik geometris. *Jurnal Kumparan Fisika*, 2(2), 91–98. https://doi.org/10.33369/jkf.2.2.91-98

Tasoğlu, A. K., & Bakaç, M. (2014). The effect of problem-based learning approach on conceptual understanding in teaching of magnetism topics. International Journal of Physics and Chemistry Education, 6(2), 110–122. https://doi.org/10.51724/ijpce.v6i2.60

Trianto. (2017). Model-model pembelajaran inovatif berorientasi konstruktivistik. In Jakarta: Bumi Aksara.

Vari, Y., & Bramastia, B. 2021. Pemanfaatan augmented reality untuk melatih keterampilan berpikir abad 21 di pembelajaran IPA. *INKUIRI: Jurnal Pendidikan IPA,* 10(2), 132. https://doi.org/10.20961/inkuiri.v10i2.57256

Yudhanegara, M. R., & Lestari, K. E. (2014). Meningkatkan kemampuan representasi beragam matematis siswa melalui pembeajaran berbasis masalah terbuka. *Jurnal Ilmiah Solusi,* 1(4), 97–106. https://doi.org/10.35706/solusi.v1i03.60

Zahra, I. R., Matius, B., & Hakim, A. (2018). Penerapan model problem-based learning untuk meningkatkan kemampuan pemecahan masalah siswa SMA pada materi gerak harmonik sederhana. *Vidya Karya*, 33(1), 21. https://doi.org/10.20527/jvk.v33i1.5389

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