

# Bibliometric Analysis: Augmented Reality Research Trends in Indonesia in Biology Learning

Asrizal Wahdan Wilsa<sup>1\*</sup>, Sutikno<sup>2</sup>, Dyah Rini Indriyanti<sup>2</sup>, Jaja<sup>3</sup>

<sup>1</sup>Elementary School Teacher Education Program, STKIP Nahdlatul Ulama Indramayu, Indramayu, Indonesia.

<sup>2</sup>Natural Science Education, Postgraduated Program, Universitas Negeri Semarang, Semarang, Indonesia.

<sup>3</sup>Faculty of Education and Science, Universitas Swadaya Gunung Jati, Cirebon, Cirebon, Indonesia.

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Corresponding Author:

Asrizal Wahdan Wilsa

[asrizalwahdanwilsa@stkipnu.ac.id](mailto:asrizalwahdanwilsa@stkipnu.ac.id)

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**Abstract:** This article aims to analyze the trend of Augmented Reality (AR) research in Indonesia in learning biology through bibliometric analysis sourced from Google Scholar and Scopus in 2013-2022. The sample articles obtained were 223 articles. The results show that AR research in biology learning in Indonesia will increase in 2019-2021 and will decrease in 2022. Universitas Pendidikan Indonesia and Universitas Negeri Malang rank first and second in publications regarding AR in biology learning in Indonesia. The results of the data visualization analysis consist of 7 clusters, namely the use of AR applications in research related to biology learning, AR relationship with learning materials, educational level, and learning outcomes, and development and application of AR in biology learning. Furthermore, the fourth to seventh clusters are clusters which show that research on AR still has opportunities to be carried out related to the use of AR applications in biology learning in Indonesia.

**Keywords:** Augmented Reality; Bibliometric Analysis; Biology Learning; Learning Media

## Introduction

Augmented Reality (AR) first performed by Ivan Sutherland in 1962. Currently, AR development has been carried out by various parties so that it can be implemented on various devices. Utilization of AR also does not require certain additional devices which generally require a lot of money and time for the purchase and installation process (Young, 2015). AR technology is a concept of a combination of virtual reality and world reality, so that 2D or 3D virtual objects can look so real and blend with actual conditions. (Billinghurst et al., 2014). This combination is the result of adding computer-generated virtual objects (Mustika et al., 2015). The combination of text, images, videos contained in AR is a source of new ways of learning communication because they cannot be obtained from textbooks (Diaz, 2018). AR learning media can visualize abstract concepts for understanding and structure of an object model so as to enable AR as a more effective medium according to the objectives of the learning media (Vitono et al., 2016).

Currently, AR is developed in the form of learning multimedia as a teacher's tool in the teaching and learning process in the classroom, and does not replace the role of the teacher as a whole in its application. (Sari et al., 2012). The application and development of AR learning media has high potential in the world of education as a medium to improve learning quality, mastery of concepts, and student creativity (Sunil & Nair, 2017). AR allows digital content in the form of audio, video, 2D and 3D objects to appear integrated with the actual conditions through the device. AR content that is presented in three dimensions (3D) is believed to be able to visualize something that is hard to see (Qumillaila et al., 2017). AR media is still classified as a new technology as multimedia whose role is so important to support the learning process. Many people believe that multimedia will be able to create learning conditions where learning with effort can be replaced by learning with fun (Hafzah et al., 2020).

The popularity of AR research has increased in recent years, this is because mobile devices have provided simpler, cheaper and more efficient access for

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users to use AR than before (Dutta et al., 2022). Research on AR learning media in biology learning in Indonesia shows that AR applications can effectively be used as an alternative learning media to help teachers and students in biology learning (Febriza et al., 2021; Mauludin et al., 2017; Qumillaila et al., 2017).

This study aims to identify publications regarding AR in biology learning and describe the characteristics of the research. Bibliometric analysis was used in this study to explore the characteristics of publications in AR in biology lessons and to understand research trends in this field.

Bibliometrics is a statistical method for analyzing scientific publications (Phoong et al., 2022; Wang et al., 2021; Zyoud et al., 2022), as a basis for determining the most popular and significant publications in a particular field of study (Zyoud et al., 2022), and presents such complete information by integrating science, mathematics and statistics in analyzing knowledge quantitatively (Zhang et al., 2019).

## Method

This study aims to identify AR-related publications in biology learning in Indonesia and then present them in a visual form.

### Research Design

This study uses visualization methods and bibliometric analysis. As a quantitative method, bibliometric analysis uses an evaluative and descriptive approach to present research trends and characteristics of a series of publications. The bibliometric visualization method is used to display an overview of the structure of certain research conditions (Garfield, 2009).

### Research Subject

The sample of this study were 223 publications obtained from the Google Scholar and Scopus databases that match the keywords chosen. The keyword in this research is Augmented Reality Indonesian Biology Learning. From 223 publications, the majority came from repositories, journal articles and proceedings.

### Research Indicator

The selected publications are publications published within the last 10 years (2013-2022) using the Publish or Perish and VOSViewer software. The indicators used in this study are the number of publications, citations, and total link strength between objects displayed in the data visualization.

### Research Procedures

The collection of metadata was collected from the Google Scholar and Scopus databases in the last 10 years (2013-2022) regarding AR research in biology learning.

The Publish or Perish software is used in this research, namely to search for articles sourced from Google Scholar and Scopus. Furthermore, the VOSViewer software was used in this study to analyze, visualize and evaluate all publication information that have been collected related to this field, such as: number of publications, document sources, agency distribution, language used in articles, distribution of biology learning materials, and the highest number of citations. VOSviewer is software that functions to create network visualizations based on terms that are commonly used in certain fields. VOSviewer is very useful and widely used in bibliometric analysis (Eck & Waltman, 2010; Shah et al., 2020). The research stages in the bibliometric analysis by Dewi et al. (2021) consist of 5 stages as follows.

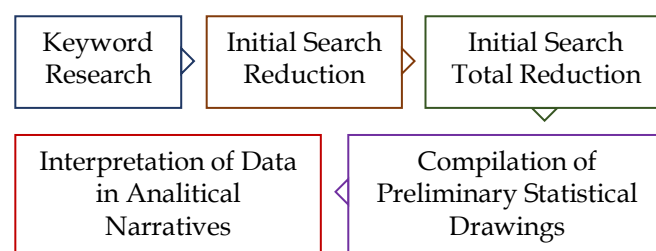


Figure 1. Stages of the Bibliometric Analysis Method

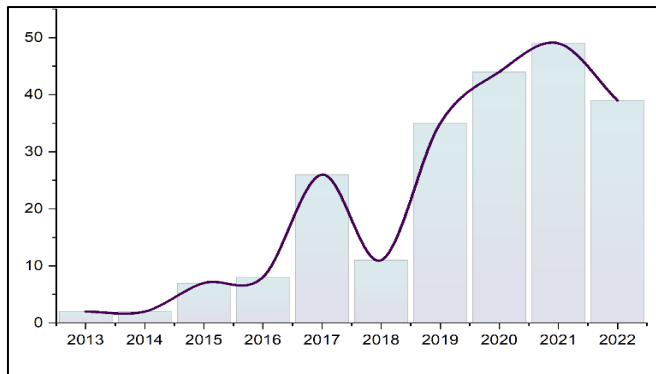
There are five stages in the bibliometric analysis method in Figure 1, that is, 1) investigating keywords or determining keywords: before carrying out data collection, the keywords determined for data search are augmented reality in Indonesian biology learning; 2) reduction of the initial search: classification or grouping of searches that only focus on predetermined keywords, in this case using the Google Scholar and Scopus databases to search for articles based on keywords; 3) reduction of the initial search total: manual selection of all search results using the VOSViewer software to define thresholds as needed, 4) preliminary statistical image compilation: grouping data as topic descriptions, such as organizing results from visualizations on number of publications, document source, distribution of publications by college, language used in articles, distribution of biology study materials, and highest number of citations, and co-occurrence of words author key; 5) data interpretation in analytical narrative: explanation of research findings based on selection results, data interpretation is done with the VOSViewer application. VOSViewer visualization provides data representation in the form of variable maps related to keywords and has opportunities to be developed.

## Result and Discussion

### Publication Output, Document Source, and Language Used

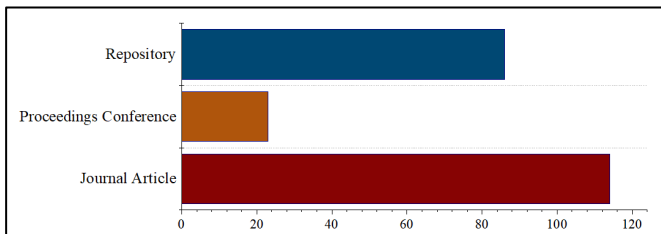
In the beginning, there were 983 publications in the Google Scholar database related to AR in biology

learning, but not all of them displayed publication results originating from Indonesia. Next, publication selection was carried out in the Publish or Perish software that matched the search keywords and 223 publication results were obtained that matched the keywords. These results are presented in Figure 2.

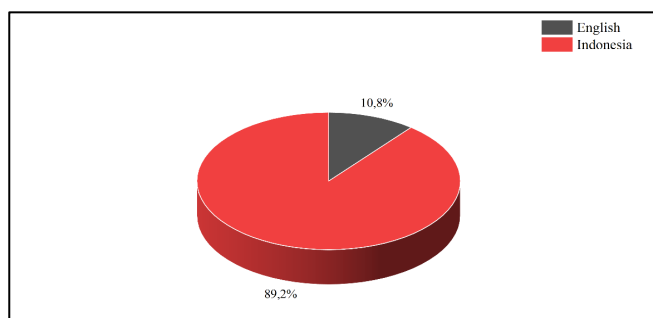


**Figure 2.** Number of Article Publications on AR in Biology Learning in Indonesia (2013-2022)

From those 223 publications, 16 journal articles and 8 proceedings articles were published in English. 98 journal articles and 15 proceedings articles were published in Indonesian. Meanwhile as many as 86 other sources come from the repository.



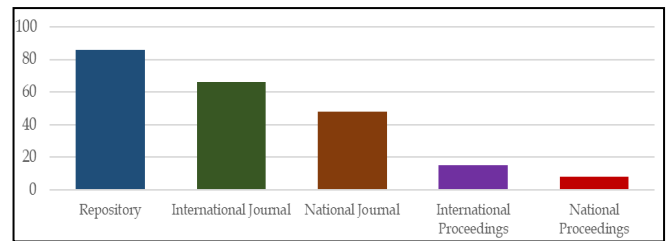
**Figure 3.** Number of Documents Based on Document Sources



**Figure 4.** Number of Documents by Language

*Distribution of Publications Based on Publication Categories and Universities*

Based on 223 identified documents, these documents are published in several categories such as in national journals, international journals, national proceedings, international proceedings, and repositories. Document distribution based on publication category is presented in Figure 5.



**Figure 5.** Distribution of Documents Based on Publication

Meanwhile, the contribution distribution of tertiary institutions in research related to AR in biology learning in Indonesia is shown in Table 1.

**Table 1.** Number of Publications Related to AR in Biology Learning by College

College	Sum of Publication
Universitas Pendidikan Indonesia	23
Universitas Negeri Malang	18
Universitas Islam Riau	15
Universitas Negeri Makasar	12
Universitas Teknokrat Indonesia	10
Universitas Negeri Semarang	5
Universitas Telkom	5
Universitas Jambi	5
Universitas Muhammadiyah Malang	4
Universitas Sebelas Maret	3

*AR-Based Learning Materials and the Most Number of Citations in Publications*

Materials used in AR-based biology learning that have been extensively researched in Indonesia include the respiratory system, the animal world, the plant world, movement systems, ecosystems, digestive systems, anatomy and physiology of the human body, bacteria, animal and plant cells, excretory systems, viruses, sensory systems, DNA and RNA, and the reproductive system. The number of studies related to the learning materials is presented in Table 2.

**Table 2.** Biology Learning Materials Integrated with AR Based on the Number of Research Conducted

Biology Learning Materials	Sum of Research
Respiratory system	17
Animal World	23
Plant World	15
Motion System	11
Ecosystem, Digestive System	8
Anatomy and Physiology of the Human Body	7
Bacteria, Animal and Plant Cells, Excretory System	6
Virus	5
Senses System	4
DNA and RNA, Reproductive System	3

The highest number of citations regarding AR articles in biology learning in Indonesia in 2013-2022 with the highest 3rd rank was obtained by Mauludin et al. (2017) with the number of citations 75, then

Qumillaila et al. (2017) with a total of 55 citations, and Febriza et al. (2021) with a total of 44 citations. Complete data is presented in Table 3.

**Table 3.** Publications related to AR in biology learning in Indonesia in 2013-2022 based on the highest number of citations

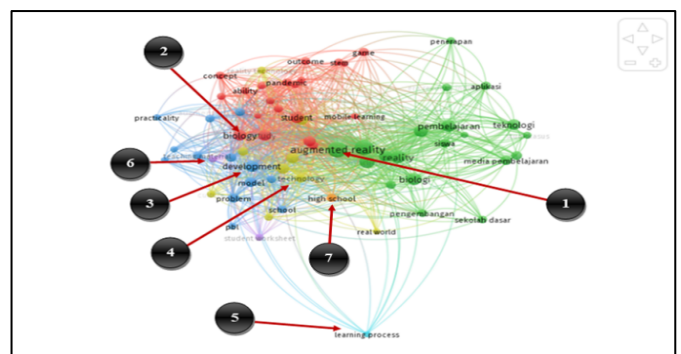
Author	Title	Sum of Citation
Mauludin et al. (2017)	Application of AR as a Learning Media for the Digestive System in Humans in Biology Subjects	75
Qumillaila et al. (2017)	Development of the Android Version of AR as a Learning Media for the Human Excretory System	55
Febriza et al. (2021)	Application of AR in Bacterial Classification Learning Media	44
Aripin & Suryaningsih (2019)	Development of Biology Learning Media Using Android-Based AR Technology on the Concept of the Nervous System	35
Mustami et al. (2019)	Validity, practicality, and effectiveness development of biology textbooks integrated with AR on high school students	16
Kamiana et al. (2019)	Development of AR Book as an Android-Based Virus Learning Media	13
Amir (2017)	Development of Textbooks and AR on the Concept of the Digestive System	13
Nurhasanah et al. (2019)	AR to facilitate students' biology mastering concepts and digital literacy	12
Sari & Ma'rifah (2020)	Development of Android-Based Mobile Learning LKPD with PBL to Improve Critical Thinking on Environmental Materials	12
Syukriah & Pranggarani (2016)	Implementation of 3D AR Technology in Making Plant Organology	12

*Visualization of AR Research Trends in Biology Learning in Indonesia*

*Visualization Based on Network Relationships*

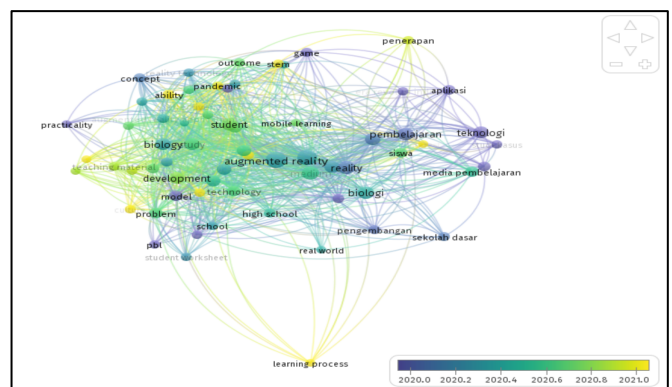
Based on 223 types of AR-based research publications in biology learning in Indonesia, research trends are visualized using VosViewer software. This visualization helps to find novelty for future research related to AR in biology learning. Figure 6 shows a network related to AR research in biology learning. The visualization of AR research in Indonesia consists of 3 main clusters which are visualized by color (green, red, blue) and the second cluster is marked by color (yellow, light blue, purple, and orange).

The first cluster in green shows the use of AR applications in research related to learning biology. The second cluster in red shows the relationship between AR and biology education related to learning materials, education levels, learning outcomes, and so on. The third cluster in blue shows how AR applications are developed and applied in biology learning. The fourth cluster, the yellow cluster, shows how AR technology is applied in biology learning at various levels of education (elementary school to university). The fifth cluster in light blue shows the learning process using AR related to problem-based learning and the learning model used. The sixth cluster in purple shows AR applications made as multimedia in learning.



**Figure 6.** AR Relationship Network in Biology Learning in Indonesia

*Visualization Based on the Number of Researches That Have Been Conducted Regarding AR in Biology Learning in Indonesia*

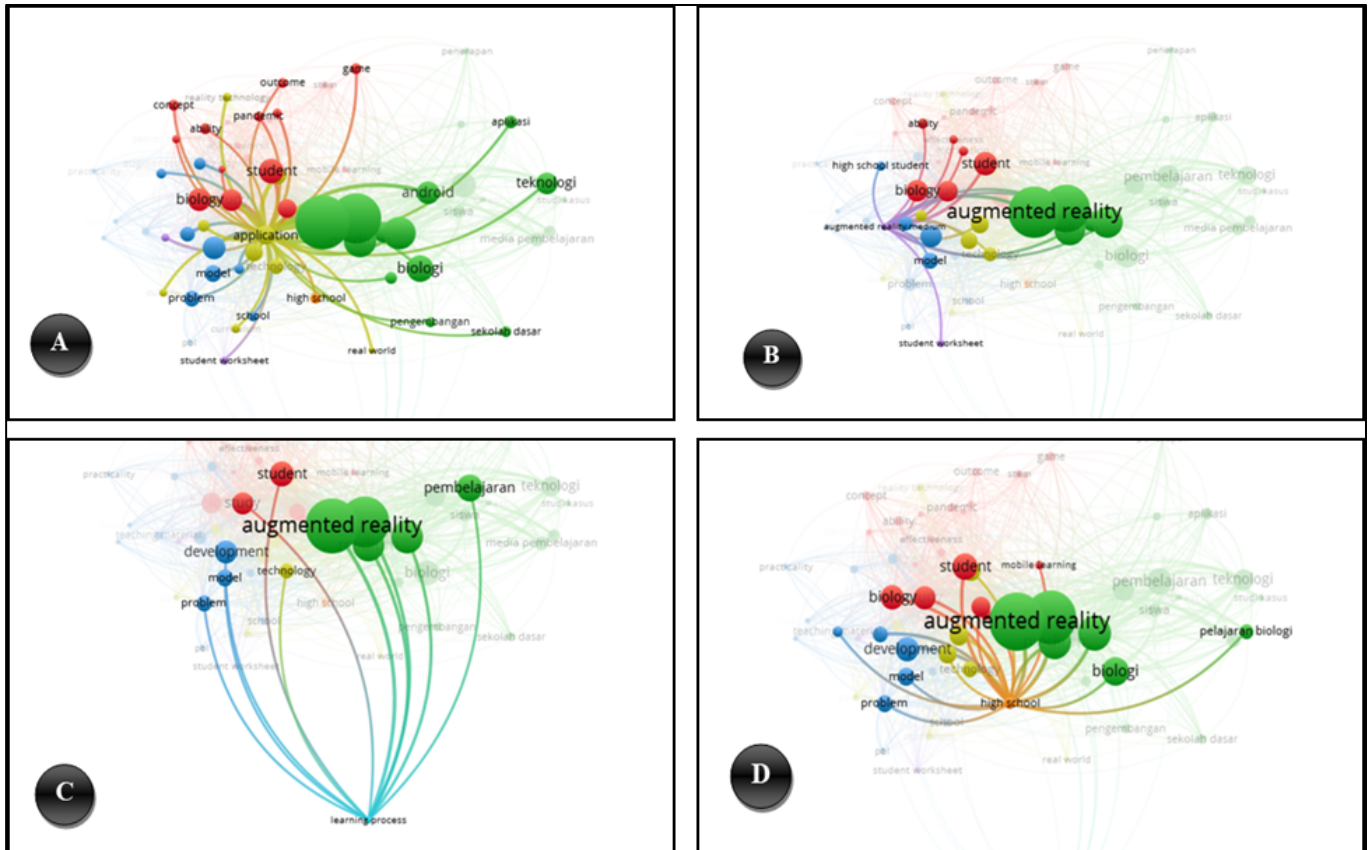


**Figure 7.** The Number of Researches that Have Been Conducted on AR in Biology Learning

The amount of research that has been conducted on AR applications in biology learning in Indonesia in 2013-2022 can be seen in the Overlay Visualization in the VosViewer software. Figure 7 shows that visualization with purple color is research that has been widely carried out, especially covering biology learning using AR. Meanwhile, the visualization in light green shows that there have been many studies covering the development of AR applications in biology learning.

*Visualization Regarding Types of Research that Have Not Been Done Much Regarding AR in Biology Learning*

Visualization with yellow, purple, light blue, and orange colors in Figure 8 a,b,c,d shows that research on AR still has opportunities to be carried out related to the use of AR applications in biology learning in Indonesia based on the application of AR to learning outcomes and skills that must be owned by students, development as a learning medium, effectiveness in the learning process, and not only applied to elementary to high school levels, but can also be implemented for learning in tertiary institutions.



**Figure 8.** (a) AR application to improve student learning outcomes and skills; (b) Development of AR as a learning medium; (c) The effectiveness of using AR in the learning process; and (d) It is not only applied to elementary to high school levels, but can also be implemented for learning in tertiary institutions.

Augmented Reality (AR) first performed by Ivan Sutherland in 1962. Research related to AR in Indonesia has increased since 2019-2021 which is marked by an increasing number of published articles. However, in 2022 research related to AR in biology learning in Indonesia will experience a decline, this can be seen from the decrease in the number of published articles. In 2021 there will be 49 articles while in 2022 there will be 39 articles.

Based on 223 identified documents from 2013-2022, these documents were published in several categories such as 48 articles in national journals, 66 articles in international journals, 8 national proceedings, 15

international proceedings, and 86 research results repositories. Several universities contributed to the publication, namely Universitas Pendidikan Indonesia with a total of 23 articles, Universitas Negeri Malang with 18 articles, Universitas Islam Riau with 15 articles, Universitas Negeri Makasar with 12 articles, and Universitas Teknorat Indonesia with 10 articles.

The author who has the first place in terms of the highest number of citations from 2013-2022 is obtained by Mauludin et al. (2017) with a total of 75 citations. The second ie Qumillaila et al. (2017) with a total of 55 citations. Third ie Febriza et al. (2021) with a total of 44 citations. Fourth, namely Aripin & Suryaningsih (2019)

with a total of 35 citations. Fifth, namely Mustami et al. (2019) with a total of 16 citations.

The scope of the problem that causes research on AR media in biology learning in Indonesia is the lack of interactive biology learning media (Raharjo et al., 2020; Nadiyah & Syafiih, 2020; Widodo & Utomo, 2021), the learning media used still uses two-dimensional (2D) media (Bahari et al., 2017; Chaniago et al., 2020; Putu et al., 2018), the need for innovation in technology-based learning media (Hidayat et al., 2018; Sugiana & Muhtadi, 2019; Yeztiani et al., 2022), rapid development of technology and information (Purnomo & Sudarmilah, 2015; Putri et al., 2020; Wahyuni et al., 2022), students' difficulties in understanding biology concepts that are abstract or microscopic in nature (Astutik et al., 2020; Fajriani et al., 2022), and challenges of the 21st century (Rahmadani & Fadilah, 2022; Tamam et al., 2020).

Biology learning materials that are integrated with AR in biology learning in Indonesia include material on the respiratory system (Naim, 2020; Nugraha & Mahmud, 2020), animal world (Kencana et al., 2020; Pratama et al., 2022), plant world (Saefudin & Julisawati, 2016; Wijayatno & Samodra, 2021), motion system (Satryawati et al., 2022), ecosystem (Muhammad et al., 2021; Sari & Ma'rifah, 2020), digestive system (Rahayu et al., 2022), endocrine system (Fajriani et al., 2022), nervous system (Supriyadi et al., 2022), sense system (Amdani et al., 2022), circulatory system (Indahsari et al., 2021; Putu et al., 2018), anatomy and physiology of the human body (Hamdani et al., 2020; Nanlohy et al., 2020; Nauko & Amali, 2021), bacteria (Nugroho et al., 2020), virus (Chatulistiwa & Rismayadi, 2021), DNA and RNA (Adiatma et al., 2020; Ridwan, 2021), animal and plant cells (Nasharuddin et al., 2021), as well as the excretory system (Aprilinda et al., 2020).

The results of research on AR media in biology learning in Indonesia show that the use of AR media in biology learning can be an interesting, practical, effective, and efficient learning medium for students (Amalia & Suryani, 2019; Musliadi, 2022; Rumbajan et al., 2022; Lathifah & Sulistiyawati, 2021), facilitate students' understanding of abstract concepts (Kurniawan et al., 2017; Suharso & Muhaimin, 2016; Putri et al., 2020), analyze students' literacy skills (Masropah et al., 2022; Oktaviana & Supriatno, 2022), increase student learning interest (Rahayu et al., 2022), motivation to learn (Cahyani & Oktavia, 2019; Maulana, 2020; Rini et al., 2022), HOTS (*High Order Thinking Skills*) (Sylvia et al., 2020), and learning outcomes (Alfiana & Purbawanto, 2021; Padang et al., 2022; Rezkiana et al., 2019). The results of this study are also supported by the results of a feasibility study on development and utilization of AR media in biology learning by experts or media experts and users who show that AR media is suitable for use as a biology learning medium. (Hamimi et al., 2021; Urifah et al., 2021; Wahdatun & Anggraito, 2021).

Based on bibliometric analysis, research on AR in biology learning in Indonesia consists of 7 clusters. The first cluster shows the use of AR applications in research related to learning biology. The second cluster shows the relationship between AR and learning materials, education levels, learning outcomes, and so on. The third cluster shows how AR applications are developed and applied in biology learning. Furthermore, the fourth to seventh clusters are clusters which show that research on AR still has the opportunity to be carried out related to the use of AR applications in learning biology in Indonesia, some of the findings obtained based on this visualization are: (1) The application of AR media can be done to measure learning outcomes and skills that students must have, (2) AR is still possible to be developed as a learning medium, (3) Effectiveness of using AR in the learning process, and (4) Research related to AR is generally carried out at the elementary to high school levels, but there is still little research on AR in biology learning in tertiary institutions.

## Conclusion

Based on bibliometric analysis, it can be concluded that research on AR media in biology learning in Indonesia has increased in 2019-2021 and has decreased in 2022. The research results are published in journals, proceedings, and repositories. Some of the popular biology learning materials used in integration with AR are the respiratory system, the animal world, and the plant world. The application of AR in biology learning in Indonesia is carried out at the elementary to tertiary education level. Some of the novelties found based on the results of data visualization are obtained as follows: (1) The application of AR can be done to measure learning outcomes and skills that students must have, (2) AR is still possible to be developed as a learning medium, (3) The effectiveness of using AR in the learning process, and (4) Research related to AR is generally carried out in elementary to high school levels, but there is still little research on AR in biology learning in tertiary institutions. These findings can be used as one of the research ideas regarding AR in biology learning in Indonesia in the future.

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