Augmented Reality as Media Based-on Artificial Intelligence Technology: A Systematic Literature Review

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ARTICLE INFO	ABSTRACT
	Augmented reality is a technology that connects the virtual and real world with the help of a camera. Augmented reality technology is very important to get an overview of the progress and the real impact of its use in biology learning. This research aims to find out articles in the journal publications about the use augmented reality in biology learning. The method of the research was systematic literature review. The method was used to identify, review, evaluate, and interpret articles which is published in biology journals based-on use augmented reality in biology learning. The resources of the data only in biology learning journals. The results of the research analysis show that there are no biology journals on scopus has scope especially the use of augmented reality. The trend of using augmented reality in biology learning from 2012-2022 started in 2016 and was highest in 2020. Biological material that uses the most augmented reality is heart and blood flow material. The level of education that makes the most use of augmented reality is college. The types of research which is most widely used are research and development. The obstacles that occur are the lack of facilities and the lack of teacher training in utilizing augmented reality. All levels of education can take advantage of augmented reality with teacher skills facilitating student learning.

Introduction

Biology is the science that studies life and living organisms in this world. All levels of education teach biology material to their students. In today's digital era, the media plays a very important role in biology learning. The use of media in learning provides many benefits, ranging from better visualization to understanding concepts for students. One of the main benefits of using media in biology lessons is its ability to provide better visualization. In biology, concepts such as cell structure, genes, systems in organisms, or biological processes are difficult to understand simply by reading texts (Azis & Pertiwi, 2021; Sukenda et al., 2019). With media such as pictures, videos or animations, students can see directly the structure and function of living organisms, as well as various complex biological processes. Good visualization can help students understand concepts more deeply and reinforce their understanding. Media in biology learning also allows students to have practical experience that cannot be obtained through theory alone (Azis & Pertiwi, 2021). Through interactive media, such as simulations or learning software, students can conduct virtual experiments, observe living organisms in detail, or even study biological mechanisms by trying out themselves. This technology provides an opportunity for students to experience biology first-hand, even if only in virtual form. Practical experiences like these can increase students' interest in studying biology and help them understand concepts better

(Nurhikmah et al., 2018; Susanti et al., 2020). In this digital era, media also allows students to access information about biology more easily. There are many online resources, such as instructional videos, scientific websites, or biology databases, that students can access quickly and easily (Muhfahroyin & Sujarwanta, 2023; Muhfahroyin & Susanto, 2018). Students can watch learning videos that clearly illustrate biology concepts, read the latest scientific articles, or explore the rich collection of pictures of living organisms. With easy access to information, students can gain a more comprehensive understanding of biology and increase student motivation. The media also enables student collaboration and involvement in biology learning projects. Through online platforms, students can communicate with fellow students and do biology assignments (Kangloan et al., 2018; Muhfahroyin & Susanto, 2018). They can participate in joint projects, exchange knowledge, or even do virtual laboratory practice. This kind of collaboration and engagement not only enhances students' social skills, but also expands their knowledge.

Augmented reality and artificial intelligence are two technologies that have come to the fore in recent years. Both have enormous potential to change the way we interact with the digital and physical world around us. Augmented reality is a technology that combines real-world elements with virtual elements, creating immersive and interactive experiences (Aththibby et al., 2021). In augmented reality, digital information, such as images, sound or video, is displayed in a real environment using a device such as a smartphone, tablet or a special headset. Meanwhile, artificial intelligence is a field related to the development of machines and computer systems that can perform tasks that require human intelligence. Artificial intelligence enables machines to learn, understand, and make decisions based on existing data (Pandarakone et al., 2019; Wu et al., 2013). Augmented reality can harness the power of artificial intelligence to enhance the user experience. Artificial intelligence can assist in several aspects of augmented reality, such as object recognition and face detection ((Bianchini, 2018; Bianchini at al, 2019). By using pattern recognition and machine learning techniques, artificial intelligence can enable augmented reality systems to accurately recognize and track objects in real environments. This provides potential for more sophisticated augmented reality applications, such as facial recognition, emotion detection, and more complex interactions with virtual objects (Tajmir & Alkasab, 2018). In addition, artificial intelligence can also be used to improve graphic quality in augmented reality experiences. By using machine learning techniques, artificial intelligence can improve visual appearance in augmented reality. This means that virtual objects rendered in a real environment will look more realistic and better integrated. Furthermore, augmented reality can also provide valuable data input for artificial intelligence systems. When users interact with virtual objects in augmented reality, data about their preferences, behavior and interactions can be collected. This data can be used to train artificial intelligence systems, improve algorithms, and produce more personalized augmented reality experiences (Sejnowski, 2020).

Biology is a science that contains systematic, rational, and objective theories about living things. Biology is a branch of science. The characteristic of learning science is studying problems related to natural phenomena, both qualitatively and quantitatively, and various problems related to the application of science to build technology and overcome the problems in people's lives. Therefore, through learning science it is hoped that students will acquire scientific provision to develop process skills and academic achievement to address real-life (contextual) problems (Wu et al., 2013). In biology learning, Augmented reality can be used to visualize the structure of organisms, life cycles, ecosystem interactions, and other biological processes. Students can use augmented reality devices, such as smartphones or tablets, to view virtual organisms in real time in a real environment. Through augmented reality applications, students can observe and study the anatomical structures of organisms that are difficult to observe in real situations. They can explore the inside of organisms and see how organs interact with each other. On the other hand, artificial intelligence can improve biology learning by analyzing complex biological data and presenting it in a form that is easier to understand (Bianchini et al, 2019). Furthermore (Bianchini, 2018; Bianchini et al, 2019) stated that artificial intelligence can process data from different sources, for example genetic databases, scientific literature, and experimental data, to provide relevant and up-to-date information to students. Artificial intelligence can also provide deeper explanations of difficult biology concepts, answer student questions, and provide personalized feedback.

Biological abstract material, such as the anatomy and physiology of the human body, is difficult to find directly, so it requires the use of learning media. Technology integration in the development of appropriate learning media can

make it easier for students to fully understand abstract concepts. One of the uses of technology in education is the use of augmented reality technology in artificial intelligence-oriented science learning. Augmented reality can visually augment real-world environments by projecting computer-generated information. Augmented reality is growing rapidly from research that aims to integrate virtual worlds with real environments. This augmented reality can be interpreted that real objects in real time are added to virtual objects that appear when using tools or devices in real objects (Chen, 2006; Di-Serio et al., 2013). Through augmented reality and artificial intelligence, students can access highly interactive and immersive learning experiences. Artificial intelligence systems can provide detailed explanations and information when students interact with virtual objects in augmented reality (Di-Serio et al., 2013). Artificial intelligence systems can also provide challenges tailored to students' abilities, allowing them to practice and test their understanding in a safe environment. This technology enables real and virtual-world interaction. The resulting content can be in the form of three-dimensional (3D) models, videos, images, sound, and text (Del-Bosque et al., 2015). Research on augmented reality has been widely carried out, based on published journal reports on the advantages, limitations, and challenges of the effectiveness, of the use of augmented reality in education. However, because augmented reality is a technology that is continuously developing, it is very important to get an overview of the progress and the real impact of augmented reality use in education, especially on biology learning from published studies.

Previous research on augmented reality was carried out in science learning. Augmented reality is used to support science learning carried out by students. Therefore, a systematic review is very important to present the current situation and to explain future research. Reviewing the results of previous research helps researchers to make a study of aspects that can be researched, namely topics, methods and sampling, results, advantages and disadvantages of augmented reality products. Admittedly, there are many systematic reviews in the literature on the use of technology in biology education. However, there are only a few systematic reviews that examine augmented reality studies. Therefore, this augmented reality study aims to bridge the existing gap in the literature by analyzing all educational studies found in various reputable databases.

Method

The method in this research is Systematic Literature Review. The Systematic Literature Review method is used to identify, review, evaluate, and interpret all available research on interesting topic areas, with relevant research questions. This research was conducted on the site: https://www.scopus.com. Furthermore, minning analysis was carried out with Publish or Perish, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart analysis. The PRISMA flowchart analysis used to document search and selection process conducted during a systematic literature review. This flowchart serves the sequential steps namely identifying, screening, and including studies in a systematic review or meta-analysis.

Here's a comprehensive breakdown of the PRISMA Analysis: 1) Identification: The initial stage involves the systematic search for relevant studies across sources in journal of biology learning. 2) Removal of Duplicates: Any duplicate articles originating from the same or different sources are removed to ensure they are not considered in further analysis. 3) Initial Screening: Articles remaining after duplicate removal are assessed based on journal name, year of publication, level of education, topics/biology materials used, research objectives, types of research, learning methods, types of research, data analysis techniques, and findings. Articles that are evidently irrelevant or do not meet the predefined inclusion criteria are excluded. 4) Further Screening: Articles that pass through the initial screening phase are then thoroughly read to ensure they meet all the inclusion criteria established for the review. 5) Final Assessment and Inclusion of Studies: Articles that remain after the further screening process are included in the systematic review and constitute the final pool of studies for analysis.

Then analyzed systematic literature reviews on biology subjects for the last 11 years (2012-2022). The steps taken were formulating the problem, searching for literature (identification), sorting the results of the literature search according to quality assessment (screening and feasibility), analyzing articles, making research conclusions.

Results and Discussion

This systematic literature review research was conducted using the keywords "Augmented Reality, Biology Learning Media" in the Scopus database for 11 years (2012-2022). Keyword searches were performed using Publish or Perish mining software. It can be reported that

when searching for publications using the keywords "Augmented Reality, Biology Learning Media", there are 99 literatures coming from various publishers, as well as journals, conferences, books, proceedings, reports, and workshop results. Furthermore, from 99 published articles, screening was carried out according to research objectives, inclusion and exclusion criteria, so that 16 articles were obtained that were eligible for literature review analysis (Table 1). The analysis includes the author's name, title, year of publication, journal name, level of education, biology topics/materials used, learning methods, research objectives, types of research/research instruments, data analysis techniques, and findings.

Table 1 Minning result of articles were eligible to analysis during 2012-2022

o	Year	Number of Articles
	2012	0
	2013	0
	2014	0
	2015	0
	2016	1
	2017	0
	2018	2
	2019	3
	2020	6
0	2021	3
1	2022	1
	Total	16

Since the augmented reality discovery in the early 1990s, augmented reality has attracted the attention of technology developers and researchers in various fields, including education. In the field of biology education, the use of augmented reality as a learning aid has increased over the past 10 years. The following is an overview of trends in the use of augmented reality in biology learning from 2012 to 2022. Year 2012-2015: The application of augmented reality in Biology Learning at the beginning of 2012, from the source, www.scopus.com does not yet exist. Several studies have been conducted to explore the potential of augmented reality in helping students with concepts other than biology. In 2016 there was 1 article entitled "Digital Gaming for evolutionary biology learning: The case study of parasite race, an augmented reality location-based game" (Aivelo & Uitto, 2016). Year 2017: Development of AR

Applications in Biology Learning not indexed by Scopus. In 2018 AR as an Independent Learning medium in recent years, AR was not only used as a learning aid but also as an evaluation and independent learning tool. The article entitled "The augmented reality for Teaching Thai Students about the human heart" was written by S. Nuanmeesri and the article entitled "Using augmented reality technologies to enhance students' Engagement and achievement in science laboratories" was written by R.C. Chang (Chang & Yu, 2018; Nuanmeesri, 2018).

In 2019 there are 3 articles use augmented reality. First, an article entitled "Visualization in basic science and engineering education of future primary school teachers in human biology education using augmented reality" was written by M. Fuchsova. The second article is entitled "Learning human anatomy using the ARA mobile application" written by S. Loucif ;(Loucif et al., 2019 Fuchsova & Korenova, 2019). The third article was written by C. Weng in 2019 entitled "Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement" (Weng et al., 2020). This article discusses how augmented reality technology can improve biology learning for students. In this article, Weng explains that the use of augmented reality as a tool in learning biology can increase students' interest and help them understand difficult concepts. By combining augmented reality technology with existing teaching materials, students can more easily understand the subject matter being taught. Several studies conducted by Weng and his colleagues show that the use of augmented reality in biology lessons can improve conceptual understanding, student engagement, and learning motivation. In addition, this technology can also help students to better visualize the structure of organs and body tissues. However, there are also some limitations to using augmented reality in biology learning. Some of these limitations include technological limitations, lack of conformity with the curriculum, and lack of training for teachers in using augmented reality technology.

In 2020 there was an increase in the use of augmented reality in biology learning, namely the first article "Development of augmented reality application for biology Education" (Arslan et al., 2020). This article discusses the development of augmented reality applications for biology education. The aim is to increase students' interest and understanding of biology material through a more interactive and fun learning experience. The second article is entitled "Integration of mobile augmented reality (MAR) Applications into biology laboratory: Anatomic Structure of the Heart" (Celik et al., 2020). This article discusses the

integration of augmented reality applications in biology laboratories to study the anatomical structure of the heart using mobile devices. The aim is to improve students' ability to understand and memorize the structure of the heart visually and interactively. The third article is entitled "An Idea to explore: Use of augmented reality for teaching three-dimensional biomolecular structures" by (Peterson et al., 2020). This article discusses the use of augmented reality to teach three-dimensional biomolecular structures to biology students. The goal is to help students visualize the structure of biomolecules in a more interactive and easy-to-understand way.

The fourth article is titled "The Genetic Code Kit: An Open-Source Cell-Free Platform for Biochemical and Biotechnology Education" by (Williams et al., 2020). This article consider an open-source learning platform used in biochemistry and biotechnology education. The platform is a genetic code kit that allows students to learn the concepts and principles of biochemistry and biotechnology more practically. The fifth article is entitled "Applying AR-based Infographics to enhance the learning of the Heart and cardiac cycle in biology class" by (Dehghani et al., 2023). This article discusses the use of augmented reality-based infographics to study the heart and cardiovascular cycle in biology lessons. The aim is to provide a more interactive and visual learning experience to increase student understanding. The sixth article is entitled "Rapid Deployment of smartphone-based augmented reality tools for Field and online education in structural biology" by (Hoog et al., 2020). This article examines the use of augmented reality-based mobile devices to study structural biology in online and in-the-field teaching. The goal is to increase accessibility and flexibility in biology education.

In 2021 the use of augmented reality technology is increasingly being applied in the field of education, including science education. This literature review article will discuss three recent articles regarding its use in biology education. The first article to be discussed is the article by L.E. Reeves entitled "Use of augmented reality to aid bioscience education and enrich student experience" (Reeves et al., 2021). This article discusses how the use of augmented reality in biosciences education can help enhance students' learning experiences and make it easier to understand difficult concepts. In this article, the authors show some examples of the use of augmented reality in biosciences education, such as using AR to visualize molecular structures, organs, and other biological processes. The second article to be discussed is an article by F. López-Cortés entitled "Secondary education students' Levels of external representation of mitotic cellular division: An augmented reality-based Experience" ((Rodríguez-Abad et al., 2022). This article explores the use of augmented reality to assist students in understanding the process of mitosis. The author shows that the use of AR can help students visualize the process of mitosis more clearly and help students to understand the concept. The third article to be discussed is that by F.G.B. Wommer entitled "Insects GO: a gaming activity for entomology teaching in middle school" (Wommer et al., 2021). This article discusses the use of AR in entomology learning in secondary schools. The author shows that the use of AR in the form of games can increase students' interest in entomology and help students understand difficult concepts.

Overall, these three articles show that the use of AR technology can enhance students' learning experiences and make it easier to understand difficult concepts in science education. The use of AR can also increase students' interest in the subject matter and assist students in developing cognitive and psychomotor skills. Therefore, the use of AR in science education can be an attractive alternative for teachers to increase effectiveness and efficiency in the teaching and learning process. In 2022, an article written by T. Gregorcic entitled "Using the structure-behavior-function model in conjunction with augmented reality helps students understand the complexity of the circulatory system" talk about the use of model in teaching circulatory systems with the help of augmented reality (Gregorcic & Torkar, 2022). This article highlights the importance of the right approach in teaching complex concepts in biology, especially in the circulatory system. The author cites several previous studies that support the use of augmented reality in education, particularly in teaching biology and medicine. One of the relevant studies is research conducted by (Aththibby et al., 2021). which found that the use of augmented reality technology can increase students' understanding of physics concepts and science process skills. The author also cites researches conducted by (Cadavieco et al., 2012; Rodríguez, 2022a; Rodríguez-Abad et al., 2022b) which shows that the use of augmented reality in teaching biology can increase students' interest and motivation to learn. In addition, Gregorcic's article also discusses the use of the structure-behavior-function model in teaching the circulatory system. This model helps students understand the relationship between structure, behavior, and function in a complex biological system. In teaching the circulatory system, this model can help students understand the relationship between the structure of the heart, blood

vessels, and their function in circulating blood throughout the body (Gregorcic & Torkar, 2022). In T. Gregorcic's article, it is also stated that the use of augmented reality in teaching the circulatory system with a structure-behavior-function model can increase students' understanding and make learning more interesting and interactive.

Biological materi using augmented reality media as a learning aid is increasing. Various biology materials have been successfully taught using AR technology, but some biology materials may be more often used as a focus in the use of AR in the classroom. The following is biology material that is studied at school using augmented reality media. The heart and blood flow of the human body are often the focus of using augmented reality technology in biology learning. By using augmented reality, students can visualize the structure of the human body in 3D and more easily understand the interactions between the organs of the body. Augmented reality application to help students understand the relationship between organs in the human body. Digestive System The digestive system is also one of the biological materials that is often studied using augmented reality technology. By using augmented reality, students can visualize how food is broken down and absorbed by the body, and know the role of each organ in the digestive system (Manrique-Juan et al., 2017).

By using augmented reality, students can visualize cell structures in 3D and understand the function of each organelle in a cell. The respiratory endocrine system is also a biological material that is often studied using augmented reality technology. By using augmented reality, students can visualize how air enters and leaves the body and how oxygen is absorbed by the body. Using augmented reality to help students understand the respiratory system in humans. The use of augmented reality in biology learning has opened up opportunities to enrich the way of teaching biology material. Anatomy of the human body, digestive system, cell biology, and respiratory system are the materials that are often delivered using augmented reality. By using augmented reality, students can visualize and understand biology concepts in a more interactive and fun way.

The level of education that makes the highest use of augmented reality in learning has become a trend in recent years, and has been used at various levels of education. However, not all levels of education equally utilize augmented reality in learning. The use of augmented reality in learning at the tertiary level is educational levels that makes the highest use of augmented reality in learning. Utilization of augmented reality at the higher education level, augmented reality is used to assist students in understanding complex concepts and to facilitate interactive learning (Del-Bosque et al., 2015). The use of augmented reality in learning at the higher education level can increase students' understanding of subject matter and increase student participation in learning.

Augmented reality is very well developed to improve the quality of learning. This is due to the advantages of augmented reality in visualizing abstract concepts and helping students understand subject matter more easily (Fourman et al., 2021). The use of augmented reality in learning in elementary schools can increase students' interest and motivation towards the subject matter. Junior high school level has also started to utilize augmented reality in learning. At this level, augmented reality is used to help students understand the subject matter better and increase student involvement in learning. The use of augmented reality shows that the use of augmented reality in learning in junior high schools can increase students' understanding of subject matter and increase student interest in learning.

Furthermore, about types of research, data collection techniques, data analysis techniques most often used to conduct research, there are many types of research using augmented reality technology for various purposes, ranging from education to health. The types of research, data collection techniques, and data analysis techniques that are most used by researchers to research augmented reality are experiments. This research requires testing augmented reality technology on a predetermined sample and comparing the results with the control group. This study helps researchers understand the effectiveness of augmented reality technology in influencing certain variables, such as learning processes and outcomes. The most widely used data collection techniques in research on augmented reality are tests, observations, interviews, and questionnaires. Interviews were used to gather information from participants about their experiences with augmented reality technology. Observation is used to see how participants interact with augmented reality technology and record what happens (Khan & Ghosh, 2021; Sharma et al., 2018). Questionnaires were used to measure participants' responses to augmented reality technology and obtain structured information about their learning.

The most widely used data analysis technique in research on augmented reality is quantitative and qualitative analysis. Quantitative analysis is used to measure the impact of augmented reality technology on certain variables and produce numbers or

statistics that can be measured. Qualitative analysis is used to understand the participants' experiences and the context of using augmented reality technology in more depth. Research on augmented reality has grown rapidly in recent years. Experimental research is the most widely used type of research, while the most widely used data collection techniques are interviews, observations, and questionnaires. For data analysis, quantitative and qualitative analysis are the most used techniques (Sharma et al., 2018). The use of augmented reality technology in research has many benefits and the potential to increase our understanding of how this technology can be used for various purposes. Another type of research is the Systematic Literature Review in several disciplines (Buchner et al., 2021).

Researcher's suggest in utilizing of augmented reality in learning has shown its effectiveness in increasing students' interest and understanding of the subject matter. However, the use of augmented reality in learning also has several motivation challenges that need to be overcome (Di-Serio et al., 2013). As a researcher, there are several suggestions offered for augmented reality users in learning. After the teacher who choosing biological substance, augmented reality content used must be relevant to the subject matter being taught too. Augmented reality content that is too general or not related to the subject matter can make students disinterested or confused in understanding the subject matter. Choosing relevant content is one of the key factors in the successful use of augmented reality in learning.

Conclusion

The trend of using augmented reality in biology learning from 2012-2022 started in 2016 and was highest in 2020. Biological material that uses the most augmented reality media are heart and blood flow material. The level of education that makes the most use of augmented reality is college. The types of research which is most widely used are research and development. The obstacles that occur are the lack of facilities and the lack of teacher training in utilizing augmented reality. All levels of education can take advantage of augmented reality with teacher skills facilitating student learning. Furthermore, teachers need to be given training regarding the use of augmented reality, so that teachers can utilize augmented reality to support biology learning.

Acknowledgment

Augmented reality design that is consistent and easy to understand is also very important in learning. This can help students more easily understand and remember the concepts learned. Augmented reality design that is simple and easy to understand can increase students' understanding and skills of the subject matter (Bakkiyaraj et al., 2020). Using good augmented reality technology is also very important in learning. Augmented reality users must ensure that the technology used can function properly and does not experience technical problems that can interfere with learning (Fourman et al., 2021). Technical problems can reduce the effectiveness of using augmented reality in learning. Providing adequate support facilities is also very important in the use of augmented reality in learning. Augmented reality users must provide sufficient support for students in using augmented reality technology, such as clear training and guidance (Cadavieco et al., 2012). Providing sufficient support can increase student interest and participation in the use of augmented reality in learning. The use of augmented reality in learning has shown its effectiveness in increasing students' interest, motivation, and understanding of the subject matter (Aththibby et al., 2021; Erbas & Demirer, 2019). However, the use of augmented reality in learning also has several challenges that need to be overcome. Choosing relevant content, maintaining consistency in augmented reality design, using augmented reality technology properly, and providing adequate support are some of the suggestions offered by researchers to augmented reality users in learning.

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Conflict of interest statement

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We are an author in this article declares that every author in this article has a real contribution, and this article clears from conflict of interest author, article not yet ever published and not in process publish in another. If we breaking the statement than we willing to subject fines double from the cost of publication, and if we withdraw this paper from the review process willing to subject fines half of the cost of publication.