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CURRENT TRENDS IN THE APPLICATION OF AUGMENTED REALITY-BASED LEARNING MEDIA IN BIOLOGY EDUCATION: A SYSTEMATIC LITERATURE REVIEW

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ABSTRAK

Perkembangan teknologi digital telah membawa perubahan signifikan dalam dunia pendidikan, termasuk dalam pembelajaran Biologi yang sering kali memuat konsep abstrak dan sulit divisualisasikan. Salah satu inovasi yang banyak digunakan untuk mengatasi permasalahan tersebut adalah teknologi Augmented Reality (AR). AR memungkinkan siswa berinteraksi dengan objek virtual tiga dimensi secara nyata sehingga dapat meningkatkan pemahaman terhadap konsep Biologi yang kompleks. Penelitian ini bertujuan untuk menganalisis tren terkini penerapan media pembelajaran berbasis AR dalam pembelajaran Biologi menggunakan pendekatan Systematic Literature Review (SLR) dengan panduan PRISMA. Sebanyak 19 artikel yang diterbitkan pada tahun 2016–2025 ditelaah berdasarkan kriteria inklusi, meliputi jenjang pendidikan formal, jenis media, metode penelitian, serta topik Biologi yang dikaji. Hasil analisis menunjukkan bahwa penggunaan AR paling banyak ditemukan pada jenjang Sekolah Menengah Atas (SMA) dengan dominasi media berbasis smartphone. Hal ini dikarenakan kemampuan berpikir abstrak dan literasi digital siswa SMA yang lebih matang, sehingga mendukung efektivitas penggunaan AR dalam memahami materi Biologi. Sebagian besar penelitian menggunakan metode kuantitatif dengan desain quasi-experimental untuk mengukur pengaruh AR terhadap hasil belajar, motivasi, dan literasi digital siswa. Secara umum, media berbasis AR terbukti mampu meningkatkan pemahaman konsep, hasil belajar, motivasi, dan keterlibatan siswa dalam pembelajaran Biologi. Dengan demikian, teknologi AR memiliki potensi besar sebagai strategi pembelajaran inovatif abad ke-21 yang interaktif, kontekstual, dan mendukung transformasi digital pendidikan Biologi.

Kata Kunci: *Augmented Reality, Biologi, Media pemeblajaran*

ABSTRACT

The development of digital technology has brought significant changes to the world of education, including in Biology learning, which often contains abstract concepts that are difficult to visualize. One innovation that is widely used to overcome this problem is Augmented Reality (AR) technology. AR allows students to interact with three-dimensional virtual objects in a realistic way, thereby improving their understanding of complex Biology concepts. This study aims to analyze the latest trends in the application of AR-based learning media in biology learning using a Systematic Literature Review (SLR) approach with PRISMA guidelines. A total of 19 articles published between 2016 and 2025 were reviewed based on inclusion criteria, including formal education levels, types of media, research methods, and biology topics studied. The results of the analysis show that the use of AR is most commonly found at the senior high school level, with smartphone-based media dominating. This is due to

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the more mature abstract thinking and digital literacy skills of senior high school students, which support the effective use of AR in understanding biology material. Most studies used quantitative methods with quasi-experimental designs to measure the effect of AR on student learning outcomes, motivation, and digital literacy. In general, AR-based media has been proven to improve students' conceptual understanding, learning outcomes, motivation, and engagement in Biology learning. Thus, AR technology has great potential as an innovative 21st-century learning strategy that is interactive, contextual, and supports the digital transformation of Biology education.
Keywords: *Augmented Reality, Biology, Learning Media*

INTRODUCTION

Biology stands as a fundamental branch of natural science dedicated to the comprehensive study of life in all its manifestations and complexities. It is not merely a static collection of knowledge comprising facts, concepts, or principles, but rather a dynamic process of discovery and inquiry that evolves over time (Febrianti & Karyadi, 2018). Despite its significance in understanding the living world, biology is frequently perceived by students as one of the most challenging academic subjects to master. This difficulty arises primarily because the curriculum is saturated with numerous scientific terms, often derived from Latin or Greek, which are rarely utilized in daily conversation. Furthermore, the subject involves complex learning concepts and intricate material related to the natural world that can be arduous to explain verbally (Syarah et al., 2021). The cognitive load required to process this specialized vocabulary, combined with the need to understand interconnected living systems, often creates a barrier to learning. Consequently, educators are constantly seeking methods to bridge the gap between these complex scientific definitions and the students' cognitive grasp of the material.

A significant hurdle in biological education lies in the intrinsic nature of the concepts themselves. Not all biological phenomena are concrete or easily observable with the naked eye; in fact, a vast proportion of the curriculum involves processes that are microscopic, abstract, or occur over vast timescales (Ariyanto et al., 2018). For instance, cellular respiration, genetic inheritance, or ecological cycles cannot be seen directly, requiring students to rely heavily on imagination, which can lead to misconceptions. To address the challenges posed by abstract and complex biology material, an appropriate and innovative learning approach is strictly required. One effective strategy is the utilization of technological advances within the learning process. By integrating modern digital tools, educators can help visualize these intangible concepts, thereby transforming abstract theories into observable phenomena. This technological integration serves to increase student interaction with the content and significantly facilitate students' understanding of difficult material. Without such visual aids, the depth of understanding remains superficial, limited to text-based memorization rather than true conceptual conceptualization.

The landscape of pedagogy is currently undergoing a radical transformation driven by rapid technological developments in education. These advancements are bringing about profound changes in the world of education, specifically within the domain of biology lessons. In this modern era, technology is becoming increasingly sophisticated, accessible, and varied, which means that a growing number of digital media formats are being utilized by teachers and students to complete academic tasks. With all these dynamic developments, technology clearly provides substantial benefits for the educational ecosystem. The learning process has become significantly more flexible and enjoyable, moving away from rigid, traditional lecture-based

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methods. Teachers are assisted in delivering material through multimedia presentations, while students find it easier to understand lessons that are supported by digital resources. The integration of these tools allows for personalized learning paces and diverse instructional styles, ensuring that education is not a one-size-fits-all experience but a tailored journey that leverages digital ubiquity to enhance academic performance and engagement in science subjects.

Amidst the array of emerging digital tools, some advanced technologies are beginning to be implemented more frequently in educational settings, with *Augmented Reality* (AR) standing out as a particularly promising innovation. AR is defined as a sophisticated technique that combines two-dimensional and three-dimensional virtual objects into a three-dimensional real environment and then projects these virtual objects in real time (Mauludin et al., 2017). Unlike Virtual Reality, which isolates the user from their surroundings, AR enhances the real world by overlaying digital information onto it. This capability enables students to learn more deeply through engaging 3D experiences that were previously impossible in a standard classroom setting. For example, learners can explore the intricate systems of the human body or the vastness of the solar system as if seeing them directly in front of them. This immersive quality bridges the gap between theoretical knowledge and physical reality, providing a tangible context for learning that captures students' attention and fosters a deeper level of curiosity and retention regarding the subject matter.

Learning complex concepts and biological processes that are difficult to explain verbally is a major challenge, especially since biology is closely related to the dynamics of nature in the surrounding environment. Consequently, effective instruction often requires visualization to explain the material comprehensively. According to Ward and William (as cited in Wibowo, 2010), the use of images allows individuals to express themselves and convey thoughts more effectively than text alone. AR technology, which possesses the capability to display high-resolution images, detailed 3D models, and interactive animations, has great potential for use as a medium for learning biology, which often contains complex and abstract concepts. From a pedagogical perspective, AR facilitates active learning through hands-on experience and visual representations that adopt the principles of Constructivist Learning Theory (Hallaby & Syahputra, 2025). Rather than passively receiving information, AR provides opportunities for students to actively develop their understanding by independently exploring virtual objects. This direct interaction with the subject matter allows learners to construct their own knowledge bases through experimentation and observation.

The application of AR is currently widely used and has permeated various professional and academic fields. Based on research data spanning from 2016 to 2025, AR is widely used in the fields of Computer Science, Social Science, and Physics Astronomy, demonstrating its versatility. In the specific field of education, AR helps students understand abstract material, such as the body's complex organ systems or microscopic cell structures, through more realistic interactive visualizations. Beyond mere content delivery, this technology not only helps students understand material through 3D visualization and direct interaction but also actively promotes essential 21st-century skills such as creativity, critical thinking, and collaboration. As students manipulate virtual objects, they engage in problem-solving and collaborative inquiry. Furthermore, AR has characteristics that are in line with the current era of revolution, where AR technology is capable of presenting interactive and independent media. This alignment makes AR the ideal solution for learning in the era of the 4th Industrial Revolution and the 5th Social Revolution, preparing students for a digitally integrated future (Trikotama et al., 2024).

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Given the rapid proliferation of this technology, researchers are interested in seeing how the use of *Augmented Reality* (AR) technology is developing in the world of education over time. Specifically, researchers want to see how AR is impacting education now and predicting how it will influence learning in the future. This forward-looking and analytical approach distinguishes this study from previous studies, which may have focused on isolated experiments rather than broader trends. This literature study also seeks to identify trends in the use of AR technology in formal schools, mapping out adoption rates and methodological shifts. In addition, the literature study is also used to explain and understand important information about the use of AR media in current educational practices and the impact it will have on curriculum design. By synthesizing existing data, this research aims to provide a comprehensive overview that can guide educators and policymakers in effectively integrating AR, ensuring that the technology serves as a robust pedagogical tool rather than a fleeting novelty.

METHOD

This research applies the *Systematic Literature Review* (SLR) method by adhering to the *Preferred Reporting Items for Systematic Review and Meta-Analysis* (PRISMA) guidelines, which are considered effective for conducting an in-depth assessment of conceptual understanding. The selection of the SLR method is based on its structured and systematic technical characteristics in collecting, critically examining, integrating, and organizing results from various previous studies to serve as a research topic or an in-depth study of research questions that need exploration (Norlita et al., 2023). The implementation of the PRISMA approach in this study ensures that the literature review process follows a rigorous, transparent, and scientifically accountable workflow. Specifically, this research protocol is designed to progress through four main interrelated procedural stages: identification, screening, eligibility, and included. This systematic framework is used to guarantee that the selected articles are truly relevant and of high quality in achieving the research objectives (Pangadongan & Safrudiannur, 2024).

The first operational stage is identification, which is a process of searching, discovering, researching, and recording data and information regarding a study object comprehensively (Hardiansyah et al., 2023). At this phase, literature searches are conducted digitally using the reputable Scopus database to obtain credible articles. The search strategy is carried out using the specific keyword “Augmented Reality in Biology Learning” to identify relevant studies. Once the initial data is collected, the research proceeds to the screening stage, which aims to select research that has strong relevance to the topic being discussed (Kurniawan, 2021). At this stage, articles are compiled and filtered based on strict inclusion criteria to ensure data suitability. Screening parameters include the publication period, document type, article accessibility (open access), type of learning media used, biological material discussed, language use, and the educational level of the study subjects.

After the initial screening process is completed, the research enters the eligibility stage or suitability assessment. In this phase, articles that have passed the screening are read and reviewed thoroughly (*full-text review*) to ensure compliance with the predetermined inclusion and exclusion criteria. This process is conducted carefully to verify the content of the articles, ensuring that the methodologies and findings align with the proposed research questions. Articles that do not meet quality standards or are not substantially relevant will be excluded at this stage. The final stage in the PRISMA protocol is included, which involves determining the final results of the article selection that has passed through a series of identification, screening,

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and eligibility processes. The articles that successfully enter this stage are then analyzed and synthesized as primary data sources. This final collection of literature serves as the empirical foundation for answering the problem formulation and drawing conclusions in this *Systematic Literature Review* study.

Table 1. Search Strategy

Source	Keyword	Result
Scopus	"Augmented Reality in Biology Education"	A search on Scopus yielded 21 articles. Next, a selection and assessment stage was carried out to determine which articles were relevant. The assessment was based on the criteria listed in Table 2

Table 2. Eligibility Criteria

Criteria	Inclusion	Exclusion
Publishing Range	2016-2025	<2016
Document Type	Article, Conference Paper	Books, book chapters, or reports that are not published in journals
Accessibility	Articles available for download	Articles that cannot be downloaded
Learning Media	Augmented Reality-based media	Non-Augmented Reality-based media
Subject	Biology	Non Biology
Language	English	Other than English
Category	Formal Education	Non-formal Education

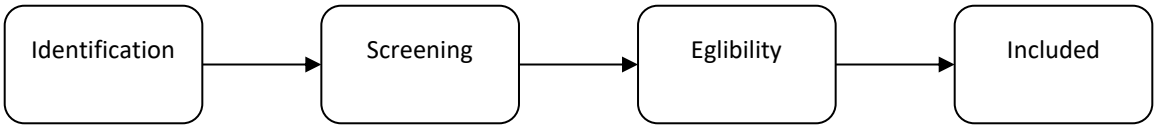

Figure 1. PRISMA Approach Stages (Nabila et al., 2025)

RESULT AND DISCUISSON

Result

Table 3. Article List

No	Title/Name	Method	Category/ Subject	Media AR	Result
1	The Effectiveness of Augmented Reality-Assisted E-Module in Improving Students Digital Literacy in High School Biology Learning.	Quantitative method with a quasi-experimental non-equivalent control group design.	Senior High School/ Biology	Augmented Reality based e-module	AR-assisted e-modules with the PBL model has a greater impact on students' digital literacy than PBL. (Cognitive).

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No	Title/Name	Method	Category/ Subject	Media AR	Result
	(Zufahmi et al., 2025).				
2	The Effectiveness of Augmented Reality Media on Student Learning Outcomes in Biology Learning (Ashari & Agustina, 2025).	True Experiment Method	Senior High School/ Biology	Augmented Reality based learning media	AR-based media can improve student learning outcomes compared to conventional learning. (Cognitive).
3	Research Trends Of Augmented Reality In Biology Learning: Content And Bibliometric Mapping Analysis (Wilsa et al., 2025).	Mix method	Senior High School/ Biology	Augmented Reality based learning media, AR Game System.	AR has been proven to increase student motivation, interest in learning, conceptual understanding, and independence in learning. (Cognitive and Affective).
4	Design of a Mobile Application with Augmented Reality to Promote Learning of Cell Biology (Archundia-Sierra et al., 2024).	This study uses the development method.	Senior High School/ Biology	Augmented Reality learning media application	AR learning resources can be an alternative learning resource in biology lessons, for example in cell material. (Cognitive).
5	The development of e-flipbook multirepresentative augmented reality in biology cells to enhance technology literacy and student learning outcomes.	This study uses the development method.	Senior High School/ Cell	Website-based AR electronic flipbook	AR-based e-flipbook media is effective in improving student learning outcomes while also training technological literacy in cell

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No	Title/Name	Method	Category/ Subject	Media AR	Result
	(Firdaus et al., 2024).				biology learning. (Cognitive).
6	Enhance Biology Learning Outcomes with Applying Augmented Reality (AR Sinaps) as Learning Media (Rini et al., 2024).	The research method used was a quasi-experiment with a posttest-only control group design.	Senior High School/ Respiratory System	Learning media Augmented Reality respiratory system (AR Sinaps).	Augmented Reality respiratory system learning media has an effect on the learning outcomes of senior high school students. (Cognitive).
7	Augmented reality to support students learning of socio-scientific issues in biology class: A systematic review of the literature (Annisa & Subiantoro, 2024).	Mixed method	Senior High School/ Biology	AR based learning media application	AR can be an alternative medium for biology teachers to facilitate learning. (Cognitive).
8	User Evaluation on a Mobile Augmented Reality Game-based Application as a Learning Tool for Biology (Lam et al., 2023).	Experimental Method	Junior High School/ Cell	Augmented reality game based learning media	AR-based game learning media can be used to assist them in the learning process. (Cognitive).
9	Learning with digital technology-facilitated empathy: an augmented reality approach to enhancing students' flow experience, motivation, and achievement in a	Quasi-experimental method.	Elementary School/ Biology	Augmented Reality based learning media	AR learning media can increase student motivation to learn, but there is no specific improvement in academic performance. (Cognitive and Affective).

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No	Title/Name	Method	Category/ Subject	Media AR	Result
	biology program (Wang et al., 2023).				
10	Integrating Chatbot and Augmented Reality Technology into Biology Learning during COVID-19 (Chuang et al., 2023).	Questionnaire survey method	Junior High School/ Biology	Chatbot based AR learning media	AR technology increases students' attention, relevance, confidence, and satisfaction in learning biology online. (Cognitive and Affective).
11	Improving Students' Literacy and Numeracy Using Mobile Game-Based Learning with Augmented Reality in Chemistry and Biology (Cahyana et al., 2023).	Quasi-experimental method.	Senior High School/ Biology & Chemistry	Game based learning with AR	Game-based learning with AR is effective in improving literacy and numeracy among high school students in the fields of chemistry and biology. (Cognitive).
12	Implementing augmented reality to improve students' biology learning outcomes: Gender-based effect (Tamam & Corebima, 2023).	Quasi-experimental method.	Senior High School/ Biology	Augmented Reality based e-book	AR effectively improves biology learning outcomes regardless of gender, making it an inclusive and relevant learning strategy to meet the demands of 21st-century education. (Cognitive).
13	Development of android-based augmented reality lab coat in biology learning (Darmawan et al., 2023).	Research and Development method Borg and Gall.	Senior High School/ Respiratory System	AR learning media on lab coats	Android-based AR Lab Coat has been successfully developed and is suitable for use as a biology learning medium, with a positive impact on

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No	Title/Name	Method	Category/ Subject	Media AR	Result
					students' understanding and motivation to learn. (Cognitive and Affective).
14	Using Augmented Reality for Biology Learning in High School: A Quasi-Experiment Study (Cheong et al., 2021).	Quasi-experimental method.	Senior High School/ Biology	AR based learning media	AR has been proven to increase positive emotions (enjoyment, pride, hope) and reduce negative emotions in biology learning. AR also has the potential to be more user-friendly and used continuously. (Affective).
15	Mobile learning development using augmented reality as a biology learning media (Susilo et al., 2021).	Research Method Luther-Sutopo	Senior High School/ Biology	Android mobile application based on Augmented Reality	AR can help students visualize biological objects in 3D, increase interaction with the material, and encourage students to learn independently. (Cognitive and Affective).
16	Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement (Weng et al., 2020).	Quasi-experimental pre-test and post-test method	Junior High School/ Biology	Printed books with AR technology	AR improves student learning outcomes, especially at the analysis level, also show that students' attitudes towards biology also improved. (Cognitive and Affective).
17	Media Interactive Learning and biology subjects implementation	Literature review	Senior High School/	Interactive learning	AR can be used as an alternative learning medium that supports the

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No	Title/Name	Method	Category/ Subject	Media AR	Result
	with augmented reality application (Moedjiono & Kusdaryono, 2017).		Human organs	media with AR.	understanding of biological concepts. (Cognitive).
18	Implementation of Android-based augmented reality as learning and teaching media of dicotyledonous plants learning materials in biology subject (Qamari & Ridwan, 2017).	Qualitative method	Senior High School/ dicotyledonous plants	AR based learning media	Android-based augmented reality (AR) media makes learning more interesting, easy to understand, and practical to use. AR is effective and has potential as a medium for biology learning. (Cognitive and affective).
19	Digital gaming for evolutionary biology learning: The case study of parasite race, an augmented Reality location-based game (Aivelo & Uitto, 2016).	Case study method with a qualitative and descriptive approach.	Teacher/ Ecology and evolution	Game based Augmented Reality	AR games improve students' understanding of the learning process. AR games provide an active and contextual learning experience through a combination of digital movements. (Cognitive and Affective).

In this more modern era, technology has become increasingly sophisticated and advanced, such as the availability of more media to support students in improving their understanding (Maritsa in Habsy et al., 2024). Understanding concepts in biology is very important in learning. However, students' mastery of biological concepts is still weak, and there are even concepts that are misunderstood (Widyastuty, 2024). Conventional learning media commonly used by teachers, such as textbooks and lectures (Raharjo et al., 2025), are unable to provide clear visualizations, making it difficult for students to understand the material in depth. These have not been able to provide clear visualizations, making it difficult for students

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to understand the material in depth. In addition, low digital literacy and the use of technology in learning have resulted in students' smart devices not being used optimally as learning tools. The lack of innovative, interactive, and enjoyable learning media also has an impact on low student motivation and interest in learning.

This condition shows that innovative efforts are needed in developing learning media that can bridge the gap between abstract concept understanding and meaningful learning experiences. One potential solution is the application of AR in biology learning. AR is a technology that combines virtual objects with real objects (Aprilinda et al., 2020). Several AR applications are designed to provide users with more detailed information about real objects. AR technology works by displaying the integration between the real world and virtual elements in the form of interactive three-dimensional visuals (Wulandari et al., 2025). This can help students visualize complex biological concepts, such as cell structure, organ systems, or physiological processes in living things. In addition, AR also makes learning more interesting and is able to expand information capacity (Paliling et al., 2025).

Based on an analysis of 19 articles discussing the use of AR technology, it appears that AR can improve conceptual understanding, facilitate the visualization of abstract objects, and encourage active engagement of students in the learning process. In addition, the use of AR in biology education has also been shown to increase learning motivation, enrich interactive experiences, and help students understand difficult material in a more concrete way. The existence of AR technology can facilitate learning activities, as shown by research conducted by Annisa & Subiantoro (2024), which states that AR can be an alternative medium for biology teachers to facilitate learning. AR can also improve student learning outcomes, as proven by research conducted by Firdaus et al. (2024), which states that the use of AR-based e-flipbook learning media can improve student learning outcomes. The T-test results showed a significant difference between the two, with a sig. value of 0.020. An evaluation stage was conducted to assess the impact of media application. This product can be concluded as a medium that can improve student learning outcomes and digital literacy in cell learning. In addition to improving learning outcomes, AR can also improve students' digital literacy. Based on the results of research conducted by Zufahmi et al. (2025), learning with AR-based e-modules showed that the average corrected digital literacy score in the control class (68.465) was lower than the average digital literacy score in the treatment class (78.877), meaning that learning using AR had a better effect on students' digital literacy.

Table 4. Category og Research

No	Category	Total
1	Elementary School	2
2	Junior High School	3
3	Senior High School	14

Based on table 4 the application of AR has been widely used in formal schools, starting from elementary, junior high, and high school levels. Based on articles that have been included in the inclusion criteria from 2016 to 2025, the application of AR technology in education has been widely applied at the high school level. There are 14 articles that apply AR at the high school level. The use of AR predominantly uses smartphones as a tool to access it. The high school level was chosen because high school students already have and understand smartphones. Based on Ratnayani's research in (Khoirunnisa et al., 2023), it was revealed that the use of gadgets among high school students during study hours at the end of the week, with

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a duration of 2-4 hours/day, was 50.6%. This indicates that the level of high school students' exposure to technology, especially smartphones, is already very high, thus supporting the application of Augmented Reality (AR)-based media in the learning process. Additionally, at the high school level, students have more mature abstract and logical thinking skills compared to previous levels, so they can more easily understand complex concepts visualized through AR.

The research methods used in the 19 articles were quantitative, literature review, research and development, and qualitative. The quantitative method was the most widely used, with 10 articles (53%). The most widely used type of quantitative method was quasi-experimental because quasi-experimental research is a research method used to measure the effect of a particular treatment on a variable without fully randomizing the subjects (Anantasia & Rindrayani, 2025). The research and development (R&D) method was used in 5 articles (26%), which generally focused on the process of developing AR learning media innovations and testing their feasibility in learning. There were 2 articles (10%) using the literature review method discussing the use of AR media at various levels and methods. Another 2 articles (11%) used a qualitative approach to explore users' experiences or perceptions of the application of AR in learning.

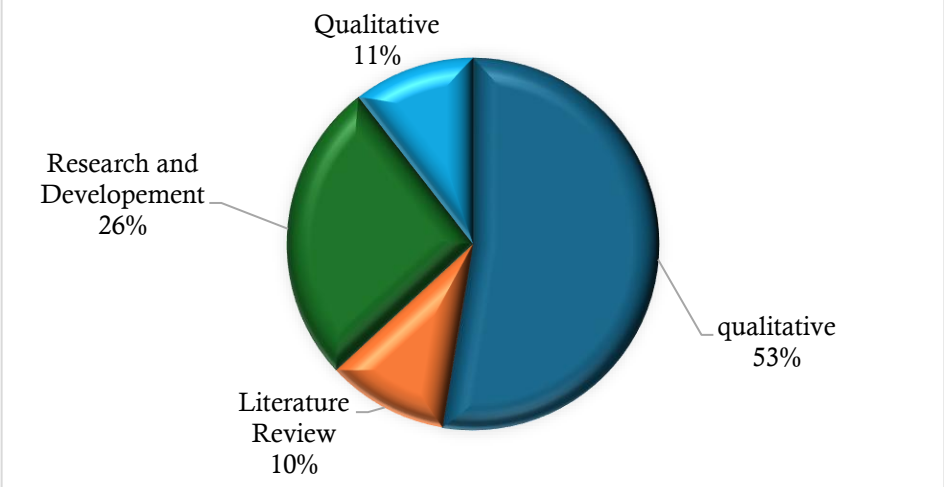

Figure 2. Diagram of The Method Used

The research methods (Figure 2) used in the 19 articles were quantitative, literature review, research and development, and qualitative. The quantitative method was the most widely used, with 10 articles (53%). The most widely used type of quantitative method was quasi-experimental because quasi-experimental research is a research method used to measure the effect of a particular treatment on a variable without fully randomizing the subjects (Anantasia & Rindrayani, 2025). The research and development (R&D) method was used in 5 articles (26%), which generally focused on the process of developing AR learning media innovations and testing their feasibility in learning. There were 2 articles (10%) using the literature review method discussing the use of AR media at various levels and methods. Another 2 articles (11%) used a qualitative approach to explore users' experiences or perceptions of the application of AR in learning.

The distribution of research methods shows that researchers tend to use experimental methods to prove the effect of using Augmented Reality (AR) media on the learning process and outcomes. In addition, there are also studies that use the Research and Development method

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as a form of innovation in creating and perfecting AR-based learning media to make it more interactive and effective for use in learning activities.

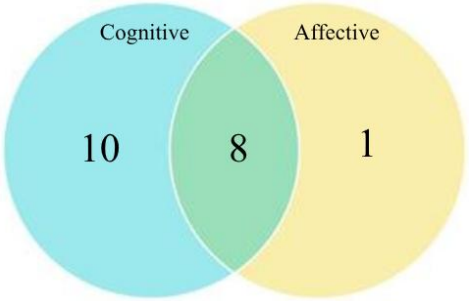

Figure 3. The Effectiveness of AR Media On Learning Outcomes

Based on Figure 2 learning outcomes are the abilities acquired by students after receiving learning experiences from teachers or educators. Some of the experiences received by students cover the affective, cognitive, and psychomotor domains (Hutapea in Agusti & Aslam, 2022). The function of learning outcomes is to measure students' success in understanding school subject matter, as demonstrated by the scores or grades obtained from tests on a number of subjects that have been studied (Purwaningsih, 2022). In addition, learning outcomes also serve as a basis for teachers in evaluating the effectiveness of the learning process that has been carried out. Through learning outcomes, teachers can determine the extent to which learning objectives have been achieved and identify parts of the material that still need to be improved or explored in greater depth. Thus, learning outcomes not only reflect student abilities, but also serve as important feedback for improving the quality of learning and teaching strategies in schools.

Based on 19 articles discussing the use of AR in biology learning, it can be concluded that AR technology has a significant positive impact on the learning process and outcomes of students. Learning outcomes are measured by looking at changes in three aspects, namely cognitive, affective, and psychomotor aspects (Setyawati et al., 2021). Ten articles stated that the use of AR in biology learning helps improve students' cognitive development. Cognitive ability is the ability of children to think more complexly and to reason and solve problems (Izzuddin, 2021). The use of AR technology in biology learning provides a more interactive and contextual learning experience because it is able to visualize abstract biological objects in a more realistic way. This helps students understand difficult concepts, such as cell structure, organs, or metabolic processes, in a more in-depth and interesting way (Ahmad et al., 2022).

The affective aspect is related to a person's attitude in accepting or rejecting something, and includes mental attitudes, feelings, and student awareness during the learning process (Inaku & Paputungan, 2022). One article states that learning with AR media can improve the affective aspect by fostering student motivation and enjoyment of learning. Innovative AR media that displays images in 3D can increase student motivation to learn, making the acceptance of material in the learning process more effective. Eight articles state that the use of AR technology in biology learning can improve two aspects, namely cognitive and affective. This shows that the use of AR not only helps students understand the material conceptually, but also fosters a positive attitude towards learning Biology. The combination of three-dimensional visualization, interactivity, and ease of access makes students more emotionally and

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intellectually involved in the learning process (Putri et al., 2021). Thus, it can be concluded that AR technology plays an important role in improving the quality of biology learning, not only from a cognitive perspective through increased conceptual understanding, but also from an affective perspective, by fostering students' motivation, interest, and positive attitudes towards the subject.

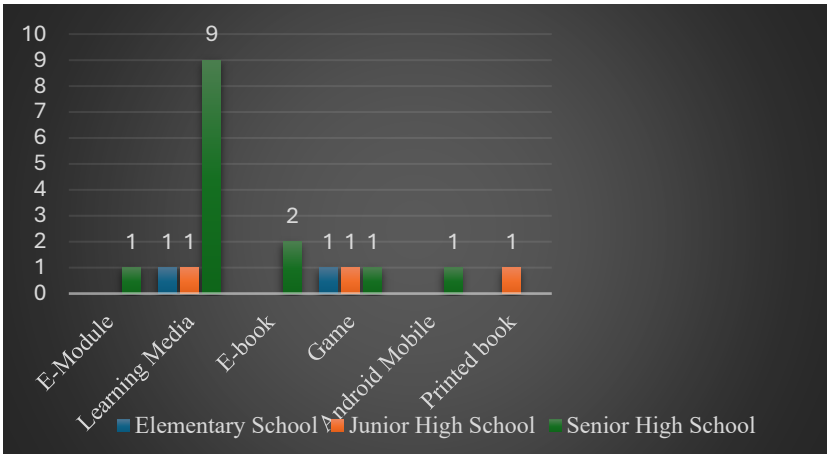

Figure 4. The most popular AR Media In Each Category

Based on figure 4 the use of AR technology is commonly found at the high school level because high school students generally study more complex and in-depth material and have more mature learning experiences (Sumatraputra et al., 2023). The application of AR technology is commonly found in learning media compared to other learning devices. The use of interesting and interactive learning media stimulates students in the learning process (Nurfadhillah et al., 2021). Based on the graph, the application of AR technology in e-modules is only found at the high school level. The application of AR technology in learning media is found at all levels of elementary, junior high, and high school, with the highest usage at the high school level. The use of AR in learning media makes it easier to convey abstract concepts in a more concrete and understandable way, opening the door to deeper understanding (Rachim et al., 2024). The application of AR technology in e-books is only found at the high school level. The application of AR technology in games is found at all levels of elementary, junior high, and high school. The use of games in learning utilizes game elements, such as rules, challenges, scores, and game-based interactions to teach specific concepts, skills, or knowledge to students (Wulandari & Safitri, 2024). The application of Android Mobile-based AR technology is only available at the high school level. The application of AR technology in printed books is only available at the junior high school level.

The Advantages of AR Media

The use of Augmented Reality (AR)-based media has many advantages, including improving digital literacy, learning motivation, learning outcomes, and students' understanding of concepts. AR technology displays images with length, width, and height, making them appear lifelike when used. In addition, the use of AR-based media also provides a more interactive and contextual learning experience. Through the display of three-dimensional (3D) objects that appear real, students can observe the structure, shape, and function of biological objects in greater depth than through two-dimensional images in textbooks. Direct interaction with these virtual objects can foster curiosity, facilitate the observation process, and help students understand abstract concepts in a more concrete way.

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CONCLUSION

Based on the results of a review of 19 articles analyzed using the Systematic Literature Review method with the PRISMA approach, it can be concluded that the application of Augmented Reality (AR) technology in Biology learning shows a positive and growing trend from year to year. The use of AR is most commonly found at the high school level with a predominance of smartphone-based media, because students at this level have more mature abstract thinking and digital literacy skills. AR technology has been proven to be effective in improving learning outcomes, especially in the cognitive and affective domains, by helping students understand abstract Biology concepts through interactive three-dimensional visualizations. In addition, AR can increase students' motivation, interest in learning, and digital literacy, and encourage active engagement in the learning process. In terms of research methods, the majority of studies use a quantitative approach with a quasi-experimental design to measure the effect of AR on learning outcomes, followed by R&D research focused on the development of innovative learning media. Thus, it can be concluded that AR has great potential as an innovative 21st-century learning strategy that can provide interactive, contextual, and enjoyable learning experiences and support digital transformation in Biology education.

REFERENCES

Agusti, N. M., & Aslam, A. (2022). Efektivitas media pembelajaran aplikasi Wordwall terhadap hasil belajar IPA siswa sekolah dasar. *Jurnal Basicedu, 6*(4), 5794–5800. https://doi.org/10.31004/basicedu.v6i4.3053

Ahmad, Z., Ahmad, H., & Rahman, Z. A. (2022). Penggunaan media pembelajaran augmented reality berbantuan Assemblr Edu untuk meningkatkan hasil belajar siswa SMA Negeri 5 Kota Ternate. *Jurnal Ilmiah Wahana Pendidikan, 8*(23), 514–521. https://doi.org/10.5281/zenodo.7421774

Aivelo, T., & Uitto, A. (2016). Digital gaming for evolutionary biology learning: The case study of parasite race, an augmented reality location-based game. *Lumat: International Journal of Math, Science and Technology Education, 4*(1), 1–26. https://doi.org/10.31129/LUMAT.4.1.3

Anantasia, G., & Rindrayani, S. R. (2025). Metodologi penelitian quasi eksperimen. *Adiba: Journal of Education, 5*(2), 183–192. https://adiba.cvsyafina.com/index.php/adiba/article/view/390

Annisa, D. N., & Subiantoro, A. W. (2024). Augmented reality to support students learning of socio-scientific issues in biology class: A systematic review of the literature. *AIP Conference Proceedings, 2622*(1), 30011. https://doi.org/10.1063/5.0133557

Aprilinda, Y., Endra, R. Y., Afandi, F. N., Ariani, F., Cucus, A., & Lusi, D. S. (2020). Implementasi augmented reality untuk media pembelajaran biologi di Sekolah Menengah Pertama. *Explore: Jurnal Sistem Informasi dan Telematika, 11*(2), 124–133. https://doi.org/10.36448/jsit.v11i2.1591

Archundia-Sierra, E., Cerón-Garnica, C., Contreras-Juárez, R., & Garcés-Báez, J. A. del C. (2024). Design of a mobile application with augmented reality to promote learning of cell biology. Dalam *International Conference on Communication and Applied Technologies* (hlm. 195–207). Springer. https://doi.org/10.1007/978-981-96-0426-5_17

https://doi.org/10.51878/science.v6i1.8929

Ariyanto, A., Priyayi, D. F., & Dewi, L. (2018). Penggunaan media pembelajaran biologi di Sekolah Menengah Atas (SMA) swasta Salatiga. *BIOEDUKASI (Jurnal Pendidikan Biologi), 9*(1), 1–13. https://doi.org/10.24127/bioedukasi.v9i1.1377

Ashari, R. N., & Agustina, L. (2025). The effectiveness of augmented reality media on student learning outcomes in biology learning. *AIP Conference Proceedings, 3142*(1), 20110. https://doi.org/10.1063/5.0262306

Cahyana, U., Luhukay, J. R., Lestari, I., Irwanto, I., & Suroso, J. S. (2023). Improving students' literacy and numeracy using mobile game-based learning with augmented reality in chemistry and biology. *International Journal of Interactive Mobile Technologies, 17*(16), 4–15. https://doi.org/10.3991/ijim.v17i16.42377

Cheong, C. W. L., Guan, X., & Hu, X. (2021). Using augmented reality for biology learning in high school: A quasi-experiment study. *Proceedings of International Conference of the Learning Sciences, ICLS*, 1167–1168. https://doi.org/10.22318/icls2021.1167

Chuang, C. H., Lo, J. H., & Wu, Y. K. (2023). Integrating chatbot and augmented reality technology into biology learning during COVID-19. *Electronics, 12*(1), 222. https://doi.org/10.3390/electronics12010222

Darmawan, E., Prajoko, S., Prabowo, B. H., Sukmawati, I., Alamsyah, M. R. N., Permadani, K. G., & Pamungkas, S. J. (2023). Development of android-based augmented reality lab coat in biology learning. *AIP Conference Proceedings, 2706*(1). https://doi.org/10.1063/5.0120332

Febrianti, E., & Karyadi, B. (2018). Penerapan model kooperatif tipe-Group Investigation (GI) pada materi sistem ekskresi manusia untuk meningkatkan hasil belajar siswa kelas XI IPA SMA N 8 Kota Bengkulu. *Jurnal Pendidikan dan Pembelajaran Biologi, 2*(1), 10–14. https://doi.org/10.33369/jppb.v2i1.5125

Firdaus, Z., Setiawan, D., Sunarmi, S., & Setiani, P. P. (2024). The development of e-flipbook multirepresentative augmented reality in biology cells to enhance technology literacy and student learning outcomes. *AIP Conference Proceedings, 3106*(1), 30033. https://doi.org/10.1063/5.0215155

Habsy, B. A., Yusiana, A. P. E., Nadya, N., & Satria, A. F. (2024). Pemanfaatan ilmu pengetahuan dan teknologi dalam pendidikan. *Jurnal Pendidikan dan Kebudayaan, 2*(4), 164–173. https://doi.org/10.61132/bima.v2i4.1391

Hallaby, S. F., & Syahputra, A. (2025). Implementasi augmented reality dalam pembelajaran biologi di Indonesia: Analisis kritis terhadap validasi metodologis dan efektivitas pedagogis. *Eduproxima: Jurnal Ilmiah Pendidikan IPA, 7*(3), 1699–1711. https://doi.org/10.29100/eduproxima.v7i3.8908

Hardiansyah, D., Ulfa, S. W., Marhamah, A., Rahayu, P., & Aqmarina, T. N. (2023). Identifikasi ciri morfologis tumbuhan tingkat tinggi pada ordo berbeda di Kampus II UIN Sumatera Utara. *Biosfer: Jurnal Biologi dan Pendidikan Biologi, 8*(2), 154–164. https://doi.org/10.23969/biosfer.v8i2.11144

Inaku, R., & Paputungan, F. (2022). Teori afektif menurut para ahli. *Journal of Education and Culture (JEaC), 2*(3). https://journals.ubmg.ac.id/index.php/JEaC/article/view/1134

Izzuddin, A. (2021). Upaya mengembangkan kemampuan kognitif anak usia dini melalui media pembelajaran sains. *EDISI, 3*(3), 542–557. https://doi.org/10.36088/edisi.v3i3.1614

https://doi.org/10.51878/science.v6i1.8929

Khoirunnisa, A., Jannah, N., Nisa, T. K., & Prihatiningsih, R. (2023). Analisis tingkat penggunaan handphone pada siswa Madrasah Aliyah Negeri di Kabupaten Malang-Turen. *Prosiding SEMDIKJAR (Seminar Nasional Pendidikan dan Pembelajaran), 6*, 1941–1951. https://doi.org/10.29407/dzwgby11

Kurniawan, D. M. (2021). *Pengaruh level physical activity anak terhadap fundamental movement skills: Systematic literature review* [Skripsi, Universitas Pendidikan Indonesia]. UPI Repository. http://repository.upi.edu/id/eprint/63344

Lam, M. C., Lim, S. M., & Tan, S. Y. (2023). User evaluation on a mobile augmented reality game-based application as a learning tool for biology. *TEM Journal, 12*(1), 550–557. https://doi.org/10.18421/TEM121-65

Mauludin, R., Sukamto, A. S., & Muhardi, H. (2017). Penerapan augmented reality sebagai media pembelajaran sistem pencernaan pada manusia dalam mata pelajaran biologi. *Jurnal Edukasi dan Penelitian Informatika (JEPIN), 3*(2), 117–123. https://doi.org/10.26418/jp.v3i2.22676

Moedjiono, S., & Kusdaryono, A. (2017). Media interactive learning and biology subjects implementation with augmented reality application. *2017 Second International Conference on Informatics and Computing (ICIC)*, 1–6. https://doi.org/10.1109/IAC.2017.8280626

Mustaqim, I. (2016). Pemanfaatan augmented reality sebagai media pembelajaran. *Jurnal Pendidikan Teknologi dan Kejuruan, 13*(2), 174–183. https://doi.org/10.23887/jptk-undiksha.v13i2.8525

Nabila, A., Aziz, A., & Suprapto, R. (2025). Systematic literature review: Pengaruh media pembelajaran digital terhadap pemahaman konsep matematis. *Sains dan Teknologi, 12*(2), 1079–1100. https://doi.org/10.47668/edusaintek.v12i2.1724

Norlita, D., Nageta, P. W., Faradhila, S. A., Aryanti, M. P., Fakhriyah, F., & Ismayam. A, E. A. (2023). Systematic Literature Review (SLR): Pendidikan karakter di sekolah dasar. *JISPENDIORA: Jurnal Ilmu Sosial Pendidikan dan Humaniora, 2*(1), 209–219. https://doi.org/10.56910/jispendiora.v2i1.743

Nurfadhillah, S., Ningsih, D. A., Ramadhania, P. R., & Sifa, U. N. (2021). Peranan media pembelajaran dalam meningkatkan minat belajar siswa SD Negeri Kohod III. *PENSA: Jurnal Pendidikan dan Ilmu Sosial, 3*(2), 243–255. https://doi.org/10.36088/pensa.v3i2.1186

Paliling, A., Mardiawati, M., & Al Kasyaf, M. A. (2025). Rancang bangun aplikasi augmented reality berbasis mobile untuk pembelajaran flora dan fauna. *Jurnal Manajemen Informatika (JAMIKA), 15*(2), 141–151. https://doi.org/10.34010/jamika.v15i2.15608

Pangadongan, N. K., & Safrudiannur, S. (2024). Tren penelitian miskonsepsi matematika di jurnal-jurnal berbahasa Indonesia tahun 2019-2023: Review tahap awal. *Prosiding Seminar Nasional Hasil Penelitian*, 98–114. https://ojs.unm.ac.id/semnaslemlit/article/view/62953

Purwaningsih, P. (2022). Peningkatan hasil belajar melalui model pembelajaran penemuan pada peserta didik kelas VIII SMP Negeri 8 Cikarang Utara Kabupaten Bekasi. *EDUCATOR: Jurnal Inovasi Tenaga Pendidik dan Kependidikan, 2*(4), 422–427. https://doi.org/10.51878/educator.v2i4.1929

https://doi.org/10.51878/science.v6i1.8929

Putri, D. G., Zulfarina, Z., & Syafii, W. (2021). Development of augmented reality for biology E-magazine. *Journal of Educational Sciences, 5*(3), 511–519. https://doi.org/10.31258/jes.5.3.p.511-519

Qamari, C. N., & Ridwan, M. R. (2017). Implementation of Android-based augmented reality as learning and teaching media of dicotyledonous plants learning materials in biology subject. *2017 3rd International Conference on Science in Information Technology (ICSITech)*, 441–446. https://doi.org/10.1109/ICSITech.2017.8257153

Rachim, M. R., Salim, A., & Qomario, Q. (2024). Pemanfaatan augmented reality sebagai media pembelajaran terhadap keaktifan belajar siswa dalam pendidikan modern. *Jurnal Riset dan Inovasi Pembelajaran, 4*(1), 594–605. https://doi.org/10.51574/jrip.v4i1.1407

Raharjo, R., Wiyati, I., Sutanto, S., Santoso, S., & Rondli, W. S. (2025). Efektivitas penggunaan media pembelajaran digital dalam meningkatkan minat dan hasil belajar siswa SDN 1 Sarirejo. *Jurnal Guru Sekolah Dasar, 2*(1), 50–60. https://doi.org/10.70277/jgsd.v2i1.5

Rini, D. S., Azrai, E. P., Khansa, A. A., & Wulandari, Y. (2024). Enhance biology learning outcomes with applying augmented reality (AR Sinaps) as learning media. *AIP Conference Proceedings, 2982*(1), 50004. https://doi.org/10.1063/5.0184458

Setyawati, E., Ngadiman, N., & Susanti, A. D. (2021). Penerapan model Explicit Instruction (EI) berbantu media Jobsheet untuk meningkatkan hasil belajar komputer akuntansi kelas XI AKL. *Tata Arta: Jurnal Pendidikan Akuntansi, 7*(1), 13–25. https://jurnal.uns.ac.id/tata/article/view/70224

Sumatraputra, A. N., Tapanuli, F. M., & Maringgita, I. (2023). Pemanfaatan aplikasi interaktif berbasis augmented reality untuk meningkatkan motivasi belajar siswa sekolah menengah. *Jurnal Literasi Digital, 3*(3), 160–170. https://doi.org/10.54065/jld.3.3.2023.599

Susilo, A., Hardyanto, W., Martuti, N. K. T., & Purwinarko, A. (2021). Mobile learning development using augmented reality as a biology learning media. *Journal of Physics: Conference Series, 1918*(4), 042013. https://doi.org/10.1088/1742-6596/1918/4/042013

Syarah, M. M., Rahmi, Y. L., & Darussyamsu, R. (2021). Analisis penerapan pendekatan STEM pada pembelajaran biologi. *BIO-EDU: Jurnal Pendidikan Biologi, 6*(3), 236–243. https://doi.org/10.32938/jbe.v6i3.1260

Tamam, B., & Corebima, A. D. (2023). Implementing augmented reality to improve students' biology learning outcomes: Gender-based effect. *International Journal of Evaluation and Research in Education, 12*(4), 2157–2164. https://doi.org/10.11591/ijere.v12i4.25645

Trikotama, R. M. A., Nurrohman, M. N., & Hutajulu, D. K. (2024). Application of augmented reality in education. *Hipkin Journal of Educational Research, 1*(3), 263–274. https://doi.org/10.64014/hipkin-jer.v1i3.26

Wang, X.-M., Hu, Q.-N., Hwang, G.-J., & Yu, X.-H. (2023). Learning with digital technology-facilitated empathy: An augmented reality approach to enhancing students' flow experience, motivation, and achievement in a biology program. *Interactive Learning Environments, 31*(10), 6988–7004. https://doi.org/10.1080/10494820.2022.2057549

https://doi.org/10.51878/science.v6i1.8929

Weng, C., Otanga, S., Christianto, S. M., & Chu, R. J.-C. (2020). Enhancing students' biology learning by using augmented reality as a learning supplement. *Journal of Educational Computing Research, 58*(4), 747–770. https://doi.org/10.1177/0735633119884213

Wibowo, Y. (2010). Visualisasi konsep-konsep biologi dengan menggunakan diagram Roundhouse. *Majalah Ilmiah Pembelajaran, 6*(2). https://journal.uny.ac.id/index.php/mip/article/view/3342

Widyastuty, E. (2024). Peningkatan pemahaman konsep biologi melalui penguatan minat dan kemandirian belajar. *Lencana: Jurnal Inovasi Ilmu Pendidikan, 2*(2), 152–164. https://doi.org/10.55606/lencana.v2i2.3624

Wilsa, A. W., Hartono, H., Subali, B., & Rahayu, E. S. (2025). Research trends of augmented reality in biology learning: Content and bibliometric mapping analysis. *Malaysian Journal of Learning and Instruction, 22*(1), 157–180. https://doi.org/10.32890/mjli2025.22.1.9

Wulandari, R., Mariska, R., Hairunisa, P., Yobee, A., Supriyadi, S., & Hermawan, J. S. (2025). Studi literatur: Analisis pembelajaran berbasis teknologi augmented reality (AR). *JGK (Jurnal Guru Kita), 9*(2), 555–570. https://doi.org/10.24114/jgk.v9i2.65335

Wulandari, S. A., & Safitri, S. (2024). Penerapan metode pembelajaran berbasis game based learning dalam materi sejarah Bandung Lautan Api di kelas XI IPS SMA Negeri 4 Pagar Alam. *Jurnal Inovasi Pendidikan dan Ilmu Sosial, 2*(1), 34–41. https://jurnal.wawasanilmu.co.id/index.php/jipis/article/view/264

Zufahmi, Z., Rohman, F., Listyorini, D., & Sari, M. S. (2025). The effectiveness of augmented reality-assisted e-module in improving students digital literacy in high school biology learning. *Salud, Ciencia y Tecnologia, 5*, 1517. https://doi.org/10.56294/saludcyt20251517

https://doi.org/10.51878/science.v6i1.8929