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The Use of Augmented Reality in Science Education in Elementary Schools: A Systematic Literature Review

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Abstract
This study aims to identify the use of Augmented Reality (AR) in science education at the elementary school level through a systematic review of published research. The study examines AR-based learning designs, classroom implementation, and its effects on conceptual understanding, learning motivation, and student engagement. A Systematic Literature Review method was employed through identification, selection, and thematic analysis of eligible articles. The findings reveal that AR enhances student engagement, clarifies abstract concepts, and supports exploratory learning activities. In addition, AR provides interactive learning experiences that contribute to improved learning outcomes. The study concludes that AR plays a significant role in strengthening science learning in elementary schools and has strong potential for broader application in educational practice.

Keywords:
Augmented Reality; Science Education; Elementary School; Systematic Literature Review; Educational Innovation

A. INTRODUCTION

Education is an effort to prepare the nation's future generations to face developments in the global era. Education must be provided in the best possible way to deliver quality education. Advances in science and technology have a significant impact on many aspects of human life, including education(Miasari et al., 2022). The Industry 5.0 era, which involves artificial intelligence and humanisation, requires teachers and educational institutions to be innovative and adaptive(AR et al., 2025). This emphasises that education can integrate technology into classroom learning.

The learning approach in Natural Sciences must focus on strong visualisation and facilitate the understanding of abstract concepts because much of the material in Natural Sciences consists of microscopic phenomena, process diagrams, causal relationships, or energy transformations that are difficult for students to see directly. Technologies such as interactive simulations, augmented reality (AR), animations, and graphic visualisations can connect theory with students' real lives. This can help them understand how scientific models are created, how variables correlate, and how experiments produce results. Studies show that viewing digital media in science can help students understand complex concepts and accelerate the process of internalising visual models in their minds. To ensure that every student not only listens or reads but also experiences, sees, manipulates, and reflects on concepts. Studies show that viewing digital media in science can help students understand complex concepts and accelerate the process of internalising visual models in their minds. To ensure that every student not only listens or reads but also experiences, sees, manipulates, and reflects on scientific concepts through visual-digital media, science literacy becomes more tangible and useful. Teachers and educational institutions must design science curricula that combine appropriate technology with traditional pedagogical methods.

Augmented Reality is a combination of real and virtual objects in a physical environment that operates interactively in real time, involving the integration of objects in three dimensions, namely virtual objects that are integrated into the real world. The combination of real and virtual objects can be achieved with the right display technology, interactivity is achieved through specific input devices, and good integration requires effective tracking(Nurliana N, 2022).This technology operates directly or in real time, allowing users to see and interact with virtual objects as if they were actually in the real world. This combination can be achieved using display devices such as AR glasses or mobile phone cameras, while interactivity is supported by input devices such as motion or touch sensors. In order for virtual objects to appear integrated with the real world, augmented reality systems also require accurate tracking to determine the position and movement of objects precisely.

According to a meta-analysis conducted by Chen, Looi, and Wu, the use of Augmented Reality (AR) in educational settings can help improve student learning outcomes. Meta-analyses conducted by Lee and Chung, as well as Chen, Wu, and Yen, show that the use of AR has a positive effect on student learning outcomes and engagement. Furthermore, a study conducted by Yang, Li, and Yu shows that augmented reality can improve students' conceptual understanding. However, the use of AR in education also faces challenges. The successful use of AR requires adequate infrastructure, investment in hardware and software, and adequate teacher training.Research on the application of Augmented Reality (AR) in science education in primary schools continues to evolve(Indahsari & Sumirat, 2023). The development of Augmented Reality (AR) effectively helps students understand abstract concepts through three-dimensional visualisation and interactive engagement, thereby increasing interest and motivation to learn. The application of AR can also be combined with project-based learning models to increase student engagement. Research on the application of AR in primary schools has yet to provide a comprehensive picture of its direction and development. Therefore, in-depth studies are needed to collect and interpret the results of previous studies in order to strengthen learning innovation with digital technology, especially the use of AR in science education in primary schools.Seeing the enormous potential of Augmented Reality (AR) in helping students understand abstract concepts through interactive visualisation and direct engagement, its use in science education in

primary schools is a need that deserves serious attention. Various studies have shown the benefits of AR in improving conceptual understanding, learning motivation, and active student engagement. However, the implementation of AR in primary education still faces complex challenges, such as infrastructure limitations, lack of teacher training, and the absence of a systematic and comprehensive implementation framework.

On the other hand, the literature on the application of AR in science education in primary schools is still scattered and does not provide a complete picture of the direction of development, effective implementation models, or its integration into a learning context that is appropriate for the characteristics of early age students.To date, there have been many studies on the use of AR in primary schools, but no comprehensive study has been conducted on the knowledge map of AR use in science lessons from 2021 to 2025. Therefore, this study contributes to providing in-depth mapping and analysis of the use of Augmented Reality in science learning in primary schools. The main contribution of this study is to develop a comprehensive framework of understanding regarding the pedagogical benefits, implementation challenges, and development potential of AR as part of 21st-century learning strategies. The findings of this study are expected to serve as a basis for designing more innovative and meaningful learning models, as well as an important reference for educators, media developers, and policymakers in improving the quality of primary education in the digital age.

A. METHODS

This study uses a Systematic Literature Review (SLR) approach to collect, assess, and analyze various previous studies related to the use of Augmented Reality (AR) in elementary schools. Through SLR, researchers can identify trends, benefits, challenges, and research gaps related to the application of AR as a learning medium at the elementary school level. This approach also ensures that research findings are based on valid and relevant scientific evidence so that they can provide a theoretical and practical basis for the development and implementation of more effective AR technology in the context of basic education.

The data collection process was carried out using several keywords, including: The Use of Augmented Reality (AR) in Science Education in Elementary Schools: Systematic Literature Review; The Implementation of Augmented Reality in Science Education in Elementary Schools; Augmented Reality in Elementary Schools; Augmented Reality for Science Education in Elementary Schools; and Augmented Reality – Virtual Reality in Elementary Schools. The search was conducted through four search engines, namely Google Scholar, Garuda, ResearchGate, and Springer.

A search using the keyword "The Use of Augmented Reality (AR) in Science Education in Elementary Schools: Systematic Literature Review" on Google Scholar found 1,090 articles. A search on Garuda using the keyword "Augmented Reality in Elementary Schools" found 286 articles. Meanwhile, a search on ResearchGate using the keyword "Augmented Reality for Science Learning in Elementary Schools" yielded 44 articles. A search on Springer using the keyword "Augmented Reality – Virtual Reality in Elementary School" yielded 1,079 articles, bringing the total number of articles found to 2,506. The details are presented in the following table:

NO	Search Engine	Keywords	Total Articles
1	Google Scholar	The Use of Augmented Reality (AR) in Science Education in Elementary Schools: Systematic Literature Review	1.090
2	Garuda	Augmented Reality in Elementary Schools	286
3	Research Gate	Augmented Reality for Science Learning in Elementary Schools	44
4	Springers	Augmented Reality – Virtual Reality in Elementary School	1.079

After finding 2506 articles, the researchers conducted inclusion and exclusion criteria to determine the articles that would be the object of this study. The inclusion criteria are as follows, as shown in the following table:

Include Criteria	Exclude Criteria
Publication range: 2021-2025	Publication range: before 2021
Indexed Journal (Scopus & Sinta)	Non-indexed Journal
Full-text accessed	Full-text cannot be accessed
The use of Augmented Reality (AR) in the context of Natural Sciences (IPA) learning	The use of Augmented Reality (AR) in Social Studies, Indonesian Language, etc. learning
AR in Elementary Schools (SD) and Islamic Elementary Schools (MI)	AR in Islamic Junior High Schools (MTS), Islamic Senior High Schools (MA), and Universities
Article	Thesis, Dissertation, book, etc.

After applying these criteria, 14 articles were considered most relevant. These fourteen articles were selected because they specifically discussed the use of Augmented Reality (AR) in science education in elementary schools, in terms of implementation, effectiveness, and impact on student learning outcomes and motivation. The selected articles were then further analyzed to identify the main themes and their contribution to the development of technology-based learning at the elementary school level.

B. RESULT & DISCUSSION

The results of a literature analysis of five major databases, namely Google Scholar, Open Knowledge, GARUDA, Sage Journals, and Springer, show an increase and decrease in the number of publications on the use of augmented reality (AR) in science education in elementary schools during the period 2021-2025. The analyzed data is presented in virtual form, such as tables and graphs, to provide a more complete picture of research developments in this field. The following is a graph showing the development of the number of articles published based on the 2021-2025 period.

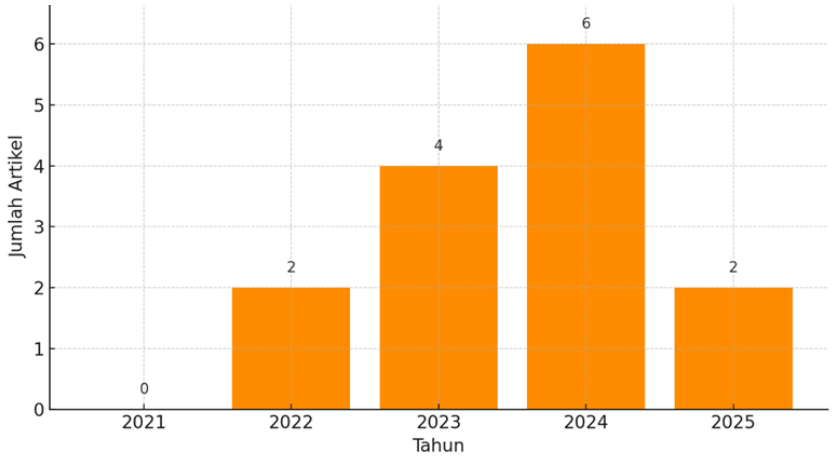

Figure 1. Development of articles published in 2021-2025 on the use of augmented reality (AR) in science education in elementary schools: systematic literature review

Based on the results of the data analysis presented in Figure 1, there is quite an interesting variation in the development of the number of publications discussing the use of Augmented Reality (AR) in science learning in elementary schools during the period 2021 to 2025. Based on the data visualized in the graph, it can be seen that there were no relevant publications in 2021, indicating that in the early period, the topic of AR in the context of basic education was still

relatively new and had not attracted much attention from researchers, especially in the field of science education. Entering 2022, two articles began to appear that explicitly highlighted the use of AR in science education, indicating an initial interest in the application of interactive technology after the COVID-19 pandemic, when digital innovation became a major focus in the world of education. This trend continued with a significant increase in 2023 with four publications, indicating that related research was gaining momentum and becoming a more serious concern among academics, especially in the context of interactive visualization-based science teaching. The peak of publications occurred in 2024, with six articles discussing similar topics, showing that the topic of AR in science education has become a popular and relevant area of study, both in the context of national and international research. However, in 2025, the number of publications decreased to two articles, most likely due to two factors: (1) the year was still ongoing, so some studies had not yet been indexed or published, and (2) the shift in research focus towards other learning technologies such as Virtual Reality (VR) or Artificial Intelligence (AI) in education, which began to rise in popularity during the same period.

This increase and decrease in the number of publications not only reflects the dynamics of academic interest in the topic of AR, but also reflects the phase of development of educational technology adoption at the elementary level. Initially (2021–2022), AR was still considered a new technology that required conceptual validation, so the research conducted tended to be exploratory and descriptive. Entering the growth phase (2023–2024), research began to shift to the experimental and evaluative stages with a focus on the effectiveness of using AR in improving learning outcomes, conceptual understanding, and student motivation in science learning. This is in line with the results of a systematic review showing that the application of AR in basic science experienced a significant increase during this period, due to the increased availability of Android-based devices, open-source educational applications, and the ease of integrating AR into learning activities. The year 2024 marked the peak period, signifying the recognition of AR as an innovative learning medium capable of changing the way students understand abstract concepts through visual and interactive experiences. Meanwhile, the decline in 2025 is not an indication of waning interest, but rather part of a natural research cycle in which scientific focus begins to shift towards cross-technology integration and other learning models such as project-based learning and inquiry-based science education. Thus, the fluctuations in publications over the past five years reflect healthy and sustainable development in AR utilization research, which continues to adapt to global trends in digital technology-based education.

Table 1. The following table presents the findings of a review analysis of the use of Augmented Reality in natural science lessons in primary schools.

No	Title and Author	Journal Name	Research Results
1.	The Effectiveness of Using Augmented Reality Media in Grade VI Science Learning on Critical Thinking Skills and Learning Outcomes in Solar System Material(Astuti et al., 2024)	Jurnal Ilmiah Pendidikan Dasar	This analysis reveals that the use of Augmented Reality (AR) significantly improves average learning performance and academic achievement, proving the effectiveness of this technology as a pedagogical tool for science teaching. This article concludes that Augmented Reality is recommended to optimise learning performance in science and also compiles relevant research on its use in primary education.
2.	The Use of Augmented Reality (AR) in Science Learning in Primary Schools(Saepudin & Wulandari, 2023)	Jurnal Jurnal Primary Edu (JPE)	This study reveals that students who use AR achieve a significant difference in their conceptual understanding (average post-test score of 82.6) compared to the control group (72.3), and achieve a very high level of learning motivation. Overall, these results indicate that Augmented

			Reality is an innovative and effective pedagogical tool for overcoming challenges related to abstract concepts and stimulating student interest in primary education.
3.	The Effectiveness of Using Augmented Reality Technology in Science Learning in Primary Schools: A Systematic Literature Review Multidisciplinary Scientific Research (Astuti et al., 2024)	Jurnal Penelitian Ilmiah Multidisipliner	A review of five important articles shows that Augmented Reality technology has proven to be highly effective as an educational tool for science lessons, improving students' understanding, engagement, and skills. The authors conclude that although AR in science education is promising, further analysis is needed to assess its overall effectiveness and quality of implementation, particularly in relation to teacher skills and the relevance of AR teaching materials.
4.	Analysis of the Effectiveness of Using Augmented Reality (AR) in Science Learning in Primary Schools: A Systematic Literature Review (I. P. Sari et al., 2024)	Journal of Psychology and Instruction	This study concludes that Augmented Reality (AR) applications consistently improve learning outcomes, engagement, and understanding among primary school students, while reducing cognitive load. In conclusion, Augmented Reality is a valuable and effective tool for educators to improve science teaching at the elementary level.
5.	Stematic Literature Review : The Trend Of Augmented Reality (Ar) In Science Teaching And Learning In Primary School(Ahmad & Abu Samah, 2024)	Sains Humanika	This review primarily aims to identify trends in Augmented Reality (AR) research, including background, study findings, contributions, research methods, devices used, science learning topics, and applied theories and models. The study shows that although interest in Augmented Reality is increasing, there is still considerable potential for research, especially in linking its application with appropriate teaching theories and methods. Overall, this study provides a comprehensive analysis for teachers and researchers on the potential of Augmented Reality to improve primary school students' success in science.
6.	The Effectiveness of Augmented Reality-Based Science Learning in Primary Schools (Syahid et al., 2024)	Seminar Nasional Pendidikan Dasar	Studies generally show that Augmented Reality can be useful in improving teaching quality, academic achievement, motivation, critical thinking, abstract reasoning (increases of 24.20% and 23.08% respectively), spatial visualisation skills, scientific knowledge, and positive attitudes and self-confidence among students. Combining AR with other methods can achieve optimal effectiveness. AR is also commonly used as a primary educational tool, including mobile applications (Planetarium Glass), AR resources or

			textbooks, and interactive and cutting-edge digital games focused on science.
7.	The Utilization Of Augmented Reality In Visualizing Ecosystem Concepts To Create Contextual And Meaningful Biology Learning: A Literature Review(Jilan et al., 2025)	Journal of Biology Creative Education	The use of Augmented Reality (AR) in education has proven to be beneficial and has a positive impact on various dimensions of science learning. At the cognitive level, AR is able to make complex abstract ideas, such as food chains and invisible ecosystem mechanisms, easier to visualise, thereby facilitating assimilation by students. At the emotional level, AR significantly increases student motivation and engagement in learning, with the most significant benefits seen in the emotional domain (56.3%), especially in biology. Furthermore, AR encourages contextual, meaningful, and experiential learning by integrating local knowledge and ecological principles, particularly through the use of ethno-AR materials and programmes dedicated to mangrove conservation.
8.	The Effectiveness of Augmented Reality (AR) in Science Learning Concepts for Primary School Students(Safira et al., 2022)	Journal of Education, Language Teaching and Science	This article highlights the effectiveness of Augmented Reality (AR) in strengthening the understanding of science concepts among fifth-grade students. This experimental study compared a control group with an experimental group that used AR during six sessions dedicated to environmental themes. The results showed a significant improvement in learning performance for the test group, with a score of N 0.70 (high level), compared to 0.34 for the control group (medium level). These findings validate the effectiveness of AR in improving science learning performance, as it enables easy visualisation of virtual objects that enhance conceptual understanding.
9.	Augmented Reality Introduction To Plant Parts For Grade 4 Elementary School Students(William Septian Umbas, 2024)	Jurnal Teknik Elektro dan Komputer	This review explores the creation and development of an Augmented Reality (AR) application for identifying plant parts, designed for fifth-grade students. The main objective of this study is to design a learning tool that is more engaging and interactive than traditional approaches by using Augmented Reality technology to project 3D elements onto an Android system. This application was designed following the Multimedia Development Life Cycle approach. Analysis reveals that the use of this Augmented Reality (AR) application significantly improves student understanding. This application was

			created using software such as Blender, Unity, and Vuforia.
10.	Augmented Reality-Based Educational Game for Introducing Plants to Primary School Children in Grade 3(A. P. Sari et al., 2022)	JIKA (Jurnal Informatika)	his article describes the creation of an augmented reality (AR)-based educational game application to enable third-grade students to explore the world of plants interactively. The system was developed by the author using the waterfall method, which includes the phases of requirements analysis, design, coding, testing, and maintenance. The findings show that students are interested in using augmented reality applications as learning tools. This article also includes various system development diagrams, such as use case diagrams and activity diagrams, and applies black-box testing to evaluate the functionality of the application.
11.	Interactive Media Development: This study aims to create multimedia-based interactive learning media for Grade IV elementary school science subjects (Hamdani et al., 2024)	Digital Transformation Technology (Digitech)	The interactive learning tools developed include a main menu, documentation pages (such as the human body and the five senses), and assessment tools in the form of practice questions or quizzes. Multimedia elements: These resources include text, visuals, audio (music and sound), as well as animations and short animated videos to clarify the material. The assessment was conducted with science teachers and 30 fourth-grade students from SDN 1 Mura.
12.	The Use of Augmented Reality (AR) in Science Learning to Foster Understanding of the Solar System Concept in Primary Schools Multidisciplinary Scientific(Tarigan, 2025)	Jurnal Ilmiah MultidisiplinMahasiswa Dan Akademisi	Augmented Reality has demonstrated its ability to illustrate abstract concepts of the solar system in a concrete manner, such as rotation, revolution, and the relative positions of the planets, which are difficult to observe directly. Augmented Reality (AR) offers interactive three-dimensional (3D) representations with rotation and zoom, thereby promoting an increase in students' spatial awareness.
13.	The Use of Digital Technology in Science Education: A Literature Review(Agustina et al., 2023)	Journal of Physics Education	Studies show that the most commonly used digital technology in science teaching is educational videos. This allows students to represent complex concepts through illustrations, animations, and diagrams.
14.	Augmented Reality Based On Project Based Learning For Class IV Science Learning(Agustina et al., 2023)	Journal of Banua Science Education	validation: 75% of students strongly agreed with the science teacher's idea to create PjBL-based AR media as an alternative digital teaching tool to assist in science teaching. Interest in teaching: 55% of students expressed a strong interest in learning science through PjBL-based AR media. Digital requirements: To create a more engaging science learning environment and overcome pedagogical

challenges, teachers and students need to take advantage of developments in digital media.

A systematic literature review shows that the use of Augmented Reality (AR) in science teaching in primary schools has a significant impact on improving student learning achievement, conceptual understanding, and critical thinking. A number of articles reviewed show that the use of Augmented Reality consistently increases student engagement, motivation, and ability to represent abstract scientific concepts, such as the solar system, ecosystems, and plant structures. AR, with its 3D representation, allows students to understand scientific phenomena more concretely and interactively while reducing their cognitive load. Therefore, AR is an innovative educational tool that can perfectly connect online learning experiences with real-life situations.

Studies show that the use of Augmented Reality encourages the acquisition of 21st-century skills, particularly collaboration, communication, and creativity among students. Research combining Augmented Reality with project-based learning reports significant improvements in critical thinking, scientific curiosity, and problem-solving skills. These benefits are not limited to the cognitive realm; they also extend to affective and social aspects, thanks to increased motivation for education and a positive outlook on science. These research findings highlight the great potential of Augmented Reality as an innovative pedagogical approach to teaching science in primary schools.

Discussion

The results of this systematic review indicate that the application of Augmented Reality (AR) in Science learning at the elementary school level consistently shows a positive impact on students conceptual understanding, learning motivation, and engagement in the learning proces(Ahmad & Abu Samah, 2024). Several studies have demonstrated that AR-based learning helps students grasp abstract scientific concepts—such as the solar system, food chains, and plant parts—through engaging and easily accessible three-dimensional representation (Astuti et al., 2024). This condition encourages active student participation in the learning process, where they act as young researchers who explore and interact directly with digital objects(Ahmad & Abu Samah, 2024; Safira et al., 2022).

Findings from various studies conclude that the implementation of Augmented Reality (AR) can develop students critical and creative thinking skill, especially when combined with exploratory activities or project based learning models(Safira et al., 2022). Through AR-based learning experiences, students have opportunities to analyze phenomena, solve problems, and generate new ideas within relevant scientific contexts. This condition aligns with the principles of constructivist theory(Astuti et al., 2024), which emphasize that students construct their knowledge through contextual and interactive learning experiences. The integration of AR with various innovative learning models, such as Project-Based Learning (PjBL), also yields significant improvements in the quality of science education at the elementary(William Septian Umbas, 2024). The combination of digital visualization and project-based activities allows students to learn scientific concepts through contextual and collaborative experiences. The integration of AR with various innovative learning models, such as Project-Based Learning (PjBL), also yields significant improvements in the quality of science education at the elementary level(Safira et al., 2022). The combination of digital visualization and project-based activities allows students to learn scientific concepts through contextual and collaborative experiences. This approach not only strengthens conceptual understanding but also fosters collaboration and creative problem solving skills in addressing real-world issues related to daily life (I. P. Sari et al., 2024).

The implementation of Augmented Reality still faces several major challenges in elementary education, such as teachers' limited ability to use or integrate the technology into teaching and learning activities. Additionally, there are infrastructural constraints, as not all schools provide adequate digital facilities, and the available AR content often lacks alignment with the national curriculum (Agustina et al., 2023). Therefore, efforts should be made to support the

integration of AR technology in education, including the development of locally relevant AR content aligned with curricular goals, teacher training on educational technology, and equitable institutional support to create learning environments integrated with technology.(Hamdani et al., 2024; Safira et al., 2022).These aspects are expected to helpoptimize sustainable digital learning and maximize the potential of AR in supporting students comprehension of scientific concepts in elementary science education(Tarigan, 2025).

C. CONCLUSION

This study concludes that the use of Augmented Reality in elementary school science learning successfully addresses the research objectives by clarifying its effectiveness, benefits, and application in classroom settings. AR supports students' understanding of scientific concepts and enhances their engagement, making it a relevant instructional tool for modern learning needs. The main contribution of this study lies in providing a clear overview of recent research developments, identifying consistent pedagogical advantages, and outlining the challenges that may arise during implementation. These insights offer valuable guidance for educators and researchers seeking to integrate technology into science education. Future research is recommended to examine the long-term impact of AR, develop curriculum-aligned AR materials, and investigate teacher readiness and institutional support for technology adoption. Further exploration of integrating AR with other emerging technologies also presents promising opportunities for continued innovation in education..

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