A Systematic Literature Review: Augmented Reality-based Learning Media to Improve Student Learning Outcomes

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Abstract: This study aims to analyze the results of previous research on the effect of augmented reality-based learning media on student learning outcomes in science learning at the elementary school level. The rapid development of technology invites us to continue to adapt so as not to be far behind. Augmented Reality presents abstract concepts in layers so students can witness them in real-time through time through augmented reality-based interactive comic media; students are invited to directly observe abstract ideas in their hands, thus creating more meaningful learning. Using the Systematic Literature review method, researchers analyzed 25 articles from 15 international journals and 10 national journals from 2019 to 2025 to determine the effectiveness of augmented reality-based learning media in improving student learning outcomes in science learning. The articles were obtained based on search results from publish or perish. The results of previous studies show that augmented reality-based learning media can consistently improve student learning outcomes in science learning. This study concludes that using augmented reality-based learning media has significant potential in supporting science learning and presenting fundamental concepts behind abstract concepts complex for students to understand. This discovery will likely encourage using augmented reality-based media in education more widely and effectively.

Abstrak: Penelitian ini bertujuan untuk menganalisis hasil penelitian terdahulu mengenai pengaruh media pembelajaran berbasis augmented reality terhadap hasil belajarsiswa dalam pembelajaran sains tingkat sekolah dasar. Perkembangan teknologi yang sangat pesat mengajak kita untuk terus beradaptasi agar tidak jauh tertinggal. Augmented reality menghadirkan konsep abstrak ke dalam layer agar dapat disaksikan secara nyata oleh siswa. Melalui media komik interaktif berbasis augmented reality, siswa diajak mengamati secara langsung konsep abstrak ke dalam genggamannya, sehingga menciptakan pembelajaran yang lebih bermakna. Dengan metode tinjauan Pustaka Sistematis, peneliti menganalisis 25 artikel yang terdiri dari 15 jurnal internasional dan 10 jurnal nasional mulai tahun 2019 hingga 2025 untuk mengetahui keefektifan media pembelajaran berbasis augmented reality dalam meningkatkan hasil belajar siswa dalam pembelajaran sains. Artikel-artikel terebut diperoleh berdasarkan hasil pencarian dari publish or perish. Hasil penelitian terdahulu menunjukkan bahwa media pembelajaran berbasis augmented reality secara konsisten dapat meningkatkan hasil belajar siswa dalam pembelajaran sains. Penelitian ini menyimpulkan bahwa penggunaan media pembelajaran berbasis augmented reality memiliki potensi yang signifikan dalam mendukung pembelajaran sains dan menghadirkan konsep nyata dibalik konsep abstrak yang sulit dipahami siswa. Melalui penemuan ini diharap dapat mendorong penggunaan media berbasis augmented reality dalam Pendidikan secara lebih luas dan efektif.

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A. Introduction

Learning will produce a more meaningful learning experience for students if it allows them to visually see and interact with abstract concepts (Abadiya & Fatmaningtyas, 2021). In the era of an independent curriculum, teachers must be able to design learning by nature and the nature of the times. Integrating technology and the surrounding environment is the key to creating meaningful learning. Children of elementary school age are in the concrete operational stage of development, according to Piaget's theory, where they are better able to understand information conveyed through concrete objects, visuals, and direct interaction than through verbal explanations alone. However, we cannot deny that some material is still abstract, making it difficult for students to understand. It is challenging for educators to bring these abstract things into the classroom. Not many educators can integrate technology into learning, which causes a lack of understanding and student learning outcomes, especially in science subjects in elementary schools.

One form of innovation that educators can utilize is Augmented Reality (AR) based learning media. This technology allows the presentation of material in an interactive visual form to help students understand abstract concepts more concretely and interestingly. Augmented Reality is a technology that incorporates 3D virtual objects into the real environment and allows users to interact in real time (Garzón, 2021). However, most AR research focuses on secondary or higher education levels, such as high school and college. Few studies have specifically explored the use of AR at the elementary school level, especially in specific subjects such as Natural Sciences (IPA), even though elementary school students need visual assistance and concrete learning experiences to understand complex and abstract materials.

In primary school, students tend to be more interested in media that involves visual elements and hands-on experience. AR-based media offers such an approach by incorporating digital elements into the real world, thus creating a more enjoyable and meaningful learning experience. Students can more easily understand the material presented through direct interaction with the digital objects displayed.

The utilization of Augmented Reality in primary education is also in line with efforts to develop 21st-century skills, namely critical thinking, creativity, collaboration, and communication (Sucipto, 2024). This AR technology has great potential to enhance students' learning experience, especially at the primary school level, where engaging and interactive learning approaches are needed by students (Tan & Tay, 2022).

Augmented Reality can be implemented through various devices, such as smartphones and laptops (Wijaya & Utomo, 2023). Augmented Reality also has the potential to increase student learning motivation through the presentation of more interesting and relevant material (Alkhattabi, 2017; Berlian, 2021). Augmented reality media can be implemented in various subjects in elementary schools, such as science, math, history, and language. In addition, Augmented Reality can assist teachers in creating a more inclusive and personalized learning environment for each student by customizing learning content and activities according to individual needs and interests. The integration of Augmented

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Reality in primary school learning can open up new opportunities for students to learn in a way that is more fun, interactive, and relevant to the real world (Erwinsah et al., 2019).

This research offers a novelty contribution by examining the use of AR-based media, especially at the elementary school level. AR media is interesting to study because AR provides an interactive learning experience. Integrating the two creates a unique hybrid media form and has a high potential to improve learning effectiveness. Some previous studies have shown that using AR media in learning has great potential to enhance students' understanding of the subject matter. Therefore, reviewing the extent to which AR-based learning media can improve student learning outcomes, especially at the primary education level, is essential.

The purpose of this study, in general, is to determine the effect and effectiveness of Augmented Reality-based media in learning based on previous research. Furthermore, this research is expected to provide an overview to teachers on how to develop AR-based learning media to improve student learning outcomes.

B. Method

This article selected the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model for analysis. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model is used as a framework for carrying out the SLR stages. The primary focus of this study is to examine how AR-based media plays a role in improving student learning outcomes.

The PRISMA steps used are Identification, Screening, Eligibility, and Inclusion. Figure 1 below further explains these steps.

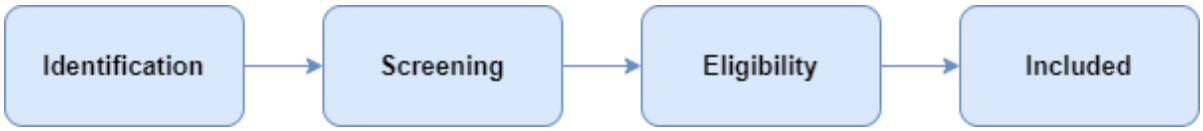

Figure 1. PRISMA Research Steps

Identification

In the identification stage, the researcher determines the research topic and collects articles from Publish or Perish and Google Scholar. The identified articles are then recorded based on the database used.

Screening

After the initial identification process was completed, the next stage was screening, which was screening the collected articles. At this stage, the titles and abstracts were examined to assess whether the publications were relevant to the study's focus and met the predetermined criteria. The main objective was to filter out literature that was truly relevant to the research topic based on the initial coverage visible from the article's summary information.

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Eligibility

Once an article has passed the initial screening stage, the next step is to test eligibility in greater depth. Each pre-screened publication was analyzed for full content to ensure it met the inclusion and exclusion requirements. The assessment is done thoroughly according to the research needs.

Included

The final stage involved analyzing the appropriate articles. The publications included at this stage were then further reviewed for systematic review. The results of this analysis form the basis for concluding the research conducted. The eligibility criteria used in this study are described in Table 1 below:

Table 1. Article Criteria Used

Criteria	Inclution	Exclution
Year of Publication	Articles published from 2020-2025	Articles published before 2020
Publication Type	Journal articles, conference proceedings, and research reports that are in line with the theme	Opinion, review, and editorial articles
Language	Indonesian and English	Articles that are other than Indonesian and English
Research Subject	Focuses on elementary and middle school students	Focus on other than the student (teacher or parent)
Research Results	Discussing the influence of AR on student learning outcomes	It does not directly discuss the effect of AR on student learning outcomes
Accessibility	Articles with full access (full text)	It does not have full-text

C. Result and Discussion

Result

1. Data Analysis

Researchers started by highlighting 100 articles contained in publish or perish. Then, the articles were filtered again to get 60 articles that discussed AR. Then, after being identified, 25 articles were found that were suitable for review because they examined the effect of AR on learning outcomes. The results of the analysis of 25 can be seen in Diagram 1 below:

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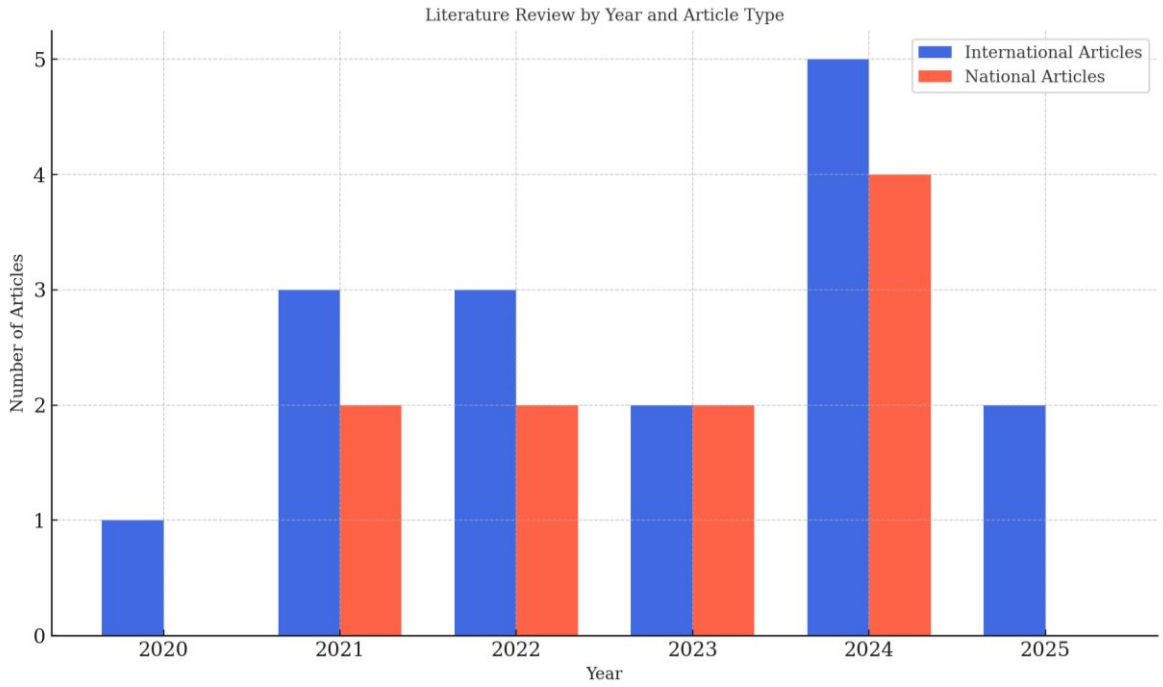

Figure 2. Results of International Journal and National Journal Analysis 2020 - 2025

The bar chart illustrates the number of international and national articles used in the literature review from 2020 to 2025. International articles are in light blue, while national articles are in pink. It can be seen that international articles were used consistently every year, with peaks in 2021 and 2022, each recording three articles. 2020 showed the least use of global articles, with only one and no national articles.

Meanwhile, national articles began to appear in 2022 and increased in the following years. The highest number of national articles was in 2024, with five articles. This shows an increase in the utilization of local sources over time, especially in the last two years. This pattern may reflect the tendency of researchers to balance domestic and foreign references in their literature reviews.

2. Critical Apraisal

Each article was critically analyzed, considering methodological quality, research design, instrument suitability, and data validity. Selected articles were critically analyzed using a critical appraisal approach to assess the quality and relevance of the research. Aspects assessed included clarity of research objectives, suitability of research design to the research questions, sampling techniques, validity and reliability of instruments, data analysis techniques used, and suitability between results and conclusions. This evaluation was carried out to ensure that the articles used in this study were suitable for scientific reference. Articles that passed the selection had clarity of purpose, appropriate research design, and presentation of results that supported the conclusions made.

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3. Literature Review Results

Based on the review of 25 selected articles, it was found that the use of Augmented Reality contributes positively to learning outcomes. Some articles show that AR can improve concept understanding, student engagement, and motivation in the learning process. In addition, this technology also supports contextual learning that is more interactive and engaging for students at various levels of education.

Regarding distribution, international articles were used consistently from 2020 to 2025, with peaks in 2021 and 2022. Meanwhile, national articles began to appear in 2022 and continued to increase until 2024, reflecting the increasing attention of local researchers to the implementation of AR in education.

4. Matrix of Literature Data Analysis

The data analysis matrix summarized each article's findings based on four main components: article title, author, journal, and research results. This matrix provides a structured overview of the patterns of findings that emerged in the literature review. To find out more about the effectiveness of Augmented Reality-based learning media, I suggest reading the analysis results of the 25 articles found in Table 2 below:

Table 2. Results of Article Analysis

Title	Authors	Journal	Reasearch Results
"Augmented Reality Technology, and It's Effect in Improving the Acceptance to Use It among 7th Graders in Medical Technology Unit."	Mohammed. F. Abu Owda	Curriculum & Methodology, Faculty of Education, Islamic University, Gaza, Palestine.	AR technology significantly increases student acceptance of its use in learning. Scores after treatment showed a significant increase compared to before AR technology.
"Augmented Reality (AR) Subject Natural Science Media for Human Framework Topics"	1. Yulianti, 2. Wardhani, 3. Hakim, 4. Aji, dan 5. Hudha	IOP Conference Series: Materials Science and Engineering	This study showed a high level of validity according to expert assessment (95%) and positive responses from teachers and students, with practicality and readability scores of 95% and 96%, respectively. In addition, effectiveness testing showed a student learning outcome score of 91% and high learning interest with similar scores.
"An Overview of Twenty-Five Years of Augmented Reality in Education"	Juan Garzón	Multimodal Technologies and Interaction	Garzón highlighted the benefits of AR in education, such as increased motivation, student

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Title	Authors	Journal	Reasearch Results
			engagement, and conceptual understanding, but also identified some key challenges that still need to be addressed: accessibility, usability, dissemination, and pedagogical approach. This article suggests that advances in technologies such as WebAR, smart glasses, and the integration of artificial intelligence (AI) could be potential solutions to improve the effectiveness and inclusiveness of AR in the future.
"The application of augmented reality in elementary school education"	1. Hidayat, Sukmawarti, 2. Suwanto	Research, Society, and Development	This research shows that AR media affects learning outcomes, motivation, and psychomotor skills and builds students' knowledge through direct interaction with virtual objects. However, the application of AR also presents challenges, especially related to student's cognitive load in managing much information at once and uneven technology skills. AR is considered to enrich the learning experience but needs to be adjusted to the readiness of facilities, teacher skills, and student development characteristics.
"Pembangunan Aplikasi Sebagai Media Pembelajaran Bangun Ruang Tingkat SD/SMP dengan Menggunakan Metode Marker Augmented Reality"	1. Nur Alamsyah 2. Rio Andriyat Krisdiawan	Jurnal Nuansa Informatika	This AR application helps students understand the concept of three-dimensional geometry and increases learning motivation through attractive visual design and familiar mobile devices. It is an innovative solution that addresses the limitations of conventional teaching aids.

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"Penerapan Teknologi Augmented Reality pada Media Promosi Fasilitas SMP Bhakti Mulia Jakarta Timur"	1. Shilki Dini Abadiya 2. Intan Dwi Fatmaningtyas	Informatics for Educators and Professionals,	Application development involves prototyping and applications such as Unity 3D, Vuforia, and Adobe Illustrator. This technology makes delivering information to prospective students more attractive and effective than traditional promotional media.
"Augmented reality media to improve science literacy and the metacognitive ability for fifth grade elementary school"	I Putu Gilang Leo Agusta	Skripsi, Universitas Pendidikan Ganesha	This research proves that AR can create a more interesting and interactive learning atmosphere so students can better understand science material, especially the human organ system. Validation results from experts, teachers, and students showed excellent media feasibility, and MANOVA statistical tests revealed significant differences between students' pretest and post-test results in science literacy and metacognition.
"Integrating augmented reality technology in education: Vector personal computer augmented reality."	1. Sin Yin Tan 2. Noel Nuo Wi	F1000 Research	A survey of 167 students and 71 educators in Malaysia found that students and educators responded positively to using an AR-based learning system named VPCAR (Vector Personal Computer Augmented Reality). In addition, VPCAR is considered more favorable than conventional methods such as PowerPoint, as it can provide a fun learning experience during online learning.
"The Application of Mobile Augmented Reality to Improve Learning Outcomes in Senior High Schools"	1. Nurhayati, Rusdi 2. Hanum Isfaeni	International Journal of Information and Education Technology,	The use of AR media significantly increased the students' average score from 56.0 to 69.8, compared to the control class, which only increased from 51.4 to 52.6.

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Title	Authors	Journal	Reasearch Results
			Expert validation of AR media showed that the media, material, and language aspects were valid. This study concludes that AR media can create a fun learning experience for students.
"Media Assemblr Edu Berbasis Augmented Reality untuk Meningkatkan Hasil Belajar Materi Sistem Organisasi Kehidupan Makhluk Hidup"	1. Padang, 2. Ramlawati, 3. Yunus	Diklabio: Jurnal Pendidikan dan Pembelajaran Biologi	The results obtained from this study are that after using AR media, learning outcomes increased with low to moderate categories, with an average N-Gain value of 0.25. Inferential statistical analysis through t-test resulted in a t-count value = 11.25, greater than t-table = 1.68, indicating that Assemblr EDU media can significantly improve student learning outcomes.
"Media Augmented Reality Untuk Meningkatkan Kemampuan Metakognitif IPA Siswa Kelas V SD"	1. Gede Rian Perdana 2. Putu Aditya Antara, 3. Gusti Ayu Putu Sukma Trisna	Jurnal Media dan Teknologi Pendidikan,	Based on media expert validation, the AR developed is very good and practical for teachers and students. The results of statistical tests of students' metacognitive abilities after using AR media also showed a significant increase.
"Development of Augmented Reality (AR) Learning Media to Increase Student Motivation and Learning Outcomes in Science"	1. Ilham Widia Yusa, 2. Ana Yuniasti Retno Wulandari, 3. Badrud Tamam, 4. Irsad Rosidi 5. Mochammad Yasir	Jurnal Inovasi Pendidikan IPA	The average value of Aiken's V is above 0.81, indicating that the media is feasible. In addition, students' responses to the media were considered very good, especially regarding attractiveness and time efficiency. The experimental class obtained a higher average score than the control class.
"Comparison of Using an Augmented Reality Learning Tool at Home and in a Classroom	1. Aldo Uriarte-Portillo , 2. María Blanca Ibáñez, 3. Ramón Zatarain-Cabada,	Multimodal Technologies and Interaction	The study's results showed that although students' motivation levels were generally similar in both environments, students who studied at home showed

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Title	Authors	Journal	Reasearch Results
Regarding Motivation and Learning Outcomes"	4. María Lucía Barrón-Estrada		higher attention, satisfaction, and learning outcomes, with fewer errors and better grades. Interaction with the AR app was also more effective in the home environment.
"Pengaruh Media Augmented Reality Pada Mata Pelajaran IPAS Terhadap Hasil Belajar siswa"	1. Devi Rahma Danti, 2. Bambang Eko Hari Cahyono, dan 3. Dewi Tryanasari	Prosiding Konferensi Ilmiah Dasar	This study showed that learning outcomes improved significantly after using AR media. This was proven by acquiring a t-count value of 3.734, greater than the t-table of 2.042, so the alternative hypothesis is accepted. The experimental class obtained an average score (86.17), while the control class obtained an average score (80.83).
"Pengaruh Media Augmented Reality (AR) Berbantuan Assemblr Edu terhadap Hasil Belajar siswa SMP IT Robbani Sintang"	1. Awaliyah Agustin 2. Hilda Aqua Kusuma Wardhani	Jurnal Keguruan dan Ilmu Pendidikan	This study showed that learning outcomes increased significantly after using AR media; the average pretest score was only 51.55, which increased to 80.55 on the post-test, and the N-Gain value was categorized as moderate with a value of 0.6. Statistical analysis using the Paired Sample Test shows a value of ($p < 0.05$), which means that AR media has a positive effect.
"Development of Augmented Reality Learning Media on IPAS Subject Matter of the Respiratory System"	1. Hanik Puji Rahayu 2. Desi Wulandari	Jurnal Penelitian Pendidikan IPA	The research that was developed is very feasible and practical. Material and media expert validation obtained eligibility scores of 81.60% and 96.60%, respectively. The effectiveness test through the pretest and post-test showed a significant increase in student learning outcomes with an N-Gain value of 0.63 (medium category) for small groups and 0.36 for large groups.

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Title	Authors	Journal	Reasearch Results
"Development of Card View Media Based on Augmented Reality Technology for Natural Resource Materials"	1. Shellyna Febri Cahyaningrum 2. Kurniana Bektiningsih	Jurnal Penelitian Pendidikan IPA	The validation results from media experts showed 85% feasibility, and from material experts, 92.64%. The student response to this media is also very positive, with a percentage of 96.05%. The effectiveness test results using the pretest and post-test showed a significant increase, with the average value increasing from 50.26 to 79.73.
"D-Learning: An Experimental Approach to Determining Student Learning Outcomes Using Augmented Reality (AR) Technology"	Jadranko Tuta dan Ljerka Luic	Education Sciences	Using the HaubicAR application, the results showed that all forms of AR-based active learning improved students' knowledge, but the group that received the complete learning (Situated + Games + research) showed a significant improvement in learning outcomes, with the final average score reaching 10.27 compared to 7.72 in the Situated group. This study concludes that using AR in various active approaches can significantly improve students' understanding, engagement, and learning outcomes.
"Penggunaan Media Augmented Reality dalam Pembelajaran IPA untuk Meningkatkan Pemahaman Konsep"	1. Purwanti, 2. Rahmat Diana, 3. Mulyadin Mulyadin, 4. Firman Yusup, 5. Rifki Nurul Fauzi	Jurnal Informatika dan Teknologi Pendidikan	The results showed that AR not only had a positive impact on concept understanding but also increased student interest, motivation, and learning outcomes. AR is very suitable for use as a modern learning media by the development of technology in the Society 5.0 era because it is flexible, interactive, and supports experiential learning.
"Pengembangan Media Pembelajaran	Azzahra Dhea Rahmawati	Skripsi, Universitas	The research using the ADDIE development model

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Title	Authors	Journal	Reasearch Results
"Siar" Materi Siklus Air Berbasis Augmented Reality Untuk Siswa Kelas V Sekolah Dasar"		Nusantara PGRI Kediri	showed that the scores from media experts and material experts were very valid, with a percentage of 87.5%, and efficient according to teachers (95%) and students (92.2%). In addition, "SIAR" media proved effective in improving learning outcomes, indicated by a classical completeness of 86%.
"Pengembangan Media Pembelajaran Berbasis Virtual Augmented Reality terhadap Kemampuan Berpikir Kritis IPAS siswa Kelas IV Sekolah Dasar"	Zaenal Abidin	Skripsi, Universitas Islam Sultan Agung	This study resulted in an increase in the average pretest score of 33.5 to 82.916 in the post-test. The paired t-test results also showed a significant difference between before and after using the media, with a significance value of 0.858 and a gain score of 1.0008, which indicates high effectiveness.
"Effectiveness of Augmented Reality Based Learning Media to Improve Critical Thinking Skills on IPAS Material"	1. Ongke Ageng Pamorti, 2. Winarno, 3. Kartika Chrysti Suryandari	Jurnal Penelitian Pendidikan IPA	This study's results indicate a real and significant difference between students who learn with conventional media and those who know with AR media. The average post-test score of the experimental class was 75.98, while the control class was only 63.56. The effectiveness test with N-Gain resulted in a value of 56.52, which is categorized as quite effective.
"Development of Augmented Reality (AR) IPAS Learning Media to Improve Critical Thinking Skills of Elementary School Students"	1. Muhammad Najib 2. Jamil Suprihatiningrum	International Journal of Indonesian Education and Teaching	The effectiveness test results through paired sample t-test showed a significant increase in students' critical thinking scores, from an average pretest of 59.6 and 49.6 to a post-test of 83.7 and 81.6. This media is also considered easy to use and effective and supports

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Title	Authors	Journal	Reasearch Results
			students' independent exploration of concepts.

Discussion

The synthesized results of 25 studies listed in the table show the results of using Augmented Reality (AR)-based learning media that positively impact various aspects of learning. These findings answer the formulation of problems and research questions related to the effectiveness of AR media in improving learning outcomes. Not only that, but AR-based learning media also significantly impact motivation, science literacy, metacognitive skills, and students' critical thinking skills.

These findings were obtained through various strong and varied methodological approaches, such as pseudo-experiments, media development using the ADDIE model, expert validation, and statistical tests such as paired t-test, MANOVA, and N-Gain calculations. Compared to the pretest and control classes, these methods significantly increased students' post-test scores after using AR media. The validity of the data is also strengthened by the involvement of various parties, such as material experts, teachers, and students, in the media evaluation process, who generally give a very positive assessment of AR media's feasibility, practicality, and effectiveness aspects.

Interpretation of the findings shows that AR can create fun, interactive, contextual, and multisensory learning experiences. It concretely allows visualization of abstract concepts, strengthens the attractiveness of learning, and increases student involvement in the learning process. However, some studies also note challenges that need to be anticipated, such as limited facilities, teacher readiness, and the potential for increased cognitive load if not accompanied by appropriate pedagogical design.

Augmented Reality also aligns with experiential learning approaches and information processing theories such as dual coding theory, which states that the combination of visual and verbal reinforces understanding and retention of information. Therefore, AR can be seen as a medium that integrates technology into learning and strengthens the learning process's theoretical foundation.

Based on the findings and interpretations above, modifications to the visual-interactive learning theory can be proposed by placing AR as a transformative media that integrates visual, kinesthetic, and authentic experience elements in one digital platform. In addition, a new hypothesis emerges that the success of AR-based learning is strongly influenced by three main components, namely media usability, pedagogical alignment, and digital readiness of teachers and students. This indicates the need for a holistic and contextual AR learning design model that considers content integration, pedagogical approaches, and technology user readiness in the educational environment.

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D. Conclusion

Based on the research results through the Systematic Literature Review (SLR) approach to 25 journal articles, using Augmented Reality (AR) media in learning significantly improves student learning outcomes. AR provides a more contextual and interactive learning experience, thus helping students understand abstract concepts more concretely. Therefore, AR is one of the innovative learning media that effectively supports improving learning outcomes.

These findings provide important implications for educational practice, especially in designing technology-based learning strategies. AR can be an alternative learning media that improves students' understanding and encourages active participation, creativity, and innovation in the teaching and learning process. Teachers and educational institutions are expected to be able to integrate this technology into the curriculum by considering the readiness of resources and the needs of learners.

However, more in-depth follow-up research is needed to maximize AR's educational potential. Future research is suggested to explore various practical AR implementation approaches, examine technical and pedagogical barriers that may be faced in the field, and develop AR designs that are adaptive to multiple student characteristics. Continuous evaluation and critical reflection on AR implementation will be constructive in creating a more optimal and sustainable technology-based learning model.

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