

THE EFFECT OF AUGMENTED REALITY MEDIA ON IPAS LEARNING OUTCOMES REGARDING THE HUMAN RESPIRATORY SYSTEM OF FIFTH-GRADE STUDENTS AT SDN PAKIS V SURABAYA

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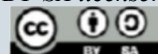
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ABSTRACT

This study aims to determine the effect of Augmented Reality learning media on IPAS learning outcomes in human respiratory system material for fifth-grade students at SDN Pakis V Surabaya. This study employed a quantitative approach using a quasi-experimental method with a nonequivalent control group design. The sample consisted of 70 students, including 35 students in class 5C as the experimental group and 35 students in class 5B as the control group, selected through purposive sampling. Data were collected using pretest and posttest instruments and analyzed using normality, homogeneity, and paired samples t-tests with IBM SPSS Statistics 21. The findings revealed that students who learned using Augmented Reality demonstrated substantially greater improvement in learning outcomes than those who received conventional instruction. The experimental group achieved a higher increase in posttest scores (25 points) than the control group (12 points), and the difference was statistically significant ($p < 0.05$). These findings indicate that Augmented Reality effectively enhances students' understanding of the human respiratory system by providing interactive and concrete learning experiences. Practically, the findings suggest that Augmented Reality can be integrated into IPAS instruction as an innovative learning medium to facilitate the teaching of abstract scientific concepts, promote students' engagement, and improve learning outcomes in elementary school classrooms. Therefore, Augmented Reality has the potential to support more effective and meaningful IPAS learning for fifth-grade students.

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INTRODUCTION

The rapid advancement of science and technology in the 21st century has significantly transformed various aspects of human life, including education. This transformation encourages educators to become more creative and innovative in

designing learning processes that accommodate students' needs in the digital era. Consequently, learning media are expected to integrate information and communication technology (ICT) to support effective and efficient teaching and learning activities. Learning media are considered instructional tools that facilitate the transfer of knowledge from teachers to students and play a crucial role in improving learning quality (Nurfadhillah et al., 2021)

The development of technology has shifted educational practices from conventional learning media toward technology-based learning environments. According to Nursyam (2019) information technology-based learning media support face-to-face learning by integrating technological innovations into classroom instruction. Furthermore, learning media are not merely supporting tools but have an essential role in helping students understand learning materials, stimulating motivation, encouraging curiosity, and improving learning experiences (Wulandari et al., 2023). Therefore, educators are encouraged to employ interactive and innovative media that can accommodate the characteristics of students in the digital era.

Learning outcomes are one of the primary indicators used to evaluate students' achievement after participating in the learning process. These outcomes encompass cognitive, affective, and psychomotor domains, reflecting students' knowledge, attitudes, and skills acquired through learning experiences (Siregar, 2024). Moreover, learning outcomes provide valuable information regarding students' progress toward achieving instructional objectives and are influenced by several factors, including the teaching strategies and learning media implemented by teachers (Supit et al., 2023). Consequently, selecting appropriate learning media is essential to enhance students' academic achievement.

Preliminary observations conducted in September 2025 at Grade 5 of SDN Pakis V Surabaya revealed that classroom instruction was still dominated by lectures and textbook-based learning. The textbooks mainly contained two-dimensional illustrations, making it difficult for students to comprehend abstract concepts in Natural and Social Sciences (IPAS). Additional printed black-and-white images provided by teachers were also considered less attractive and less effective in facilitating students' understanding. As a result, 54% of students (19 out of 35 students) scored below the Minimum Mastery Criterion (KKM) of 75. These findings indicate that students experience difficulties in understanding scientific concepts and connecting them with real-life situations, partly because the learning media used are still limited and less interactive.

IPAS is a subject that examines the interactions among humans, living organisms, and their environments while developing students' scientific thinking and problem-solving abilities. The primary objective of IPAS learning is to foster students' curiosity and help them understand themselves and their surroundings (Darniyanti et al., 2023). However, some topics in IPAS, particularly the human respiratory system, are often difficult for elementary school students to understand because they involve abstract scientific concepts that require appropriate visualization and interactive learning experiences.

One innovative technology that has attracted considerable attention in education is Augmented Reality (AR). AR is a technology that combines virtual objects with the real world in real time, enabling users to interact with three-dimensional objects within their actual environment (Syahputra et al., 2024). In educational settings, AR has been shown to facilitate students' understanding of abstract concepts through realistic visualization and interactive experiences. Moreover, AR can bridge the gap between theory and practice while enhancing students' critical thinking and problem-solving skills (Dhaas, 2024).

Several studies have demonstrated the effectiveness of AR in science education. AR enables students to visualize abstract concepts interactively, thereby improving their conceptual understanding and increasing learning motivation (Dendodi et al., 2024). Furthermore, the implementation of AR in science learning has been reported to be more effective than conventional learning media, as it enhances students' interest, comprehension, and retention of learning materials (Tasya'ah et al., 2025). In addition, AR creates enjoyable learning experiences that contribute positively to students' learning outcomes and motivation (Acesta & Nurmaylany, 2018).

Although previous studies have demonstrated that Augmented Reality (AR) can improve students' motivation, conceptual understanding, and learning outcomes in science education, most of these studies have focused on general science subjects or secondary education settings. In addition, limited research has specifically examined the effectiveness of AR in IPAS learning on the topic of the human respiratory system for elementary school students, particularly within the context of Indonesian primary schools. Furthermore, studies investigating the implementation of AR using a quasi-experimental design that directly compares its effectiveness with conventional learning media in elementary IPAS classrooms remain scarce. This

gap highlights the need for empirical evidence regarding the effectiveness of AR in supporting elementary students' understanding of abstract scientific concepts.

To address this gap, the present study investigates the effect of Augmented Reality learning media on fifth-grade students' learning outcomes in IPAS, specifically on the topic of the human respiratory system at SDN Pakis V Surabaya using a quasi-experimental nonequivalent control group design. The novelty of this study lies in evaluating the implementation of AR within the Indonesian elementary IPAS curriculum on abstract biological concepts while providing empirical evidence of its effectiveness compared with conventional instruction. Therefore, this study not only examines the statistical effect of AR on learning outcomes but also offers practical evidence for integrating interactive digital learning media into elementary science education. The findings are expected to contribute to the growing body of literature on technology-enhanced learning and provide practical recommendations for teachers seeking to improve the quality of IPAS instruction through innovative digital media.

METHOD

This study employed a quantitative approach using a quasi-experimental method with a nonequivalent control group design to investigate the effect of Augmented Reality (AR) learning media on students' learning outcomes (Adil et al., 2023)(Adil et al., 2023, The research was conducted at SDN Pakis V Surabaya during the 2025/2026 academic year. The population consisted of all fifth-grade students, while the sample was selected using purposive sampling. Class 5C (n = 35) was assigned as the experimental group and Class 5B (n = 35) as the control group. The experimental group received instruction using Augmented Reality media, whereas the control group was taught using textbooks and conventional lecture-based instruction.

The learning intervention was conducted over four instructional meetings, each lasting approximately 70 minutes, excluding the pretest and posttest sessions. Before the intervention, both groups completed a pretest to measure their initial knowledge of the human respiratory system. During the treatment, students in the experimental group learned the topic using Assemblr EDU-based Augmented Reality, which enabled them to observe and interact with three-dimensional visualizations of the human respiratory system through smartphones. The teacher guided students in exploring AR content, facilitated classroom discussions, and provided learning activities based on the displayed visualizations. In contrast, students in the control group studied the same learning materials using textbooks, printed images, and teacher explanations without AR support. At the end of the intervention, both groups completed a posttest to evaluate changes in learning outcomes.

Data were collected using 20-item multiple-choice pretest and posttest instruments designed to measure students' cognitive learning outcomes on the topic of the human respiratory system. The instruments were validated by experts and demonstrated satisfactory validity, while reliability testing using Cronbach's Alpha yielded coefficients of 0.741 for the pretest and 0.701 for the posttest. The data were analyzed using normality and homogeneity tests, followed by a paired samples t-test with a significance level of 0.05 to examine differences between pretest and posttest scores within each group and to determine the effect of the AR intervention on students' learning outcomes.

RESULT AND DISCUSSION

Validity testing was conducted using the Product-Moment correlation method with IBM SPSS Statistics 21 on 20 items from the pretest and posttest. The results showed an overall two-tailed significance level (Sig.) of <0.05, indicating that the research instrument is valid. In the reliability test using Cronbach's alpha, a result of >0.60 was obtained, indicating that the instrument has reliable reliability and adequate measurement consistency.

The study was conducted on 70 fifth-grade students of SDN Pakis V Surabaya, consisting of 35 students in the experimental class and 35 students in the control class. The experimental class was taught using Augmented Reality (AR) media, whereas the control class received learning through textbooks and lecture methods.

Table 1. Research findings from the experimental class

	Pretest	Posttest	Total	Difference
Total	1890	2765	4655	875

Average	54	79	133	25
Minimum	35	60	95	25
Maximum	70	100	170	30

Table 2, Research findings from the control class

	Pretest	Posttest	Total	Difference
Total	1830	2255	4085	425
Average	52	64	116	12
Minimum	35	50	85	15
Maximum	70	80	150	10

The results showed that both groups experienced an increase in learning outcomes after the learning process. However, the increase in the experimental class was higher than that of the control class. The average score of the experimental class increased from 54 to 79, with an improvement of 25 points, while the control class increased from 52 to 64, with an improvement of 12 points. These findings indicate that the use of Augmented Reality media contributed more effectively to improving students' learning outcomes than conventional learning methods.

Before hypothesis testing, the data were subjected to normality and homogeneity tests. The results revealed that all pretest and posttest data in both classes were normally distributed because the significance values were greater than 0.05. Furthermore, the homogeneity test indicated that the variances of the two groups were homogeneous (Sig. > 0.05), indicating that the data met the assumptions required for further statistical analysis.

Table 3, Paired Sample T-Test

	Mean	Std.Dev	Error Mean	Lower	Upper	t	df	Sig.(2-tailed)
PreControl- PostControl	-12,143	8,684	1,468	-15,126	-9,160	-8,272	34	,000
PreExperiment - PostExperiment	-25,000	7,071	1,195	-27,429	-22,571	-20,917	34	,000

The Paired Samples t-test indicated a significant difference between pretest and posttest scores in both the control and experimental classes ($p = 0.000 < 0.05$). The experimental class showed a greater improvement than the control class, indicating that Augmented Reality media significantly improved students' learning outcomes.

Table 4, N Gain Score

Data	Class	Mean N-Gain	Category
Pretest and Post test Score	Experimental	0,561	Medium
	Control	0,242	Low

To further evaluate the effectiveness of the intervention, the normalized gain (N-gain) score was calculated for both groups. As presented in Table 4, the experimental group achieved a mean N-gain score of 0.561, which falls within the moderate improvement category, whereas the control group obtained a mean N-gain score of 0.242, categorized as low. The higher N-gain score in the experimental group indicates that students who learned using Augmented Reality experienced greater improvement in learning outcomes than those who received conventional instruction. These findings suggest that Augmented Reality facilitates students' understanding of abstract concepts by providing interactive and concrete visualization, thereby promoting more meaningful learning experiences.

Table 5, Independent T-Test

Variable	T	df	P-Value
Learning Outcome	8,232	68	0,000

An independent samples t-test was conducted to determine whether there was a significant difference in the N-gain scores between the experimental and control groups. Prior to hypothesis testing, Levene's test indicated that the assumption of homogeneity of variance was satisfied ($F = 0.127$, $p = 0.723 > 0.05$). Therefore, the results under the assumption of equal variances were interpreted.

The analysis revealed a statistically significant difference in the mean N-gain scores between the two groups ($t(68) = 8.232$, $p < 0.001$). The experimental group demonstrated a significantly higher mean N-gain score ($M = 0.561$, $SD = 0.175$) than the control group ($M = 0.242$, $SD = 0.147$). These findings indicate that students who learned using Augmented Reality achieved greater learning improvement than those who learned through conventional teaching methods.

The results confirm that the implementation of Augmented Reality significantly enhances students' learning outcomes in the human respiratory system topic. The interactive three-dimensional visualization provided by Augmented Reality enables students to better understand abstract scientific concepts, resulting in more effective learning compared with textbook-based instruction. Consequently, Augmented Reality can be considered an effective instructional medium for improving elementary students' achievement in IPAS learning.

The findings of this study indicate that the implementation of Augmented Reality (AR) significantly improved students' learning outcomes in IPAS, particularly on the topic of the human respiratory system. Students in the experimental group achieved significantly higher posttest scores and N-gain values than those in the control group, indicating that AR was more effective than conventional learning in facilitating conceptual understanding (Dewi et al., 2024). These findings suggest that integrating interactive digital media into elementary science instruction can positively influence students' cognitive achievement (Acesta & Nurmaylany, 2018).

The higher learning achievement observed in the experimental class may be attributed to the ability of Augmented Reality to transform abstract concepts into concrete and interactive learning experiences. Through three-dimensional visualization, students were able to observe the structures and functions of the human respiratory organs more clearly than through textbook illustrations alone. This interactive visualization helped students connect theoretical explanations with realistic representations, thereby reducing misconceptions and facilitating deeper conceptual understanding (Syahputra et al., 2024).

This finding can also be explained through Constructivist Learning Theory, which states that knowledge is actively constructed through learners' interaction with learning experiences rather than passively received from teachers. During AR-based learning, students explored three-dimensional objects, observed the respiratory organs from different perspectives, and actively discussed their observations with peers and teachers. Such activities encouraged students to build their own understanding based on direct exploration, making learning more meaningful and improving conceptual mastery.

Furthermore, the findings are consistent with the Cognitive Theory of Multimedia Learning, which argues that meaningful learning occurs when learners process verbal explanations together with visual representations through separate cognitive channels. Compared with static textbook images, AR provides dynamic three-dimensional visualization that reduces cognitive load and facilitates information processing. As a result, students are better able to organize, integrate, and retain scientific information, leading to higher learning achievement (Mayer & Fiorella, 2022).

Another important factor contributing to the effectiveness of AR is its ability to increase students' motivation and engagement during classroom learning. Interactive learning environments encourage students to participate actively because they can directly manipulate digital objects and observe scientific phenomena in real time. Such learning experiences stimulate curiosity, maintain students' attention, and create enjoyable learning situations, all of which contribute to improved learning outcomes. According to Ryanto et al. (2025) learning media capable of attracting learners' attention and increasing their engagement are more likely to produce meaningful learning outcomes. Similar findings have also been reported by Wulandari et al. (2023) who found that technology-based learning media can increase students' motivation and interest in learning.

The findings of the present study are consistent with previous empirical studies. Tansha & Siregar (2026) reported that Augmented Reality enables students to understand abstract concepts through interactive three-dimensional visualization. Likewise, Fakhrudin & Kuswidyarnarko (2020) concluded that AR-based learning media improve learning outcomes because

they provide more attractive, concrete, and meaningful learning experiences. Sathyapriya et al. (2024) also explained that AR facilitates students' understanding of concepts that are difficult to observe directly. Similar results were obtained by Dewi et al. (2024) who found that AR significantly improved elementary students' IPAS learning outcomes. Acesta & Nurmaylany (2018) reported an increase in students' average scores from 60.00 to 81.66 after implementing AR media, while Kamaruddin & Thahir (2021) demonstrated that students who learned using AR achieved significantly better learning outcomes than those receiving conventional instruction. The consistency between the present findings and previous studies strengthens the evidence that AR is an effective instructional medium for elementary science education.

From a practical perspective, this study suggests that Augmented Reality can be integrated into IPAS learning as an innovative instructional medium, particularly for topics involving abstract scientific concepts. Rather than replacing the teacher's role, AR functions as a complementary learning tool that enhances visualization, classroom interaction, and students' conceptual understanding. Therefore, elementary school teachers are encouraged to incorporate AR into science instruction to create more engaging, student-centered, and technology-enhanced learning environments that are aligned with the demands of twenty-first-century education (Destyani et al., 2026).

Despite these promising findings, several limitations should be acknowledged. First, this study involved only 70 fifth-grade students from one elementary school, which limits the generalizability of the findings to other educational settings. Second, the intervention was conducted over a relatively short period and focused solely on the human respiratory system topic. Consequently, the long-term effectiveness of Augmented Reality across different science topics remains unclear. Third, the study measured only students' cognitive learning outcomes, without examining other important variables such as learning motivation, critical thinking skills, collaboration, or long-term knowledge retention. Future studies are therefore recommended to involve larger and more diverse samples, extend the duration of the intervention, and investigate additional learning variables to obtain a more comprehensive understanding of the educational benefits of Augmented Reality in elementary science learning (Fraenkel et al., 2019).

Overall, the findings demonstrate that Augmented Reality significantly enhances elementary students' learning outcomes by facilitating conceptual understanding through interactive three-dimensional visualization, increasing students' engagement in learning, and providing meaningful learning experiences. These findings reinforce the growing evidence that Augmented Reality is an innovative and effective instructional medium for improving the quality of IPAS learning in elementary schools

CONCLUSION

This study concludes that the use of Augmented Reality (AR) learning media has a significant positive effect on students' learning outcomes in IPAS, particularly on the topic of the human respiratory system. Students who learned using AR demonstrated significantly greater improvement in learning outcomes than those who received conventional instruction, indicating that interactive three-dimensional visualization effectively facilitates students' understanding of abstract scientific concepts. These findings provide empirical evidence that integrating AR into elementary science learning can enhance students' conceptual understanding and academic achievement.

From a practical perspective, this study suggests that elementary school teachers can utilize Augmented Reality as an innovative instructional medium to create more interactive, engaging, and meaningful learning experiences, especially for science topics involving abstract concepts. The implementation of AR can support teachers in improving the quality of IPAS instruction while promoting active student participation in the learning process.

Nevertheless, this study was limited to one elementary school and focused only on the human respiratory system topic within a relatively short intervention period. Therefore, future studies are recommended to involve larger and more diverse samples, implement longer intervention periods, and examine the effectiveness of Augmented Reality across different science topics and learning variables, such as learning motivation, critical thinking skills, and long-term knowledge retention. Such investigations will provide a more comprehensive understanding of the educational potential of Augmented Reality in elementary education.

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