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Implementation of Augmented Reality in Elementary School Science Education on the Solar System

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A B S T R A C T

The limited use of learning media which are neither concrete nor interactive in elementary school science education has made it difficult for students to understand abstract concepts and has reduced their motivation. The purpose of this study is to describe the application of Augmented Reality (AR) in science education. The method used was a qualitative descriptive approach involving five teachers as classroom observers, employing observation and documentation techniques analyzed using the Miles and Huberman model. The results showed that the implementation of AR across all stages of learning fell into the "good" and "very good" categories. The five stages achieved the following scores: planning (96%), student preparation (90%), classroom implementation (91%), discussion and reflection (87%), and learning evaluation (87%). Thus, this study concludes that the implementation of Augmented Reality in IPAS learning has been carried out effectively. Future research could examine the impact and effectiveness of AR in IPAS learning quantitatively and using a wider variety of instruments.

1. Introduction

Elementary school education plays a crucial role in laying the foundation for students' knowledge and skills. However, the implementation of learning in elementary schools still faces various limitations (Mustoip et al., 2023; Rahmawati, 2022). A key issue in this study is that science education in elementary schools continues to face various challenges (Adri & Suwarjono, 2025). Teachers often rely on conventional methods and limited teaching materials that tend to be less concrete and engaging, resulting in students who are less motivated and struggle to grasp abstract concepts (Huda et al., 2026; Rakhman et al., 2024). Consequently, IPAS

instruction tends to be theoretical and fails to provide meaningful learning experiences (Komariah et al., 2023). IPAS is an integrated learning approach that connects the natural sciences with the social sciences (Munawarah et al., 2025; Zahro et al., 2024). Technological advancements present new opportunities and innovations that can be implemented in learning materials integrated with digital media. The use of digital media enables the creation of interactive learning materials capable of visually representing abstract concepts. Learning with digital media also creates an adaptive learning environment tailored to students' needs (Inal et al., 2022). Thus, technological advancements serve as a driving force and a key determinant of the success of educational transformation (Herniyastuti et al., 2025).

One approach that can be used to address this issue is the use of Augmented Reality (AR) technology as a learning tool. Augmented Reality can be used as a learning tool and medium through various methods (Masrukhin et al., 2024). This technology can present three-dimensional (3D) objects that can be viewed realistically through digital devices, making it easier for students to understand abstract material and enhancing the effectiveness of learning (Fombona-Pascual et al., 2022; Pramuditya et al., 2022). Augmented reality (AR) not only presents images but can also be combined with sound, animation, and video, making the learning process more engaging, contextual, and enjoyable (Resti et al., 2024). Thus, augmented reality (AR) has great potential to improve the quality of science education in elementary schools.

This is consistent with research by (Purnama & Nurhania, 2025), which revealed that the use of augmented reality can significantly improve students' understanding of science material by providing interactive visualizations of abstract concepts. This technology is also capable of increasing students' engagement and motivation to learn because it provides a more engaging and enjoyable learning experience (Sattar et al., 2025). In their study, (Dewi et al., 2024) concluded that the use of augmented reality learning media in the IPAS subject has a significant impact on improving students' learning outcomes. Learning that utilizes augmented reality technology can provide a deeper and more lasting understanding of the human body system (AlGerafi et al., 2023). Furthermore, the implementation of AR in learning can also have a significant impact on students' numeracy skills (Muti'ah et al., 2024). The integration of AR into learning has also been shown to improve students' critical thinking skills at the elementary school level (Rumanti & Christy, 2026).

This issue highlights the urgency of conducting research on the implementation of augmented reality (AR) technology as a medium in IPAS learning to determine students' motivation and learning outcomes. Students' learning outcomes are influenced by their interest and motivation to learn. This study was conducted by integrating augmented reality (AR)-based media into IPAS instruction and analyzing students' motivation and conceptual understanding of IPAS using augmented reality (AR)-based media. The objective of this study is to describe the implementation of augmented reality (AR) in IPAS instruction at the elementary school level. This study is grounded in Piaget's constructivist learning theory, which emphasizes the importance of direct experience in building students'

knowledge, and Mayer's multimedia theory, as augmented reality (AR) technology can combine text, images, audio, and animation into a single medium, thereby aligning with the principles of multimedia learning.

This study offers several innovations: technology-based media that is easy to use anywhere and anytime; a focus on implementation in elementary school IPAS lessons; the simultaneous use of constructivism and Mayer's multimedia theory as a foundation; and the use of augmented reality (AR) media, which can be utilized over the long term and keeps pace with the times. It is hoped that the results of this study will provide practical benefits for teachers in developing innovative learning strategies, for students in enhancing their motivation and conceptual understanding related to learning outcomes, and for schools in strengthening the quality of IPAS instruction. Additionally, this study can serve as a reference for the broader development of technology-based learning media at the elementary school level.

2. Methodology

This study employs a qualitative descriptive approach. The purpose of this research is to describe the conduct and implementation of learning using Augmented Reality in the IPAS curriculum for sixth-grade students at SDN Gesi 1 in Gesi Subdistrict, Sragen Regency. The study was conducted in November 2025 at SDN Gesi 1 in Gesi Subdistrict, Sragen Regency. The study involved five teachers as observers who conducted observations during the learning process. The lesson covered the solar system, with 26 students participating. The data in this study consisted of primary data collected directly by the researcher using research instruments. The research data were obtained from observation sheets documenting the implementation of Augmented Reality in IPAS lessons for sixth-grade elementary school students. Data collection utilized direct observation during the learning process. The five teachers served as observers to evaluate the implementation of IPAS lessons using Augmented Reality. Observations were conducted by directly observing phenomena in the classroom without intervention to obtain real data regarding the implementation of Augmented Reality (AR) media. The observation instruments are presented in Table 1.

Table 1. Observation Instrument

Stages	No. Item
Planning	1, 2, 3, 4
Student Preparation	5, 6, 7, 8
Classroom Implementation	9, 10, 11, 12, 13, 14, 15, 16
Discussion and Reflection	17, 18, 19, 20, 21
Learning Assessment	22, 23, 24, 25, 26

The research instruments consisted of observation and documentation forms. The observation form was developed as a Likert-scale questionnaire. Observers filled in the answers to the questions and statements provided in the questionnaire based on the actual teaching and learning process. Teachers also provided written notes and comments on the observation sheets during the learning process. The

documentation contained important notes and photographs of the learning process that illustrated the use of Augmented Reality in IPAS instruction. The instruments used were validated by learning experts and deemed valid for use as research instruments. This means that the observation sheets can be used as valid and credible measurement tools.

The stages of this research refer to the stages of AR implementation in IPAS learning at the elementary school level. There are five main stages, as explained earlier: planning, student preparation, classroom implementation, discussion and reflection, and learning evaluation. The planning stage involves preparing the tools used in AR implementation. The student preparation stage involves coordinating students and providing instructions before AR implementation. Classroom implementation involves IPAS learning activities using AR. Students actively conduct direct observations using AR and discuss their findings with group members. The discussion and reflection stage involves students presenting their findings, while the teacher provides feedback and reinforcement. Finally, the evaluation phase involves assessing the effectiveness of AR implementation in IPAS instruction.

The research data were analyzed using a data analysis model (Miles & Huberman, 1992), which states that activities in qualitative data analysis are conducted interactively and continue continuously until completion, so that the data are saturated. The research data were presented in the form of a four-point Likert scale, where 1 = Not Appropriate, 2 = Somewhat Inappropriate, 3 = Appropriate, and 4 = Very Appropriate. Data analysis was then conducted by calculating the percentage of achievement obtained for each indicator. The interpretation of the data analysis results describes the status of AR implementation in IPAS learning based on the criteria presented in Table 2. Research data triangulation was performed to ensure the validity and consistency of the data between the observation results and the questionnaire responses, comments provided directly by teachers, and documentation of the learning process.

Table 2. Interpretation of the Implementation of AR in IPAS Learning

No	Percentage	Criteria
1	$90 < N \leq 100\%$	Very good
2	$80 < N \leq 90\%$	Good
3	$65 < N \leq 80\%$	Fair
4	$55 < N \leq 65\%$	Not so good
5	$N \leq 55\%$	Very poor

(Sadieda et al., 2022)

3. Results and Discussion

Research data was collected using previously developed observation and documentation instruments. Data from observations conducted using questionnaires was analyzed by calculating the percentage achieved at each stage of implementation. The results of the analysis were grouped based on criteria

related to the feasibility of implementing AR media in IPAS instruction at the elementary school level. The analysis results show that the five stages of Augmented Reality implementation which include planning, student preparation, classroom implementation, discussion and reflection, and learning evaluation in IPAS instruction for sixth-grade elementary school students are presented in Figure 1.

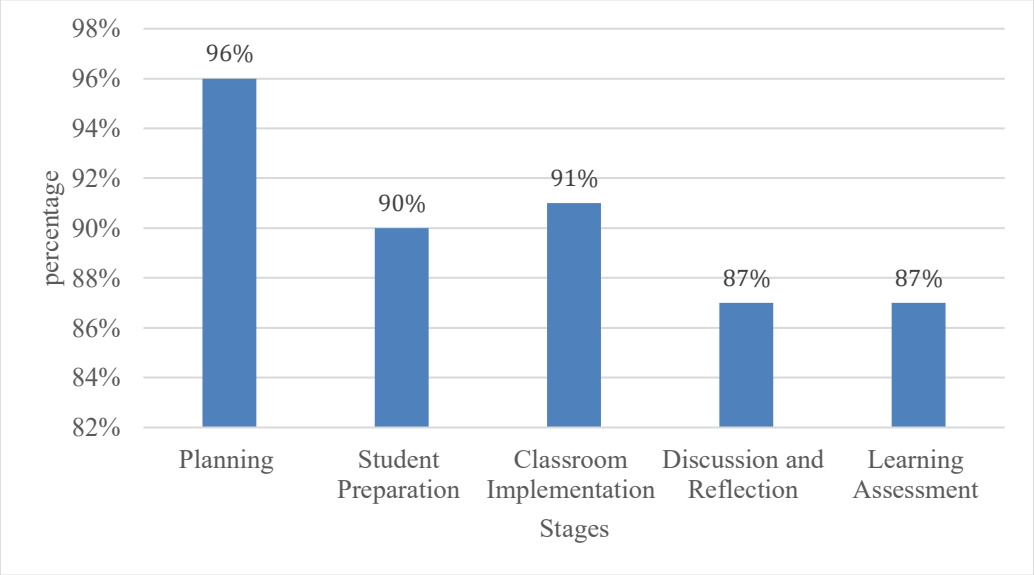

Figure 1. Percentage of observation results based on implementation stages

The implementation of Augmented Reality (AR) in IPAS lessons at Gesi 1 Public Elementary School focused on the Solar System. During the implementation process, students learned about the Solar System an abstract concept that cannot be observed directly. Until now, lessons have relied solely on images found online or in textbooks. The use of AR represents a new innovation because it can display more realistic images and visuals of the Solar System, complete with animations and supporting explanations. These results were evident in the planning stage, which achieved a score in the "very good" category of 96%. According to the observer, the selection of the Solar System material and the AR presentation of the Solar System were highly appropriate and helped students understand the concepts very well. The teacher was also highly skilled in operating and instructing students on the use of AR during the learning process, ensuring that no obstacles arose during implementation.

The second stage involved preparing students for the implementation of Augmented Reality. The achievement rate was 90%, which falls into the "good" category. The instructions provided by the teacher before students used Augmented Reality were very comprehensive and clear. The teacher explained the rules and procedures for use so that students would not be confused when using Augmented Reality. At this stage, students began to show enthusiasm and understood each instruction given by the teacher. After this stage, students were expected to be ready to learn the material on the solar system using Augmented Reality.

The third phase was the core phase, involving the implementation of Augmented Reality in IPAS instruction on the Solar System. The observation results showed excellent outcomes, with 91% of students achieving the "very good" category. During the implementation, students accessed and used Augmented Reality effectively. Throughout the process, students actively engaged in the learning activities in accordance with the instructions provided. Discussions among students in small groups also took place during the implementation of Augmented Reality. This indicates that learning with Augmented Reality was interactive, involving interactions between students and the AR as well as among students within their groups. During the implementation, the teacher also provided additional instructions and simple assistance when students had difficulty connecting what they saw in the AR with the actual concepts. This process maximized students' understanding, and the learning objectives were successfully achieved.

The fourth stage is also quite important, with 87% of students rated in the "good" category. The process of discussion and reflection both during and after the implementation of Augmented Reality in IPAS learning is essential. In this stage, students reflect on what they have learned and raise questions about the obstacles and difficulties they still face. To address the challenges students encounter, teachers provide concise material to reinforce their understanding and correct any misconceptions that may have arisen during the implementation of Augmented Reality. Teachers can also provide feedback on students' questions or achievements. This ensures that students fully understand the concepts and are able to explain the concepts they have grasped.

The learning evaluation phase marked the conclusion of the Augmented Reality implementation process in IPAS instruction at the elementary school level. The 87% achievement rate, which falls into the "good" category, indicates that the post-implementation evaluation process was carried out effectively. Teachers provided learning evaluations regarding the Augmented Reality implementation process that had been conducted. Teachers also assessed students' learning outcomes and motivation during the learning process. This serves as an indicator of the implementation's success. Consequently, students' learning outcomes and motivation can be better explained.

These observational findings, presented as quantitative data, are corroborated by the observers' comments regarding the successful implementation of AR in IPAS instruction. This corroboration underscores and explains the alignment between the observational scores and the comments provided. It also offers a more comprehensive and in-depth explanation of the successful implementation of AR in IPAS instruction. During the planning phase, the observer stated that preparations prior to the implementation of Augmented Reality had been carried out well. The following are some of the arguments provided by the observer: *"Before the lesson, the teacher had prepared everything very well; the teacher was also able to select materials suitable for AR." "Before the lesson, I observed that the planning phase was quite thorough and well-structured, but there is a need to improve time efficiency." "The lesson plan was structured and incorporated the use of computers, which had not been part of my previous lessons."* The observer's

feedback and comments indicate that the planning phase was carried out appropriately and that time management needs to be improved. This is to ensure that learning objectives are achieved optimally. This alignment is also evident in the student preparation phase and is reflected in the consistency between the survey responses and the comments provided.

During the implementation phase, augmented reality has proven effective as a learning tool that presents material and concepts in a more interactive and clear manner. The visual displays make it easier for students to conceptualize ideas in a more tangible way. Observers offered the following comments during the implementation phase: *"The implementation process has gone smoothly and is engaging, making it easier for students to understand the concepts." "Classroom learning is no longer boring, though there was a minor issue earlier where students felt confused about how to operate the technology; however, the teacher was quick to help resolve the problem." "Augmented reality makes students seem more enthusiastic and motivated to learn."* These results indicate that, in practice, augmented reality can be implemented in line with its primary objectives. Although there were minor challenges, they were promptly anticipated and resolved with the best possible solutions.

During the implementation of augmented reality, the learning documentation captures classroom situations in which students use and access augmented reality. An overview and documentation of the augmented reality implementation are presented in Figure 2. Students use augmented reality in groups within the classroom. In this setting, they exchange ideas and present arguments. This fosters active interaction during learning, which helps them better understand the concepts. Overall, the results of implementing augmented reality (AR) media in sixth-grade IPAS lessons at SDN Gesi 1 show that the use of AR technology has a positive impact on students' learning processes and experiences.

Figure 2. Documentation of the Augmented Reality Implementation

Discussion

The findings of this study indicate that the implementation of augmented reality (AR) in IPAS instruction for sixth-grade students on the topic of the solar system went smoothly and was successful at all stages. Findings based on questionnaire-

based observations yielded relatively high percentages. This indicates that the implementation of Augmented Reality has been carried out effectively in IPAS instruction at the elementary school level. All five stages received ratings in the "good" and "fairly good" categories. Consequently, its implementation can certainly provide maximum impact and benefits for the learning process.

The use of augmented reality in teaching abstract concepts helps students understand those concepts through improved visual aids. This aligns with previous research indicating that AR can aid in understanding abstract concepts through interactive visualization (Radianti et al., 2020). Augmented reality can present 3D visuals, making them appear more realistic and easier to observe (Ibáñez & Delgado-Kloos, 2018). Furthermore, this study also supports the theory that augmented reality, when accompanied by explanations, helps improve students' understanding and cognitive abilities (Mayer, 2014).

The successful implementation of Augmented Reality demonstrates that its use in IPAS learning, particularly in Solar System-related material, is appropriate. This finding supports previous research indicating that Augmented Reality is suitable and appropriate for use in teaching abstract concepts that require realistic visualization (Falah et al., 2024). The use of Augmented Reality in previous studies also indicates that similar findings can improve mastery of Solar System and astronomy concepts (Ferrari et al., 2024; Putra et al., 2024). These findings certainly suggest that the present study can provide additional insights and reinforce existing research results and theories.

Although the findings of this study describe the implementation of Augmented Reality in teaching the Solar System, several limitations remain and need to be addressed in future research. The analysis, which was limited to describing the process, did not explain how AR affects variables related to student learning outcomes. Furthermore, the data in this study focused only on observations made by teachers during the learning process. Therefore, future research could be designed to explain the impact of AR use on various variables related to learning outcomes. Additionally, future research could employ a wider variety of instruments to enhance the credibility of the findings.

4. Conclusion

The research results and findings indicate that the use of AR has been successfully implemented across all stages of learning. The planning, preparation, implementation, and evaluation stages yielded highly satisfactory results based on observations. This implementation has created a more interactive learning experience, increased student engagement and enthusiasm, and helped students understand abstract concepts. Thus, the use of Augmented Reality has the potential to serve as a medium for continuously improving the quality of learning. Further testing and research on the effectiveness of AR in IPAS learning need to be conducted using quantitative data so that the results obtained are more objective and reflect actual conditions.

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