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Development of Interactive Teaching Materials Based on Augmented Reality to Improve the Learning Outcomes of Sciences in Grade IV Students

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Abstract

This study aims to develop Augmented Reality-based teaching materials. Testing the validity, practicality, and effectiveness of Augmented Reality-based teaching materials for fourth-grade students of SDN 30 Lubuklinggau. This type of research is Research and Development with the ADDIE development model. The subjects of this study were fourth-grade students of SDN 30 Lubuklinggau. Data collection techniques used observation, interviews, questionnaires, and tests. Based on the results of the validity of Augmented Reality-based teaching materials using Aiken's V, the language validator assessment was 0.96, the media validator was 0.83, and the material validator was 0.82. Analysis of the teacher and student practicality sheet assessments showed that Augmented Reality-based teaching materials met the criteria of being very practical with an average score of 92.24%. Then the analysis of the effectiveness assessment obtained an average N-Gain score of 0.76 with a high category. Based on the research results, it can be concluded that the Augmented Reality-based teaching materials are proven valid, practical, and effective, making them suitable for use in fourth-grade science lessons at SDN 30 Lubuklinggau. Furthermore, the developed teaching materials are expected to support a more interactive and engaging learning process for students.

Keywords Development; Augmented Reality; ADDIE; Elementary School; Teaching Materials.

INTRODUCTION

Education is a continuous process aimed at developing students' potential holistically, encompassing intellectual, emotional, moral, and social aspects. In its implementation, learning is a key component determining educational success. Setiawan et al. (2022) explain that education is a process aimed at developing all

students' potential so they can develop optimally in accordance with educational goals. Therefore, developing innovative teaching materials is a crucial effort to improve the quality of the learning process and outcomes.

In the Independent Curriculum, Natural and Social Sciences (IPAS) is designed as an integrated subject that integrates science and social studies concepts through an interdisciplinary approach. Evitasari et al (2025) However, the nature of IPAS material, which contains many abstract concepts, often hinders elementary school students from optimally understanding the material. This situation demands teaching materials that can present concepts in a more concrete, engaging, and interactive manner.

Based on the results of observations and interviews with fourth-grade students of SD Negeri 30 Lubuklinggau in the first semester of the 2025/2026 academic year, several obstacles were found in science learning, such as lack of student attention during learning, limited use of interesting teaching materials and media, and a lack of visual aids to support conceptual understanding. These conditions have an impact on low student learning outcomes. Of the 21 students, only 6 students achieved the KKM of 70, while 15 students (71%) have not achieved completeness. These findings indicate the need for learning innovations that can increase student engagement and learning outcomes.

One alternative that can be used to overcome this problem is the development of AR-based teaching materials. Nee & Ong (2023) Therefore, this technology allows students to see object visualizations more realistically, thus helping them understand abstract concepts. AR-based teaching materials can also increase student interaction with learning materials, create a more engaging learning experience, and encourage active student participation during the learning process.

Several previous studies have shown that the use of Augmented Reality has a positive impact on learning. Riyanti et al. (2024) stated that the use of AR can significantly increase student creativity and learning outcomes. Furthermore, Annie et al. (2024) These research results indicate that AR has great potential to be used as an innovative medium and teaching material in 21st-century learning.

However, previous research still reveals gaps. Most studies focus on the use of AR as a learning medium, while research on the development of Augmented Reality-based teaching materials specifically applied to science learning in elementary schools is relatively limited. Furthermore, there are few studies that comprehensively test product feasibility through aspects of validity, practicality, and effectiveness. Therefore, further development research is needed to produce Augmented Reality-

based teaching materials that are appropriate to the needs of elementary school students and can be used effectively in learning.

Based on the description, this study aims to develop Augmented Reality-based teaching materials for the fourth-grade science subjects of SD Negeri 30 Lubuklinggau and test their validity, practicality, and effectiveness. The results of this study are expected to produce teaching materials that are suitable for use in learning and able to improve student learning outcomes in the science subjects.

METHODS

This study used the Research and Development (R&D) method with the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it has systematic and structured steps in developing learning products, resulting in teaching materials that meet students' needs. Gamal (2023) explains the research and development (R&D) method that underlies the use of the ADDIE model.

The research was conducted at SD Negeri 30 Lubuklinggau during the odd semester of the 2025/2026 academic year. The subjects were 21 fourth-grade students, consisting of 9 boys and 12 girls. The research also involved three validators: a linguist, a media expert, and a material expert, to assess the feasibility of the developed product.

The analysis stage is conducted through observation and interviews to identify needs and problems that form the basis for product development (Susanto & Andriana, 2020). Chen (2019) explains that the design stage includes the preparation of product designs and research instruments. In the development stage, the designed teaching materials are developed and validated by linguists, media experts, and material experts. The implementation stage is carried out through product trials, which include individual trials, small group trials, and large group trials. The evaluation stage is carried out to refine the product based on the results of validation, practicality tests, and effectiveness tests. Winarni (2018) explains that the ADDIE development model is more comprehensive and rational than other development models.

The use of research tools and instruments aims to help researchers obtain valid data that meets research needs(Sukmawati et al., 2023). The tools and materials used in this study include a computer or laptop for developing teaching materials, software supporting the creation of Augmented Reality, an Android-based smartphone as a medium for using the application, grade IV science materials, and research instruments in the form of observation sheets, interview guidelines, validation questionnaires, practicality questionnaires, and learning outcome test questions.

Data collection techniques are a strategic step in research because they aim to obtain valid data according to research needs(Habsy et al., 2024). Data collection techniques used include observation, interviews, questionnaires, and tests. Observations and interviews are used to obtain information regarding learning needs and the initial conditions of the school. Questionnaires are used to collect data on the validity and practicality of teaching materials, while tests are used to measure the effectiveness of teaching materials through pretest and posttest results.

Data analysis was conducted quantitatively descriptively. Validity data were analyzed using the Aiken's V index to determine the level of feasibility of teaching materials based on expert assessments. Practicality data were analyzed using the percentage scores obtained from teacher and student questionnaires. Effectiveness data were analyzed using the N-Gain formula based on student pretest and posttest results. Teaching materials were declared valid if they obtained an Aiken's V value $\geqslant 0.60$, practical if they obtained a practicality percentage $\geqslant 61\%$, and effective if they obtained an N-Gain value $\geqslant 0.30$.

FINDINGS AND DISCUSSION

Findings

This research resulted in a product in the form of Augmented Reality-based teaching materials for the fourth-grade science subject at SD Negeri 30 Lubuklinggau. The development of the teaching materials was carried out using the ADDIE model, which consists of the stages of analysis, design, development, implementation, and evaluation. The quality of the resulting product was reviewed based on aspects of validity, practicality, and effectiveness to determine the suitability of the teaching materials for use in the learning process.

Validity testing was conducted by three validators: a linguist, a media expert, and a content expert. The assessment was conducted using a validation sheet compiled based on linguistic aspects, media presentation, and the suitability of the learning materials. The validation results are presented in Table 1.

Table 1. Validation Result of Augmented Reality Based Teaching Materials

No	Validator	Aiken's V Value	Category
1	Linguist expert	0,96	High
2	Media expert	0,83	High
3	Material expert	0,82	High
	Average	**0,87**	**High**

Based on Table 1, the validity values obtained from linguists were 0.96, media experts 0.83, and material experts 0.82. The average validity value of 0.87 indicates that

the Augmented Reality-based teaching materials are in the high category. These results indicate that the developed teaching materials meet the linguistic, media presentation, and material suitability aspects, making them suitable for use in learning.

The high validity score indicates that the development process met the learning needs of elementary school students. The use of simple and communicative language facilitated student understanding of the material presented. Furthermore, the integration of Augmented Reality technology provided more engaging object visualizations, helping students grasp science concepts more concretely. These findings align with those of Albers et al (2019), who stated that validation is a crucial stage in product development to ensure quality and feasibility before implementation.

After being declared valid, the teaching materials were tested for practicality using teacher and student response questionnaires. The assessment was conducted to determine ease of use, clarity of instructions, and the material's appeal during the learning process. The results of the practicality test can be seen in Table 2.

Tabel 2. Result of the Practicality Test of Teaching Material

Assessment Aspect	Percentage	Category
Practicality of Teacher and Student	92,24	Very Practical

Based on Table 2, the Augmented Reality-based teaching materials achieved a practicality percentage of 92.24%, categorized as very practical. These results indicate that the teaching materials are easy to use by both teachers and students during the learning process.The high level of practicality indicates that the learning materials can provide a more interactive and enjoyable learning experience. Students can access virtual objects via smartphones, making the learning material more engaging. Furthermore, clear instructions make it easier for students to operate the learning materials independently. These findings support previous research that suggests that the use of Augmented Reality can increase student engagement in the learning process through more interactive and visual presentation of materials.

The effectiveness of the teaching materials was measured by comparing students' pretest and posttest results. Analysis was conducted using the N-Gain formula to determine the improvement in learning outcomes after using Augmented Reality-based teaching materials. The results of the analysis are presented in Table 3.

Tabel 3. Result of the Effectiveness Test of Teaching Materials

Pretest Average	Posttest Average	N-Gain	Category
40,45	85,45	0,76	High

Based on Table 3, the average student pretest score of 40.45 increased to 85.45 in the posttest. The N-Gain calculation results showed a value of 0.76, which is considered high. Thus, Augmented Reality-based teaching materials are effective in improving student learning outcomes in science subjects.

These improvements in learning outcomes demonstrate that the use of Augmented Reality technology can help students grasp concepts previously difficult to grasp through conventional learning methods. The three-dimensional visualization of objects allows students to observe the material more realistically, making the learning process more meaningful. Furthermore, active student engagement during learning contributes to improved conceptual understanding, which impacts learning outcomes.

Discussion

The results of this study indicate that Augmented Reality-based teaching materials not only function as supporting learning media but also as a tool capable of increasing the effectiveness of the learning process. These findings align with constructivist learning theory, which emphasizes that knowledge is more easily understood when students gain direct and active learning experiences. Through the visualizations provided by Augmented Reality technology, students can connect abstract concepts with real-world representations, thereby deepening their understanding.

The findings of this study demonstrate that Augmented Reality (AR)-based teaching materials significantly contribute to improving students' understanding of science concepts and learning outcomes. The high validity score (Aiken's V = 0.87) indicates that the developed product is appropriate in terms of content, language, and media design, while the practicality score of 92.24% confirms that both teachers and students can easily utilize the teaching materials in classroom learning. These results are consistent with previous studies by Annie et al. (2024) and Riyanti et al. (2024), which reported that AR technology can enhance student engagement, motivation, and conceptual understanding through interactive three-dimensional visualization. In elementary science education, many concepts are abstract and difficult for students to comprehend through conventional textbooks alone. Therefore, the integration of AR technology provides concrete learning experiences that enable students to observe and interact with virtual objects directly, making learning more meaningful and enjoyable.

Furthermore, the effectiveness result indicated by the N-Gain score of 0.76 suggests that the developed teaching materials successfully improved students' learning achievement from a pretest average of 40.45 to a posttest average of 85.45.

This finding can be explained through constructivist learning theory, which emphasizes that knowledge is actively constructed through direct experiences and interactions with learning environments. AR technology supports this process by creating immersive and student-centered learning experiences, encouraging active participation, exploration, and deeper cognitive processing. The increase in learning outcomes also indicates that technology-based teaching materials can address the limitations of conventional instruction, particularly in presenting abstract science concepts. Consequently, the implementation of AR-based teaching materials can serve as an innovative alternative for improving the quality of science education in elementary schools and preparing students for learning in the digital era.

Overall, the research results indicate that the developed Augmented Reality-based teaching materials meet the criteria of validity, practicality, and effectiveness. Product validity is demonstrated by the results of expert assessments with a high category, practicality is demonstrated by positive responses from teachers and students with a very practical category, and effectiveness is demonstrated by the increase in student learning outcomes with a high category. These findings contribute to the development of innovative teaching materials that utilize digital technology to support science learning in elementary schools. In addition, the research results strengthen the view that the integration of Augmented Reality in teaching materials can be an alternative solution to improve the quality of learning and student learning outcomes in the digital era.

CONCLUSION

This study aims to develop Augmented Reality-based teaching materials for the fourth grade science subjects of SD Negeri 30 Lubuklinggau and test the level of validity, practicality, and effectiveness. The results of the study indicate that the developed teaching materials meet the criteria of valid, practical, and effective for use in learning. The validity of the product is indicated by the results of the assessment of language experts of 0.96, media experts of 0.83, and material experts of 0.82 with an average Aiken's V value of 0.87 which is included in the high category. The practicality of the teaching materials obtained a percentage of 92.24% with a very practical category based on teacher and student responses. Meanwhile, the effectiveness of the teaching materials is indicated by the N-Gain value of 0.76 which is in the high category, so it is proven to be able to improve student learning outcomes.

Based on these results, it can be concluded that the developed Augmented Reality-based teaching materials are suitable for use as an alternative innovative teaching material in science learning in elementary schools. The integration of

Augmented Reality technology can help students understand concepts more concretely, increase engagement in the learning process, and provide a more interactive and meaningful learning experience. The findings of this study contribute to the development of technology-based teaching materials that can support the improvement of learning quality and student learning outcomes in the digital era.

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