

# Development of Interactive Learning Media Assisted by Augmented Reality on Solar System Material to Enhance Elementary School Students' Learning Interest

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## ABSTRACT

Learning processes in elementary schools that are still dominated by conventional media, such as textbooks and two-dimensional images, tend to cause student boredom and low learning interest. Therefore, the development of Augmented Reality (AR)-based learning media is needed to present learning materials in a more interactive and contextual manner in order to enhance students' interest and learning experiences. This study aims to develop interactive learning media assisted by Augmented Reality on the Solar System topic for elementary school students and to examine the feasibility and effectiveness of the media in improving students' learning interest and learning outcomes. This research employed the ADDIE development model, consisting of Analyze, Design, Develop, Implement, and Evaluate stages. The effectiveness of the media was measured by comparing pretest and posttest results using the gain index analysis. The validation results show that the AR learning media Tata Surya is included in the very feasible category, with a score of 96% from media experts, 94% from material experts, and 96% from language experts. an increase in learning outcomes from 34.14 to 90.36, as well as an increase in learning interest from 42.68 to 86.79. The increase in learning outcomes is reinforced by an average N-gain value of 0.85 which is included in the high category. In addition, user responses are in the very good category, with teacher assessments of 93% and students of 90%. Based on these findings, it can be concluded that the interactive learning media assisted by Augmented Reality on the Solar System topic is highly feasible and effective in enhancing elementary school students' learning interest and learning outcomes.

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## 1. INTRODUCTION

One of the conceptual challenges in elementary school science learning is low student engagement and interest in abstract material, particularly in science. Topics like the Solar System require strong visualization skills and spatial understanding, while classroom learning still relies heavily on lectures

and textbooks. This leads to students being less actively engaged, easily bored, and struggling to develop a deep understanding of concepts.

This problem is reinforced by empirical evidence in the field based on observations and interviews conducted by researchers in April 2025 at a public elementary school in North Bogor District, Bogor City. Observations showed that of 28 sixth-grade students, science learning was still dominated by lecture methods with textbooks as the main source. A total of 22 students (78.6%) appeared passive, lacked focus, and showed signs of boredom during the learning process. This low participation was related to the minimal use of interactive learning media that directly involved students. However, around 8 students (28.6%) showed a more positive response when the teacher used simple visual media such as images and short videos. Students appeared more enthusiastic, actively asked questions, and understood the material more easily when assisted by visualization.

These findings indicate a gap between students' learning needs and the learning approaches used. Technology-based learning media capable of concretely visualizing abstract concepts, increasing engagement, and fostering student interest in learning are needed. One relevant solution is the use of Augmented Reality (AR) in science learning, particularly in the Solar System. AR allows the incorporation of three-dimensional virtual objects into the real world in real time, allowing students to observe and interact directly with models of planets, their orbits, and movements.

Theoretically, the use of AR aligns with multimedia learning theory and the cognitive theory of multimedia learning, which states that learning will be more effective when information is presented through an integrated combination of visual and verbal elements. 3D visualization in AR can reduce the abstractness of the material, lower cognitive load, and help students build more accurate mental representations. Furthermore, AR also supports experiential and contextual learning, as students are directly involved in the exploration process. The interactivity presented by AR has the potential to trigger situational interest, namely interest in learning that arises from interesting and meaningful learning stimuli.

Several previous studies have shown that AR media is effective for learning about the Solar System. Research by Sati, Kurniawan, and Herlambang (2024) showed that AR media can improve elementary school students' conceptual understanding and received very positive responses from both teachers and students. Research by Setyawan and Bata (2024) also reported that AR media based on Unity and Vuforia are suitable for use and effective in helping students understand space concepts. However, there is still limited research specifically documenting the process of developing AR media using the ADDIE model and examining its impact on student learning interest in the context of elementary school science learning, especially in public schools.

Based on the description of the problem, this research is directed to develop interactive learning media assisted by Augmented Reality (AR) on the Solar System material as an effort to present more concrete, interesting, and meaningful science learning for elementary school students. The development of this media is not only focused on the aspect of technological innovation, but also on fulfilling learning needs that are able to increase student involvement, interest, and conceptual understanding of abstract material. Therefore, this research comprehensively examines the feasibility level of AR learning media based on expert validation, changes in student learning interest after using the media, and improvements in student learning outcomes as measured by the N-gain value after the application of Augmented Reality-assisted learning media on the Solar System material.

Thus, this research is expected to provide theoretical and practical contributions in the development of innovative, contextual, and oriented science learning media to increase the learning interest of elementary school students. With these findings, it is clear that Augmented Reality media has great potential in supporting science learning in elementary schools. The use of this media not only increases interest and motivation to learn, but also bridges the gap between abstract concepts and reality that can be reached by students through direct visualization.

## 2. METHODS

This study uses the Research and Development (R&D) method, which aims to produce a product in the form of interactive learning media assisted by Augmented Reality (AR) and can overcome learning problems and test the effectiveness of the product (Sugiyono, 2019). The development model chosen is the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) because this model is systematic and flexible, so it can be adjusted to the needs in developing effective learning products. This development research design includes three main stages, namely: (1) product development and validation, (2) limited trials, and (3) field tests. In the media effectiveness testing stage, this study uses a pre-experimental design with a one-group pretest–posttest pattern, where students are given an initial test (pretest) before using the media and a final test (posttest) after using the media to determine changes in student learning outcomes and learning interests.

### 2.1 Research Procedure

The research procedure was carried out in stages according to the ADDIE model. The Analysis stage was conducted to identify learning needs, student characteristics, and problems faced in learning science on the Solar System. The Design stage included designing AR learning media, compiling storyboards, designing displays, and planning research instruments. The Development stage was carried out by developing AR learning media, which was then validated by material experts and media experts to determine the level of product feasibility. The Implementation stage included conducting limited trials and field tests, while the Evaluation stage was conducted to assess media feasibility, learning interests, and student learning outcomes and to make product improvements based on the evaluation results.



Figure 1 Research Procedure

### 2.2 Research Sampling and Sample Flow

The subjects of this study were 28 sixth-grade students (Phase C) at Neglasari Public Elementary School in Bogor City, selected using a purposive sampling technique. To test the effectiveness of the media, this study employed a pre-experimental design with a one-group pretest–posttest pattern. Students were given a pretest before using the media and a posttest after using the media to determine changes in learning outcomes and learning interest. The study involved two distinct sample groups, each with its own testing phase:

- a. A limited trial, involving 10 students to determine readability, ease of use, and initial responses to the AR learning media.
- b. A field trial, involving 28 students to test the feasibility of broader use of the media and to measure student learning interest and learning outcomes.

This research was conducted in accordance with ethical research principles. The researcher obtained official permission from the school and the consent of the students' parents/guardians prior to the study. All students were involved voluntarily, participant identities were kept confidential, and the data obtained was used solely for academic and research purposes.

### 2.3 Data Collection Techniques

The research instruments were adapted to the variables being studied, namely media suitability, learning interest, and student learning outcomes. The instruments used included:

- Observation: The instrument used for observation was a checklist containing assessment columns based on the Guttman scale.
- Interview: Interviews were conducted with teachers teaching at Phase C to obtain information about field problems, teachers' needs, and students' needs, in order to understand learning constraints and the need for developing Augmented Reality–assisted learning media.
- Validation sheet for material experts and media experts to assess the feasibility of AR learning media.
- Student learning interest questionnaire: compiled based on several dimensions of learning interest, including: (a) interest in learning, (b) attention and focus, (c) active involvement, and (d) feelings of enjoyment in learning. The questionnaire instrument is used as an assessment sheet with a checklist-type answer (√) using a 1 to 5 assessment scale.
- Test: The test instrument in this study was used to measure students' levels of understanding and skills related to the taught material. It was administered through a pretest before the use of learning media and a posttest after the use of the media.

### 2.4 Research Instruments

The research instruments consisted of expert validation instruments and response questionnaires, including validation by a media expert, a language expert, and a subject-matter expert, as well as questionnaires for teachers and students. The language expert validation instrument was used to assess the suitability of language use for elementary school students, grammatical accuracy, clarity of presentation, and compliance with spelling conventions. The media expert validation instrument evaluated visual quality, interactivity, ease of navigation, integration of Augmented Reality objects with learning content, as well as media accessibility and performance. The subject-matter expert validation instrument examined the alignment of content with the Merdeka Curriculum learning outcomes, conceptual accuracy, completeness, and relevance to students' developmental characteristics. In addition, teacher and student response questionnaires were used to identify the attractiveness, ease of use, and impact of the Augmented Reality media on learning motivation, activeness, and understanding. All research instruments underwent a validation process conducted by three validators, namely a media expert, a language expert, and a subject-matter expert. The validity of the test instruments was examined using the Pearson Product–Moment correlation, while reliability was measured using the KR-21 formula for dichotomous test items and Cronbach's Alpha for Likert-scale responses, with reliability coefficients above 0.80 indicating a high level of reliability.

**Table 1.** Language Expert Validation (Sari, L. P., 2024)

No.	Statement	1	2	3	4	5
1.	The language used is appropriate to the comprehension level of elementary school students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	The sentences are constructed using correct and appropriate grammatical structures.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	The material is free from grammatical errors that could interfere with understanding.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	The spelling used complies with the latest Indonesian Spelling Guidelines (PUEBI).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	The use of punctuation is accurate, consistent, and supports reading fluency.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	The language used is easy to read and understand for students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	The language delivery flows smoothly with a logical sequence and is not confusing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	The terminology used is consistent and easy for students to understand.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	The terms used are not confusing and are appropriate to the context of the	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

No.	Statement	1	2	3	4	5
10.	material. The language of the media emphasizes simplicity without reducing the meaning of the material.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Table 2.** Media Expert Validation (Rahmawati, N., 2024)

No.	Aspect	Statement	1	2	3	4	5
1	Visual Appearance	The media display is attractive and appropriate for the characteristics of elementary school students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		colors, fonts, and layout are used harmoniously, consistently, and are easy to read.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Interactive Design	The media allows active user interaction (clicking, object rotation, etc.).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Augmented Reality objects are easy to control and respond well to user actions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Navigation and Instructions	Navigation between pages or features is easy to understand and consistent.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Usage instructions are available and clear for beginner users (students).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Media and Content Integration	The displayed Augmented Reality objects are aligned with the learning content	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		Augmented Reality visualizations support the understanding of abstract concepts (e.g., the Solar System).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Format and Technology Access	The media format can be easily accessed through students' devices (smartphones/tablets/laptops).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		The media does not require high-end applications or specifications that may burden students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Performance and Stability	The media runs smoothly without technical disruptions or errors.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		The Augmented Reality application loads quickly and runs lightly during use.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Table 3.** Subject Matter Expert Validation (Putri, A. D., 2024)

No.	Statement	1	2	3	4	5
1.	The content aligns with the learning outcomes of the Merdeka Curriculum for the elementary school level.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	The content is relevant to the developmental stage and abilities of elementary school students.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	The material is organized based on correct scientific concepts and complies with academic standards.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	The content is free from misconceptions or conceptual errors.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	The language and presentation of the material are appropriate to the comprehension level of elementary school students (simple and clear).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	The material is structured with an appropriate level of depth and breadth, neither too complex nor too superficial.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	The content includes up-to-date information in accordance with developments in science and technology.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	The material can be effectively visualized through the use of Augmented Reality media.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	The learning material and AR display complement each other to facilitate understanding of abstract concepts.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.	The material is connected to examples and contexts from students' everyday lives.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Table 4.** Teacher and Student Response Questionnaire (Hidayar, R., 2021)

No.	Statement	1	2	3	4	5
1.	The Augmented Reality media I observed is interesting.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	The images or animations in the learning media help me understand the lesson.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	I become more active when learning using Augmented Reality media.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	I feel happy learning using Augmented Reality media.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	Learning becomes more interesting and less boring with Augmented Reality media.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	I am more curious when learning using Augmented Reality media.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	The Augmented Reality media is easy to use and not confusing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	This media makes me more motivated to study harder.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	I find it easier to remember the material after learning with Augmented Reality media.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.	The content in the learning media matches what I need to understand the lesson material.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Table 5.** Student Learning Interest Questionnaire (Hidayar, R., 2021)

No	Indicator	score				
		STS	TS	KS	S	SS
1	I feel more curious about the science material after using Augmented Reality					
2	The science material presented through Augmented Reality made me curious to learn more.					
3	Augmented Reality makes science lessons more engaging than traditional learning methods.					
4	I feel more enthusiastic about taking science lessons that involve Augmented Reality.					
5	Using Augmented Reality makes me want to study science more diligently.					
6	I don't feel bored when studying science using Augmented Reality.					
7	I pay full attention to the material presented through Augmented Reality.					
8	Augmented Reality helps me focus more on the science material being taught.					
9	I find it easier to understand the science material with Augmented Reality.					
10	I actively try and interact directly with the material using Augmented Reality.					
11	Augmented Reality makes me more involved in science learning.					
12	I feel fully engaged in the learning process when using Augmented Reality.					
13	I am satisfied with the use of Augmented Reality in science learning.					
14	I hope Augmented Reality in science learning can continue to be used in the future.					
15	Augmented Reality makes science learning a more enjoyable experience.					
<b>Score</b>						
<b>Total Score</b>						

All research instruments have undergone a validation process conducted by three validators, namely a media expert, a language expert, and a subject-matter expert.

- a. The test validity was examined using the Pearson Product-Moment correlation.
- b. Reliability testing was measured using the KR-21 formula for dichotomous test items and Cronbach's Alpha for Likert-scale responses. An index value above 0.80 indicates a high level of reliability.

**Table 6.** Summary of Instrument Reliability

Type of Instrument	Validity Test	Reliability Test	Criteria
Test Items	Valid	KR-21 = 0.986	High
Student Questionnaire	Valid	$\alpha = 0.83$	Very reliable
Teacher Questionnaire	Valid	$\alpha = 0.86$	Very reliable

## 2.5 Data Analysis Techniques

Both qualitative and quantitative approaches are employed in this research:

- a. Qualitative: Qualitative data were obtained from written interview results, as well as critiques and suggestions provided by subject-matter experts, media experts, and language experts.
- b. Quantitative:
  - 1) Expert validation scores were calculated using the Content Validity Ratio (CVR) based on Lawshe's formula, as follows:

$$CVR = \frac{ne - N/2}{N/2}$$

Notes :

ne = number of experts who agree that an item is relevant

N = total number of experts who evaluated the item

Interpretasi CVR :

Jika CVR  $\geq 0.99$ , the item is very valid

Jika CVR  $\geq 0.67$ , the item is valid

Jika CVR  $< 0.67$ , the item requires revision

- 2) Student response questionnaire results were analyzed using the following formula:

$$P = \frac{f}{N} \times 100$$

Notes:

P = percentage score of questionnaire data,

f = total score obtained

N = maximum possible score

- 3) Improvement in learning outcomes was analyzed using the N-Gain method, with the following categories: high ( $> 0.70$ ), medium ( $0.30-0.70$ ), and low ( $< 0.30$ ).

## 3. FINDINGS AND DISCUSSION

### 3.1 Findings

The results of this study are presented systematically based on the stages of the ADDIE model, which include analysis, design, development, implementation, and evaluation. Each stage is described to illustrate the process of developing the learning media in a coherent and comprehensive manner. The data presentation is supported by visualizations in the form of tables and graphs to clarify the research findings, facilitate data interpretation, and strengthen the analysis of the results obtained.

#### 3.1.1 Analysis

A preliminary investigation at SD Kesatuan Bogor showed that while most students demonstrated an interest in reading, only half of them practiced reading in a responsible manner. In addition, the majority of students expressed strong enthusiasm for educational games; however, such learning media had not yet been implemented by the school. Classroom observations revealed that instruction was still dominated by the use of textbooks and presentation slides, which resulted in students experiencing difficulties in comprehension, particularly in identifying main ideas from texts. These findings were reinforced by interviews with teachers and students, indicating that existing literacy activities had not been optimally effective. Therefore, these conditions emphasize the urgent need for interactive, game-based learning media to enhance students' reading comprehension skills.

**Table 7.** Results of the Preliminary Study Findings (Source: processed by the researcher)


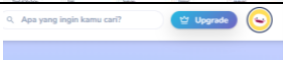

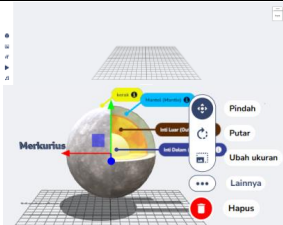
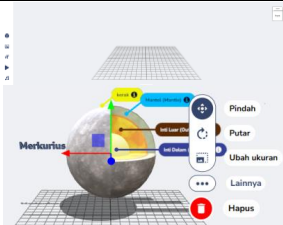
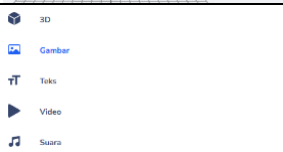

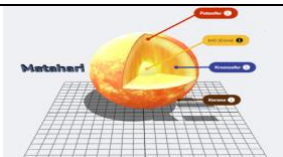

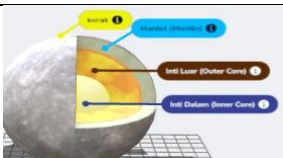
No	Aspect	Findings	Conclusion
1.	Literature Review	The use of Augmented Reality (AR) technology in science learning, particularly for the Solar System topic, is theoretically and empirically supported as an effective medium for presenting abstract concepts through interactive 3D visualizations, aligned with the curriculum, and with strong potential to enhance elementary school students' learning interest.	The use of Augmented Reality (AR)-based learning media for the Solar System topic is highly needed because it can
2.	Field Study	The findings show that 80% of students stated that they need Augmented Reality (AR)-based learning media for the Solar System material, while 20% stated that they do not. These results confirm that the majority of students view AR media as an important and innovative learning tool that helps visualize abstract Solar System concepts more clearly and makes them easier to understand.	visualize abstract concepts in a concrete and interactive manner, overcome the limitations of conventional media, and has been proven to enhance elementary school students' learning interest, conceptual understanding, and engagement.
3.	Classroom Observation	Observational results indicate that students experience difficulties in understanding the shapes, order, and characteristics of planets due to limited visual media, causing their understanding to remain largely memorization-based. This condition highlights the need for Augmented Reality (AR)-based learning media to support more concrete and conceptual visualization of the Solar System material.	
4.	Interviews	Based on interviews with three teachers and ten sixth-grade students at SD Negeri Neglasari, an urgent need was identified for Augmented Reality (AR)-based learning media to increase students' interest and engagement in learning the Solar System topic, particularly because conventional teaching methods were considered less effective in capturing students' attention.	

Theoretically and empirically, the use of Augmented Reality (AR)-based learning media for the Solar System topic is considered effective because it can present abstract concepts through interactive 3D visualizations that are aligned with the curriculum and support the enhancement of students' learning interest. From the learners' perspective, the majority of students (80%) stated that they need AR media because it helps them understand the material more concretely, while a small proportion (20%) have not yet perceived such a need. Based on observation results, the limitations of visual media have caused students' understanding to remain largely memorization-based, particularly in comprehending the shapes, order, and characteristics of planets. Meanwhile, from the educators' perspective, interview findings indicate that both teachers and students need AR media as a solution to increase engagement, attention, and learning interest, given that conventional teaching methods are considered less effective in delivering Solar System material.

### 3.1.2 Design

After conducting a needs analysis through a preliminary study, the next stage was the design and development of the product. The product designed was an Augmented Reality (AR)-based learning medium on the Solar System topic. The design stage began with formulating the research objectives, followed by an analysis of Learning Outcomes (CP), Learning Objectives (TP), and the Learning Objectives Flow (ATP). Subsequently, topic identification and content analysis of the Solar System material to be presented in the AR media were carried out. The design process was also supported by discussions or Focus Group Discussions (FGDs) with lecturers, teachers, and students, which served as the basis for developing the product design to ensure its alignment with learning needs and student characteristics.

**Table 8.** Storyboard of Interactive Learning Media Assisted by Augmented Reality on the Solar System Topic

No	Design	Description
1		Open the website <a href="https://edu.assemblrworld.com">https://edu.assemblrworld.com</a> using a web browser on a computer or laptop connected to the internet. Make sure the internet connection is stable so the creation process runs smoothly.
2		If you already have an Assemblr EDU account, click the Login button and enter your email address and password. If you do not yet have an account, click Sign Up to create a new account by filling in the required information (name, email, and password).
3		After successfully logging in to the main page, click the "Create Project" or "Create AR Project" menu. A dialog box (workspace) will appear, which serves as the development area for the Augmented Reality media. In this workspace, users can add various visual elements such as text, images, 3D models, or other interactive objects.
4		Use the Add Object menu, then select 3D Model.
5		Type keywords such as "planet," "sun," or "solar system" in the search field to display a collection of relevant 3D models.
6		Select the appropriate object and place it in the workspace. Users can adjust the size, position, and rotation of the object to make the display more proportional.
7		Click the Text menu to add descriptions or information about each planet, such as the planet's name, distance from the sun, rotation period, or other unique characteristics. Adjust the text color, font size, and position to ensure readability.
8		Set general information that includes learning objectives and learning outcomes as references for students during the learning process.
9		Design the learning media interface to display the names of the planets, information on their characteristics and structural components, and add other relevant supporting data or facts to enrich students' understanding of the solar system material.
10		Each planet's name is displayed using a large and clear font so that it is easy for students to read. Information about planetary characteristics and structural components is presented concisely yet informatively to facilitate understanding.

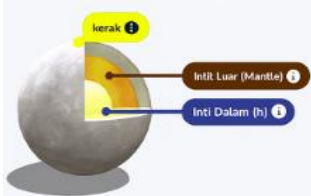
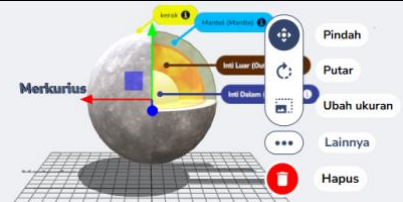
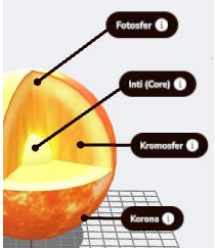
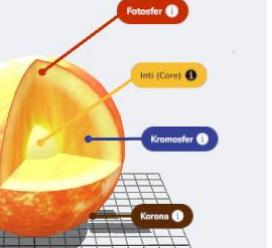
Thematically, the sequence in the storyboard begins with an introduction to the Solar System, followed by an exploration of the eight planets in order, starting from Mercury to Neptune. Each planet is accompanied by a brief description of its size, color, distance from the Sun, and distinctive characteristics. Next, the storyboard presents a planet comparison session, where students can observe the differences between inner planets and outer planets. The final stage focuses on creative activities, such as assembling a miniature Solar System or answering interactive quizzes as a form of evaluating conceptual understanding.

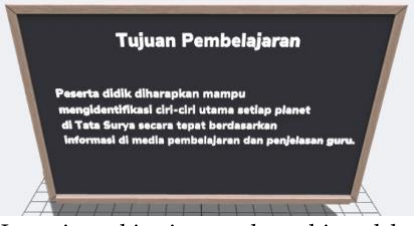


### 3.1.3 Development

The development stage was carried out in a structured manner by considering pedagogical aspects, technical elements, and the psychological characteristics of learners. This approach aimed to produce learning media that are not only visually appealing but also capable of enhancing students' learning interest and conceptual understanding of the Solar System material. To ensure product quality, a validation process was conducted by media experts to obtain constructive feedback, suggestions, and critiques as a basis for refining the Augmented Reality (AR)-assisted Solar System learning media so that it would be more feasible and effective for use in elementary school learning. The results of the media expert validation showed an improvement in the assessment score from 54 in the first stage to 58 in the second stage out of a maximum score of 60. When converted into percentages, the media feasibility score increased from 90% in the first stage to 96% in the second stage, indicating that the media falls into the "very feasible" category for use.

The results of the language expert validation indicated that the media obtained a score of 36 out of 50, or 72%, which falls into the feasible category. After revisions were made according to the validator's feedback, the language validation score in the second stage increased to 47 out of 50, or 94%, thus categorizing it as very feasible for use in learning. This improvement was particularly evident in aspects of grammar and punctuation, which were the main focus of revision. Meanwhile, the results of the material expert validation in the first stage showed a score of 32 out of 50, or 64%, categorized as fairly feasible. The validator provided several suggestions, particularly related to alignment with the Merdeka Curriculum, the depth of discussion of the Solar System material, and the integration between learning content and the Augmented Reality display. Based on this feedback, the researcher refined the media. As a result, in the second stage, the validation score increased significantly to 48 out of 50, or 96%, which falls into the very feasible category for use in the learning process. The following are the comments, suggestions, and complete validation results provided by the experts:

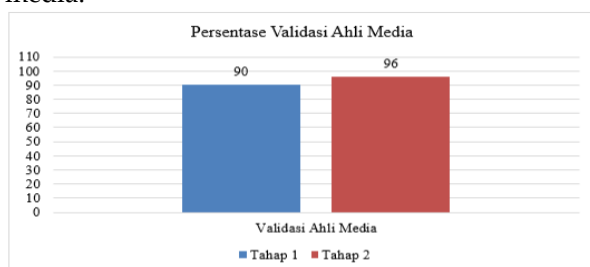
**Table 9.** Development of Augmented Reality Learning Media

Before Revision	After Revision
 <p>The initial display of the application appeared simple, presenting only limited information, which made it less engaging and informative.</p>	 <p>The initial interface was improved to become more attractive and informative, equipped with a simpler menu layout so that users can easily understand the flow of media usage.</p>
 <p>The color scheme used for displaying planetary information tended to be monotonous.</p>	 <p>Several planetary information icons were rearranged with more contrasting sizes and colors.</p>

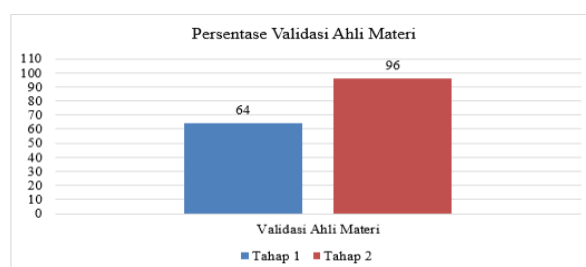
Before Revision	After Revision
<p>Clear learning objectives were not yet included in the AR media.</p>	 <p>Learning objectives to be achieved have now been clearly included in the AR media.</p>
 <p>There were no systematic and clear usage instructions, so users did not receive complete guidance on how to scan markers, access 3D objects, or explore each planet.</p>	 <p>Systematic and clear usage instructions were added, including how to scan markers, access 3D objects, and the steps for exploring each planet.</p>

### 3.1.4 Implementation

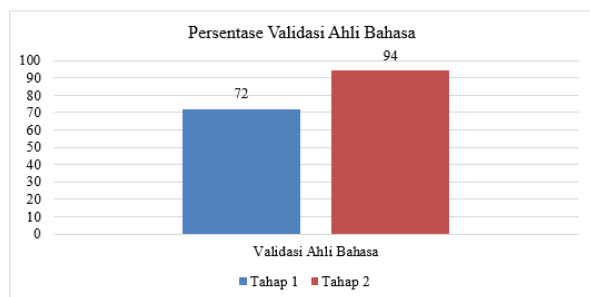
After the development of the instructional media was completed, the next stage was the validation process conducted by three experts: a media expert, a subject matter expert, and a language expert. This validation aimed to ensure that the Augmented Reality (AR)-based instructional media developed met appropriate quality standards and was effective for use in IPAS learning at the elementary school level. The validation process involved evaluating the material, media, and language aspects to assess the product’s academic and practical acceptability. Based on the validation results, the instructional media was deemed suitable for use with several minor revision suggestions, such as improving navigation and enhancing interactivity. The experts’ evaluations were further strengthened through Content Validity Ratio (CVR) analysis to quantitatively confirm the level of content validity of the instructional media.



(Sumber : data diolah)



(Sumber : data diolah)

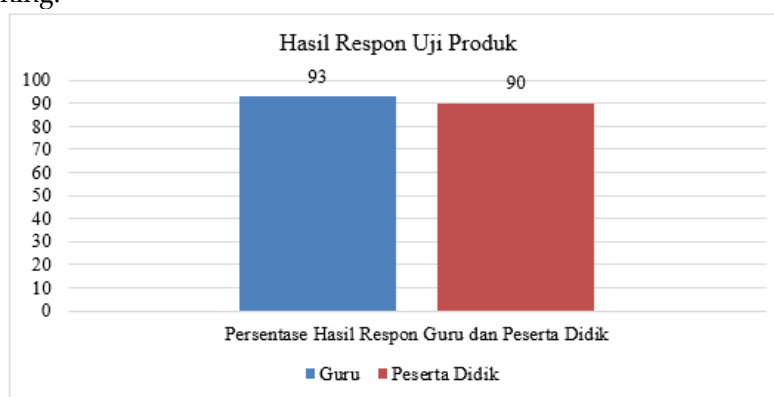


(Sumber : data diolah)

**Figure 1.** Graph of Media, Content, and Language Expert Validation Results  
(Source: processed by researchers)

Augmented Reality (AR)-based learning media showed significant quality improvement based on expert validation results. The media feasibility assessment used a 1–5 scale rubric with the following categories and cut-off values: 81–100% = Very Feasible, 61–80% = Feasible, 41–60% = Fairly Feasible, 21–40% = Less Feasible, and  $\leq 20\%$  = Not Feasible. In the first stage, media expert validation obtained a value of 90% and increased to 96% in the second stage, which indicates that the media has optimally met almost all feasibility criteria, including aspects of visual design, interactivity, ease of access, and application performance stability. This value is in the “Very Feasible” category, so the media is declared ready to be used in learning without requiring significant further revisions. Language validation also improved, from a score of 36 out of 50 (72%) in the first stage to 47 out of 50 (94%) in the second stage, with the most prominent improvements in grammar and punctuation. Meanwhile, the validation by material experts in the initial stage obtained a score of 32 out of 50 (64%) with the category of “Quite Adequate”, but after revisions based on expert input, the score increased to 48 out of 50 (96%) and entered the category of “Very Adequate”. Overall, the final validation results showed that all aspects experienced significant improvements after refinement, with final scores of 96% from material experts, 96% from media experts, and 94% from language experts, respectively. These three results indicate that Augmented Reality-based learning media has met the eligibility criteria and is suitable for use in the learning process in elementary schools.

After the validation stage was completed, a limited trial was conducted involving one Grade VI teacher and ten Grade VI students at SD Negeri Neglasari. This trial was carried out in the school environment under the direct supervision of the IPAS subject teacher. The evaluation was conducted using a teacher response questionnaire covering six main aspects: visual appearance, interactive design, navigation consistency, integration of media with learning content, suitability of technological format, and media stability and performance. Each statement was rated using a Likert scale of 1–5, where a score of 1 indicated “very poor” and a score of 5 indicated “very good.” The trial results showed that the teacher’s response to the Augmented Reality-based learning media reached a score of 93%, which falls into the “Very Feasible” category. The teacher assessed that the media had an attractive visual appearance, was easy to operate, and was effective in helping explain abstract concepts such as the Solar System. Meanwhile, student responses achieved a score of 90%, categorized as “Very Good.” The students stated that learning using AR media was more engaging than conventional methods, helped them understand the material more concretely, and increased their interest, motivation, and curiosity toward IPAS learning.



(Sumber : data diolah)

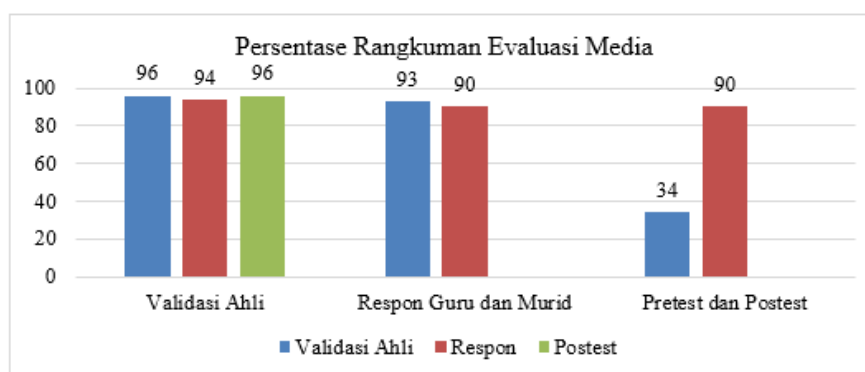
**Figure 2.** Graph of Product Trial Response Results (Source: processed by researchers)

### 3.1.5 Evaluation

The evaluation results showed that the teacher response to the AR learning media received a final score of 93%, categorized as “Very Appropriate,” while the student response reached 90%, categorized as “Very Good.” These scores indicate that the AR-based learning media developed met the eligibility criteria in terms of content, appearance, ease of use, and relevance of the material. Teachers assessed that this media was very helpful in explaining abstract concepts about the Solar System concretely

through three-dimensional visualizations, making it easier for students to understand. Meanwhile, students felt more enthusiastic, active, and motivated to learn science because this media provided an interactive and enjoyable learning experience.

The following "Media Evaluation Summary Percentage" graph displays the overall results of the evaluation phase of the development of Augmented Reality (AR) learning media for the Solar System topic for sixth-grade students at Neglasari Public Elementary School. This graph summarizes three main components of the assessment: expert validation results (material, media, and language), teacher and student responses, and learning effectiveness results through a comparison of pretest and posttest scores.



(Sumber : data diolah)

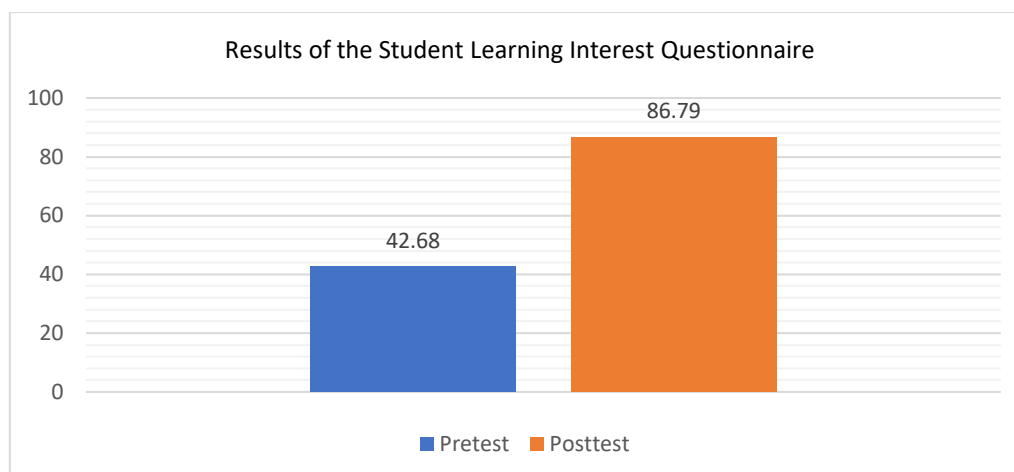
**Figure 3.** Graph of Product Evaluation Results (Source: processed by researchers)

Overall, the results of the three evaluation aspects show that the Solar System Augmented Reality learning media is not only academically and technologically feasible, but also effective in increasing student engagement and learning outcomes. Therefore, this media can be used as an innovative alternative in science learning at the elementary school level, especially in topics that require visualization of abstract concepts such as the Solar System.

### 3.1.6 Students' Interest In Learning

Based on the results of the pretest questionnaire, the average value of students' learning interest was 42.68, with the lowest value being 30 and the highest value being 65, with a standard deviation (SD) of 9.54. This value indicates that students' learning interest before using AR media was in the moderate category, with a fairly large level of data distribution, which indicates that students' learning interest still varies. After using Augmented Reality-based learning media, the results of the posttest questionnaire showed an increase in students' learning interest. The average value of learning interest increased to 86.79, with the lowest value being 75 and the highest value being 98. Based on the category grouping, 18 students (64.3%) were in the very high category, while 10 students (35.7%) were in the high category, with a standard deviation (SD) of 5.87. The decrease in the standard deviation value in the posttest indicates that students' learning interest became more even and consistent after participating in learning using AR media.

Increased interest in learning was evident across all measured aspects. Interest increased because students perceived AR media as providing a new and engaging learning experience through three-dimensional visualizations of the Solar System. Attention improved because students were more focused and less distracted during the learning process. Active engagement increased, as students were more willing to experiment with the media, ask questions, and participate in discussions. Meanwhile, feelings of enjoyment also increased, as evidenced by positive responses from students who felt learning was more enjoyable and less boring.

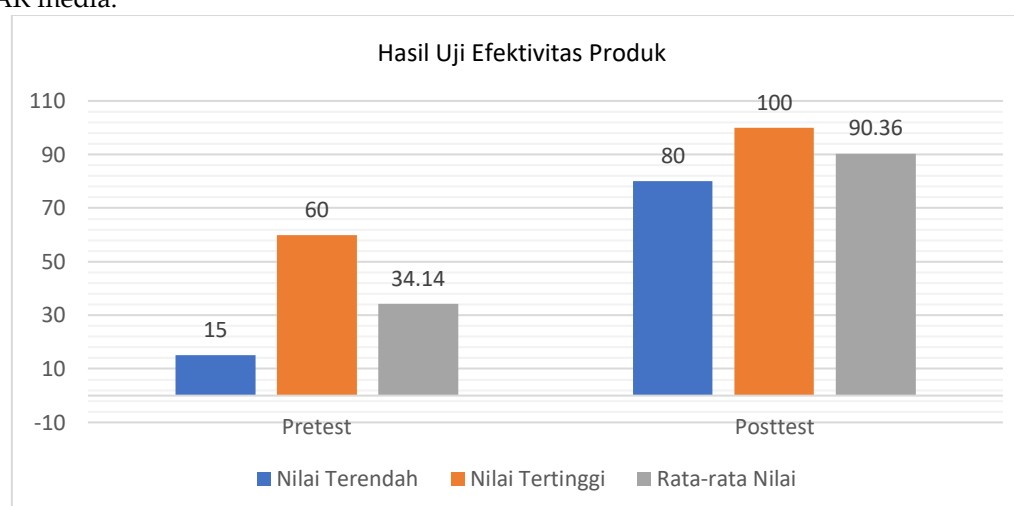


**Figure 4.** Graph of Student Learning Interest Questionnaire Results (Source: processed by researchers)

Overall, a comparison of the pretest and posttest questionnaire results shows a clear increase in student learning interest, both in terms of average scores and data homogeneity. These findings indicate that the use of Augmented Reality-based learning media can increase student interest, attention, and overall engagement in science learning on the Solar System topic.

### 3.1.7 Test Results

The evaluation began with a test of the effectiveness of Augmented Reality (AR)-based learning media by administering a pretest and posttest to 28 sixth-grade students of Neglasari State Elementary School. The mean value of learning outcomes before the use of Augmented Reality media (pretest) was 34.14, with a median value of 35, a standard deviation of 13.15, a lowest value of 15, and a highest value of 65. The large standard deviation indicates that the level of student learning interest before learning was still varied and tended to be low. After the use of Augmented Reality-based learning media, the mean value of student learning outcomes (posttest) increased to 90.36, with a median of 90, a standard deviation of 6.23, a lowest value of 80, and a highest value of 100. The smaller standard deviation in the posttest indicates that student learning interest became more even and stable after the application of AR media. The increase in learning outcomes was reinforced by an average N-gain value of 0.85 which was included in the high category, indicating a significant increase in learning understanding after using AR media.



**Figure 5.** Graph of Student Test Results (Source: processed by researchers)

These findings indicate that three-dimensional visualization and interactivity presented through AR can help students understand abstract concepts of the Solar System, such as planetary movement, relative size, and interplanetary positions, more concretely. Observations also show that students

become more active, enthusiastic, and have a high level of curiosity during learning, while teachers assess that AR media facilitates material delivery and increases student engagement in the learning process.

### 3.2 Discussion

The expert validation results reaching 96% (Very Feasible category) indicate that the Augmented Reality (AR)-based learning media has met the standards of feasibility of content, appearance, interactivity, and ease of use. The success of this media can be explained theoretically through three-dimensional (3D) visualization presented in AR. 3D visualization is able to reduce the level of abstraction of Solar System concepts, such as the relative size of planets, orbital movements, and interplanetary positions, thereby helping students build more accurate mental representations. This finding is in line with multimedia learning theory which states that the simultaneous integration of visual and verbal elements can improve conceptual understanding and reduce students' cognitive load (Cheng & Tsai, 2013). Furthermore, the interactivity aspect of AR media plays a crucial role in fostering situational interest, which is the learning interest that arises from engaging and contextual learning stimuli. Students' direct interaction with virtual objects, such as rotating, zooming, and observing planets in real-time, makes learning more challenging and enjoyable. This is reflected in the results of teacher and student responses, which reached an average of 91.5%, indicating a very high level of media acceptance. This finding aligns with the views of Ibáñez (2018) and Azuma (2017) that interactive learning not only involves students interacting with the material but also encourages social interaction through discussions and questions and answers, which ultimately increase students' cognitive and affective engagement.

The effectiveness of AR media is also reflected in the improvement in learning outcomes, as indicated by an increase in the average score from 34% in the pretest to 90% in the posttest. This improvement indicates a significant change in the understanding of science concepts after the use of AR media. Theoretically, these results can be explained through experiential and contextual learning, where students do not merely receive information passively but are actively involved in the exploration process. This finding aligns with Nugroho et al. (2022) who stated that the use of digital technology can strengthen students' cognitive and emotional engagement. However, this study expands on these findings by emphasizing that learning interest is an important mechanism bridging technology use with improved learning outcomes. Compared to previous studies, such as Hidayat (2024), Maziyah and Zumrotun (2025), and Yulia et al. (2024), this study not only shows that AR media is feasible and interesting to use, but also provides specific contributions in the form of systematic documentation of the media development process using the ADDIE model, the media's suitability to the elementary school science curriculum, and an explicit focus on student learning interests as the main variable. Thus, AR in this study is not only positioned as a visualization tool, but as a pedagogical strategy to foster motivation and learning engagement in abstract material.

However, this study has several limitations. The sample size was relatively small and only involved one school, so the generalizability of the results is limited. The short duration of the intervention allowed for the emergence of a novelty effect, where increased learning interest is influenced by initial interest in new technology. Furthermore, this study did not use a control group, so learning outcomes cannot be directly compared with conventional learning. The possibility of test-practice effects on the pretest and posttest administration also needs to be considered.

Based on these findings, this study has several practical implications. Science teachers can integrate AR media as material reinforcement, both during the concept exploration stage and the closing stage of the lesson. To maintain effectiveness, teachers need to organize classroom management well, for example by using AR alternately, dividing exploration tasks, and conducting directed discussions. Furthermore, the AR media developed in this study has the potential to be expanded to other abstract science materials, such as the respiratory system, ecosystems, or energy transformations, thus supporting more interactive and meaningful learning in elementary schools.

#### 4. CONCLUSION

Based on the research results and discussion, it can be concluded that Augmented Reality (AR)-assisted learning media on the Solar System material has been successfully developed systematically through the ADDIE model and is able to meet the needs of science learning in elementary schools. The resulting media is considered very suitable for use because it has fulfilled the aspects of material feasibility, display, language, and media function in accordance with learning standards. The use of AR media has been proven to be able to improve students' conceptual understanding and learning interest, especially in visualizing the abstract concept of the Solar System to be more concrete and interactive. In addition, the responses of teachers and students showed very positive acceptance, where the media was considered interesting, easy to use, and supports the creation of more active and meaningful learning. Thus, the AR learning media of the Solar System is suitable and recommended for use in science learning in elementary schools. However, this study has several limitations, including a relatively limited sample size and the study was only conducted in one school, so the results cannot be generalized widely. In addition, the relatively short duration of media implementation does not allow for measuring students' long-term learning retention. Based on these limitations, several directions for further research are suggested, namely: (1) involving a larger sample size with diverse student characteristics and conducted in different schools or regions; (2) using a control group or quasi-experimental design to obtain a stronger comparison regarding the effectiveness of AR media; and (3) examining students' long-term learning retention and developing the application of AR media to other abstract science and science materials.

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