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Interactive Media Development Using Augmented Reality Applications to Improve Student Learning Outcomes in Mathematics Learning in Grade V Elementary School

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A B S T R A C T

This study aims to develop and test the feasibility of interactive media based on Augmented Reality (AR) in Mathematics learning on spatial geometry material in fifth grade elementary schools. The development of this media uses a 4D development model consisting of four stages, namely Define, Design, Develop, and Disseminate. In the Define stage, a needs analysis is conducted through observation and interviews with teachers to identify obstacles in Mathematics learning. The Design stage includes designing the AR media display and compiling spatial geometry materials according to student characteristics. The Develop stage includes the creation and validation of the media by material experts, language experts, and media experts, which resulted in validation scores of 96.42%, 93.75%, and 95.83%, respectively, with a very valid category. The Disseminate stage was conducted through trials at SDN 10 Koto Tinggi Surian and SDN 08 Tambang Surian to measure the practicality and effectiveness of the media. The results of the practicality test showed a student response of 91.67% and a teacher response of 94.15%, with a very practical category. Meanwhile, the results of the effectiveness test using the N-Gain Score analysis showed a significant improvement in student learning outcomes, with an average score of 0.74 at SDN 10 Koto Tinggi Surian and 0.71 at SDN 08 Tambang Surian, which are in the high category. Thus, the AR-based interactive media developed using the 4D model has proven valid, practical, and effective in improving understanding of spatial concepts and supporting the implementation of the Independent Curriculum.

1. Introduction

Effective learning should involve visual and manipulative experiences so students can directly observe and compare geometric shapes. Material on geometric shapes

requires visual and interactive media to help students understand the characteristics and differences between shapes. This demonstrates the importance of using learning media that supports visualization in the learning process (Sucahyo et al., 2024).

Along with the development of technology, interactive-based learning media has begun to be introduced to overcome the limitations of conventional media. According to Adam et al., (2024) Interactive media is media that allows for two-way communication between users and learning materials, so that students are not merely passive recipients of information but also actively interact with the material being studied. This is also in line with Hakim & Windayana, (2016) stated that the use of interactive media in learning can significantly increase student attention and involvement compared to conventional learning methods.

One technology that offers an interactive experience is Augmented Reality (AR). AR is a technology that combines virtual elements into the real world in real time through devices such as smartphones or tablets (Rahman et al., 2024). In the world of education, AR has great potential to revolutionize the way students learn by creating more lively and engaging learning experiences. According to Masruroh et al., (2023) The use of AR in mathematics learning can improve conceptual understanding, accelerate the learning process, and significantly increase student motivation and engagement. Using AR, students can see and interact directly with realistic three-dimensional models of geometric shapes in their surroundings.

The integration of Augmented Reality in learning Mathematics on spatial structures offers various benefits. Students not only see static images but can interact directly with three-dimensional objects that can be rotated, enlarged, and explored from various angles (Sari et al., 2022). This is also in line with Qorimah & Sutama, (2022) Research shows that the use of AR in learning improves students' cognitive abilities, a crucial skill for understanding spatial concepts. Furthermore, AR provides a more personalized and adaptive learning experience, allowing students to learn at their own pace and at their own pace. The use of AR in mathematics learning also encourages the development of students' digital competencies, in line with the demands of today's changing times Rabi'ah, (2023), the application of technology such as AR in education can prepare students to face future challenges that are increasingly based on technology and innovation.

Based on the results of interviews conducted on April 15 and 16, 2025 with fifth-grade teachers at SDN 10 Koto Tinggi Surian and SDN 08 Tambang Surian, information was obtained that so far mathematics learning is still carried out conventionally and has not utilized modern technology such as Augmented Reality (AR)-based media. Teachers said that limited knowledge and skills in using digital media are one of the main reasons why learning still relies on conventional methods and media. Teachers also admitted that the media used is still very limited and lacks variety, so far, teachers have relied on commonly used aids such as rulers and plastic geometric models so that they have not been able to support students' understanding optimally, especially in geometric materials that require strong visual understanding. This condition has an impact on low student learning outcomes.

2. Methodology

The type of research used in this study is research and development. According to Borg and Gall, development research aims to develop and validate educational products. Meanwhile, Nurna (2022) explains that development research functions to produce and refine a product or learning media. Unlike research that focuses on testing theories, development research starts from real-world problems in classroom learning, which require new innovations in the form of software or hardware as alternative solutions. In this study, the author developed interactive learning media using Augmented Reality technology to support mathematics learning in fifth grade elementary schools. The development model used is the 4D model (Four-D Models). This model includes four main stages, namely: (1) Define (defining material and concept needs); (2) Design (designing product design); (3) Develop (product development until it is suitable for use); and (4) Disseminate (disseminating the product to a wider user base).

At the define stage,This study was conducted by observing the problems of mathematics learning in elementary schools, especially in the material of spatial shapes in grade V of SDN 10 Koto Tinggi Surian and SDN 08 Tambang Surian. The results of the observation showed that teachers still predominantly use static images in textbooks or videos from the internet to explain the shape of the solid. These media have not fully helped students understand the properties of solid shapes, because they only display two-dimensional shapes without providing a real visual experience. In the design stage, the researcher developed interactive media based on Augmented Reality (AR) applications as a supporting tool for learning mathematics in grade V, especially in the material of solid shapes. This media is designed to help teachers convey abstract mathematical concepts more concretely through interactive three-dimensional visualizations. During the development stage, the designed interactive Augmented Reality-based media will undergo a validation process by experts consisting of media experts, content experts, and language experts.

This validation process aims to assess the feasibility, accuracy, and suitability of the developed media for the needs of fifth-grade elementary school mathematics learning. The dissemination phase of this research aimed to introduce and implement the developed interactive Augmented Reality (AR) media in elementary schools. Dissemination took place at SDN 08 Tambang Surian and SDN 10 Koto Tinggi Surian, involving teachers and fifth-grade students as trial subjects. AR media developed This is done with the aim of providing an explanation of the test data so that it can be understood. Data analysis is used to revise the product that has been developed.. Media experts are responsible for assessing the accuracy and suitability of the appearance and use of media in teaching materials so that they are in accordance with the applicable curriculum as seen in table 1.

Table 1. Media expert instruments

No	Assessment Items	Question
1.	The use of AR in the accuracy of font selection	1
2.	The use of AR in the accuracy of letter colors	2
3.	The display quality of AR images is very attractive	3
4.	AR usage is flexible (can be used independently and with guidance)	4
5.	Completeness of interactive features	5
6.	Ease of use of interactive buttons	6
7.	Interactive AR product packaging display	7

Source:(Ummi & Erita, 2021)

Material experts have the responsibility to assess the accuracy and suitability of the content of teaching materials with the curriculum used, as detailed in table 2.

Table 2. Material expert instruments

No	Assessment Items	Question
1.	The truth of the material of geometric shapes	1
2.	Clarity of material on spatial structures	2
3.	Flat shape material is easy to understand	3
4.	The material contained in AR Interactive Media refers to the Merdeka curriculum	4
5.	Level of material importance	5
6.	Adapting to developments in science and technology	6
7.	Usefulness of the material	7

Source:(Ummi & Erita, 2021)

Linguists assess the readability, clarity, and appropriateness of language use in teaching materials to ensure they are easily understood by students. As detailed in Table 3.

Table 3. Language expert instruments

No	Assessment Items	Question
1.	The shape and size of the letters used using AR are easy to read	1
2.	The description of the information conveyed in AR Interactive Media is easy for students to understand.	2
3.	AR Interactive Media uses simple sentences	3
4	Interactive Media using AR is easy to understand	4
5.	AR interactive media uses good and correct Indonesian language rules or in accordance with EBI	5
6.	Sentences used are appropriate to the students' ability level.	6

Source: Modified from(Ummi & Erita, 2021)

If any aspects of the validation phase are found to be inconsistent, the media is revised based on the suggestions and input provided by experts. This revision is a crucial step in ensuring that interactive Augmented Reality media is more effective, engaging, and meets the needs of fifth-grade students in understanding spatial geometry. Data collection on teacher and student responses to the practicality of

Augmented Reality-based interactive media was conducted using a practicality questionnaire. Teachers completed the questionnaire based on their observations during the learning process, while students completed the questionnaire after the learning activity was completed, as shown in Table 4.

Table 4. Teacher responses

No	Assessment Items	Question
1.	The relevance of spatial geometry material to AR interactive media	1
2.	The language used in delivering AR material is very relevant.	2
3.	Text in AR is easy to understand	3
4.	AR images and illustrations	4
7.	AR color composition	5
8.	Ease of operation	6
10.	Interest in interactive media	7
11.	Uses in learning	8

Source :(Ummi & Erita, 2021)

A limited-scale trial was conducted at SDN 08 Tambang Surian and SDN 10 Koto Tinggi Surian for fifth-grade students to obtain an overview of the practicality of using the Augmented Reality application as a Mathematics learning medium. This can be seen in Table 5.

Table 5. Student response questionnaire

No	Indicator	Question
1	Display of learning media	1
2	Language in learning media	2
3	Use of writing, colors and images in learning media	3
4	Instruction Which clear on instructional Media	4
5	Interest in using media	5
6	Help understand reading and communicating using media	6
7	Activeness in the learning process	**7**

Source :(Ummi & Erita, 2021)

The effectiveness test was conducted through a pre-test and a post-test. The pre-test was administered before students used the AR media, while the post-test was administered after the AR learning process was completed. The results of both tests were then analyzed using the N-Gain Score formula to determine improvements in student learning outcomes.

3. Results and Conclusion

Validation Test Results

a. Media Expert Validity Test Analysis

The media validity test data was obtained from a lecturer at Adzkia University's Information Systems department. The validation process was conducted on August 8, 2025.from the validator are presented in the following table 6.

Table 6. Media Validity Test

No	Assessment Items	Evaluation
1.	The use of AR in the accuracy of font selection	4
2.	The use of AR in the accuracy of letter colors	4
3.	The display quality of AR images is very attractive	3
4.	AR usage is flexible (can be used independently and with guidance)	3
5.	Completeness of interactive features	3
6.	Ease of use of interactive buttons	4
7.	Interactive AR product packaging display	4
	Score obtained	25

b. Analysis of Language Expert Validity Test

Validity test data were obtained from Indonesian Language Education lecturers at Muhammadiyah University of Solok. The validation test was conducted on August 10, 2025.by linguists is presented in table 7 below.

Table7. Language Validity Test

No	Assessment Items	Evaluation
1.	The shape and size of the letters used using AR are easy to read	4
2.	The description of the information conveyed in AR Interactive Media is easy for students to understand.	4
3.	AR Interactive Media uses simple sentences	3
4	Interactive Media using AR is easy to understand	3
5.	AR interactive media uses good and correct Indonesian language rules or in accordance with EBI	4
6.	Sentences used are appropriate to the students' ability level.	4
	Score obtained	22

c. Analysis of Material Expert Validity Test

Validity test data were obtained from Adzkia University Elementary Education lecturers as subject matter experts. The validation process was conducted once on August 8, 2025, by the subject matter validator, as presented in Table 8 below.

Table 8. Material Validity Test

No	Assessment Items	Evaluation
1.	The truth of the material of geometric shapes	4
2.	Clarity of material on spatial structures	4
3.	Flat shape material is easy to understand	4
4.	The material contained in AR Interactive Media refers to the Merdeka curriculum	3

5.	Level of material importance	4
6.	Adapting to developments in science and technology	4
7.	Usefulness of the material	4
	Score obtained	27

This validation process aims to ensure that the media developed truly meets the eligibility criteria in terms of content, appearance, language, and technical use. The media (Figure 1) The initial appearance of the interactive media based on Augmented Reality is designed to be simple but attractive to provide a pleasant first impression for students.

Figure 1. Initial Media View

Media (Figure 2) The use of buttons on this Augmented Reality-based interactive media is designed to be easy for elementary school students to understand and operate.

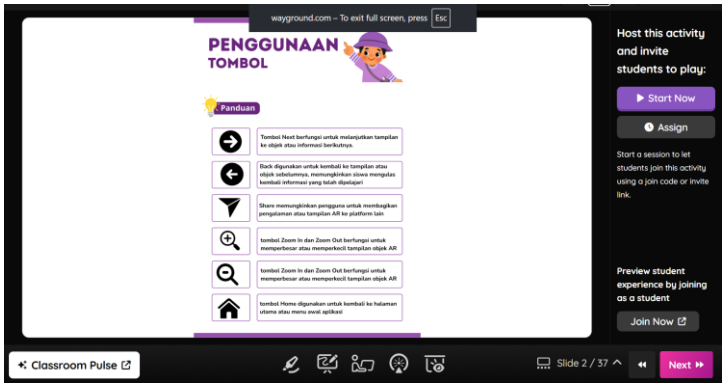

Figure 2. Button Usage Instructions

The media (Figure 3) The material is arranged in a logical sequence, starting from an introduction to various geometric shapes such as cubes, cuboids, prisms, pyramids, cylinders, cones, and spheres, then continuing with their properties.

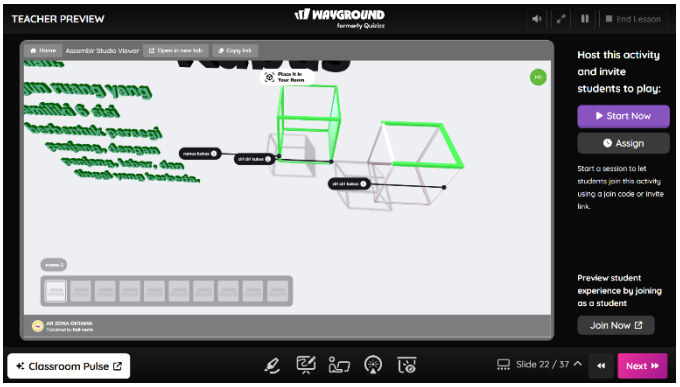

Figure 3. Contents

In this study, researchers selected SDN 10 Koto Tinggi Surian and SDN 08 Tambang Surian as the research schools. The teachers involved were the fifth-grade homeroom teachers, and the implementation took place in the fifth-grade classrooms on August 12, 2025. Data on the practicality of the media were obtained through an assessment questionnaire. Before the teachers filled out the questionnaire, the researcher first provided an explanation regarding the use of Augmented Reality (AR)-based learning media, and directly demonstrated the appearance and how the media worked when used in learning. The results of the teacher response questionnaire on Augmented Reality (AR) based learning media are as follows:

Table 9. Teacher responses

Name	Score	Criteria
SDN 08 Koto Tinggi Surian	92.7%	Very practical
SDN 10 Tambang Surian	96.36%	Very practical

At the end of the lesson, students were given an assessment questionnaire to fill out as a form of response to the learning experience using the media.

Table 10. Student responses

Name	Score	Criteria
SDN 10 Koto Tinggi Surian	89.46%	Very practical
SDN 08 Tambang Surian	88.88%	Very practical

The effectiveness test of interactive media based on Augmented Reality in Mathematics learning for grade V of Elementary School was conducted by administering pretests and posttests at SDN 08 Tambang Surian and SDN 10 Koto Tinggi Surian on August 12, 2025. The trial results show an increase in student learning outcomes in each school as follows.

Table 11. Results of effectiveness data

Name	Score	Criteria
SDN 10 Koto Tinggi Surian	0.7261	Very Effective
SDN 08 Tambang Surian	0.7095	Very Effective

4. Conclusion

Based on the research results, it can be concluded that the developed interactive Augmented Reality (AR)-based learning media has met the criteria of being valid, practical, and effective for use in Mathematics learning in elementary schools. The results of expert validation from material experts, language experts, and media experts, all of which are included in the very valid category. In the practicality test, teacher responses at SDN 10 Koto Tinggi Surian and student responses showed a very practical category, while at SDN 08 Tambang Surian, teacher responses and student responses were overall in the very practical category. Furthermore, the results of the effectiveness test showed that the average N-Gain Score of SDN 10 Koto Tinggi Surian and at SDN 08 Tambang Surian, both of which were included in the high category. Thus, this AR-based learning media has proven to be feasible, easy to use, interesting, and effective in improving students' understanding of spatial concepts, so it is recommended as a Mathematics learning innovation that is in line with the principles of the Independent Curriculum.

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