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Development of Augmented Reality Card Media to Increase Interest and Cognitive Learning Mathematics in the Elementary Schools

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ABSTRACT

This research is motivated by students who tend to be easily bored, and do not understand mathematics learning material on the material of building space. This happens because of the lack of teacher's ability to use appropriate and concrete learning media in classroom learning. There are still many teachers who use the pictures available in the book only for the material of building space, so that many students do not understand the material of building space taught. Thus, the purpose of this study is to analyze the needs, design, develop technology-based learning media, especially Augmented Reality-based media cards by conducting feasibility tests evaluated by experts, improving student understanding and knowing feedback from users. The research method used is Reseacrh and Development (R&D) by applying the ADDIE procedure which consists of five stages, namely analysis, design, development, implementation and evaluation. Based on the research results, the media feasibility evaluation obtained an average of 93,26%. This product trial was conducted at SDN Sawah Besar 01 by conducting three meetings, namely pretest, treatment, and posttest. Based on the results of the cognitive understanding test, it shows that there is an increase in student understanding by using Augmented Reality-based Card media in learning. Augmented Reality-based Card media also received positive responses by students through student response questionnaires.

Introduction

Education is a basic need of every human being because education has an important role in determining the progress of national life. Therefore, education must be able to prepare the younger generation in facing future challenges that will be characterized by increasingly sophisticated and complex technology (Putri Lestari et al., 2022). According to Suryana & Muhtar (2022), technological advances that occur can be certain challenges and opportunities that we must face and utilize properly if we can quickly adapt to these changes. The development of technology and information in Indonesia has entered Society 5.0.

According to Subandowo (2022), society 5.0 is a society that can solve various challenges and problems that occur in the social environment by using technology with various innovations in it. The rapid development of technology requires the world of education to utilize increasingly sophisticated technology as a facility that can optimize learning activities. Examples of technology utilization in teaching and learning activities are using advanced technologies such as Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), and the Internet of Things (IoT) (K. N. S. Rahayu, 2021). The utilization of this advanced technology, if it can be used as well as possible, is expected to create quality graduates and competence in the industrial world. In addition, students are expected to have thinking and learning skills, so that the learning approach that was originally teacher-centered learning changes to a student-centered learning approach.

These changes are certainly a new challenge for teachers to have more abilities than just delivering teaching material in class, teachers are required to have technological and innovative skills. This is in line with the opinion of Alimuddin (2019) who assesses that in the era of society 5.0, teachers are required to be more innovative and dynamic in teaching activities in the classroom. Educators must also have 21st century life skills, namely leadership, digital literacy, communication, emotional intelligence, entrepreneurship, global citizenship, team working and problem solving. 21st century skills are currently known as 4C skills which include creativity, critical thinking, communication and collaboration. Schools as educational institutions are required to have 21st century skills, namely creative thinking, critical thinking and problem solving, communication, and collaboration (Septikasari & Frasandy, 2018). This shows that the challenges in the field of education in facing the era of society 5.0 make various parties need to strive to be able to have the ability and skills to face increasingly sophisticated technological developments and optimize learning activities to remain effective so as to produce competent graduates as expected.

Technological developments in school education have a good impact on the way teachers teach, the way students learn, and the development of materials that are continuously updated according to the times. The real evidence that technological developments have a huge impact on learning in schools is the use of digital-based learning media. Learning media is a supporting component in the process of running learning in the classroom (Mujahidin et al., 2021), by using learning media, it is hoped that it can attract students to take part in the learning process and improve learning outcomes. According to Perwita & Fujiastuti (2021), interest and motivation will always be followed by a feeling of pleasure and from that will be obtained, so students have a desire to pay attention to some activities. But in reality, teachers who act as facilitators in learning do not have the ability and skills in technology, so they still need training in utilizing technology for implementation. This causes, the utilization of the use of technology in learning is not maximized and runs effectively, so that many students are not enthusiastic about the learning provided by the teacher, especially in this case is learning mathematics. The majority of students find math boring and unpleasant. This is due to the abstract nature of math learning and the lack of real media used by teachers. This is supported by the findings of research conducted by Mashuri & Budiyono (2020) in one of the elementary schools which shows the fact that the

application of the media used in learning geometry material volume of space is still not appropriate, where the teacher only uses pictures of space found in books or whiteboards as teaching media. Teachers who teach mathematics only use media in the form of pictures, only a few teachers use software-based media that facilitate the abstraction of lessons for students (Nurmawati & Ismartoyo, 2024). This has an impact on the lack of interest in learning and low enthusiasm of students which can lead to low learning outcomes. Whereas learning mathematics is in elementary school aims to make students have the ability to understand mathematical concepts, reasoning, problem solving, forming attitudes and skills in the application of mathematics (Sawitri & Agustika, 2022).

These problems are also experienced by fifth grade students at SDN Sawah Besar 01 through observations and interviews with 20 fifth grade students. Of the 20 students, only 2 students liked math and had no difficulty in learning math, while more students felt that math was a difficult and unpleasant lesson. This is due to the teacher's limitation in using learning media in delivering teaching materials. Teachers mostly use LKS media, 2-dimensional images, powerpoints and learning videos to explain learning materials. These learning media are less interactive in the material of building volume in mathematics learning because the material is abstract, making it difficult to imagine in the minds of students. This is in line with the opinion of Mahsup et al., (2018) that the ability of elementary school students to calculate the volume of spatial shapes is still very low, especially in calculating the volume of blocks and cubes because it is abstract. Spaces are three-dimensional shapes that have height and thickness (Alyusfitri et al., 2020).

Making abstract math lessons real in the minds of students is a difficulty for teachers. According to Deda et al., (2024) mathematical ideas can be learned better with the help of materials made specifically for this purpose, such as teaching aids, so that students can see, use and think directly about the objects being studied, making it easier to understand the abstract mathematical concepts given. Inappropriate and non-interactive learning media can cause students to get bored easily, resulting in low interest in learning which can have an impact on learning outcomes. Therefore, the inappropriate application of learning media can be a major problem in visualizing abstract concepts in mathematics learning (Faradiba et al., 2024). So the need for learning media that is real and can improve students' understanding of concepts in the material of building space. It is intended that the learning that students learn can be more effective and efficient, and more varied so that there is student interest in participating in the learning process in class (Rofilah & Tsurayya, 2021).

One of the learning media resulting from technological developments that can be used is Augmented Reality (AR)-based card learning media. According to Azuma (in Arifin et al., 2020). Augmented Reality is a technology that combines 3-dimensional virtual objects into a real environment and displays in real-time. Augmented Reality only enhances or complements reality, not like virtual reality that replaces it completely (Rozi et al., 2021). This can make this AR-based card learning media an interesting learning media. This is in line with the opinion of Sungkono et al., (2022) that animated 3-dimensional objects make learning more interesting for students.

Based on the above problems, researchers propose Augmented Reality-based learning media for the volume material of cube and beam spaces that are present in 3-dimensional form. The development of Augmented Reality-based 3-dimensional space learning media uses the ADDIE development model (Analyze, Design, Implement, and Evaluation). This study aims to determine the needs analysis of AR-based media card development, describe the steps of media development Card three-dimensional space based Augmented Reality, know the feasibility and practicality of media Card three-dimensional space based Augmented Reality, and analyze the results of media trials Card three-dimensional space based Augmented Reality on student learning outcomes.

Research Methods

This study uses Research and Development (R&D) as a research method. According to Sugiyono (2021), the function of research and development produces or develops and validates new products. To produce certain products can use research that is analyzed in accordance with the needs and can test the effectiveness of these products in order to provide benefits (Okpatrioka, 2023). Products developed in education can be in the form of learning media, books, modules and curriculum.

The research design used in this study is the ADDIE research model developed by Reiser and Mollenda in the 1990s. The ADDIE method has the ability to guide in building dynamic and effective devices or programs (Akhyanto et al., 2022). This ADDIE research model has the advantage of systematic stages of work consisting of 5 stages, namely the first stage is Analysis, at this stage information is collected about learning needs, learning objectives to be achieved, and student characteristics. This analysis will help researchers understand the needs of students. At this analysis stage there are 2 stages, namely the performance analysis stage and the needs analysis stage. The next stage is Design. After the information gathering stage, the next analysis step is design. At this design stage, appropriate learning media development will be designed, so that effective learning activities will be created. This stage is the initial stage in designing development media. The third stage is the Development Stage. The third stage is the Development stage, namely developing learning media based on the initial plan. At this stage, the media production process that will be developed will then be validated by a team of experts. Then Implementation. The implementation stage is the stage of applying what has been developed in the learning environment. This stage aims to ensure that what is developed is effective and has an impact on the learning process in the classroom. The last is the Evaluation Stage. This evaluation stage is to assess the effectiveness of the media developed to achieve the learning objectives that have been set. This evaluation is carried out formatively and summatively.

This research was conducted at SDN Sawah Besar 01, which is located at Jalan Tambak Dalam Raya No.2, Sawah Besar, Gayamsari Sub-district, Semarang City. This study involved 20 fifth grade students. The sampling technique in this study used nonprobability with saturated sampling because all members of the population were used as samples, namely all fifth-grade students at SDN Sawah Besar 01, Gayamsari District, Semarang City with a total of 20 students. The data collection techniques used in this study were observation, interview, questionnaire and test.

Observation in a study can be interpreted as focusing attention on an object to be studied by involving all senses, such as sight, smell, hearing, touch to obtain data (Nur & Utami, 2022), while interviews are one of the techniques that can be used to collect research data which involves the process of interaction between the interviewer and the interviewee (Rivaldi et al., 2023). Observations and interviews were conducted with 10 teachers and 20 grade V students before the implementation of the research to identify the problems and learning media needed by SDN Sawah Besar 01 which became the research site. The questionnaire used in this study contains questions about the experience of grade V students in using augmented reality-based media cards in learning mathematics. In addition, the questionnaire was also used to evaluate the feasibility of the product developed and to find out the responses, in the form of criticism and suggestions by experts.

The analysis used to process the questionnaire data using the formula and questionnaire analysis criteria from Arikunto & Suharsini (2018) is as follows.

$$\mathbf{Ps} = \frac{S}{N} \mathbf{x\ 100\%}$$

Description:
Ps = Percentage
S = Number of scores obtained
N = Number of ideal scores

Table 1. Criteria of the Questionnaire

Percentage (%)	Criteria
81 – 100	Very Good
61 – 80	Good
41 – 60	Good Enough
21 – 40	Not Good
0 – 20	Not Very Good

The criteria for the product validation feasibility test questionnaire conducted by experts are described in table 2 below.

Table 2. Eligibility Criteria of the Product Validation

Validity Criteria	Validity Level
81,26% - 100%	Very Valid, or can be used without revision
62,51% - 81,25%	Valid or can be used but needs minor revisions
43,76% - 62,50%	Invalid, recommended not to be used because it needs major revisions
25,00% - 43,75%	Very invalid or should not be used

(Source: Fuad, 2019)

Questionnaires intended for students to see student responses to the use of Augmented Reality-based media cards use a Guttman scale. The Guttman scale is a scale that only provides two answer options, for example yes-no, good-bad, never-been, and others (Bahrun et al., 2018). In this study, the Guttman scale used is the answer “Yes” or “No”. Researchers

use the Guttman scale when they want to get a firm answer to the problem being asked. The Guttman scale consists of 2 levels, namely for "Yes" is given a value = 1, while for "No" is given a value = 0. The formula used to analyze the data obtained from the student response questionnaire is as follows.

$$\text{Range} = \frac{Highest\ Score - Lowest\ Score}{Score\ range}$$

$$\text{Range} = \frac{1-0}{2}$$

$$= 0{,}5$$

The range of the Guttman interval scale used is as follows.

Table 3. Range of Guttman Interval Scale

Value	Description
≧ 50%	Enough
< 50%	Less

In implementing the product, the researcher also conducted a test to students to see changes in knowledge and understanding possessed by students. Researchers used a one group pretest-posttest pre-experimental design to conduct tests on students (Sugiyono, 2021a). In this research design, one group of students is given a pretest question before carrying out learning with treatment using media or tools, then given a posttest (Umam & Jiddiyyah, 2020).

The data that has been obtained after conducting a series of tests, then processed to perform a normality test using the Shapiro Wilk test considering the number of students is less than 50 people. The next step is the average difference test, then analyzed using the N-Gain test to determine the effectiveness of the learning media products that have been developed, in this case the Augmented Reality (AR) based Card media. The N-Gain formula used is as follows.

$$\text{N-Gain} = \frac{Skor\ posttest - Skor\ pretest}{Skor\ maksimal - skor\ pretest}$$

Furthermore, the criteria used in this study are the N-Gain score category according to Meltzer (in Fadlina, et al., 2021) in table 4 below.

Table 4. Category of N-Gain Score

Percentage (%)	Criteria
g > 0,7	High
0,3 ≤ g ≤ 0,7	Medium
g < 0,3	Low

Findings and Discussion

The results and discussion of this Augmented Reality (AR)-based 3-dimensional space card media development research are explained systematically based on each stage of the ADDIE model which includes: analysis, design, development, implementation, and evaluation stages.

In the analysis stage, researchers collected data and information with a preliminary study to determine the needs of fifth grade students at SDN Sawah Besar 01. In this stage, researchers distributed interview sheets to 10 class teachers at SDN Sawah Besar 01 and 20 fifth grade students of SDN Sawah Besar 01. From the interview sheet, researchers found that students had little interest in learning and unsatisfactory cognitive learning outcomes. In addition, the use of learning media used in learning has not used much technology-based learning media. This causes, the learning process feels monotonous because it still uses less real media in learning math, causing students to be uninterested in learning and listening to the delivery of material by the teacher. It can be concluded that grade V students experience a lack of interest in learning and low cognitive learning outcomes due to the use of learning media that is not varied and innovative.

The data that has been obtained from the analysis stage, then used as a reference to create a media design. The design of Augmented Reality (AR) based Card learning media is certainly guided by the curriculum used, namely the Merdeka Curriculum to create material that will later be included in Augmented Reality (AR) based Card media. In designing this Augmented Reality (AR) based Card media, researchers create a Storyboard which is a reference in the need for the media development process. The example of the storyboard created is shown in Figure 1 below.

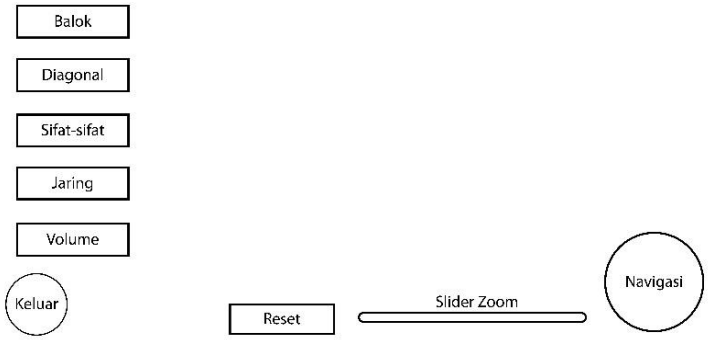

Figure 1. Storyboard of Augmented Reality (AR) based Card.

In this Augmented Reality (AR) based media design stage, some of the materials obtained are obtained from the Freepik.com website as a support for the design components in the media, besides that researchers also create and edit designs using the Adobe Illustrator application which includes cube and beam volume material, such as properties, diagonal space, diagonal plane, diagonal plane and cube. Augmented Reality-based Card media is designed as interesting as possible with images, text, and various colors in it. In addition, the design of the Augmented Reality (AR) based media card is also carried out by adjusting the characteristics of elementary school students both in terms of color, size, font, and image so that students are interested and have an interest in learning mathematics, so it is expected to improve learning outcomes.

If all the necessary design components have been completed, then the next is the development stage. In the development stage, researchers use the Blender application to create 3D objects. After that, researchers create Augmented Reality (AR)-based Card media

applications using Unity3d. Components that have been completed and obtained at the design stage, then developed and loaded in the Unity3d application in accordance with the storyboard that has been made at the previous stage. That way, the layout of the Augmented Reality (AR) based media card looks neat, structured and functional. After completing the development of Augmented Reality-based Card media (AR), then the results are printed using thick paper. Cards that have been printed, can later be scanned via smartphone. Figure 2 below is a display of cards that have been printed and can be used for learning through scanning the barcode on the back of the card.

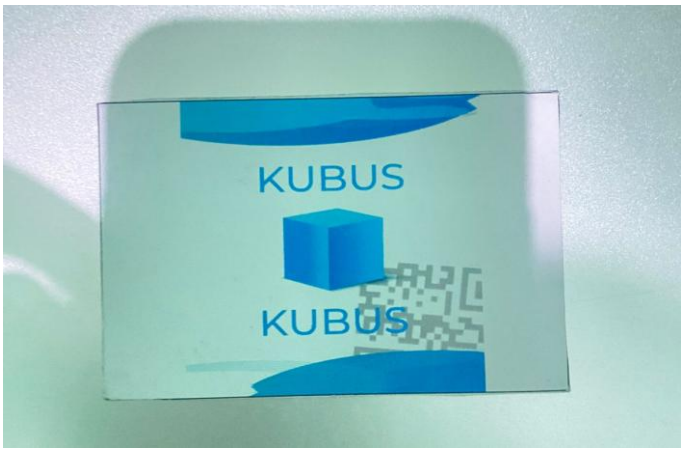

Figure 2. Display of card that can be scanned

This shows that Augmented Reality (AR)-based Card media is a flexible learning media because it can be used anytime and anywhere. The following is an application display of Augmented Reality (AR)-based Card media that has been developed according to the storyboard reference shown in figure 3.

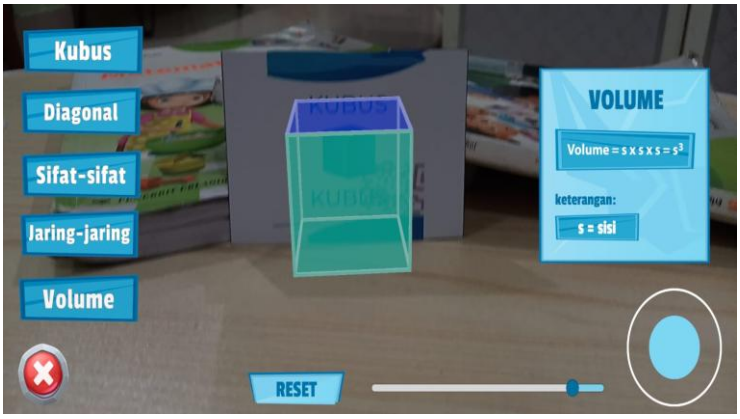

Figure 3. Application view of Augmented Reality (AR) based Card

In the application, students can choose the menu they want to learn by pressing the material button that is available on the layer. The material contained in the application also varies, namely cubes and beams and their properties, diagonals, diagonal planes, jarring-nets and volume. The display of the properties of the space bagun on the augmented reality-based card application is shown in Figure 4 and Figure 5 as follows.

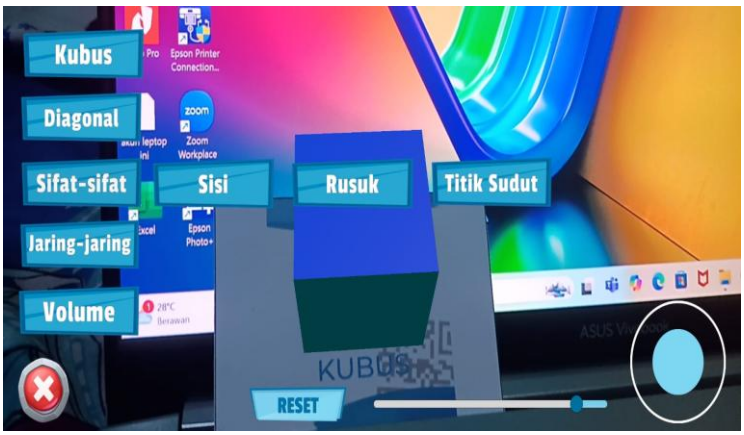

Figure 4. Material Options Properties of Cube Spaces

Figure 5. Display menu options properties of cubes

The diagonal menu display and the diagonal plane on the beam space in the Augmented Reality (AR) based Card application are shown in Figure 6 and Figure 7 as follows.

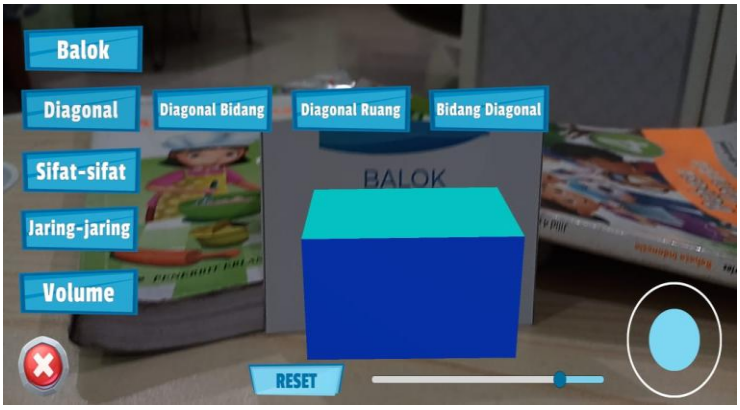

Figure 6. Diagonal Menu on Building a Beam space

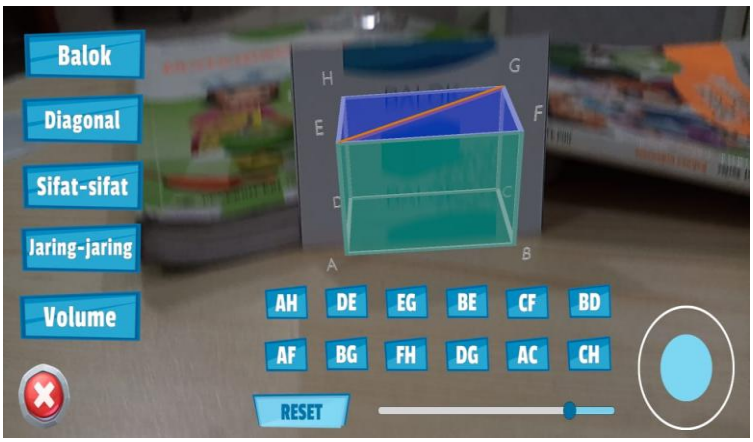

Figure 7. Display of Diagonal Fields on Beams

After the Augmented Reality (AR) based media card has been developed, then a validation test is carried out to determine the feasibility of the product or media that has been developed. In this study, the product validation test was carried out by material experts and media experts who were lecturers at PGRI Semarang University. In addition to conducting feasibility tests on material experts and media experts, researchers also conducted feasibility tests on 3 teachers at SDN Sawah Besar 01 as media practicality test experts. The following are the results of the recapitulation of the feasibility test validation questionnaire from the experts.

Table 5. Recapitulation of the Eligibility Validation Results

Validator	Precentage
Material Expert	94,44%
Media Expert	92,85%
Media Practicality Expert	92,5%

Based on the results of the data, it can be seen that the assessment of each expert received a high score above 81%. In accordance with Arikunto's assessment criteria used in this study and shown in table 1 above, that the assessment obtained is included in the “High” category. According to P. Rahayu & Kholilullah (2018), the acquisition of scores above the average proves that the developed media is good for application to students.

The next stage is implementation, which is carried out through three meetings. At the initial meeting, students were given pretest test questions to determine and assess the ability of students' initial cognitive understanding of volume, cube and beam building materials. In the second meeting, students are involved in learning activities using media that have been developed by researchers, namely Augmented Reality (AR) based media cards in the classroom. In the last stage, namely the third stage, students work on posttest questions given to evaluate the ability of students' final cognitive understanding of the material of the volume and beam space.

The data obtained from the series of test activities, then analyzed using SPSS 22. The analysis includes normality test, mean difference test, and N-Gain test to determine changes that occur in students' cognitive understanding of the material of building space, volume and

beam. The results of the pretest and posttest of fifth grade students at SDN Sawah Besar 01 show changes. It can be seen from the average obtained in the pretest of 53, while the posttest obtained an average greater than the pretest average, which was 89. This shows that the posttest score is higher than the pretest score. To see how much effectiveness was obtained from this study, the N-Gain test was conducted and obtained a result of 0.76. When viewed and interpreted based on the criteria of the N-Gain category according to Meltzer, it can be interpreted that there was an increase that was included in the "High" category.

After students learn by using Augmented Reality (AR)-based media cards, students are asked to provide feedback and assessment of Augmented Reality (AR) media cards through a student response questionnaire containing 10 questions. The questionnaire results show that students respond quite well to the use of Card Augmented Reality (AR) media. When viewed from the overall response obtained from 20 students, that is 98%. Then the results are interval according to Guttman, then get the results ≧ 50% with the category "Enough". This shows that Augmented Reality-based media cards meet practical criteria and are very feasible to use in learning.

The evaluation stage is the stage of analysis based on media assessments that have been given by experts in the validation sheet. From the assessment of the experts showed under the Card Augmented Reality (AR) media is feasible as a learning medium in the classroom. In addition to looking at the evaluation of the validators, the evaluation stage is also reviewed from the acquisition of student cognitive understanding test assessment data in the form of prettest and posttest at the time of media implementation and the results of questionnaires of student responses in using Card Augmented Reality (AR) media there was an increase of 76.57 with a high category. Similar research has been conducted by Ikhsan et al. (2022) also shows that there is a change in the form of increased understanding by using Augmented Reality (AR) based application learning media of 0.52 which is included in the "Medium" category. The results of the student response questionnaire obtained a positive response with an assessment according to Guttman, which is ≧ 50% in the "Enough" category, which means that the Augmented Reality-based Card media meets practical criteria and is very feasible to use in learning. According to Wiliyanti et al. (2024), AR-based learning media can improve concept understanding and increase student interest in learning, so this AR-based media is very feasible to use in learning.

Conclusion

Augmented Reality-based Media Card is a technology-based learning media developed using ADDIE model procedures which include analysis, design, development, implementation, and evaluation stages. Augmented Reality-based Card Media was successfully developed by conducting feasibility tests and can provide an increase in student understanding of the material of cube and beam spaces in mathematics lessons. In addition, this AR-based card learning media gets a good response by students. Based on this, Augmented Reality (AR) based card media can be used in learning math. If future researchers are interested in researching this research further, they can carry out more in-depth observations or

preliminary studies, recording the implementation of field trials in detail, and testing effectiveness.

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