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Evaluation of the Impact of 3D Space Building Learning Using Augmented Reality Based on Android Applications

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ABSTRACT

Mathematics is a subject that is considered difficult by many students, especially geometric materials. Grade 5 students at SDN Bugel 2 had a low average score in learning geometric shapes with an achievement of 40,7. The aim of this research is to increase students' understanding of spatial construction materials in class 5 through learning applications. This research was conducted using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) method. The result of this research is to create a 3D space building learning application based on Augmented Reality which can make it easier for students to understand space building learning. This learning application is effective and can improve student understanding. This is proven by the average quiz score increasing to 81,9.

1. Introduction

Technology has brought many changes to human life to date, from technology that helps solve small problems to large problems. Not only that, now technological developments, especially in the field of information and communication technology, have developed so rapidly. This has resulted in various information and communication technology products such as laptops, smartphones, etc. Apart from the industrial world, technology is also needed in the educational world. In the world of education, technology can be used as a medium or means to support the teaching and learning process in schools. In the world of learning, innovation is needed to create an interesting learning atmosphere.

One of the media that can be developed with technology is 3D media. 3D learning media is an intermediary or tool used by educators with students to facilitate the delivery of learning material[1]. Meanwhile, according to Learning the media is a solution to overcoming learning problems and can help students understand information. Mathematics has long been considered by students to be a difficult and scary subject. Not only learning simple algorithms such as addition and multiplication, one of the materials that students consider difficult is learning geometric shapes. Students often feel confused when faced with this material. " A spatial structure is an object that has surface boundaries and space within it."[2] Space is a branch of mathematics that discusses three-dimensional objects in the real world, so to understand them requires strong and correct analytical skills and basic concepts as a basis for solving problems. In fact, there are still many students at Bugel 2 State Elementary School who experience difficulties in solving spatial construction problems, which results in low student learning outcomes in spatial construction material.

Based on interviews with teachers at SDN Bugel 2, several problems were found in the learning process, namely that teachers are currently unable to develop technology-based learning media and the learning media currently used is limited. Of the 28 students, there were 20 students who had difficulty understanding the spatial construction material. This is proven from the results of questionnaire research. Students do not understand the basic concepts of spatial construction materials. Apart from that, the lack of interesting supporting media reduces students' motivation to take part in learning mathematics in geometric shapes, so that students have difficulty understanding the theory underlying the implementation of the exercises. This supporting media is needed to increase the effectiveness of learning process activities to make it easier for students to learn spatial building materials, but teachers and students have not yet optimized these facilities. Researchers have the idea of creating an Augmented Reality-based learning application. Augmented Reality has several advantages, such as students being able to see and interact with 3D Building Space objects. Apart from that, it can help students understand the material easily. Based on the problem identification above, the

problems that will be discussed in this research can be formulated as follows: (1) How to design a learning media application on the material Building Space with One Image Target using Augmented Reality for Bugel 2 Elementary School students? (2) How do you implement learning media applications on the Mathematics Space Building material with One Image Target using Augmented Reality at SD Negeri Bugel 2? (3) What is the impact of evaluating learning media applications on the material Building Space with One Image Target using Augmented Reality for Bugel 2 Elementary School students?

Technology is designed as a tool to assist humans in taking action. Technology can reduce uncertainty in the process of achieving goals.[3] Technology was created to help humans exchange innovations quickly and easily.[4] Learning the media is used as a tool to convey information, so that it can attract students' attention and interest.[5] Learning the media is anything that supports the learning process in helping teachers to make it easier to convey material to students.[6]. " Mathematics is a science that studies quantities, structures and patterns in the real world. Mathematics helps us to think logically and systematically in solving problems and making decisions. Mathematics uses abstract concepts and has a structured and orderly structure. Deductive reasoning is used in mathematics to draw conclusions from known premises".[7] "Mathematics is a scientific discipline that provides the basis for basic arrangements and measurements in various fields. This science provides systematic methods and processes for formulating precise concepts and consistent symbols, enabling deeper understanding and exploration of knowledge."[8]. In mathematics, a spatial form is an entity that has dimensions and volume. The elements that make up the shape of this space include sides, edges and corners. Sides are areas that limit the shape of a room to the space around it. An edge is a straight line formed from the meeting of two edges. Meanwhile, an angle is the meeting point of three sides or three edges.[9] 3D is a medium that contains educational messages, with a collection of images that have been manipulated to create movement, and audio that creates a live impression.[10] "Augmented reality is a developing technology that combines two-dimensional and three-dimensional virtual objects in a real-world environment and projects these virtual objects into realistic forms in real time." [11]"Augmented reality is a technological development that combines two-dimensional and three-dimensional virtual objects in a real-world environment and projects these virtual objects into realistic forms in real time."[12] [13] " Android is an open platform specifically designed for mobile devices such as smartphones and tablets." Meanwhile, Among the popular mobile operating systems, Android is a platform that originates from Linux and is focused on devices with touchscreen technology. [14].

2. Method

In order for this research to run well, the following planning flow was created.

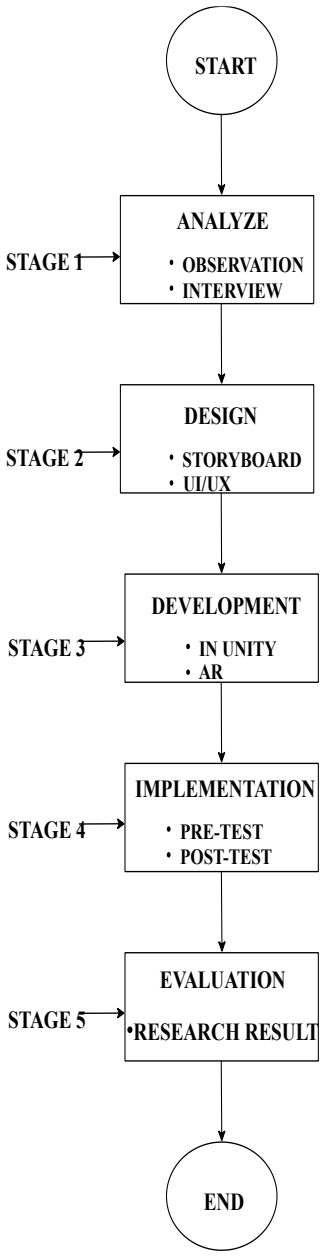

Figure 1. Research Design

In figure 1, researchers focus on developing applications to improve learning outcomes for Bugel 2 State Elementary School students in building materials.

The ADDIE model presents the fundamental steps in building a learning system[15]. By understanding the five stages you can create a structured and purposeful learning experience for your students. The ADDIE approach serves as a guide in managing various complex diseases and results in the development of effective education and learning resources[16]. The development model applied in this research is ADDIE. ADDIE is a generic learning

design that provides a process with stages: Analyze, Design, Development, Implementation, Evaluation.

At this stage, the researcher carries out analysis to collect data that will be used in the process of creating a spatial building learning application. There are three stages of analysis carried out by researchers, namely:

Observation, at this stage, the researcher made observations at the Bugel 2 state elementary school, to observe the teaching and learning process on building materials. The researcher observed the teacher explaining and explaining spatial construction material to fifth grade students. The teacher explains spatial construction material to students using conventional learning methods, namely using books.

Interview, at this stage, the researcher conducted interviews with teachers regarding students' interest in learning spatial materials and learning's media facilities at Bugel 2 State Elementary l.

Design, at this stage, the researcher creates an application design. There are three stages in making a design, namely storyboard and UI/UX design. Storyboard Creation Stage At this stage, the researcher visualizes ideas and concepts into a storyboard. In the storyboard, the researcher arranges pictures and sketches sequentially to illustrate the flow and interactions in the application so that they appear more clearly. Creating a *User Interface* (UI) and *User Experience* (UX), At this stage, the researcher designs the UI/UX that will be created in the spatial building learning application. Researchers determine the layout, colors, typography, buttons and animations to be used. Apart from that, researchers also design convenience, usability, effectiveness, enjoyment and user satisfaction when using the application

Development, After the analysis and design stages have been created, at this stage the researcher designs and develops the application according to the storyboard and UI/UX that have been designed. Researchers created a learning application using Unity software, which can be used to create 3D applications using augmented reality.

In implementation, at this stage, the researcher will apply conventional learning to grade 5 students. The researcher gives mathematics problems using geometric material. 28 students will study spatial construction material using 2 learning methods, namely, using conventional learning methods and using application learning methods. After explaining the material about building space, students do the same quiz with 6 questions.

Evaluation, at this stage the researcher will apply learning to students using the learning application that has been created. Researchers will provide the same material and quizzes as students who are explained using conventional learning to 14 different students at the implementation stage.

The result of the research Are to improve the understanding of spatial shapes in class 5 through learning applications. Design using case diagrams is used to model the learning media that will be designed.

3. Result and Discussions

3.1. Analyze

The results of the analysis stage are used to analyze problems experienced by teachers and students when learning mathematics, especially spatial building materials. Analysis of problems experienced by teachers and students, in creating Augmented Reality-based spatial learning media certainly cannot be separated from the background of the problems that teachers and students face. In collecting information about students' problems, researchers used interview, observation or observation methods at the research location and filled out questionnaires for grade 5 students at Bugel 2 State Elementary School.

Interview, From the results of interviews obtained from one of the mathematics teachers at the research location, the researchers found a problem faced by teaching staff, namely the absence of learning media used in the teaching and learning process, especially spatial building materials. Teachers still use worksheet books as a medium for teaching, where there are students who experience boredom while studying. Many students also pay less attention to teachers in the teaching and learning process, which results in students getting low grades during evaluations or quizzes.

Questionnaire, From the results of the questionnaire obtained from 28 students at Bugel 2 State Elementary School, there were many students who had difficulty learning mathematics and did not like mathematics lessons. Many students want to learn media that can help them understand mathematics lessons, especially geometric shapes.

Development Toolkit Analysis, in the process of developing the space building learning application, researchers used the Unity application based on augmented reality. Competency Analysis, in the competency analysis stage, researchers carried out a pre-test by learning using books and a post-test was carried out after learning using a spatial learning application.

3.2. Design

At this stage the researcher creates an application design or storyboard in the process of creating a spatial learning media application. Storyboard or creating application designs has the function of guiding researchers in creating spatial learning application designs, in the application that the researcher will make, the researcher takes learning material from several source questions, such as grade 5 elementary school thematic books, articles, previous journals, the researcher prepared 6 practice questions according to the material taught to students, namely material about

spatial shapes. The material, questions and exercises were given in one application as practice so that students already understood the material about spatial shapes basic and competencies used by researchers are in accordance with the k13 curriculum.

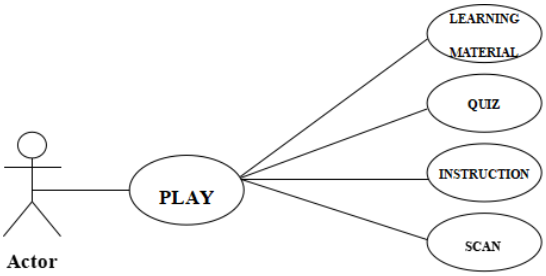

Figure 2. Use Case Diagram

This use case describes the process of using an application where the actor is a student or application user. When the actor clicks the play button, the application will automatically switch to the next page, namely the main menu which consists of materials, quizzes, scans and instructions.

3.3. Development

The development stage is the stage for creating the application design. The aim of making this application is so that students can use learning media using digital technology in the form of Android. The use of Android in mathematics learning supports the results of previous research which shows the feasibility of using the media. The design begins by creating the initial appearance of the application, the main menu display consisting of materials, quizzes, scans, instructions, settings, profile and exit button from the application. In this report the researcher will show several views of the application design that will be used in the teaching and learning process.

Figure 3. Main Menu Display

3.4. Implementation

After the application has been created, then at the dissemination stage a field trial is carried out to determine students' responses to the spatial learning media. Student responses are used to measure the

practicality of the spatial building learning media that has been tested on students.

In Figure 3, the main menu will appear. When you click on the menu, you will go to the main display menu. On the main menu there are several other menus, namely, material menu, quiz menu, scan menu, settings menu, profile menu, instructions menu and exit menu. The main menu consists of 7 options that users can choose from.

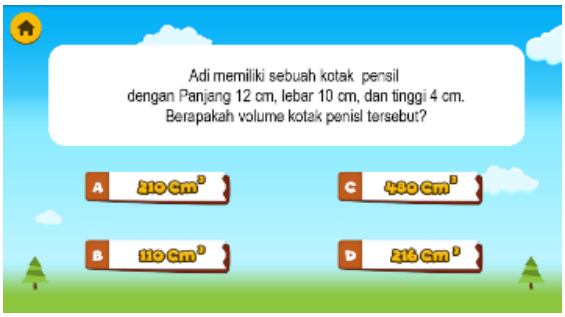

Figure 4. Material Menu Display

In Figure 4, the quiz menu is a menu consisting of six multiple choice questions to which the user can immediately select the answer. If the user answer incorrectly, a wrong sound will appear and if the user answers correctly, then they will continue to the next question.

Figure 5. Scan Augmented Reality Display

After the user downloads, scan the AR barcode in the instructions' menu. Users can use the barcode to display 3D spatial structures provided by the application maker. The user must direct the barcode at the camera properly and with sufficient lighting to display the perfect 3D shape. Users also have to scan barcode alternately or one by one because the technology used is one image target.

Before carrying out the trial phase using the learning application, students are first taught spatial building material using conventional teaching methods. After that, students did a 6 Space building quiz. After teaching using conventional methods, students are taught spatial construction material using an application and working on the same problems. This teaching takes the same time as teaching using learning applications.

In table 1 is the results of the learning trials show that students' grades and understanding of spatial

shapes have increased significantly by using application learning media. This is shown by the results of the quiz scores given.

Table 1. Quiz Score Results

Comparison Of Average Scores Using Book and Application					
Book (Pre-test)			Application (Post-test)		
No	Name	Mark	No	Name	Mark
1	Rizky Maulana	45	1	Rizky Maulana	60
2	Frander Orzorn	30	2	Frander Orzorn	75
3	Anwar Furrizki	30	3	Anwar Furrizki	75
4	Asyifa Azahra Putri	45	4	Asyifa Azahra Putri	75
5	Bella Puspita Sari	30	5	Bella Puspita Sari	75
6	Fahira Ismaila Putri	30	6	Fahira Ismaila Putri	90
7	Rauzan Ramma Al-Dria	45	7	Rauzan Ramma Al-Dria	90
8	Intan Dwi Maharani	30	8	Intan Dwi Maharani	90
9	Zahiratul Fauzia	30	9	Zahiratul Fauzia	90
10	M.Faizal	30	10	M.Faizal	90
11	Eli Hartika	30	11	Eli Hartika	90
12	Chesya Frealina Aprililiya Putri	45	12	Chesya Frealina Aprililiya Putri	90
13	M.Lanora	30	13	M.Lanora	90
14	Muhammad Nizam Alfarezy	30	14	Muhammad Nizam Alfarezy	90
15	Yuki Septi Pratiwi	45	15	Yuki Septi Pratiwi	75
16	Bilal Al Faqih	45	16	Bilal Al Faqih	90
17	Azzahra Nurul Amelia	60	17	Azzahra Nurul Amelia	90
18	Fathi Falah Subagio	45	18	Fathi Falah Subagio	75
19	Zaskia Anjani Irawab	45	19	Zaskia Anjani Irawab	90
20	Nesya Aura Aedilah	45	20	Nesya Aura Aedilah	90
21	Zaskya Anjani Putri	45	21	Zaskya Anjani Putri	75
22	Davis Wanata Halim	60	22	Davis Wanata Halim	90
23	Irfan Bachri A	30	23	Irfan Bachri A	60
24	Nur Azam Syuhada Putra	15	24	Nur Azam Syuhada Putra	60
25	Ahmad Yaasiin Alfarzy	60	25	Ahmad Yaasiin Alfarzy	90
26	Syalwa Zahirani Setiyawan	60	26	Syalwa Zahirani Setiyawan	90
27	M.Rizqi Maulana	30	27	M.Rizqi Maulana	60
28	Muhammad Fadly	60	28	Muhammad Fadly	90
Average		40,7	Average		81.9

After conducting a learning trial using the application, the average student score increased by 40,7, while the score for learning using conventional methods was only 81,9. Respondents then filled out a questionnaire. The questionnaire given is in the form of a questionnaire on paper which contains questions to

support the feasibility of the learning application. This questionnaire was given to 28 grade 5 students. The results of the questionnaire were summarized using UAT (User Acceptance Beta Testing Method).

Conclusion of the results of testing the learning application using the UAT method, in which respondents answered 6 questions given to 28 grade 5 students. The average value of the respondents was 90.47%.

Table 2 shows that the rate questionnaire and table 3 shows application succeeded in helping and making it easier for respondents to learn about spatial shape.

Table 2. Questionnaire Rate

Information	Score	Percentage
Strongly agree (SA)	5	80%-100%
Agree (A)	4	60%-80%
Neutral (N)	3	40%-60%
Don't agree (DA)	2	20%-40%
Strongly Disagree (SD)	1	0%-20%

Table 3. Questionnaire Result

STATEMENT	SA x 5	A x 4	N x 3	DA x 2	SD x 1	AMOUNT	PERCENTAGE
Does this building learning application help you in the teaching and learning process?	22	6				134	95.71
Does the design of the building learning application attract your attention?	18	10				130	92.85
Do you understand the material in the spatial building learning application?	6	19	2	1		114	81.42
Is the language used in the learning application easy for you to understand?	15	11	1	1		124	88.57
Does the existence of 3D spatial shapes help you in recognizing spatial shapes?	23	4	1			134	95.71
Do the practice questions help you understand the geometric material?	18	6	2	2		124	88.57
AVERAGE							90.47

3.5. Evaluation

The evaluation results show that the AR-based 3D spatial learning application is more effective in improving student learning outcomes. This application helps students understand the concept of building space more easily and with fun. Based on the results of the learning evaluation, it was concluded that there was a significant increase in students' knowledge about building space after using the application as seen in table 1. There was an increase in enthusiasm for learning in 5th grade elementary school students obtained from the results of the questionnaire that had been processed by the researcher, showing that 5th grade students at SD Negeri Bugel 2 are more interested in learning to use applications with an application display that is not boring. Students consider this application useful in helping them understand spatial shapes.

4. Conclusions and Suggestions

4.1 Conclusions

Limitations in making this learning application include the availability of technological devices for making the application, which requires an adequate laptop, and the limitations of technological devices when researchers implement the application for students, thus requiring students to use cellphones alternately, because students are not permitted to carry cellphones to school.

Based on the results of research on the quizzes carried out, it shows a very significant increase in

student scores. Before using the application, students only got an average score of 40.75, whereas after using the spatial building learning application created by researchers, the students' score was 81.9.

Based on research data, it can be stated that the spatial learning media application really helps students in learning by obtaining 90,47%, so it can be stated that this spatial learning media application is very suitable for use. The media design in the learning media for building space materials obtained 95,71%, so it can be stated that the material in the learning media is valid and can be used for students. The language in the learning media material has a chance of getting 88.57%, so it can be stated that the material in this learning application is valid and can be used by students. The practice questions contained in the application received 88.57, indicating that students liked the practice questions given by researchers in this spatial building learning application. From all the assessment results given by students on the questionnaire, it indicates that this building learning application is very suitable for them to use to help understand and increase students' enthusiasm for learning.

4.1 Suggestions

Based on the results of the research that has been carried out, there are suggestions that can be used by all parties. The suggestion that would be conveyed to students is that this learning medium regarding spatial construction material can be used as a media tool to help students, especially elementary school students, understand spatial construction material. For teachers, this fun learning medium for spatial building materials using augmented reality can be used as an alternative teaching tool, because it can attract students' attention so that it is used for teaching and learning activities and makes them more enthusiastic to follow and students can better understand the learning activities. For researchers who want to research learning media, it can be used to support fun mathematics learning activities. Further research can consider other subjects or materials when wanting to create learning media or when combining them with other learning methods to increase learning variety.

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