

# Augmented Reality-Based Mathematics Teaching Materials Developments for Spatial Reasoning in 5<sup>th</sup> Grade Elementary School Students

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## ABSTRACT

This research was conducted in order of knowing the characteristics, validity, practicality, and effectiveness of the mathematics learning media with animation using augmented reality media applications for 5th-grade elementary school students. The results of observations and interviews conducted before undertaking the research showed that learning activities still used conventional books and the media used for teaching is relatively minimum so Mathematics learning is less effective. The research used the "Research and Development" (R&D) method by adopting ADDIE in its stages. ADDIE stands for Analyst, Design, Development, Implementation, and Evaluation. The trial in this study was conducted at SDN Sangrahan 02, Kranggan District, Temanggung Regency, Central Java, with a total of 25 students. The validity test in this study was carried out by giving a questionnaire to the experts regarding the learning media that had been developed. The validation results obtained media validators with the 109 value which is the most valid category, meanwhile, the validator material reached the 68 value which remains the most valid category. The results of the pre-test and post-test scores were tested using an N-gain value of 62,4 with the highest category, it means that augmented reality-based Mathematics media was very effectively used to improve the spatial reasoning of fifth-grade elementary school students.

**Keywords:** Augmented Reality, Spatial reasoning, Mathematics

## INTRODUCTION

According to the results of tests and evaluations of the 2015 PISA assessment, students' performance in Mathematics shows a low category. Based on the results of the 2015 Mathematics PISA, it was found that Indonesia was ranked 63rd out of 70 countries evaluated. The ranking and average score are not much different from the results of the previous year's PISA in 2012 which were also in the low material mastery group. Mathematics is the most important subject in the education field because Mathematics encompasses all aspects of life, so Mathematics cannot be separated in daily life such as counting, determining shapes, sizes, and others, thus Mathematics is mandatory to learn.

Augmented reality media is one of the 3D-based learning media that is easily accessible and attractive because it displays a 3D image of Mathematics learning, particularly in the volume of cubes and blocks chapters so that learning media has great benefits to support effectiveness in learning. According to Azuma (Wardani & Sari, 2015) AR is a technology that combines two or three virtual dimensions and then projects the virtual stuff into the real environment. As done by Salim Soma, et al (2020), in the article "Augmented Reality-based Mathematics Worksheet for Online Learning During Covid-19 Pandemic" in the Journal of Educational

Studies recommend that the results show that Augmented Reality-based Mathematics worksheets have the highest quality results.

## **LITERATURE REVIEW**

### **1. Teaching Material**

According to (Pratiwi, 2015) revealed that teaching material is all forms of materials used by teachers or instructors in conducting teaching and learning activities in the classroom. Meanwhile, (Prastowo, 2012) explained that teaching material is an arrangement of materials that have been collected and come from various learning sources that are made systematically that display a complete figure of competencies that will be mastered by students in the learning process.

### **2. Types of Teaching Material**

Basically, teaching material is divided into several types and forms. Experts have made several categories of these teaching materials. (According to Kosasih, 2020) the types of teaching materials are divided into four, namely: modules, student worksheets (LKS), handouts, and presentations.

### **3. Teaching Material Benefits**

According to (Hamdani, 2011) revealed the benefits of teaching materials for teachers and students. Teaching material is useful for teachers as a guide that will direct all their activities in teaching and is a substance of competence that must be taught to students. Teaching material is useful for students as a guide that will direct all their activities in the learning process and are also a substance of competence that must be learned. In addition, teaching material is useful as an evaluation tool for achievement or mastery of learning outcomes.

### **4. Mathematics**

According to (Adoniou and Qing, 2014) Mathematics is a universal language, which implies an understanding of problem-solving regardless of the language used. Furthermore, according to (Delphie, 2009) Mathematics is a symbolic language that has

the practical function to express quantitative and spatial relationships.

### **5. Augmented Reality Media**

Augmented Reality or commonly called AR is a technology developed by virtual objects into the real world through intermediaries (Sugianto, 2014). Efforts to merge the real world into the virtual world through computers so that the boundary between the two is very thin, Augmented Reality (AR) is a variation of Virtual Environment (VE) or more commonly known as Virtual Reality (VR). While virtual reality has the meaning of a situation where the user as a whole is in a virtual environment.

### **6. Advantages and Disadvantages of Augmented Reality Media**

Augmented reality media that will be implemented has advantages and disadvantages. The advantages of augmented reality media are: it can present 3D animations, in which learning takes place interactively involving students thus it is not boring and can collect information about activities per student directly for the sake of assessment. The disadvantages of augmented reality media are: that it requires a type of android with certain conditions, the availability of a reliable internet connection, as well as knowledge and mastery of certain android programs.

### **7. Digital-Based**

According to (Rahmi, 2019) that technology-based or digital learning media is directly related to the students' learning experiences, this new experience can later foster enthusiasm in carrying out the learning process.

## **MATERIALS & METHODS**

The research method used in this study is the method of development (R & D). Robert Maribe Brach by adopting the ADDIE model in its implementation. ADDIE model forms a cycle that contains 5 stages consisting of Analysis, Design, Development, Implementation, and

Evaluation. The design steps in the research to be carried out are as follows:



Research Stages and ADDIE Development

This development research was obtained from the results of students and teachers. The test instrument used several instruments to determine the validity of media and material experts, including an analytical questionnaire that used a score interval category that adjusts the number of instrument items so that it uses a scale rating according to Syahrir in his 2016 research.

Table 1 Value Scale Category Kategori Nilai Skala (Syahrir, 2016)

Interval Score	Value	Category
$(M + 1,50S) > X$	A	Best
$(M + 0,50S) < X \leq (M+1,50S)$	B	Good
$(M-0,50S) < X \leq (M+0,50S)$	C	Deficient
$(M- 1,50S) < X \leq (M-0,50S)$	D	Bad

Information:

M = Average ideal score, (ideal maximum score + ideal minimum score).

S = ideal standard deviation, 1/6 (ideal maximum score – ideal minimum score)

X = Total score

Based on the formula in table I, it can be obtained the guidelines for converting qualitative values 1 to 4 into quantitative categories to conclude how the quality of the media developed. The subjects of this research were students and teachers of 5th-grade at SDN Sangrahan 02, Kranggan District, Temanggung Regency, Central Java, Indonesia. Research and development collection techniques were obtained from qualitative and quantitative data. Qualitative

data were obtained from interviews with teachers and students, observations, and documentation. Quantitative data were obtained from a questionnaire on the attractiveness of students and teachers, and pretest-posttest questions

## RESEARCH RESULT AND DISCUSSION

The existence of teaching materials is very influential on learning. In addition, the media is expected to be applied effectively even during the covid pandemic. The advantages of using digital learning media will make it easier for students to improve their cognitive abilities (Lilawati, 2020).

### Augmented Reality Media Validation Result

Before conducting the trial, augmented reality learning media needs validation from the experts. Media validation is carried out once by media and material experts. Validation was carried out by lecturers at Muhammadiyah University of Surakarta and Amikom University of Yogyakarta who had backgrounds in their respective fields.

#### 1. Validation Expert Media

Augmented reality media was validated by media experts aiming to determine the suitability of augmented reality media display, materials and visual communication in detail which is described in table 2.

Table 2 Media Expert Recapitulation Total Score Maximum Score Category

Total Score	Maximum Score	Average	Category
106	116	3,7	The most valid

Based on table 2, the media validator gave a score of 62 from the maximum score with an average of 3,7. The assessment guide used by the researcher is (Syahrir, 2016) based on the interval according to the items of the media validation instrument contained in the interval score  $X > 93$ . This can be interpreted that the augmented reality media made is extremely valid to use.

## 2. Material Expert Validation

Material expert validation of augmented reality teaching materials aims to determine the level of material validity according to Core Competencies and Basic Competencies. in detail described in table 3.

**Table 3 Material Expert Recapitulation**

Total Score	Maximum Score	Average	Category
68	72	3,75	The most valid

Based on the material experts gave a score of 68 and a maximum score of 72 with an average of 3.8. Based on the validity material expert in augmented reality media, it was assessed by the material validator expert with an interval of  $X > 58$  with a very valid category.

### Attractiveness Trial Result

The attractiveness trial is a measurement of the level of attractiveness in augmented reality media products to measure whether or not the product that has been developed is attractive. Augmented reality media

products before being used were tested on a large scale at SDN Sanggrahan 02, Temanggung, Central Java, Indonesia, and augmented reality media were tested on a small scale. The purpose of small-scale testing is to minimize deficiencies in the products that have been developed. A small-scale trial was carried out with as many as 15 in 5th students and teachers who would be given augmented reality (AR) media. Augmented reality products are given as the next learning media that will be studied by students within a certain time then students are asked to fill out a questionnaire response to the augmented reality media. A large-scale trial is an absolutely perfect product because the product has been refined from suggestions after the small-scale trials.

The results of the large-scale trial conducted at SDN 02 Sanggrahan Temanggung, Central Java, Indonesia with a total of 25 students and 5th-grade teachers are described in detail in table 4 below.

**Table 4 Student Attractiveness Questionnaire Recapitulation**

Trial	Number of Students	Score	Maximum Score	Category
Small-Scale	15	591	600	Highly Attractive
Large-Scale	25	981	1000	Highly Attractive

Based on the results of the small-scale trial in the table above that has been carried out by students with a total of 15 getting a score of 38 from a maximum score of 40 with an interval of  $X > 32$  with a highly attractive category.

In a large-scale trial that has been carried out at SDN 02 Sanggrahan Temanggung, Central Java, Indonesia with a total of 25

students with an improved product based on suggestions from a small-scale attractiveness test. The results of the large-scale trial score, namely 1539 from a maximum score of 1690 with an interval of  $X > 1280$ , mean it is a highly attractive category. As for the small and large-scale teachers' trials in detail can be seen in table 5 below.

**Table 5 Recapitulation of Teachers Attractiveness Questionnaire**

Trial	Number of Students	Score	Maximum Score	Category
Small-Scale	1	38	40	Highly Attractive
Large-Scale	1	39	40	Highly Attractive

Based on table 5 above, the small-scale trial on the teacher got a score of 38 out of a maximum score of 40 with an interval of  $X > 32$  which means, it is in the highly attractive category. The results of large-scale trials get a score of 39 out of a maximum score of 40 with an interval of  $X$

$> 32$ , which means that it is in the highly attractive category.

### The Effectiveness of Augmented Reality Media

The effectiveness of the research that has been done can be seen from the distribution

of pre-test and post-test questions in a large-scale trial in 5th-grade SDN 02 Sanggrahan, Temanggung, Central Java, Indonesia. Before the questions were tested, the quality was first tested in 6th-grade, which consisted of 15 students. Testing questions consist of validity, reliability, level of difficulty and distinguishing power with the number of questions used as many as 15 multiple-choice questions.

### 1. Validity

In successful learning, using augmented reality media that has been implemented an evaluation test is needed. As for validity test calculation, the researcher used the Microsoft Excel in the 2013 version. The validity test used the product moment formula, which is to see the correlation comparison ( $r_{xy}$ ) of all items with the price of  $r$  table. If  $(r_{xy}) > \text{table}$  then the item is declared valid and vice versa if  $(r_{xy}) < \text{table}$  then the item is declared invalid. Detailed validity results can be seen in table 6 below.

Table 6 Item Validity Test Results

Question Form	Criteria	Question Number	Amount
Multiple Choices	Valid	1,2,3,4,5,6,7,8,9,10,12,14,15,16,17,18,19,20	18 Items
	Invalid	11,13	2 Items

Based on table 6 above, there are multiple choice questions with a total of 18 valid questions and 2 invalid questions. Valid questions totaling 20 items can be used to test completeness and increase students' spatial reasoning abilities, while invalid questions totaling 4 items are not used.

### 2. Reliability

Reliability was analyzed after the validity test, the researcher analyzed the test to determine the reliability index. To find out whether the test is reliable or not, the researcher used criteria with equal to or greater than 0.70 limits, meaning the test is declared to have high reliability and vice

versa. After the questions were tested using Microsoft Excel 2013 version. The reliability results on multiple choice questions were obtained at 0.9146, meaning that the reliability of the questions was very high.

### 3. Difficulty Level

Through calculations using Microsoft Excel 2013 version, it can be determined which questions have a level of difficulty with the criteria of very easy; easy; medium; difficult; and very difficult.

Based on the calculation results with Microsoft Excel 2013 version, the results can be seen in table 7 below.

Table 7 Difficulty Level Analysis

Question Form	Criteria	Question Number	Amount
Multiple Choices	Very Easy	8,16	2 Items
	Easy	0	0 Items
	Medium	1,2,3,4,5,6,7,9,10,11,13,14,15,17,18,19,20	18 Items
	Very Difficult	0	0 Items

The results of the analysis in table 7 using data on the level of difficulty, the researcher used questions of medium and difficult level of difficulty criteria, while the criteria for the very easy and easy questions were not used.

### 4. Differential Power

The analysis of the discriminatory power question is used to determine whether the questions can distinguish students with high and low abilities. Table 8 below is the result of the differential power analysis of the items.

**Table 8 Differential Power Analysis**

Question Form	Criteria	Question Number	Amount
Multiple Choices	Worst	0	0 Items
	Bad	0	0 Items
	Medium	17	1 Items
	High	1,2,3,4,5,6,8,10,11,12,13,14,18,19,20	15 Items
	Highest	7,9,15,16	4 Items

The results of data analysis 8 above using data on differentiating power, the researcher used criteria questions: medium, high and highest, while the criteria of bad and worst were not used.

Based on the test consisting of validity, reliability, level of difficulty, and differentiating power of 15 students, 15 multiple choices can be used by the researcher to conduct pre-test and post-test to improve learning outcomes and students' understanding abilities.

The pre-test learning of 25 students before using augmented reality resulted in 9 (36%) students who have achieved completeness, meanwhile, only 16 (74%) students have not completed it yet

On the other side, the pre-test spatial of 25 students before using augmented reality resulted in 21 (84%) students who achieved completeness, meanwhile, 4 (16%) students have not completed it yet. Upon implementing the learning process using augmented reality teaching material-based, then the post-test assessment was undertaken, and it was obtained from learning outcomes and spatial understanding abilities.

The results of the post-test learning showed that of the 25 students who achieved completeness, 21 students (84%). While those who have not completed as many as 4 (16%), with an average value of 74%). Pre-test and post-test were assessed by normality test through Kolmogorov-Smirnov, particularly by using Microsoft excel 2013 version. The learning result showed pre-test as much as 0.167 higher than 0.05, and thus, normally distributed. Meanwhile, the post-test resulted in 0.140 higher than 0.05, hence distributed normally.

The result of the spatial post-test ability of 25 students showed that there were 20

(82%) students achieved completeness, meanwhile, those who have not completed yet were 5 (18%) students, with an average of 85%. Pre-test and post-test were assessed by normality test through Kolmogorov-Smirnov, particularly by using Microsoft excel 2013 version. The learning results showed that the pre-test was 0.241 more than 0.05, thus, normally distributed, and the post-test 0.172 was greater than 0.05 which means the data was normally distributed.

Calculation of N-Gain and learning using augmented reality teaching material showed the result of average learning in 62,4 pre-tests and 94 post-tests. The increase calculation of N-Gain was as much as 0.9250 with a fairly effective category. The research showed that learning with augmented reality teaching material is effective to increase spatial reasoning ability. This thing being said if augmented teaching material is effective enough to use learning results and student' spatial reasoning ability in 5th-grade of elementary school.

## CONCLUSION

Based on research result that has been undertaken, thus, it can be concluded that: 1) Development of Mathematics learning material by augmented reality based is used to increase students' spatial reasoning in 5th-grade of elementary school; 2) Mathematics learning material by augmented reality based is assessed as valid by the validator, learning validator media by 62 scores is categorized as highly valid, learning validator material by 45 scores is categorized as highly valid.; 3) Mathematics learning material by augmented reality-based, is seen as attractive by students in 5th-grade and teachers in SDN 02 Sanggrahan, Temanggung, Central Java.

The attractive result measurement of Mathematics learning material using augmented reality based on students is as much as 1538 out of 1680 maximum scores, it is used the interval of  $X > 1262$ , which means categorized as highly attractive; 4) Learning augmented reality is effective to increase the study result and spatial ability of students in 5th-grade at SDN 02 Sanggrahan. The result of N-gain is as much as 61.347 categorized as a medium, this means Mathematics learning material used augmented reality-based is fairly effective to function the enhancement of students' spatial reasoning in 5th-grade.

**Conflict of Interest:** None

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