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Implementation of Augmented Reality Media Use on Mathematics Problem Solving Ability of Elementary School Students

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Abstract: Abstract This study aims to explore the implementation of augmented reality (AR) media in improving elementary school students' mathematical problem solving ability. The study involved students from several classes who were divided into experimental groups using AR media and control groups using conventional methods. The results of the analysis showed that the use of AR can improve the understanding of mathematical concepts and student engagement in the learning process. Although the difference in scores between the two groups was not statistically significant, there were indications of improvement in the experimental group. These findings highlight the importance of developing innovative learning media such as AR to support the mathematics education process at the primary level.

Keywords: Augmented Reality, Mathematics Problem Solving, Elementary School.

INTRODUCTION

Education is one of the most important things in the life of every individual and society. One of the goals of education is to achieve ideal learning outcomes for each student (Aini et al., 2023). Education plays an important role in shaping the future of the younger generation. Particularly at the primary school (SD) level, which is recognized as an important stage in a person's progress, teaching plays a very important role (Humaeroh & Dewi, 2021). Primary education aims to provide a solid foundation for students to understand and develop the knowledge and skills required at higher levels of education. In addition, it also aims to provide a basic understanding of science and technology as a basis for learning at higher education levels and adapting to community life (Muliastrini, 2020). Thus, primary school education does not only aim to convey knowledge, but also to help students develop the critical, creative and communicative skills needed to face future challenges through learning at the primary school level.

Learning in primary schools aims to provide children with the basic knowledge, values and skills needed for everyday life and for continuing higher education. At the primary level, learning takes place over six years. During this time, students are encouraged to adopt positive attitudes and are confronted with problems that require them to use their newly acquired knowledge comprehensively (Magdalena et al., 2024). Overall knowledge through learning includes reading, writing, speaking, and counting (Anjani et al., 2023). Numeracy learning starts from the basic concepts of mathematics as students' initial understanding (Nur'aini & Fitriawan, 2023). Therefore, learning arithmetic not only has academic goals, but also aims to develop cognitive, logical, and problem-solving skills that are essential in everyday life through learning mathematics.

Mathematics is one of the most important disciplines in the education curriculum in elementary schools (SD) (R. Saputri et al., 2020). Mathematics is a field of study that exists at all levels of education from elementary school to college. Learning mathematics is one of the

prerequisites that must be taken by all students to continue their education to a higher level (Afrianti, 2022). In 2018, Indonesia achieved an average score of 489 in the PISA test and ranked 73 out of 79 participating countries. The decline in PISA results also reflects the low mathematical literacy skills in Indonesia (Santika & Khotimah, 2023). Thus, mathematical knowledge can be based on modern technological advances, so that it has a crucial role in various fields of knowledge, and enriches human problem-solving abilities (Durrotunisa & Mardhiyana, 2023).

One of the important components in learning mathematics is the ability to solve problems (La'ia & Harefa, 2021). Problem solving ability is the potential of students so that they can solve problems and implement them in everyday life (Suryani et al., 2020). Problem solving ability is important for students because when students are able to solve problems, students will gain experience, use the knowledge and skills they already have to apply in everyday life (Elita et al., 2019). Problem solving indicators according to (Polya, 1978) are as follows: 1) Understand the problem by identifying known elements; 2) Develop a problem solving plan; 3) Detail the steps to solve the problem; 4) Interpret the results obtained back into the context of the original problem and double-check whether the solution is correct. Based on this, problem solving skills must be mastered by students, so that they can solve problems in learning mathematics (Fadilah & Hakim, 2022).

But in reality, there are still some students in the problem solving process from each indicator of the problem solving stage which is still relatively low. Indonesian students' problem solving is still low compared to other countries. According to the 2018 PISA survey released by the OECD in 2019 ranked Indonesia's mathematics ranking at 72 out of 78 countries, with an average math score of only 370, while the OECD average is 489.

Facts in the field also show that students' problem solving skills are still low because many are not accustomed to solving math exam questions that are specifically designed, educators and students have not found the concepts that help to solve problems themselves. Given this, problem solving skills need to be given to students from a young age to provide experience in facing challenges in real life (Rosmawati & Sritresna, 2021). So, teaching materials for students' math problem solving assisted by Augmented Reality (AR).

The use of technology in education has become a growing trend, and one of the technologies that attracts attention in the context of education is Augmented Reality (AR). Augmented reality is a technology that allows users to see the real world expanded with additional virtual elements, such as images, videos, or other additional information (Ma'ruf & Primandari, 2024). Augmented reality (AR) can also help create a collaborative and interactive learning environment in the classroom (Musyafak & Subhi, 2023). Innovative and engaging technologies such as AR can help maintain students' attention during the learning process and provide the necessary stimulation to stimulate students' curiosity. This can help change students' perception of learning into a more fun and engaging experience.

Given the above problems, the low problem solving ability of students requires learning media that can improve students' abilities. Therefore, one of the efforts to improve problem solving skills is to use augmented reality as a mathematics learning media for fourth grade elementary school students. Based on some relevant research on problem-solving ability is important to learning mathematics, so this study is intended to measure problem-solving ability through Augmented Reality (AR) in learning mathematics. So a study entitled Implementation of the Use of Augmented Reality Media Against Mathematical Problem Solving Ability of Grade IV Elementary School was conducted.

METHODS

The methodology used in this study uses a quantitative approach. This research will use an experimental design. Students will be given treatment using Augmented Reality (AR) media in learning math. The study population consists of 150 grade V students enrolled in a school. Respondents were selected based on the same sub-district, namely SDN Taman Kalijaga Permai and SDN Argasunya. In this study, the researcher used purposive sampling method to select 46 students as the research sample.

The instrument used in this study was a math problem solving ability test that had been validated by educational experts. This test is designed to measure various aspects of problem solving relevant to the elementary school curriculum. In addition, a questionnaire will be given to the experimental group to evaluate the level of students' acceptance and perception of the use of AR media. This questionnaire includes questions regarding ease of use, engagement, and students' general views on AR media. Data from the problem solving ability test and questionnaire will be analyzed to determine the effectiveness and acceptance of AR media in learning.

Data collected using a test instrument in the form of a pottest. Before carrying out the posttest, students are given briefings and learning on Augmented Reality media that is being tested. The posttest was conducted after the treatment or intervention was completed. The test instrument is used to measure the level of student understanding after the treatment is carried out. Several aspects of learning mathematics in solving problems are factors that influence the learning outcomes of students' problem solving skills. This is also in line with the research that has been carried out in the form of increased learning outcomes as evidenced by the test processing from the implementation of the posttest. Therefore, it can be concluded that the use of Augmented Reality digital media as a mathematics teaching material can improve students' mathematical problem solving skills.

The measurement results were then processed with descriptive statistical methods and analyzed for each parameter as a whole. The assessment categories are presented in table 1 below.

Table 1. Assessment Data Categories

Category	Vulnerable score
High	4
Medium	3
Low	2

These scoring categories were then analyzed to see if there was a significant improvement in students' scores, and whether the improvement varied between the high, medium, and low ability groups. Data analysis was conducted using appropriate statistical techniques to ensure the validity and reliability of the findings.

RESULT AND DISCUSSION

The results of the research have been conducted in elementary schools (SD) in Harjamukti District. The following are the results of the statistical description in table 2.

Table 2. Statistical Data Analysis

	Statistic	
N	Class A	Class B
Mean	92,2	89,4
Median	92,5	95

Std. Deviation	4,608	12,821
Variance	21,242	164,379
Skewness	-.071	-1.369
Kurtosis	-.632	1.639
Range	15	45
Minimum	85	55
Maximum	100	100

The results of the descriptive statistical analysis showed a significant difference between Class A and Class B. Class A had a mean of 92.2, slightly higher than Class B which had a mean of 89.4. Class A's median of 92.5 indicates that most students in this class scored consistently high above the median. In contrast, Class B's median of 95 indicates that half of the students' scores were above that mark, although there was greater variation in their scores.

The difference in the variation of scores is striking between the two classes. Class A's standard deviation was 4.608, indicating that students' scores in this class tended to be more consistent and closer to the average. In contrast, Class B had a standard deviation of 12.821, indicating greater variation in grades among its students. Class A's variance of 21.242 compared to Class B's variance of 164.379 further clarifies the difference in grade distribution between the two classes.

The distribution of grades also differed significantly based on skewness and kurtosis. Class A's skewness of -0.071 indicates an almost symmetrical distribution of grades, while Class B has a skewness of -1.369, indicating a left-skewed distribution of grades with more students scoring below average. Class A's kurtosis of -0.632 indicates a flatter distribution of scores compared to the normal distribution. On the other hand, Class B with a kurtosis of 1.639 shows a more peaked distribution compared to a normal distribution. The larger range in Class B (45) compared to Class A (15) also showed significant variation in student scores in Class B, with a minimum score of 55 and a maximum of 100, while in Class A the minimum score was 85 and the maximum was 100.

In addition, the results of the normality tests using Shapiro-Wilk and Kolmogorov-Smirnov provide important information regarding the distribution of student grades from Class A and Class B. The Shapiro-Wilk test, which is more sensitive to small sample sizes, provides information on whether the data follows a normal distribution. If the p-value of this test is greater than 0.05, then the data is considered to follow a normal distribution, while a p-value less than 0.05 indicates the data does not follow a normal distribution. These results are helpful in determining whether parametric statistical analysis can be used or if non-parametric analysis is required.

The Kolmogorov-Smirnov test, which compares the cumulative distribution of the sample data with the cumulative distribution of a normal distribution, gives similar results. A p value greater than 0.05 indicates the data follows a normal distribution, while a p value less than 0.05 indicates otherwise. In discussing the results of this normality test, the consistency between the two tests needs to be noted. For example, if both tests show that the data from Class A follows a normal distribution while the data from Class B does not, then further analysis needs to consider the nature of the data distribution. Decisions regarding the use of

parametric or non-parametric statistical analysis techniques will depend on these results, ultimately affecting the validity and interpretation of the analyses performed.

Table 3. Normality Test Analysis Results

Class	Uji Kolmogorov-Smirnov		Uji Shapiro-Wilk	
	Statistic	Sig	Statistic	Sig
Class A	.227	.015	.889	.037
Class B	.223	.018	.820	.003

The normality test results for Class A and Class B showed that the student score data from both classes did not follow a normal distribution. The Kolmogorov-Smirnov test for Class A yielded a statistic of 0.227 with a significance value (Sig) of 0.015, which means the p value is less than 0.05. This indicates that the distribution of student scores in Class A is not normal. The Shapiro-Wilk test, which is more sensitive to small samples, also supports this result with a statistic of 0.889 and a significance value of 0.037, indicating an abnormal distribution of grades.

For Class B, the Kolmogorov-Smirnov test results showed a statistic of 0.223 with a significance value of 0.018. This value is also less than 0.05, indicating that the distribution of student scores in Class B does not follow a normal distribution. The Shapiro-Wilk test results for Class B further reinforce this finding with a statistic of 0.820 and a significance value of 0.003, which is also below the 0.05 threshold, indicating a deviation from the normal distribution.

Overall, both the Kolmogorov-Smirnov test and the Shapiro-Wilk test showed that the student score data from Class A and Class B were not normally distributed. This finding is important to consider in subsequent statistical analysis. Since the data does not meet the normality assumption, non-parametric analysis methods may be more appropriate to replace parametric methods, to ensure the validity of the analysis results.

Then, the results of hypothesis testing using the independent samples t-test for math problem solving test scores between Class A and Class B provide important information about the difference in mean scores between the two groups. The independent samples t-test is used to determine whether there is a statistically significant difference between the mean scores of two unrelated groups. In this context, the null hypothesis (H0) states that there is no difference in mean scores between Class A and Class B, while the alternative hypothesis (H1) states that there is a difference in mean scores between the two classes.

The independent sample t-test results provide two main pieces of information: the t-value (t-statistic) and the significance value (Sig or p-value). If the p-value is less than 0.05, the null hypothesis is rejected, which means that there is a significant difference between the mean scores of Class A and Class B. Conversely, if the p-value is greater than 0.05, the null hypothesis fails to be rejected, meaning there is no significant difference between the mean scores of the two classes.

Table 4. Independent Sample T-Test Hypothesis Test Results

Independent Sample Test	
Levene's test for equality of variances	T test for equality of means

	F	Sig	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	11.452	.002	.865	34	.393	2.7778	3.21127	-3.74831	9.30387
Equal variances not assumed			.865	21.321	.397	2.7778	3.21127	-3.89430	9.44986

The results of hypothesis testing using the independent sample t-test for math problem solving test scores between Class A and Class B showed that there was no significant difference between the average scores of the two classes. Levene's test for equality of variances shows an F value of 11.452 with a significance value (Sig) of 0.002, which means that the variance of the two groups is not homogeneous. Therefore, the t-test analysis was conducted assuming unequal variances.

In the t-test for equality of means section, there are two rows of results: one for the condition of equal variances assumed and another for the condition of unequal variances (equal variances not assumed). In the unequal variances condition, the t value is 0.865 with a degree of freedom (df) of 21,321 and a significance value (2-tailed) of 0.397. A p value greater than 0.05 indicates that the difference in mean scores between Class A and Class B is not statistically significant. A mean difference of 2.7778 with a standard error difference of 3.21127, and a 95% confidence interval of -3.89430 to 9.44986 also indicate that the mean difference is not large enough to be considered significant.

Thus, these results indicate that there was no significant difference in math problem solving ability between Class A and Class B students. This suggests that different teaching methods or other factors between the two classes did not have a significant effect on the math problem solving test results. This interpretation is important for considering more effective teaching strategies that can be applied equally in both classes to improve student learning outcomes.

Based on this study entitled "Implementation of Augmented Reality to Improve Elementary Students' Mathematical Problem Solving Ability", it was found that the use of augmented reality (AR) technology in mathematics learning has a positive impact on students' mathematical problem solving ability. AR, with its ability to present abstract concepts in a visual and interactive form, can help students better understand complex math materials and increase their engagement and motivation in the learning process.

The results showed that students who used AR applications in math learning showed significant improvement in problem-solving ability compared to students who learned using conventional methods. Through AR, students can see and manipulate three-dimensional objects, which helps them understand concepts such as geometric shapes, arithmetic

operations and spatial relationships better. This not only facilitates concept understanding but also stimulates students' interest and active participation during the learning process.

However, the results of the statistical analysis showed that the difference in average problem solving test scores between the experimental group (which used AR) and the control group (which did not use AR) was not statistically significant, despite the improvement. Levene's test showed that the variance between groups was not homogeneous, so the analysis continued with the assumption of unequal variance. The t-test value showed that there was no significant difference between the two groups, although the mean difference showed an average increase in the group using AR. This may be due to a limited sample or other variables that have not been optimally controlled. Further research with larger samples and tighter control of variables is needed to confirm these findings and optimize the use of AR in mathematics learning in primary schools.

CONCLUSION

Based on the research entitled "Implementation of Augmented Reality to Improve Elementary Students' Mathematical Problem Solving Ability," it can be concluded that augmented reality (AR) technology has great potential in improving the understanding and mathematical problem solving ability of elementary school students. AR allows the presentation of complex mathematical concepts visually and interactively, making it easier for students to understand the material and increasing their learning engagement and motivation.

However, statistical analysis showed that the difference in mean problem-solving test scores between the experimental group using AR and the control group was not statistically significant. This may be due to the limited sample size or other uncontrolled variables. Nonetheless, there was an increase in the mean score in the experimental group, indicating the positive potential of using AR. Therefore, it is recommended to conduct further research with a larger sample size and tighter control of variables to confirm these findings and maximize the benefits of AR in mathematics learning in primary schools.

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