JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

Games-Based Learning Integrated Entry Point Strategy Assisted by Augmented Reality for Mathematical Problem Solving

Nuhyal Ulia[1], Rida Fironika Kusumadewi[2], Mohamad Hariyono[3], Rizky Tantina[4], Afifatul Maulida[5]

[1,2,4,5]Department of Elementary School Teacher Education, Universitas Islam Sultan Agung, Indonesia
[3]Department of the Elementary School Teacher Education, Universitas Terbuka, Indonesia
*Email: nuhyalulia@unissula.ac.id

ARTICLE INFO

Keywords:
Game-Based Learning
Entry Point Strategy
Augmented Reality
Problem Solving

ABSTRACT

Purpose –To examine the effectiveness and the effect of Games-Based Learning Integrated Entry Point Strategy Assisted by Augmented Reality on elementary school students' mathematical problem-solving abilities.

Methodology – The type of research used is a Quasi-experimental design with a pretest-posttest-only control group design. Data collection uses test instruments, with data analysis techniques including normality tests, homogeneity tests, paired-sample t-tests, gain t-tests, and independent t-tests. The population in this study was fifth-grade students of SDN 1 Purwogondo and SDN 01 Ngagel. The sample in this study consisted of 30 students, 15 in the experimental group and 15 in the control group.

Findings – Game-based learning integrated with an entry point strategy assisted by Augmented Reality is effective on elementary school students' mathematical problem-solving abilities, as indicated by the results of the independent t-test obtained sig 0.000 < 0.05 and the results of the paired sample t-test obtained sig 0.000 < 0.05 with a high gain value of 0.75. meaning there is an increase in students' mathematical problem-solving abilities after Game-based learning integrated with an entry point strategy assisted by Augmented Reality

Contribution – This study contributes to elementary school teacher education by integrating an Augmented Reality-assisted entry point strategy into a Games-Based Learning model that effectively improves elementary school students' mathematical problem-solving skills.

Received 29 April 2026; Received in revised form 10 May 2026; Accepted 17 July 2026
Jurnal Eduscience (JES) Volume 13 No. 4 (2026)
Available online 30 August 2026

INTRODUCTION

Problem-solving skills are important for students to master in learning mathematics because they will always encounter mathematical problems. Indirectly, students learn how to face challenges both in learning mathematics and in real-life contexts (Aisyah et al., 2025). In addition, problem-solving skills are one of the competencies in 21st-century skills (Siswanto et al., 2025) and is one of the main skills emphasized in NCTM (Owens et al., 2019) as an essential skill for facing the challenges and problems of everyday life .<|join|>as an essential skill for facing the challenges and problems of everyday life. The low mathematical problem-solving ability of students is caused by the use of inappropriate learning models and the lack of learning media that can stand out to students and make it easier for them to solve mathematical problems (Guntur et al., 2025). Problem-solving is essential in learning mathematics. Mathematical problem-solving skills can be applied in everyday activities to solve everyday problems. Students' ability to solve mathematical problems is often a challenge for them, so teachers must strive to address it. Many teachers still use the lecture method in their learning process, meaning students are passive, and the teaching and learning activities are dominated by the teacher (*teacher-centered*) (Widyastuti et al., 2025). Mathematics learning at all levels of education should be designed to not only reinforce abstract concepts but also integrate the ability to solve problems related to real situations (Muntheawati et al., 2025). To improve problem-solving skills, teachers can stimulate students' problem-solving processes through problems prepared by the teacher that are deeper or more complex, which are presented in a supportive learning environment, such as media or demonstrations, in which the entire problem-solving process can be captured. (Häkkinen et al., 2016).

In the modern era of education, technology plays a crucial role in enriching the teaching and learning process. One technological innovation that is becoming increasingly popular among educators is Game-Based Learning (GBL) (Prananda et al., 2025). Teachers must be able to find new and effective methods and approaches to learning that are tailored to classroom conditions. Game-based learning can be applied to these situations. Game-based learning has become a popular choice in learning environments with the development of computer and smartphone technology. (Pranata, 2023).

Some of the advantages of game-based learning are a) game-based learning allows active learning, increases student interest and involvement, and provides quick feedback, b) high student involvement in solving problems in the game will train students' critical thinking skills, c) can have a positive impact on students' academic achievement, problem-solving skills and student learning motivation, d) learning is more interactive and fun, e) in some cases, games can build dialogue and break down socio-cultural barriers, f) eliminate boredom in learning, because learning is done by playing, g) improve various skills. Apart from having advantages, game-based learning also has several disadvantages, including a) it is complex and time-consuming in the process of making it, b) not all teachers have the skills to make games, so they need to take certain courses, c) the classroom atmosphere is too active and sometimes causes noise so it is not conducive, and e) it requires more tools and instruments. (Wahyuning, 2022).

Entry points are a flexible and applicable learning strategy. They can be combined with various learning models. They serve as entry points to facilitate student interest and readiness to learn. They can also accommodate diverse student abilities. (Sri Cahyani & Nurlaeli, 2024)Providing multiple entry points into the same material can make learning more engaging and challenging. In practice, teachers identify and activate students' prior knowledge, which serves as an entry point in the learning design. (Hasanuddin, 2020).

Current learning media have also evolved along with technological advancements. Today's technology allows for the integration of the digital and real worlds, a technology called Augmented Reality. (AR)2021; Mikkael. AR is a technology that combines the real and virtual (digital) worlds by displaying three-dimensional (3D) objects in the real world through the camera, so that the camera appears to show the 3D object as if it exists in the real world. AR also makes it possible to display illustrations that are difficult to realize concretely (Setiawan et al., 2022). This is an opportunity to use AR in learning activities. Augmented Reality (AR) is increasingly developing, making this technology much sought after (Suharso, 2012). The advantages of AR (Mustaqim & Kurniawan, 2018) are 1) more interactive, 2) effective in use, 3) can be implemented widely in various media, 4) simple object modeling, because it only displays a few objects, 5) creation that does not cost too much, and 6) easy to operate. While the disadvantages of AR are: 1) Sensitive to changes in viewpoint, 2) There are not too many makers, and 3) Requires a lot of memory on the installed equipment. Research on the development of learning media using Augmented Reality (AR) has been conducted extensively, including research by Afthori et al. (2019), which uses the Unity3D and Vuforia software applications to display created 3D objects.

Based on interviews and observations at SDN 1 Purwogondo and SDN 01 Ngagel, students' problem-solving abilities remained low; some were below the KKTP (National Minimum Competency Level). Therefore, an effective learning model is needed to develop students' mathematical problem-solving abilities. Therefore, an effective learning model is needed for students' mathematical problem-solving abilities. Game-based learning, integrated with an entry-point strategy and augmented reality, is expected to have a positive and effective effect on students' problem-solving abilities.

Based on the background, the problem formulation is as follows: Does games-based learning, integrated with an entry-point strategy assisted by augmented reality, influence the mathematical problem-solving abilities of elementary school students? Moreover, are games-based learning integrated with an entry point strategy assisted by augmented reality effective on the mathematical problem-solving abilities of elementary school students? The purpose of this study is to test the influence of game-based learning integrated with an entry point strategy assisted by augmented reality on the mathematical problem-solving abilities of elementary school students and to test the effectiveness of game-based learning integrated with an entry point strategy assisted by augmented reality on the mathematical problem-solving abilities of elementary school students.

From the identified problems, it was found that the ongoing learning has not used a learning model that students like, has not used interactive strategies, and has not used current digital learning media, resulting in students' learning being less enthusiastic. Finally, the learning outcomes, as reflected in students' mathematical problem-solving abilities, remain low, so there needs to be a solution to address this problem. Based on this problem identification, researchers propose a problem-solving approach using game-based learning integrated with an entry-point strategy assisted by augmented reality, in the hope that it will be effective in improving students' mathematical problem-solving abilities.

This research presents state-of-the-art and novel approaches to game-based learning integrated with an entry-point strategy aided by augmented reality. Many previous studies have examined game-based learning in isolation, without linking it to specific strategies or augmented reality media. Extensive research on game-based learning has been conducted. (Anggraini et al., 2021; Banani et al., 2024; Diana, 2022; Pratiwi et al., 2024; Putra et al., 2024; Sanjoyo et al., 2024) However, a combination of entry-point strategies and augmented reality media has never been used to improve problem-solving ability. This study differs from previous research in that the treatment provided was game-based learning integrated with entry-point strategies and augmented reality. This study is novel in that it integrates game-based learning with entry-point strategies and augmented reality to improve students' mathematical problem-solving abilities.

METHODOLOGY

Research Design

The type of research used is quasi-experimental or pseudo-experimental to test the effects and differences between two groups, namely the experimental and control groups. Two sample classes are required for the research design. In this study, the researcher used a quantitative approach, a research method based on post-positivist philosophy, to examine a specific population or sample. Quantitative research uses data in the form of numbers and statistical analysis. The experimental class will receive treatment, while the control class will not. The design used is a pretest-posttest-only control design, in which the pretest is administered to the experimental group, and the posttest is administered after treatment. The experimental group receives treatment in the form of game-based learning integrated with an entry-point strategy assisted by augmented reality, while the control group uses conventional learning (Gerst et al., 2020). The purpose of conducting experiments is to identify and analyze symptoms or effects that result from administering certain treatments. The experimental research method is a research approach carried out through experimental activities and is classified as a quantitative method. This method is used to test the effect of independent variables, in the form of treatments, on dependent variables as outcomes by setting research conditions under controlled conditions.

Participant

The population of this study consisted of fifth-grade elementary school students in Kendal and Pati Regencies. The research locations were SDN 1 Purwogondo, Boja, Kendal, and SDN 01 Ngagel, Dukuhseti, Pati. The sample consisted of fifth-grade students from SDN 1 Purwogondo and SDN 01 Ngagel, with one group serving as the experimental group and the other as the control group. The population of this study comprised 40 fifth-grade students from SDN 1 Purwogondo and SDN 01 Ngagel. The sampling technique used is simple random sampling, in which the sample is drawn at random. The sample in this study consisted of 30 students, 15 in the experimental group and 15 in the control group.

Data Collection

To obtain accurate data in research, tests can be used. According to Musfirah et a.,l (2025) A test is a tool for measuring and collecting information about an object's characteristics. There are two types of test instruments used in this study: a pretest, which is an activity used to assess students' knowledge of the material to be presented. The pretest is administered before the learning activity, and a posttest is administered at the end of the learning process for the material to determine students' understanding of the material and the key points learned. (Magdalena et al., 2021). Based on this explanation, this study used an essay-based test on problem-solving skills, consisting of a pretest and a posttest. Before using the test instrument, a pilot test was conducted to determine its validity, reliability, discriminatory power, and difficulty level.

Instrument

In this study, the instrument was a test sheet designed to measure students' mathematical literacy. The instrument used in this study was a test, which served as a tool for researchers to determine the presence or absence of, and the level of, the ability of the object being studied. Essay questions are a form of test that requires students to submit their answers in writing by explaining the process, steps, or reasoning used to solve a problem. (Rohim, 2019). This question aims to determine students' mathematical problem-solving abilities.

Data Analysis

This study used data analysis techniques, including normality tests, homogeneity tests, independent t-tests, paired-samples t-tests, and gain tests. Each test is explained as follows:

Normality Test

This test aims to determine whether the initial sample data is normally distributed. If the data is normally distributed, the statistical test is parametric. If the data is not normally distributed, the statistical test is non-parametric. The hypotheses are as follows:

H0: The sample comes from a normally distributed population

H1: The sample comes from a non-normally distributed population

The normality test was conducted using SPSS using the Shapiro-Wilk test. With a significance level of 5%, if the sig. value in the Shapiro-Wilk test is >5%, H0 is accepted, and if the sig. value is <5%, H0 is rejected.

Homogeneity Test

The homogeneity test is conducted to determine whether two or more groups have the same level of variation. SPSS is used to measure the homogeneity of variance between two data groups. The hypotheses are as follows:

H0: Both samples have homogeneous variances

H1: Both samples have non-homogeneous variances

The significance level applied is α = 0.05. The homogeneity test is performed in SPSS, with the following qualification: if the calculated F-value exceeds the table F-value, the variances are homogeneous. However, if the calculated F-value is greater than the table F-value, then the variances are non-homogeneous. The homogeneity test in SPSS can also be seen in the results of Levene's Test of Equality of Variances. The decision-making criteria are very simple and based on the significance value (Sig.) or p-value displayed in the Test of Homogeneity of Variances table. If Sig. > 0.05, the data are considered homogeneous (equal variances between groups).

Independent T-test

An independent t-test is used to measure differences between two groups. This study measured the differences between the group using games-based learning integrated with an entry-point strategy and augmented reality and the group using a conventional learning model. The hypotheses used are as follows:

H_0: $\mu_1 \leq \mu_2$ (The average problem-solving ability of students in the games-based learning integrated with an entry-point strategy and augmented reality is less than or equal to the average problem-solving ability of students in the conventional class).

H_i: $\mu_1 > \mu_2$ (The average problem-solving ability of students in the games-based learning integrated with an entry-point strategy and augmented reality is better than the average problem-solving ability of students in the conventional class).

To test for differences in means, a homogeneity test, or test for equality of variances, is first performed. H0 is accepted if the formula used is highly dependent on the results of the equality of variance test between the two groups.

In the SPSS output table, the results of the independent sample t-test can be seen in the Levene's Test for Equality of Variances column. If Sig. If Levene > 0.05, the data are homogeneous; then look at "Equal variances assumed" in the t-test for Equality of Means section. If Sig. value < 0.05 indicates a significant difference between the experimental and control groups.

Paired Simple t-test

The paired-pairs t-test for mean differences in problem-solving ability was intended to determine differences in problem-solving ability in classes using game-based learning integrated with the entry point strategy and augmented reality before and after treatment. The hypotheses are as follows.

$H_0 : \mu_1 \leq \mu_2$ (mean problem-solving ability after treatment ≤ before treatment)

$H_1 : \mu_1 > \mu_2$ (mean problem-solving ability after treatment > before treatment)

The formula used is the same as the one-sample t-test, namely:

$$t = \frac{d - 0}{s/\sqrt{n}}$$

Where d = the average difference between the two measurements and s = the standard deviation of the difference between the two measurements, while n is the number of data pairs. With α = 5% and dk = $dk = (n_1 + n_2 - 2)$ if t_count>t_table then H_0 is rejected and H_1 is accepted. In the SPSS output, the paired-samples t test results are shown in the Paired Samples Test table, in the Sig column (if sig.). If < 0.05, there is a significant difference between the values before (Pre-test) and after (Post-test). This means that the treatment/method you provide has an influence or effect.

Gain Test

To determine the improvement in students' problem-solving skills based on pretest and posttest scores, the following formula for Normality Gain (g) can be used:

$$(g) = \frac{postes\ value - pretes\ value}{maksimum\ value - pretes\ value}\ x\ 100\ \%$$

The Normality Gain (g) value obtained is then interpreted according to the Normality Gain (g) criteria, as presented in Table 1 below.

Table 1. Criteria for Normality Gain (g)

Normality Gain (g)	Criteria
$(g) < 0,3$	Low
$0,3 \leq (g) \leq 0,7$	Medium
$(g) \geq 0,7$	High

FINDINGS

The test instrument used to measure students' problem-solving abilities has passed the validity, reliability, difficulty level, and discrimination tests, meeting the requirements for data collection. The study results were obtained from test data, both pretest and posttest, administered to the experimental and control groups. The experimental group received game-based learning integrated with an entry-point strategy assisted by augmented reality, while the control group received conventional learning. The test is given to measure students' problem-solving abilities. In accordance with the data analysis used, namely the normality test, homogeneity test, paired sample t-test, independent t-test, and gain test. The normality test is used to determine whether the data are normally distributed. The results of the data processing are as follows.

Descriptive Statistical Analysis Results

Descriptive statistical analysis, including measures of central tendency and dispersion, was conducted as a preliminary step to summarize the characteristics of the research data before proceeding to inferential statistical analysis. The descriptive statistics provide a basis for understanding participants' overall performance in each group and provide initial evidence of differences in learning outcomes before hypothesis testing. Furthermore, these findings help determine whether the data exhibit reasonable variation and whether the observed scores adequately represent participant performance. The complete results of the descriptive statistical analysis are presented in Table 1 below.

Table 1. Output of Descriptive Statistics

	Experimental class	Control class
Mean	88.6111	82.5455
Median	90.0000	83.0000
Mode	90.00[a]	90.00[a]
Std. Deviation	8.71199	12.83124
Variance	75.899	164.641
Range	30.00	40.00
Minimum	70.00	60.00
Maximum	100.00	100.00
Sum	1595.00	1816.00

Based on Table 1 (Descriptive Statistics), the results show differences in learning outcomes between the experimental and control classes. The experimental class achieved a mean score of 88.61, higher than the control class's 82.55. This indicates that, in general, students in the experimental class achieved better learning outcomes. The median score for the experimental class was 90.00, while the control class had 83.00. The higher median in the experimental class indicates that half of the students scored above 90. Meanwhile, the mode for both classes was 90, meaning 90 was the most frequently occurring score in both groups. Differences were also seen in the level of data dispersion. The experimental class had a standard deviation of 8.71 with a variance of 75.90, while the control class had a standard deviation of 12.83 with a variance of 164.64. The smaller standard deviation and variance in the experimental class indicate that students' scores were more homogeneous, or evenly distributed, than in the control class, which had greater variation. Overall, descriptive statistics indicate that the experimental class performed better and more consistently than the control class. Higher mean and median scores, along with lower standard deviations, variances, and ranges, indicate this. Thus, preliminary data indicate that the treatment administered to the experimental class may improve learning outcomes.

Normality Test Results

A normality test is performed to determine whether the data are normally distributed, a fundamental assumption for applying parametric statistical tests. In this study, the normality of post-test scores for the experimental and control groups was examined using the Kolmogorov–Smirnov and Shapiro–Wilk tests. The decision criterion for the normality test is based on the significance value (Sig.). The results of the normality test provide a basis for determining whether further analysis can be conducted using parametric statistical methods. The complete results of the normality test are presented in Table 2 below. The post-test data, after normality testing in SPSS, are shown in Table 2 below.

Table 2. Output of Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Postes control group	0.213	15	0.065	0.945	15	0.454
Postes experiment group	0.229	15	0.034	0.920	15	0.196

Based on Table 2 above, the Shapiro-Wilk column shows a sig value of 0.454 > 0.05, indicating that the post-test data in the control class are normally distributed. Meanwhile, the Shapiro-Wilk column below shows a sig value of 0.196 > 0.05, indicating that the post-test data in the experimental class are normally distributed. Given the normality assumption as assessed by the Shapiro–Wilk test, the research data meet one of the prerequisites for parametric statistical analysis. Therefore, further analyses, such as the homogeneity of variance test and the independent-samples t-test, can be conducted to determine whether there are significant differences in learning outcomes between the experimental and control classes.

Homogeneity Test Results

After assessing normality, a homogeneity test of variance was conducted to determine whether the variances of the experimental and control groups were statistically equal. In this study, the homogeneity test was conducted using Levene's Test for Equality of Variances. The decision criterion was based on the significance value (Sig.), where a significance value greater than 0.05 indicates that the group variances are homogeneous. In contrast, a significance value less than 0.05 indicates that the variances are significantly different. The results of the homogeneity test provide a basis for selecting the appropriate statistical procedure at the hypothesis testing stage. The complete results of the homogeneity test are presented in Table 3 below.

Table 3. Output of the Homogeneity test

		Levene's Test for Equality of Variances	
		F	Sig.
VAR00001	Equal variances assumed	2.073	0.518

The results of the homogeneity test using Levene's Test for Equality of Variance are presented in Table 3 above. The analysis yielded an F value of 2.073 and a significance (Sig.) of 0.518. Because the significance value (0.518) is greater than the predetermined significance level of 0.05, the null hypothesis of equality of variance cannot be rejected. This indicates that there is no statistically significant difference in variance between the experimental and control groups. This finding indicates that the data meet the assumption of homogeneity of variance, meaning that the variability of scores in both comparative groups is the same. As a result, equality of variance is satisfied, allowing the researcher to proceed with the parametric statistical analysis using the Independent Samples t-test under the Equality of Variance Assumption.

Independent T-Test Results

After ensuring that the assumptions of normality and homogeneity of variance were met, an independent sample t-test was conducted to determine whether there was a statistically significant difference in post-test scores between the experimental and control groups. This analysis aimed to test the research hypothesis by comparing the learning outcomes of students who received the experimental treatment with those who received conventional instruction. The results of the independent-samples t-test provide empirical evidence of the instructional treatment's effectiveness in improving student learning outcomes. The complete results of the hypothesis testing are presented in the following table—the result of the Independent Sample t Test in Table 4 below.

Table 4. Output of Independent Sample t Test

	t	df	Sig. (2-tailed)	Mean	Std. Error	95% Confidence Interval Lower	95% Confidence Interval Upper
Equal variances assumed	9.596	38	0.000	34.247	3.56879	27.022	41.472
Equal variances not assumed	9.972	36.798	0.000	34.247	3.43434	27.288	41.207

Table 4 presents the results of an independent-samples t-test, conducted to examine whether there was a statistically significant difference in post-test scores between the experimental and control groups. Since the homogeneity test indicated that the assumption of equality of variances was met (Levene's Test, Sig. = 0.518 > 0.05), interpretation is based on the Assumption of Equality of Variances row. The analysis yielded a t-value of 9.596 with 38 degrees of freedom (df = 38) and a two-tailed significance level (Sig. = 0.000). Since the significance value was less than the predetermined alpha level of 0.05, the null hypothesis (H_0) was rejected, while the alternative hypothesis (H_1) was accepted. These findings indicate a statistically significant difference in post-test scores between the experimental and control groups. Furthermore, the mean difference between the two groups was 34.247, indicating that the mean post-test score of one group differed by approximately 34.25 points from the other group. A positive mean difference indicates that the experimental group achieved higher post-test scores than the control group. Overall, the Independent Samples t-test indicates that the instructional treatment applied to the experimental group had a significant positive effect on student learning outcomes—students who received the experimental treatment achieved significantly higher post-test scores than students in the control group.

Paired Simple T-Test Results

After comparing post-test scores between the experimental and control groups using an independent-samples t-test, a paired-samples t-test was conducted to examine the effectiveness of the instructional treatment in each group. This statistical test is appropriate for comparing two related sets of scores, namely pre-test and post-test results obtained from the same participants. By analyzing the mean differences between these paired measurements, the test determines whether the observed improvement in student learning outcomes is statistically significant. The results of the paired-samples t-test provide important evidence regarding the magnitude of student learning improvement in each group. These findings complement the results of the independent-samples t-test by showing not only differences between groups but also the extent to which student performance improved after receiving the instructional treatment. The full-sample results of the paired-samples t-test are presented in the following table 5 below.

Table 5. Output of Paired Samples t Test

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval Lower	95% Confidence Interval Upper	t	df	Sig. (2-tailed)
Pair 1	Pretest - Postes	33.33	8.16	2.10	28.81	37.85	15.811	14	0.000

Table 5 presents the results of a paired-samples t-test conducted to determine whether there was a statistically significant difference between students' pre-test and post-test scores after the implementation of the learning treatment. This analysis evaluates the effectiveness of the intervention by comparing the learning outcomes of the same participants before and after the treatment. The results show a mean difference of 33.33 points between pre-test and post-test scores, indicating that student performance improved substantially after the learning intervention. The standard deviation of the paired differences was 8.16, indicating moderate variation in the magnitude of improvement across participants. Furthermore, the standard error of the mean was 2.10, indicating that the estimated mean difference was relatively precise and reliable. The statistical analysis yielded a t-value of 15.811 with 14 degrees of freedom (df = 14) and a two-tailed significance value (Sig. = 0.000). Because the significance value was far below the established alpha level of 0.05, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted. These findings confirm a statistically significant difference between pre-test and post-test scores. Overall, the results of the paired-sample t-test indicate that the instructional treatment had a highly significant positive effect on student learning outcomes. The substantial increase in post-test scores compared to pre-test scores indicates that the implemented instructional approach effectively improved student academic achievement. These findings provide strong empirical support for the intervention's effectiveness and reinforce the results of the independent-samples t-test, which also demonstrated the superiority of the experimental treatment over the conventional learning approach.

Gain Test Results

The results of the paired-samples t-test showed a statistically significant difference between students' pre-test and post-test scores after the implementation of the Entry Point Strategy integrated with Game-Based Learning (GBL) and Augmented Reality (AR). The significance value obtained from the analysis was below the 0.05 threshold ($p < 0.05$), indicating that the observed improvement in students' problem-solving skills was not due to chance. The effectiveness of the learning intervention was further supported by a normalized gain (N-gain) score of 0.75, which falls into the great improvement category. According to commonly used classifications, an N-gain value greater than 0.70 indicates that the learning intervention is highly effective in improving student achievement. An N-gain of 0.75 means that students achieved approximately 75% of the maximum possible improvement from their initial level of understanding. These findings indicate that the observed improvement in problem-solving skills is not only statistically significant but also educationally meaningful.

DISCUSSION

This study aims to examine the influence and effectiveness of implementing Games-Based Learning (GBL), integrated with entry point strategies and augmented with Augmented Reality (AR), on the mathematical problem-solving abilities of elementary school students. This study explores the synergy among modern pedagogy (Games-Based Learning), differentiation strategies (Entry Point Strategy), and immersive technology (Augmented Reality) in improving the mathematical problem-solving abilities of elementary school students. This study investigates the effectiveness and significance of integrating the Games-Based Learning (GBL) approach with entry-point strategies using Augmented Reality (AR) technology to enhance mathematical problem-solving abilities among elementary school students. Based on the hypothesis testing and comparative statistical analyses conducted, the empirical findings in this study confirm that the tripartite learning ecosystem (GBL, Entry Point, and AR) serves as a strong catalyst for students' cognitive development in mathematics. The results of the paired-samples t-test in the experimental group showed a p-value (sig.) of $0.000 < 0.05$. Statistically, these results strongly reject the null hypothesis, indicating a highly significant change in abilities between before and after the intervention. Descriptively, the jump in average ability from the pre-test (55.33) to the post-test (88.67) represents a shift in the classroom learning paradigm. Based on empirical findings, the integration of these three elements has been shown to have a significant positive impact that exceeds conventional learning models. Based on the results of the prerequisite test and an inferential analysis using a paired-samples t-test in the experimental class, a significance value of 0.000 < 0.05 was obtained. These results reject the null hypothesis (H0) and accept the alternative hypothesis (Ha), indicating a significant difference between the scores before (pre-test) and after (post-test) the treatment. Descriptively, this is evidenced by the jump in average student scores from a pre-test average of 55.33 to 88.67 on the post-test, as shown in Figure 1 below.

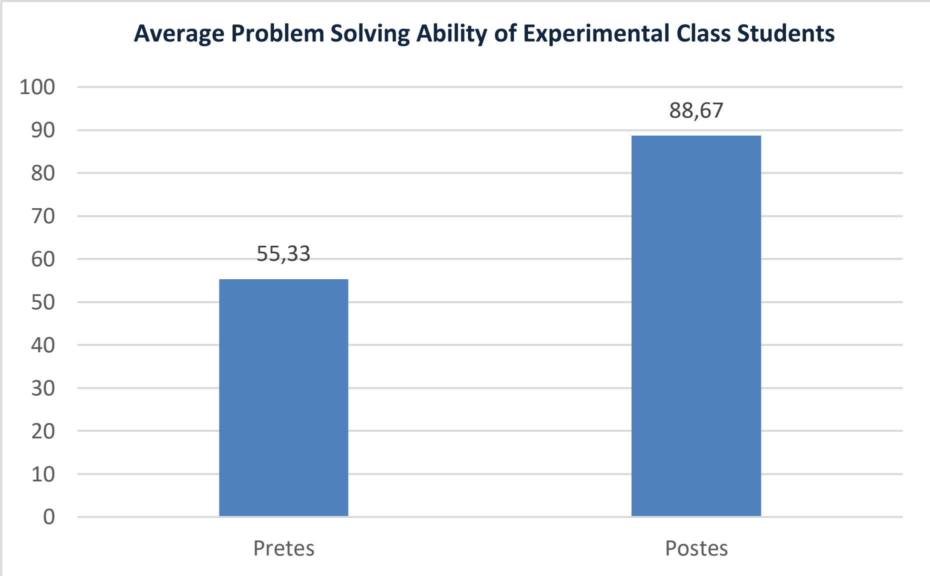

Figure 1. Graph of the average pretest-posttest of the experimental class

The results of the paired-samples t-test showed a significance value of 0.000, indicating a significant change in students' abilities after the treatment. The average increase from 55.33 to 88.67 is not just a number but a representation of a shift in how students process mathematical information. This finding indicates that implementing Games-Based Learning, integrated with the entry-point strategy and augmented with Augmented Reality, has a positive and tangible impact on students' mathematical problem-solving abilities. This improvement is also reflected in each achievement indicator for students' mathematical problem-solving abilities, which shows a positive trend. This significant influence can arise from the characteristics of elementary school students who are still in the concrete operational stage. The use of Augmented Reality helps make abstract mathematical concepts more real and interactive. At the same time, the Games-Based Learning approach creates a fun learning environment, so that students are more motivated to try and are not afraid of making mistakes when solving problems.

Theoretically, elementary school students are at the concrete operational stage. At this stage, students need physical representations to understand abstract concepts. Augmented Reality (AR) technology serves as a cognitive bridge, visualizing three-dimensional mathematical objects in the students' real world. The literature shows that AR can reduce cognitive load because students no longer need to imagine abstractly; instead, they can interact directly with digital objects. Supported by the Games-Based Learning (GBL) framework, the learning environment shifts from passive to active. Games provide a "scope of action" where failure is considered part of the learning process. This is crucial in mathematical problem-solving, where students often give up when faced with difficulties. In this study, the game element encouraged students' persistence in finding solutions. This is demonstrated by the achievement of students' problem-solving ability indicators, as shown in Figure 2 below.

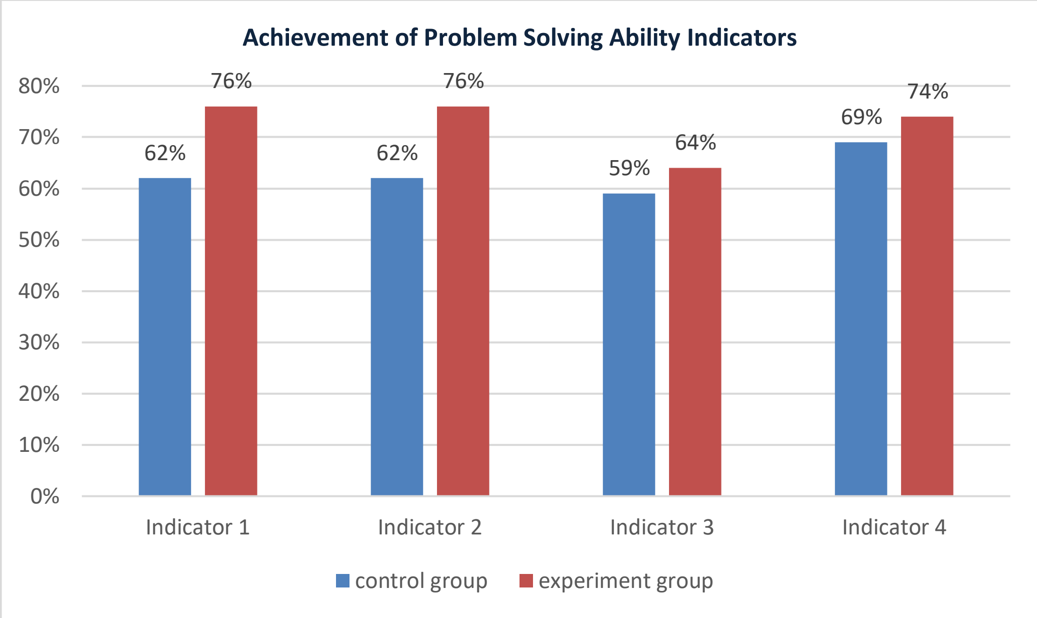

Figure 2. Graph of achievement indicators for problem-solving ability in the experimental class

Based on Figure 2 above, there is an increase and achievement in students' problem-solving ability indicators between the pretest and posttest. This can be explained through the lens of cognitive load theory. At elementary school age, students often experience cognitive dissonance when faced with abstract and multidimensional mathematical problems. At elementary school age, students often experience cognitive dissonance when faced with abstract and multidimensional mathematical problems. The presence of Augmented Reality (AR) serves as an epistemological bridge, directly translating these abstractions into manipulable three-dimensional visual entities. This finding aligns with research (Elsayed & Al-najrani, 2021), which confirms that AR technology significantly reduces students' working memory load and improves visual thinking skills in solving complex mathematical problems (Akbar et al., 2025) also demonstrated that AR integration in elementary school mathematics classes can boost inferential and evaluative skills, which are the main foundation of problem-solving. Improved achievement in each indicator of mathematical problem-solving (such as understanding the problem, formulating a solution plan, carrying out calculations, and evaluating the results) in the experimental class demonstrates that students do not lose their way.

The entry-point strategy ensures that a failure to understand a concept from one perspective is immediately addressed by providing another perspective that better suits their learning style. To measure the extent of improvement after the treatment, a Normalized Gain (N-Gain) test was conducted. The analysis results showed that the N-Gain test score in the experimental class was 0.75. Based on the N-Gain index interpretation criteria, a value of 0.75 falls within the high category. This confirms that the applied learning model not only has an impact but also maximizes students' capacity for mathematical problem-solving. The entry-point strategy plays a crucial role here, as it accommodates diverse student learning styles—providing different entry points so each student can understand the same mathematical problem before ultimately finding the right solution. This significant improvement was attributed to the implementation of the Entry Point strategy. Adapted from Howard Gardner's concept of Multiple Intelligences, this strategy provides students with multiple "entry points" for understanding the same mathematical topic. In this study, entry-point strategies (such as narrative, numerical, aesthetic, or hands-on) facilitated by AR and games enabled students with different learning styles to achieve the same competency targets. Supporting literature suggests that when students are provided with learning access that aligns with their cognitive preferences, engagement increases, which in turn strengthens memory retention and analytical skills.

The analysis of problem-solving indicators showed that students were not only able to answer questions but also demonstrated improvements in procedural steps such as understanding the problem, planning a solution, implementing the plan, and reviewing the results (Polya's stages). Rooted in the theory of Multiple Intelligences, the entry point strategy is a manifestation of differentiated learning. Mathematics, often viewed as monolithic, can be approached through various entry points: linguistic, numerical, aesthetic, narrative, and even hands-on/kinesthetic (Chan et al., 2022). When this strategy is integrated with interactive technology, it becomes a catalyst for students with diverse learning profiles. In a recent review of the adaptation of computational thinking and problem-solving, Aminah et al. (2022) highlight that accommodating diverse thinking routes is essential for all students to participate in knowledge construction, rather than simply passively receiving information. This integration is further strengthened by the Games-Based Learning (GBL) approach. GBL transforms a previously tense classroom atmosphere into a safe, exploratory environment where students can engage in trial and error. GBL can bring students into a flow experience—a psychological state in which they fully immerse themselves in challenges due to a balance between the problem's difficulty and their existing skills. Through this mechanism, students' persistence in finding mathematical solutions increases drastically. The difference is also evident in the comparison of the average post-test scores of the two groups in the experimental class (88.67) and in the control class (77.67). This significant difference in averages demonstrates that learning with Games-Based Learning, integrated with an entry-point strategy and augmented by Augmented Reality, is far more effective than conventional approaches, as shown in the following graph.

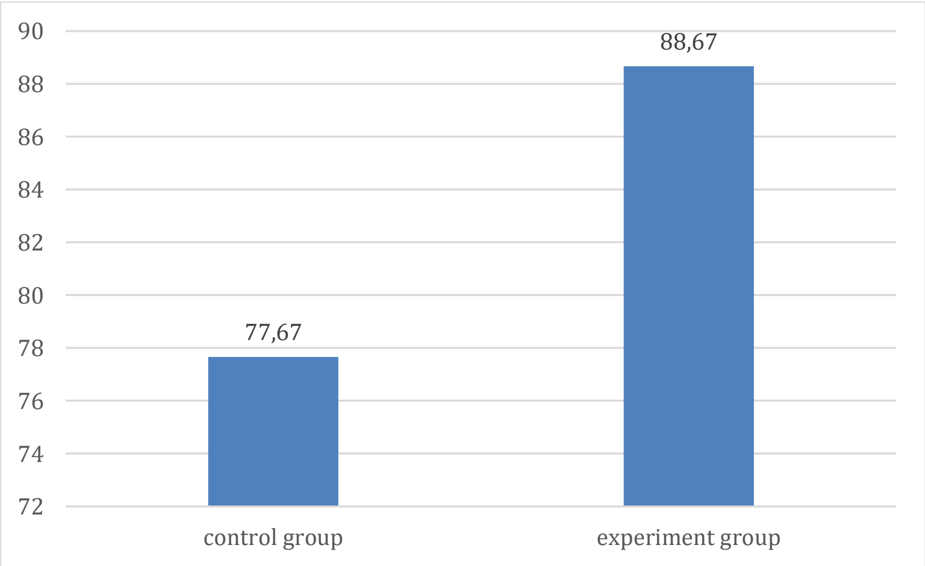

Figure 3. Graph of average problem-solving ability

In conventional learning, students tend to be passive and only receive one-way information, so their problem-solving abilities (which require higher-order thinking skills/HOTS) are less developed. Conversely, in the experimental class, the integration of the three elements (GBL, Entry Point, and AR) created a student-centered learning ecosystem. Students became more active in exploring problems, manipulating 3D objects through AR, and solving challenges through structured game mechanics. The final analysis, using an independent-samples t-test to compare performance between the experimental and control classes, yielded a p-value of $0.000 < 0.05$. This proves the superiority of the integrative learning ecosystem over the conventional model. In the conventional learning paradigm, information transfer is still transactional and teacher-centered. Students may be able to solve simple algorithmic problems, but when faced with non-routine mathematical problems, their reasoning capacity stagnates. In contrast, game-based learning combined with AR demands a high level of interactive engagement. (Angraini et al., 2023). The significant difference in ability between the two classes demonstrates that problem-solving cannot be transformed simply through verbal instruction or repeated practice problems, but rather requires facilitating an immersive learning environment that simultaneously stimulates students' inductive and deductive reasoning abilities. The achievement indicators for problem-solving ability in the experimental and control classes are shown in Figure 4 below.

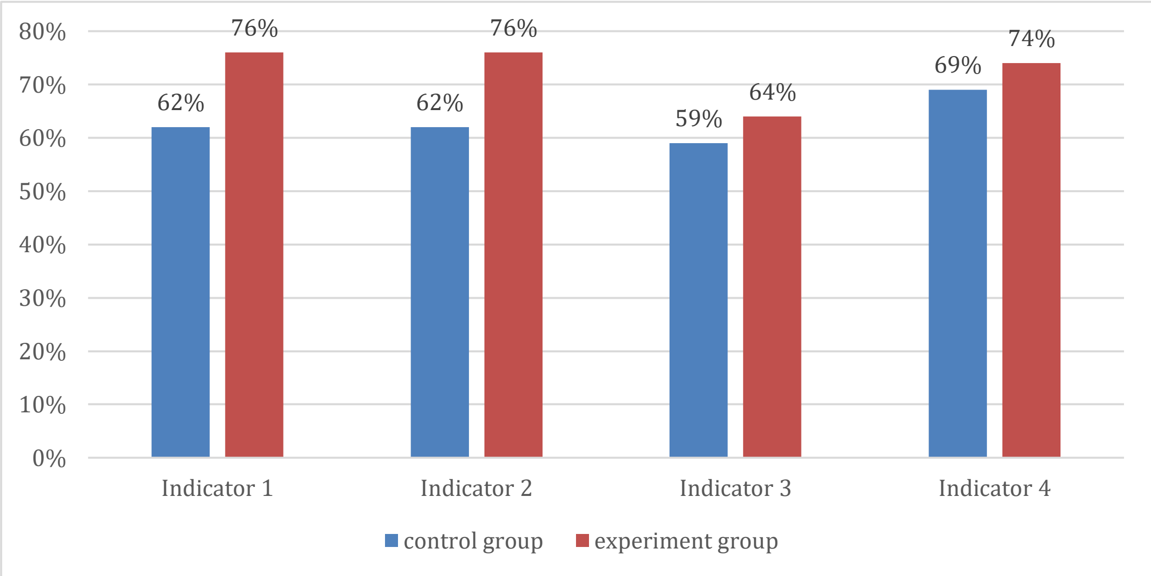

Figure 4. Problem-solving ability indicator achievement graph

The results of the independent sample t-test showed a significance value of 0.000 < 0.05. This probability value is less than the 0.05 significance level, indicating a statistically significant difference in the mathematical problem-solving abilities of students in the experimental class compared with those in the control class. The results of the independent-samples t-test confirmed a significant difference between the experimental class (average 88.67) and the control class (average 77.67). Although the control class experienced an increase, its magnitude was smaller than that of the experimental class. Conventional one-way learning often fails to facilitate higher-order thinking skills (HOTS). In contrast, the integration of GBL-AR and entry points forces students to be active subjects. This learning creates a flow state, in which students are highly focused and enjoy the problem-solving process because the game's challenges are balanced with their abilities. Mathematical problem-solving abilities are not just about calculating, but also about the ability to reason. Digital Natives explain that today's generation of students has a different cognitive structure, where they absorb visual and interactive information more quickly. This explains why the experimental group using AR and gaming aids demonstrated significantly superior performance compared to the control group, still using conventional models. Thus, the results of this study provide a theoretical contribution: combining cutting-edge technology with differentiated pedagogical strategies is key to optimizing students' mathematical potential, particularly their problem-solving skills, in the digital age.

CONCLUSION

Game-based learning, integrated with an augmented reality-assisted entry-point strategy, affects students' problem-solving abilities, as shown by statistical analyses using paired-samples t-tests, which indicate a significant increase in student performance before and after learning. A significance value (2-tailed) of 0.000 is obtained, indicating that the use of game-based learning integrated with an augmented reality-assisted entry point strategy affects students' problem-solving abilities by increasing student involvement in the learning process. Games-based learning, integrated with an augmented reality-assisted entry-point strategy, provides an interactive and enjoyable learning experience, thereby motivating students to learn. This learning model supports a fun learning process through games and contemporary media based on augmented reality by facilitating various student profiles through the entry point strategy. The results of the independent sample test show Sig. = 0.000, where the significance value of Sig is less than 0.05, indicating that there is a real difference between the control group and the experimental group. This difference indicates that students who learn through game-based learning integrated with an augmented-reality-assisted entry-point strategy have better problem-solving abilities than students who learn conventionally. Games-based learning, integrated with an entry-point strategy aided by augmented reality and integrating games, student profiles, and technology into learning, has proven effective in improving students' mathematical problem-solving abilities. Therefore, it can be suggested that game-based learning, integrated with an entry-point strategy aided by augmented reality, can serve as an alternative learning method in the classroom, with improved effectiveness through thorough preparation by teachers before teaching.

REFERENCES

Afthori, D. A., Kurniadi, D., & Atmadja, A. R. (2019). Perancangan Media Interaktif Rumus Bangun Ruang Menggunakan Teknologi Augmented Reality Berbasis Android. *Integrated (Information Technology and Vocational Education)*, *1*(2), 9–13. https://doi.org/https://doi.org/10.17509/integrated.v4i2.xx

Aisyah, S., Syam, S. S., & Chandra. (2025). Analisis Kesulitan Peserta Didik dalam Pemecahan Masalah Matematis pada Soal Cerita di Sekolah Dasar. *Morfologi: Jurnal Ilmu Pendidikan, Bahasa, Sastra Dan Budaya*, *3*(3), 44–52. https://doi.org/https://doi.org/10.61132/morfologi.v3i3.1619

Akbar, A., Herman, T., Suryadi, D., Putra, E. D., & Blegur, J. (2025). *Integrating Augmented Reality in Mathematics Learning to Improve Critical Thinking Skills of Elementary School Students*. *9*(2), 764–779. https://doi.org/http://dx.doi.org/10.28991/ESJ-2025-09-02-014 ©

Aminah, N., Sukestiyarno, Y. L., Wardono, & Cahyono, A. N. (2022). Computational Thinking Process of Prospective Mathematics Teachers in Solving Diophantine Linear Equation Problems. *European Journal of Educational Research*, *11*(3), 1495–1507. https://doi.org/https://doi.org/10.12973/eu-jer.11.3.1495

Anggraini, H. I., Nurhayati, & Kusumaningrum, S. R. (2021). Penerapan Media Pembelajaran Game Matematika Berbasis HOTS dengan Metode Digital Game-Based Learning (DGBL) di Sekolah Dasar. *Jurnal Pendidikan Indonesia (Japendi)*, *2*(11), 1885–1896. https://doi.org/DOI:10.36418/japendi.v2i11.356

Angraini, L. M., Yolanda, F., & Muhammad, I. (2023). Augmented Reality : The Improvement of Computational Thinking Based on Students ' Initial Mathematical Ability. *International Journal of Instruction*, *16*(3), 1033–1054. https://doi.org/https://doi.org/10.29333/iji.2023.16355a

Arifin, A. M., Pujiastuti, H., & Sudiana, R. (2020). Pengembangan media pembelajaran STEM berbasis augmented reality untuk meningkatkan kemampuan spasial matematis siswa. *Jurnal Riset Pendidikan Matematika*, *7*(1), 59–73. https://doi.org/10.21831/jrpm.v7i1.32135

Banani, P. F., Chan, F., & Rosmalinda, D. (2024). Meningkatkan pemahaman belajar peserta didik melalui model pembelajaran. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *09*(4), 231–243. https://doi.org/https://doi.org/10.23969/jp.v9i04.20064

Chan, S. W., Looi, C.-K., Ho, W. K., & Kim, M. S. (2022). Tools and Approaches for Integrating Computational Thinking and Mathematics: A Scoping Review of Current Empirical Studies. *Journal of Educational Computing Research*, *60*. https://doi.org/10.1177/07356331221098793

Diana, H. (2022). Game-Based Learning Berbantuan Media Board Game Klaster untuk Meningkatkan Kemampuan Literasi Siswa. *Jurnal Didaktika Pendidikan Dasar*, *6*(2), 661–676. https://doi.org/10.26811/didaktika.v6i2.622

Elsayed, S. A., & Al-najrani, H. I. (2021). *Effectiveness of the Augmented Reality on Improving the Visual Thinking in Mathematics and Academic Motivation for Middle School Students*. *17*(8). https://doi.org/https://doi.org/10.29333/ejmste/11069

Fatimatuzzahro, M., M. S., & Alfarisi, R. (2021). Pengembangan Media Pembelajaran Komik Matematika Asik (MASIK) Berbasis Augmented Reality untuk Materi Volume Bangun Ruang. *Jurnal Ilmu Pendidikan Sekolah Dasar*, *8*(1), 7–29. https://doi.org/10.19184/jipsd.v8i1.24755

Gerst, M. D., Kenney, M. A., Baer, A. E., Speciale, A., Wolfinger, J. F., Gottschalck, J., Handel, S., Rosencrans, M., & Dewitt, D. (2020). Using visualization science to improve expert and public understanding of probabilistic temperature and precipitation outlooks. *Weather, Climate, and Society*, *12*(1), 117–133. https://doi.org/10.1175/WCAS-D-18-0094.1

Guntur, M., Salsabilla, A., Sahronih, S., & Sholeha, H. H. (2025). Efektivitas Model Problem-Based Learning Berbasis Artificial Intelligence (Slidesgo) dalam Meningkatkan Kemampuan Pemecahan Masalah. *Prima Magistra: Jurnal Ilmiah Kependidikan, ISSN 6*(1), 1–11. https://doi.org/https://doi.org/10.37478/jpm.v6i1.4958

Häkkinen, P., Järvelä, S., Mäkitalo-siegl, K., Ahonen, A., Näykki, P., & Valtonen, T. (2016). Preparing teacher-students for twenty-first- century learning practices (PREP 21): a framework for enhancing collaborative problem-solving and strategic learning skills. *Teachers and Teaching*, *0602*(July), 25–41. https://doi.org/10.1080/13540602.2016.1203772

Hasanuddin, M. I. (2020). Pengetahuan Awal (Prior Knowledge) : Konsep dan Implikasi dalam Pembelajaran. *EDISI : Jurnal Edukasi Dan Sains*, *2*(2), 217–232. https://doi.org/10.36088/edisi.v2i2.860

Hidayat, W. N., Sutikno, T. A., Patmanthara, K., C. D. I., & Firdaus, A. F. (2019). Peningkatan keterampilan guru SMK dalam pembuatan media pembelajaran berbasis augmented reality. *Jurnal Graha Pengabdian*, *1*(2), 93–103. https://doi.org/10.17977/um077v3i22021p89-98

Magdalena, I., Annisa, M. N., Ragin, G., & Ishaq, A. R. (2021). Analisis Penggunaan Teknik Pre-Test Dan Post-Test Pada Mata Pelajaran Matematika Dalam Keberhasilan Evaluasi Pembelajaran Di Sdn Bojong 04. *Jurnal Pendidikan Dan Ilmu Sosial*, *3*(2), 150–165. https://doi.org/10.36088/nusantara.v3i2.1250

Mikkael, R. H., Yanti, E. R., Aulawi, H., Anggraeny, P. N., & Kurniawan, D. (2022). Pelatihan Pembelajaran Sejarah Islam Dengan Augmented Reality. *Jurnal Karya Untuk Masyarakat*, *3*(1), 1–9. https://doi.org/10.36914/jkum.v3i1.658

Muntheawati, N., Arrahim, & Mujiani, D. S. (2025). Pengaruh Model Realistic Mathematics Education (RME) terhadap Kemampuan Pemecahan Masalah Matematika di Sekolah Dasar. *ELSE (Elementary School Education Journal)*, *9*(1), 12–19. https://doi.org/http://dx.doi.org/10.30 651/else.v9i1.23952

Musfirah, N., Nurbaya, N., & Rasyid, A. (2025). Pengembangan instrumen hasil penilaian belajar tes dan non tes. *Socius: Jurnal Penelitian Ilmu-Ilmu Sosial*, *2*(11), 120–125. https://doi.org/10.5281/zenodo.15534085

Mustaqim, I., & Kurniawan, N. (2018). Pengembangan Media Pembelajaran Pai Berbasis Augmented Reality. *Lentera Pendidikan : Jurnal Ilmu Tarbiyah Dan Keguruan*, *21*(1), 59–72. https://doi.org/10.24252/lp.2018v21n1i6

Owens, D. C., Herman, B. C., Oertli, R. T., Lannin, A. A., & Sadler, T. D. (2019). Secondary science and mathematics teachers' engagement with environmental issues through socioscientific reasoning. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(6). https://doi.org/10.29333/ejmste/103561

Prananda, G., Isriani, W. P., Huda, N., Efrina, G., & Fauzi, M. S. (2025). Pelatihan Penggunaan Game-Based Learning Untuk Meningkatkan Keterlibatan Dan Prestasi Siswa Bagi Guru Di Tingkat Dasar. *Journal of Human And Education*, *5*(1), 67–70. https://doi.org/10.31004/jh.v5i1.2102

Pranata, O. D. (2023). Penerapan Game-based Learning sebagai Alternatif Solusi dalam Pengajaran di Kelas Heterogen. *Jurnal Pengabdian Al-Ikhlas*, *8*(3). https://doi.org/10.31602/jpaiuniska.v8i3.7597

Pratiwi, R., Yuhanna, Y., Sopiah, S., Habadi, N., Harahap, R., & Aminah, R. (2024). Peningkatan Kreativitas Belajar Peserta Didik melalui Metode Game-Based Learning. *Jurnal Pengabdian Sosial*, *1*(7), 592–596. https://doi.org/10.59837/7hza6b55

Putra, L. D., Arlinsyah, N. D., Ridho, F. R., Syafiqa, A. N., & Annisa, K. (2024). Pemanfaatan Wordwall dalam Model Game-Based Learning untuk Digitalisasi Pendidikan di Sekolah Dasar. *Jurnal Dimensi Pendidikan Dan Pembelajaran*, *12*(1), 81–95. https://doi.org/10.24269/dpp.v12i1.8749

Rohim, D. C. (2019). Strategi Penyusunan Soal Berbasis HOTs pada Pembelajaran Matematika SD. *Briliant: Jurnal Riset Dan Konseptual*, *4*(November), 436–446. https://doi.org/https://doi.org/10.28926/briliant.v4i4.374

Sanjoyo, T. B. P., Sriwijayanti, R. P., & Anjarwati, A. (2024). Penerapan Media Pembelajaran Puzzle Menggunakan Game-Based Learning untuk Meningkatkan Pemahaman Konsep Siswa pada Konsep " Penjumlahan Bersusun " Kelas I SDN Mayangan IV. *Journal Of Social Science Research*, *4*(2), 5978–5993. https://doi.org/10.31004/innovative.v4i2.10066

Sari, A. K., Ningsih, P. R., Ramansyah, W., Kurniawati, A., Siradjuddin, I. A., & Sophan, M. K. (2020). Pengembangan Kompetensi Guru Smk N 1 Labang Bangkalan Melalui Pembuatan Media Pembelajaran Augmented Reality Dengan Metaverse. *Panrita Abdi. Jurnal Pengabdian Pada Masyarakat*, *4*(1), 52.

https://doi.org/10.20956/pa.v4i1.7620

Setiawan, B., Rachmadtullah, R., Sugandi, E., & Farid, D. A. M. (2022). Pelatihan Pembuatan Media Pembelajaran Berbasis Augmented Reality Pada Kelompok Kerja Guru Sekolah Dasar Desa Kemasantani, Mojokerto. *Etos: Jurnal Pengabdian Masyarakat*, *4*(1), 72–79. https://doi.org/10.35814/etos.v4i1.1991

Siswanto, E., Rahayu, W., & Meiliasari. (2025). Optimalisasi Kemampuan Pemecahan Masalah Matematika melalui Implementasi Pembelajaran Problem-Based Learning (PBL): Systematic Literature Review. *SJME (Supremum Journal of Mathematics Education)*, *09*(01), 181–195. https://doi.org/https://doi.org/10.35706/sjme.v9i1.185

Sri Cahyani, R., & Nurlaeli, A. (2024). Implementasi Strategi Pembelajaran Ekspositori Pada Mata Pelajaran Pendidikan Agama Islam. *Jurnal Manajemen Dan Pendidikan Agama Islam, Volume 3*, 305. https://doi.org/https://doi.org/10.61132/jmpai.v3i3.1100

Suharso, A. (2012). Model pembelajaran interaktif bangun ruang 3D berbasis augmented reality. *Solusi*, *11*(24), 1–11. https://doi.org/https://doi.org/10.35706/solusi.v11i24

Wahyuning, S. (2022). Pembelajaran Ipa Interaktif Dengan Game-Based Learning. *Jurnal Sains Edukatika Indonesia (JSEI)*, *4*(2), 1. https://doi.org/10.17977/um039v7i12022p028

Widiyatmoko, A., Taufiq, M., Wusqo, I. U., Purwinarko, A., Darmawan, M. S., Memoriano, E., & Laksono, A. (2021). Pelatihan Pemanfaatan Model Problem-Based Learning Augmented Reality (Science) pada MGMP Guru IPA Kota Semarang. *Journal of Community Empowerment*, *1*(2), 12–18. https://doi.org/10.15294/jce.v1i2.53415

Widyastuti, D., Rahayu, R., Zulfia, S. K., & Ermawati, D. (2025). Peningkatan Kemampuan Pemecahan Masalah Matematis Siswa Melalui Model Problem-Based Learning Berbantuan Media PUPICA. *APOTEMA: Jurnal Program Studi Pendidikan Matematika*, *11*(1), 116–128. https://doi.org/10.46918/equals.v6i2.1936