



Problem-Based Learning-Based Electronic Teaching Materials: The Effect on the Mathematical Problem-Solving Ability of Junior High School Students

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ARTICLE INFO	ABSTRACT
<p>Published Online: 11 July 2025</p> <p>Corresponding Author: Fitri Nur Asanti</p>	<p>The teaching and learning process is very closely related to using teaching materials. The teaching materials used should be able to build the skills that exist in students, one of which is the ability to solve mathematical problems. However, until now, students' mathematical problem-solving skills are in the low group. Based on a survey conducted by PISA in 2022, the mathematical problem-solving ability of Indonesian students is still below the international level. This study analyses the influence of using Problem-Based Learning (PBL)-based electronic teaching materials on students' mathematical problem-solving skills. The research was conducted at SMPN 3 Sungai Raya and involved two groups, an experimental class using PBL-based electronic teaching materials and a control class using conventional learning methods. Data were obtained through pretest and posttest tests, which were analysed using the Mann-Whitney U non-parametric test because the data were not normally distributed based on the Kolmogorov-Smirnov and Shapiro-Wilk tests. The results of the analysis showed that there was no significant difference in students' initial ability (pre-test) between the two groups, with a significance value of 0.616 (>0.05). However, after being given the treatment, there was a significant difference in the post-test ($0,000 < 0,05$) results, indicating that the PBL approach significantly improved the students' mathematical problem-solving ability. The gain score analysis also showed a significant difference between the experimental and control classes ($0,000 < 0,05$), which confirmed that PBL-based teaching materials were more effective in improving students' abilities than conventional methods.</p>
<p>KEYWORDS: Electronic Teaching Materials, Problem-Based Learning, Problem-Solving Ability</p>	

I. INTRODUCTION

Mathematical problem-solving skills are fundamental in mathematics education. The National Council of Teachers of Mathematics emphasizes that these skills must be integrated throughout mathematics learning, as they foster critical and analytical thinking and help students grasp mathematical concepts beyond memorization [1]. Polya stated that mathematical problem-solving ability is finding solutions to problems using a systematic approach [2].

Putri et al. describe problem-solving as a process involving recognition of the problem, comprehension of context, planning solutions, and evaluating outcomes [3]. Hartinah et al. stress that such processes promote active engagement, cognitively and emotionally [4]. According to Polya, mathematical problem-solving involves four structured steps: understanding the problem, devising a plan, executing the

plan, and reviewing the results [2]. This systematic method cultivates logical and critical thinking.

Schoenfeld adds a metacognitive dimension, emphasizing that students must manage their resources such as time, energy, and knowledge effectively when solving problems [5]. Krulik and Rudnick characterize problem-solving as a complex thinking process involving the creative application of mathematics in unfamiliar situations [6]. Despite its importance, several studies reveal that Indonesian students' problem-solving abilities remain low.

Albab et al. and Ulandari et al. found that most students demonstrated weak problem-solving performance [7,8]. This aligns with data from the 2022 Programme for International Student Assessment (PISA), in which Indonesian students scored an average of only 366 in mathematics, approximately 106 points below the OECD average. These results suggest

“Problem-Based Learning-Based Electronic Teaching Materials: The Effect on the Mathematical Problem-Solving Ability of Junior High School Students”

that Indonesian students struggle to apply mathematical knowledge in real-world contexts [9]. To address this gap, more student-centered learning approaches are needed. Problem-Based Learning (PBL) is one such approach.

Arends and Kilcher state that PBL immerses students in authentic, complex problems, encouraging them to explore solutions independently and collaboratively [10]. Tan notes that PBL allows students to develop essential problem-solving skills by engaging with real-life scenarios [11]. Torp and Sage describe PBL as a dynamic process requiring critical thinking and inquiry, while Graaff and Kolmos highlight its emphasis on collaboration and communication [11,12]. Sungur and Tekkaya further explain that PBL nurtures independent learning and innovation [14].

Studies have shown that PBL positively influences mathematical problem-solving skills [14,15]. One way to integrate PBL is through teaching materials. Nurrita states that teaching materials play an important role in delivering knowledge [17]. Sidik and Kartika note that electronic teaching materials enhance student engagement through interactive features [18]. Agustiana and Novtiar as well as Wahyuni and Angraini found that problem-solving-based teaching materials significantly improve students' problem-solving abilities [19,20].

Based on this, the current study aims to examine the effect of PBL-based electronic teaching materials on junior high school students' mathematical problem-solving skills.

II. RESEARCH METHODS

The type of research used in this study is quantitative research with a pseudo-experimental approach (quasi-experiment). This study uses two class groups, namely the experimental class and the control class, but in entering the subjects it is not done randomly, but by using an existing group [21]. The experimental group carried out learning using electronic teaching materials based on problem-based learning, while the control group carried out learning using teaching materials provided by the school.

The research design used in this study is a Non-equivalent Control Group Design, which is used to obtain data on students' mathematical problem-solving skills. The researcher used pre-tests and post-tests in two class groups to find out the initial ability and the ability after the learning process owned by students. The pre-test and post-test given are in the form of questions. The following is a table of research design using the Nonequivalent Pretest-Posttest Control Group Design.

Table 1. Nonequivalent Pretest-Posttest Control Group Design

Group	Pre-test	Treat	Post-test
Control	O_k		P_k
Eksperimen	O_e	X	P_e

This study was conducted in November 2024 during the odd semester of the 2024/2025 academic year at SMPN 3 Sungai Raya, Kubu Raya Regency, West Kalimantan. The participants were ninth-grade students, with the intervention focused on geometry, particularly the surface area and volume of polyhedra. The research population consisted of six ninth-grade classes, totaling approximately 187 students. The sample was selected using existing classroom groups, with class IX D assigned as the control group and class IX E as the experimental group, each comprising 32 students who participated in the full instructional and testing sequence.

The primary instrument in this study was a test to assess students' mathematical problem-solving abilities before and after the treatment. The pretest and posttest, both composed of four essay questions, were constructed based on predetermined indicators aligned with the learning objectives. The pretest aimed to evaluate students' prior understanding of polyhedra from elementary school, while the posttest assessed their ability to apply mathematical problem-solving strategies after instruction.

The teaching intervention, delivered only to the experimental group, involved four sessions using electronic teaching materials developed with a Problem-Based Learning (PBL) approach. Each session included conceptual explanations, problem-solving exercises, and class discussions designed to foster deeper understanding and independent learning. Prior to the intervention, classroom observations were conducted to gain insights into students' initial abilities and to inform instructional design.

Data analysis included normality and homogeneity tests. The Shapiro-Wilk test was used to examine the normal distribution of the data, and multivariate homogeneity was assessed using Pearson's correlation coefficient. If the assumptions were not met, the non-parametric Mann-Whitney U test was applied.

Hypothesis testing for pretest and posttest results was conducted using Hotelling's T^2 multivariate test at a significance level of $\alpha = 0.05$ to determine whether there were statistically significant differences between the experimental and control groups before and after the intervention. The statistical hypotheses for both pretest and posttest comparisons were $H_0: \mu_1 = \mu_2$ and $H_1: \mu_1 \neq \mu_2$. The F-statistic was calculated, and H_0 was rejected if $F_{hitung} > F_{\alpha,p,(n_1+n_2-p-1)}$ or if the p-value < 0.05 , indicating significant differences between groups. The effect of PBL-based electronic teaching materials on students' problem-solving abilities was interpreted through pairwise comparison results. A positive mean difference (experimental control) with $p < 0.05$ indicated a statistically significant positive impact of the intervention.

III. RESULTS AND DISCUSSION

Result

The results obtained from this study are presented as follows.

1. Normality Test

Kelas	Kolmogorov-Smirnov ^a			Shapiro-Wilk			
	Statistic	df	Sig.	Statistic	df	Sig.	
Pretest	Kelas Kontrol	.177	32	.012	.898	.32	.005
	Kelas Eksperimen	.219	32	.000	.931	.32	.041
Posttest	Kelas Kontrol	.176	32	.013	.887	.32	.003
	Kelas Eksperimen	.145	32	.086	.924	.32	.027

a. Lilliefors Significance Correction

Figure 1. Test of Normality

Based on the calculations that have been carried out using the help of SPSS, the results of the significance values through the Kolmogorov-Smirnov and Shapiro-Wilk tests on the pre-test data have significance values, so that in the $< 0,05$ pre-test data the normal assumptions are not met. Meanwhile, in post-test data, one data point has a significance value, but the other data point does not. Because the data is not normally distributed, the test cannot be performed on the data, so Hotelling's T^2 Mann-Whitney U Test will be carried out.

2. Test the mean difference of the initial condition

Kelas	N	Mean Rank	Sum of Ranks
Nilai_PreTest: Kelas Kontrol	32	31.34	1003.00
Kelas Eksperimen	32	33.66	1077.00
Total	64		

Nilai_PreTest	
Mann-Whitney U	475.000
Wilcoxon W	1003.000
Z	-.502
Asymp. Sig. (2-tailed)	.616

a. Grouping Variable: Kelas

Figure 2. Test the mean difference of the initial condition

Based on the Mann-Whitney U test conducted in the pre-test of the control and experimental classes, the Asymp. Sig. (2-tailed) value was obtained, which means that there was no significant difference from $0,616 > 0,05$ in the pre-test scores of the two classes.

3. Test the mean difference after being given the treatment

Kelas	N	Mean Rank	Sum of Ranks
Nilai_Posttest: Kelas Kontrol	32	22.59	723.00
Kelas Eksperimen	32	42.41	1357.00
Total	64		

Nilai_Posttest	
Mann-Whitney U	195.000
Wilcoxon W	723.000
Z	-4.282
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kelas

Figure 3. Test the mean difference after being given the treatment

Based on the Mann-Whitney U test conducted on the post-test of the control and experimental classes, the Asymp. Sig. (2-tailed) value was obtained, which means that there was a significant difference from $0,000 < 0,05$ in the post-test scores of the two classes.

4. Test the influence of PBL-based electronic teaching materials on students' mathematical problem-solving ability

Kelas	N	Mean Rank	Sum of Ranks
Gain: Kelas Kontrol	32	24.17	773.50
Kelas Eksperimen	32	40.83	1306.50
Total	64		

Gain	
Mann-Whitney U	245.500
Wilcoxon W	773.500
Z	-3.595
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Kelas

Figure 4. Test the influence of PBL-based electronic teaching materials on students' mathematical problem-solving ability

Based on the Mann-Whitney U test conducted on the difference between the pre-test and post-test (gain) scores, the value of Asymp. Sig. (2-tailed) was obtained, which means that there is a significant difference in the gain value of the two classes, or it can be said that the PBL-based electronic teaching materials given to the experimental class have an effect. $0,000 < 0,05$ paragraphs must be indented as well as justified, i.e. both left-justified and right-justified.

DISCUSSION

This study demonstrates that electronic teaching materials based on Problem-Based Learning (PBL) significantly improve students' mathematical problem-solving skills. Due

“Problem-Based Learning-Based Electronic Teaching Materials: The Effect on the Mathematical Problem-Solving Ability of Junior High School Students”

to the non-normal distribution of data, as indicated by the Kolmogorov-Smirnov and Shapiro-Wilk tests, the Mann-Whitney U test was selected for statistical analysis. The pretest results showed no significant difference between the control and experimental groups, suggesting that students had comparable initial abilities.

After the implementation of PBL-based teaching materials, posttest and gain score analyses revealed significant differences. Students in the experimental group showed greater improvement in their problem-solving performance than those in the control group. This finding highlights the effectiveness of PBL in fostering critical thinking, deeper understanding, and student engagement during mathematics learning.

PBL encourages learners to actively explore concepts, collaborate with peers, and solve real-world problems. Unlike conventional instruction, which often promotes passive learning, PBL integrates meaningful challenges that help students apply mathematical knowledge more flexibly. These benefits are reflected in the improved performance of the experimental class.

Given these results, educators should consider incorporating PBL and technology-enhanced materials into mathematics instruction. Such approaches not only strengthen students' problem-solving skills but also develop communication, collaboration, and lifelong learning competencies. Further research could explore the broader impact of PBL-based tools across subjects and student populations.

IV. CONCLUSIONS

Based on the results of data analysis and discussion, the following conclusions can be drawn:

1. Equality of Initial Conditions

The results of the Mann-Whitney U test on the pretest value showed the Asymp value. Sig. (2-tailed) was 0.616 (>0.05), which means that there was no significant difference between the initial ability of students in the control class and the experimental class. This shows that both groups have equal mathematical problem-solving abilities before the treatment is given.

2. Effect of Treatment on Final Results

The results of the Mann-Whitney U test on the posttest value showed the Asymp value. Sig. (2-tailed) by 0.000 (<0.05). This indicates that there is a significant difference between the post-test scores of students in the experimental class and the control class. Students in the experimental class who used PBL-based electronic teaching materials obtained better results than students in the control class.

3. Gain Score

Analysis of the gain score (difference between pretest and posttest) using the Mann-Whitney U test showed the Asymp value. Sig. (2-tailed) by 0.000 (<0.05). This indicates that there is a significant difference in the improvement of

mathematical problem-solving ability between the experimental class and the control class. Students in the experimental class showed a greater improvement than students in the control class.

4. Effectiveness of PBL-Based Electronic Teaching Materials

Based on the significant differences found in the posttest and gain score, it can be concluded that PBL-based electronic teaching materials significantly improve students' mathematical problem-solving skills. The PBL approach has a positive impact on learning, making students more active, critical, and involved in solving problems. These results, educators should consider incorporating PBL and technology-enhanced materials into mathematics

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“Problem-Based Learning-Based Electronic Teaching Materials: The Effect on the Mathematical Problem-Solving Ability of Junior High School Students”

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