

# Enhancing Students' Mathematical Problem-Solving Skills through Problem-Based Learning in Systems of Linear Equations in Two Variables at Junior High School Level

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ARTICLE INFO (11 pt)	ABSTRACT (11 pt)
<p><b>Article History</b></p> <p>Received : 30 Jan 2026                      Revised : 14 Feb 2026                      Accepted : 26 Feb 2026                      Available Online : 28 Feb 2026</p> <hr/> <p><b>Keywords:</b>                      Problem-Based Learning                      Mathematical Problem-Solving Skills                      Systems of Linear Equations</p> <hr/> <p><b>Please cite this article APA style as:</b>                      Indriyati, M. &amp; Rodliyah, I. (2026). Enhancing Students' Mathematical Problem-Solving Skills through Problem-Based Learning in System of Linear Equations in Two Variables at Junior High School Level. <i>Vygotsky: Jurnal Pendidikan Matematika dan Matematika</i>, 8(1), pp. 41-50.</p>	<p>This study investigated the effect of Problem-Based Learning (PBL) on students' mathematical problem-solving skills in Systems of Linear Equations in Two Variables (SPLDV), a contextual algebra topic that has received limited empirical attention in Indonesian junior high schools. Using a posttest-only control group design, the study involved 63 Grade VIII students of State Junior High School 2 Ngoro. The experimental group learned through PBL, while the control group received conventional instruction. The experimental group achieved a significantly higher posttest mean (78.12) than the control group (<math>p &lt; 0.05</math>). The effect size (Hedges' <math>g = 1.14</math>) indicated a very high effect, suggesting that PBL is particularly effective for improving students' problem-solving skills in contextual SPLDV learning.</p>

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## 1. Introduction

Education plays a strategic role in improving the quality of human resources, as it is regarded as a long-term investment that directly contributes to the development of individual competence, productivity, and competitiveness in responding to global dynamics (Becker, 1993). The quality of a nation's human resources is largely determined by the effectiveness of its educational processes, particularly in shaping students' thinking abilities, decision-making skills, and problem-solving competencies required in real-life situations (OECD, 2018). Therefore, improving educational quality has become a crucial strategy in addressing global challenges, which requires learning processes that focus not only on knowledge acquisition

but also on the development of higher-order thinking skills.

Mathematics is a fundamental subject taught from elementary school to higher education and plays an essential role in the advancement of science and technology. The success of mathematics learning is not merely measured by students' skills to memorize formulas, but also by their skills to understand concepts and solve mathematical problems accurately (Sumiati & Agustini, 2020). Learning that emphasizes factual knowledge alone is considered insufficient to prepare students to face complex and contextual problems (Trilling & Fadel, 2009). Consequently, mathematics instruction should be directed toward the development of higher-order thinking skills, including the abilities to analyze, evaluate, and systematically solve problems (Zohar & Dori, 2003).

In the context of mathematics education, problem-solving skills is one of the core competencies that students must master. Mathematical problem solving not only reflects students' procedural skills but also indicates the depth of conceptual understanding and the skills to connect mathematics with real-life situations (Polya, 1973). Students with strong problem-solving skills are generally able to understand problems, design appropriate solution strategies, and evaluate the obtained solutions logically and reflectively.

One mathematical topic that requires strong problem-solving skills is the System of Linear Equations in Two Variables. This topic is a core subject at the junior high school level and is closely related to modeling real-life situations into mathematical representations. However, research by Cuong & Tien-Trung (2025) indicates that students often experience difficulties in connecting algebraic concepts with contextual problems, which negatively affects their mathematical problem-solving skills. Therefore, mastery of System of Linear Equations in Two Variables concepts requires well-developed problem-solving skills so that students are able to relate mathematical concepts to contextual situations effectively (Mardiyah et al., 2024).

Based on preliminary classroom observations, students' mathematical problem-solving skills in SPLDV was found to be relatively low. Students experienced difficulties in understanding problem statements, identifying variables, and designing appropriate solution strategies. Classroom practices were still dominated by conventional teacher-centered instruction, resulting in limited student engagement during learning activities (Zulkarnain, 2023). Notably, SPLDV learning tasks are predominantly presented as contextual word problems derived from everyday situations, which require students to translate real-world scenarios into algebraic models. This inherent contextual nature makes SPLDV particularly well-suited to Problem-Based Learning, which is grounded in learning through authentic, real-world problems.

Such learning practices limit students' involvement in constructing and applying problem-solving strategies. Learning that is predominantly procedural tends to restrict students' cognitive engagement, resulting in limited opportunities to develop critical and reflective thinking skills (Hattie, 2020). This condition highlights the need for learning approaches that actively engage students in higher-level thinking processes. Previous studies by Abdullah & Munawwaroh (2024) revealed that classroom learning is still largely dominated by teachers, which reduces students' participation in discussion, exploration, and problem-solving activities, thereby contributing to low mathematical problem-solving skills.

Problem-Based Learning (PBL) is considered a relevant alternative learning model. PBL positions contextual problems as the starting point of learning, encouraging students to engage in exploration, discussion, and reflection in order to construct solutions (Hmelo-Silver, 2020). In PBL, learning problems are designed to involve students actively in questioning and problem-solving processes related to both content and context under investigation (Major & Mulvihill, 2018).

Although numerous studies have demonstrated the effectiveness of PBL, several recent findings suggest that its implementation does not always yield optimal results when students are not accustomed to active learning. This indicates that the effectiveness of PBL is highly dependent on the learning context, subject matter, and student characteristics (Hermawan & Siliwangi, 2024). Kappassova et al. (2025) further emphasized that PBL requires systematic instructional planning to help students adapt to active learning, particularly in abstract mathematical topics. Therefore, more specific investigations focusing on particular materials are necessary to obtain a more comprehensive understanding.

Based on the literature and classroom conditions, there remains a gap between the demand to develop students' mathematical problem-solving skills and classroom practices that continue to rely on conventional approaches. Moreover, studies that specifically examine the effect of PBL on students' mathematical problem-solving skills in SPLDV at the junior high school level remain limited. Accordingly, this study offers novelty by focusing on SPLDV and employing a quantitative experimental approach to examine the effect of PBL on students' mathematical problem-solving skills.

This study aims to: (1) describe the effect of the Problem-Based Learning model on Grade VIII students' mathematical problem-solving skills in SPLDV; and (2) determine the magnitude of the effect of the Problem-Based Learning model on students' mathematical problem-solving skills in SPLDV.

## 2. Method

This study employed a quantitative approach using a quasi-experimental posttest-only control design. The independent variable was the Problem-Based Learning (PBL) model, and the dependent variable was students' mathematical problem-solving skills. The population comprised all Grade VIII students of SMP Negeri 2 Ngoro in the 2025/2026 academic year (nine classes). The sample was selected using cluster random sampling, with Class VIII-H assigned as the experimental group (32 students) and Class VIII-I as the control group (31 students), resulting in a total sample of 63 students.

The treatment was conducted over two meetings in both groups on the topic of SPLDV. The experimental group was taught using PBL, while the control group received conventional instruction with the same learning objectives and content.

The research instrument was a mathematical problem-solving test consisting of three essay items (with the third item divided into two sub-items) developed based on Polya's indicators. Content validity was established through expert judgment provided by one mathematics education lecturer and one junior high school mathematics teacher. Data were analyzed using prerequisite tests (normality and homogeneity) followed by an independent samples t-test.

## 3. Results and Discussion

The descriptive statistics of posttest scores indicate differences in students'

mathematical problem-solving skills between the experimental and control groups. Based on the descriptive statistical analysis presented in Table 1, the results indicated that the mean posttest score of the control class was 66.13, while the experimental class achieved a higher mean posttest score of 78.12. The descriptive analysis shows higher mean posttest scores in the experimental group compared to the control group. Subsequently, normality and homogeneity tests were conducted as prerequisite analyses.

**Table 1.** Descriptive Statistics of Posttest Scores

Group	N	Minimum	Maximum	Mean	Std. Deviation
Experimental Posttest	32	60	100	78.12	1.862
Control Posttest	31	40	85	66.13	1.865
Valid N (listwise)	63				

### 3.1. Normality Test

The normality test results of Table 2 indicate that the posttest data on students' mathematical problem-solving skills in both the experimental and control groups were normally distributed. In the experimental group, the Kolmogorov-Smirnov significance value was 0.072 and the Shapiro-Wilk significance value was 0.217. In the control group, the Kolmogorov-Smirnov significance value was 0.165 and the Shapiro-Wilk significance value was 0.061. All significance values exceeded 0.05, indicating that the data in both groups met the normality assumption and were appropriate for subsequent parametric analysis.

**Table 2.** Normality Test Result

Test	Group	Kolmogorof-Smirnov			Shapiro-wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
Mathematical Problem-Solving Skills	Experimental Posttest	.148	32	.072	.956	32	.217
	Control Posttest	.134	31	.165	.935	31	.061

### 3.2. Homogeneity Test

The homogeneity test results in Table 3 show that the variances of students' mathematical problem-solving scores in both the experimental and control groups were comparable. The Levene's test yielded a significance score of 0.814, indicating no substantial difference in score variskills between the two groups. This finding indicates that the score dispersion in both the experimental and control classes was generally analogous, signifying equivalent levels of score variation in both groups. Consequently, the condition of homogeneity of variances was fulfilled, allowing for the suitable comparison of the two groups utilizing parametric statistical analysis in the wnsuring hypothesis testing.

**Table 3.** Test of Homogeneity of Variances

Test	Levene Statistic	df1	df2	Sig.
Mathematical Problem-Solving Skills	.056	1	61	.814

### 3.3. Hypothesis Test

Hypothesis testing in this study was conducted using an independent samples t-

test, which was applied to compare the mathematical problem-solving skills of students taught using the Problem-Based Learning model and those taught using conventional learning methods. As presented in Table 4, the independent samples t-test revealed a statistically significant difference in students' mathematical problem-solving scores between the experimental and control groups ( $p < .001$ ). The mean difference between the two groups was 11.996 points, with the experimental group obtaining higher posttest scores than the control group. This finding indicates that students who learned through Problem-Based Learning achieved substantially higher mathematical problem-solving performance than those who learned through conventional instruction in the topic of Systems of Linear Equations in Two Variables.

**Table 4.** Independent Sampel Test for Mathematical Problem-Solving Skills

	Levene's Test for Equality of Variances		t-test for Equality of Means				95% Confidence Interval of the Difference		
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std.Error Difference	Lower	Upper
Equal Variances Assumed	.056	.814	4.551	61	.000	11.996	2.636	6.725	17.267
Equal Variances not Assumed			4.552	60.979	.000	11.996	2.635	6.727	17.265

These results suggest that engaging students in learning activities centered on contextual problems and collaborative problem-solving, as implemented in the Problem-Based Learning model, is associated with better mathematical problem-solving outcomes. The present findings are consistent with previous research by Arfiani & Rismen (2025) which reported significant improvements in students' mathematical problem-solving skills following the implementation of Problem-Based Learning compared to conventional teaching approaches. Together, these results strengthen the empirical evidence that Problem-Based Learning is an effective instructional approach for enhancing students' mathematical problem-solving skills, particularly in the context of Systems of Linear Equations in Two Variables at the junior high school level.

### 3.4. Effect Size

Furthermore, to determine the effect size, effect size is a method used to measure the magnitude of the influence of one variable on another, which is not affected by sample size. It describes the strength of the relationship or the difference between independent variables. In this study, effect size calculation is employed to identify the extent of the influence of the Problem-Based Learning model on students' mathematical problem-solving skills on the topic of Systems of Linear Equations in Two Variables (SPLDV) in Grade VIII.

Effect size is used to determine how strong the impact of the Problem-Based Learning model is on students' mathematical problem-solving skills in the SPLDV material for Grade VIII by applying the Hedges' formula. Before obtaining the

Hedges' value, the researcher must first calculate the pooled standard deviation of both groups, which consist of the experimental class and the control class, namely,

$$\begin{aligned}
 SD^*_{pooled} &= \sqrt{\frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{n_1 + n_2 - 2}} \\
 &= \sqrt{\frac{(32 - 1)(10.530)^2 + (31 - 1)10.385^2}{32 + 31 - 2}} \\
 &= \sqrt{109.39} \\
 &= 10.45
 \end{aligned}$$

Therefore, the Hedges' value is obtained as follows,

$$\begin{aligned}
 Hedges'g &= \frac{M_1 - M_2}{SD^*_{pooled}} \\
 &= \frac{78.12 - 66.13}{10.45} \\
 &= \frac{11.99}{10.45} \\
 &= 1.14
 \end{aligned}$$

Interpretation of Effect Size Using Classification (Tamur et al., 2020).

**Table 5.** Effect Size Category

Effect Size (ES)	Category
$-0,15 \leq ES \leq 0,15$	No level
$0,15 < ES \leq 0,40$	Low level
$0,40 < ES \leq 0,75$	Moderate level
$0,75 < ES \leq 1,10$	High level
$1,10 < ES \leq 1,45$	Very high level
$ES \geq 1,45$	Very good level

Based on the classification proposed by Tamur et al. (2020) the Hedges' g value of 1.14 falls into the very high category. This finding indicates that the impact of the Problem-Based Learning (PBL) model on students' mathematical problem-solving skills is not only statistically significant but also substantial in practical terms. In classroom practice, this means that the performance gap between students taught using PBL and those taught using conventional instruction is meaningful and observable.

The strong effect of PBL observed in this study can be attributed to the characteristics of PBL, which emphasize learning through contextual and real-world problems. Such learning activities encourage students to actively interpret problem situations, construct mathematical models, and develop systematic

solution strategies, thereby supporting deeper conceptual understanding and more effective problem-solving processes (Ozer & Sezer, 2021). Learning through contextual problems also facilitates meaningful learning and conceptual transfer, enabling students to better apply mathematical concepts to real-life situations (Sungur & Tekkaya, 2021). Previous findings further indicate that PBL is associated with improvements in students' problem-solving performance and conceptual understanding (Tarhan & Ayyildiz, 2020).

Based on these findings, several practical implications can be drawn. Mathematics teachers are encouraged to integrate Problem-Based Learning, particularly when teaching topics that involve contextual word problems such as Systems of Linear Equations in Two Variables. Teachers may design learning activities that begin with real-life problem situations and guide students to collaboratively explore solution strategies. For future research, longer intervention periods and the inclusion of different mathematical topics are recommended to further examine the consistency of the PBL effect on students' mathematical problem-solving skills.

#### **4. Conclusions**

This study investigated the effect of the Problem-Based Learning (PBL) model on Grade VIII students' mathematical problem-solving skills in the topic of Systems of Linear Equations in Two Variables. The findings indicate that students who were taught using the PBL model achieved significantly higher posttest scores than those who received conventional instruction. This demonstrates that the application of PBL leads to better learning outcomes in terms of students' mathematical problem-solving skills.

Furthermore, the magnitude of the effect was classified as very high, indicating that the impact of the PBL model is substantial in practical classroom contexts. These results suggest that the implementation of Problem-Based Learning provides meaningful benefits for improving students' mathematical problem-solving skills. Therefore, PBL can be considered an effective instructional approach for mathematics learning at the junior high school level, particularly for topics that involve contextual problem situations such as Systems of Linear Equations in Two Variables.

#### **Author Contributions**

The first author was responsible for conceptualizing the study, developing the research methodology, conducting the investigation, collecting and analyzing the data, and writing the initial draft of the manuscript. The second author contributed by providing research supervision, validating the research findings, and reviewing and revising the manuscript.

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#### **Declaration of Competing Interest**

The authors declare that there is no conflict of interest related to this research.

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