Res. Math. Nat. Sci. vol. 5, no. 2, pp. 76–82, 2026, doi: doi:10.55657/rmns.v5i2.319

RMNS

Research in the Mathematical and Natural Sciences
Journal Homepage: https://journal.scimadly.com/index.php/rmns
eISSN: 2828-6804

Original Research

Improving Mathematics Learning Outcomes in Systems of Linear Equations in Two Variables Using the Problem-Based Learning Model

Rahmat[1,*], Ismail Djakaria[2], and Novianita Achmad[3]

[1] *Department of Mathematics Education, Universitas Negeri Gorontalo, Bone Bolango 96554, Indonesia*
[2] *Department of Statistics, Universitas Negeri Gorontalo, Bone Bolango 96554, Indonesia*
[3] *Department of Mathematics, Universitas Negeri Gorontalo, Bone Bolango 96554, Indonesia*

Article information

***Corresponding author:**
Rahmat
mamatuge06@gmail.com

Received: 20 January 2026
Revised: 25 July 2026
Accepted: 30 July 2026
Published: 31 July 2026

Published by:
scimadly PUBLISHING

Abstract

This study aims to improve students' mathematics learning outcomes on Systems of Linear Equations in Two Variables (SLETV) through the implementation of the Problem-Based Learning (PBL) model. This type of research is Classroom Action Research (CAR) conducted at SMP Negeri 1 Suwawa during the even semester of the 2024/2025 academic year, with 31 eighth-grade students (class VIII-B) as subjects. The research took place in a single cycle consisting of four meetings (three learning process meetings and one final test meeting). The instruments used included Lesson Plans, Student Worksheets, observation sheets for teacher and student activities, and learning achievement tests. Observation results indicated that the percentage of teacher activity in the "good" and "very good" categories increased from 63.6% in Meeting 1 to 90.9% in Meeting 3, with an overall average of 75.7%. The percentage of student activity in the "good" and "very good" categories increased from 59.1% in Meeting 1 to 90.9% in Meeting 3, with an overall average of 77.2%. Learning test results showed that among the 25 students who took the evaluation, 19 students achieved mastery (76%), thereby meeting the established classical success indicator ($\geq 75\%$). Thus, the application of the PBL model is effective in improving students' mathematics learning outcomes on SLETV.

Keywords: Learning Outcomes; Problem-Based Learning; Systems of Linear Equations in Two Variables; Classroom Action Research

1. Introduction

Mathematics is one of the main foundations in the formal education system that plays a vital role in the development of other disciplines as well as in daily life problem-solving [1, 2]. Mastering mathematics is not merely focused on numerical calculations; rather, it serves as a vehicle to train students' logical, systematic, and critical reasoning skills [3, 4]. Given its fundamental role, a solid understanding of mathematical concepts is an essential prerequisite for supporting students' academic success at both primary and secondary education levels [2, 4].

Despite the strategic role of mathematics, in reality, the majority of students still perceive mathematics as a relatively complex and intimidating subject. This situation leads to low learning interest and student learning achievement falling below the Minimum Mastery Criteria (KKM) [5, 6]. Learning outcomes are essentially changes in cognitive abilities or competencies achieved by students after undergoing the learning experience process, which are measured through evaluation activities [7–9].

Based on initial interviews with the mathematics teacher and observations at SMP Negeri 1 Suwawa, it was found that the mathematics learning achievement of class VIII-B students was low. The primary constraint faced by students centered around their understanding of the Systems of Linear Equations in Two Variables (SLETV) material [10, 11]. Students tended to have difficulty translating word problems into mathematical models [12] and struggled to solve exercises whenever the problem format was slightly modified from the classic examples provided by the teacher [11]. Furthermore, the level of student participation and confidence in presenting answers or expressing ideas in front of the class remained limited [5, 13].

The low mathematics learning outcomes are influenced by several factors [5, 6]. First, the teaching methods used still tend to be predominantly teacher-centered and conventional, where the teacher focuses on completing the curriculum content rather than ensuring students' depth of understanding [6, 11]. Second, instructional interactions have not fully facilitated active student participation and group dynamics, making the process of constructing mathematical knowledge feel monotonous and unmotivating [1, 14].

To address these issues, improvements in classroom learning quality are needed through the application of innovative learning models capable of actively engaging students [2, 13]. The Problem-Based Learning (PBL) model is an approach based on contextual problems designed to encourage students to work collaboratively, analyze problems, and discover concepts independently [1, 15]. Implementing PBL positions students as active learning subjects while the teacher acts as a facilitator [2, 14]. Through the stages of the PBL model, students are trained to discuss, express opinions, and develop mathematical problem-solving skills and creative thinking [3, 10, 16].

Based on this background, this classroom action research was conducted with the objective of improving students' mathematics learning outcomes on Systems of Linear Equations in Two Variables (SLETV) through the implementation of the Problem-Based Learning (PBL) model in class VIII-B of SMP Negeri 1 Suwawa [7, 10, 15].

2. Methods

2.1 Research Approach and Design

The research design used in this study is Classroom Action Research (CAR). This study aims to improve and enhance the quality of classroom mathematics learning processes and student outcomes. The research was conducted at SMP Negeri 1 Suwawa in the even semester of the 2024/2025 academic year. The subjects were 31 students of Class VIII-B, consisting of 16 male students and 15 female students.

The research was carried out in a single cycle consisting of four meetings (three meetings for the learning process and one meeting for the end-of-cycle test). The implementation procedure followed the CAR framework, which comprises four main phases: (1) planning, (2) acting, (3) observing, and (4) reflecting [17–19].

2.2 Data Collection Techniques and Research Instruments

Data in this study consist of qualitative and quantitative data:

Qualitative Data: Consists of observation data regarding teacher and student activities during the learning process. These data were collected using teacher activity observation sheets and student activity observation sheets. Assessment of activity aspects follows a Likert scale of 0–4, as presented in Table 1 and Table 2.

Quantitative Data: Consists of achievement data on students' mathematics learning outcomes in Systems of Linear Equations in Two Variables (SLETV), obtained from a written test administered at the end of the cycle.

Table 1: Scoring Scale for Teacher Activity Observation

Description of Observed Aspect	Score
Teacher performs the observed aspect poorly	0
Teacher performs the observed aspect unsatisfactorily	1
Teacher performs the observed aspect adequately	2
Teacher performs the observed aspect well	3
Teacher performs the observed aspect exceptionally well	4

Table 2: Scoring Scale for Student Activity Observation

Description of Observed Aspect	Score
Student performs the observed aspect poorly	0
Student performs the observed aspect unsatisfactorily	1
Student performs the observed aspect adequately	2
Student performs the observed aspect well	3
Student performs the observed aspect exceptionally well	4

2.3 Data Analysis Techniques

The data analysis techniques used in this research encompass observation data analysis (qualitative) and learning outcome test data analysis (quantitative).

2.3.1 Observation Data Analysis (Teacher and Student)

The average percentage of teacher and student activity implementation is calculated using the following percentage formula:

$$P_A = \frac{S}{S_{\max}} \times 100\% \tag{1}$$

where P_A is the percentage of activity achievement, S is the total score obtained, and $S_{\max}$ is the overall maximum score.

The observation percentage results are categorized based on the following criteria:

- 0% – 19%: Poor
- 20% – 59%: Unsatisfactory
- 60% – 69%: Adequate
- 70% – 79%: Good
- 80% – 100%: Very Good

2.3.2 Learning Outcome Data Analysis

The average score of students' mathematics learning outcomes is calculated using the arithmetic mean formula [17]:

$$\bar{x} = \frac{\sum x}{N} \tag{2}$$

where $\bar{x}$ is the mean score of learning outcomes, $\sum x$ is the sum of all student scores, and N is the total number of students taking the test.

Furthermore, the level of classical learning mastery is calculated using the mastery percentage formula [17, 19]:

$$P_K = \frac{f_t}{N} \times 100\% \tag{3}$$

where P_K is the percentage of classical learning mastery, f_t is the number of students who achieved mastery (reaching the Minimum Mastery Criteria score ≥ 75), and N is the total number of students taking the test.

This classroom action research is declared successful (success indicator met) if the percentage of students' classical learning mastery reaches at least 75% ($P_K \geq 75\%$).

3. Results and Discussion

This classroom action research was conducted in Class VIII-B at SMP Negeri 1 Suwawa with a total of 31 student subjects (16 male students and 15 female students). The action was carried out in a single cycle consisting of four meetings, comprising three learning process meetings using the Problem-Based Learning (PBL) model on Systems of Linear Equations in Two Variables (SLETV) material and one evaluation meeting (end-of-cycle learning achievement test). The implementation followed the four phases of CAR: planning, acting, observing, and reflecting.

3.1 Action Planning

During the planning phase, the researcher and the subject teacher prepared all learning tools and research instruments. The materials prepared included Lesson Plans aligned with PBL syntax, Student Worksheets, learning scenarios, and data collection instruments consisting of teacher activity observation sheets, student activity observation sheets, and a test specification grid along with learning achievement test questions.

3.2 Action Implementation

The implementation was carried out in the classroom according to the designed lesson plans. The learning process applied the steps of the PBL model on SLETV material, which included: (1) orienting students to the problem, (2) organizing students for learning, (3) guiding individual and group investigations, (4) developing and presenting artifacts/works, and (5) analyzing and evaluating the problem-solving process [1, 10, 15].

3.3 Observation

3.3.1 Teacher Activity Observation Results

Teacher activity was observed using an observation sheet covering 22 indicator aspects, divided into preliminary activities (5 aspects), core activities (13 aspects), and closing activities (4 aspects). A summary of the progress in teacher activity observation results is presented in Table 3.

Table 3: Percentage of Teacher Activity Observation Results

Evaluation Criteria	Meeting 1 (%)	Meeting 2 (%)	Meeting 3 (%)	Average (%)
Very Good	2 (9.1%)	3 (13.6%)	4 (18.2%)	13.6%
Good	12 (54.5%)	13 (59.1%)	16 (72.7%)	62.1%
Adequate	4 (18.2%)	3 (13.6%)	2 (9.1%)	13.6%
Unsatisfactory	2 (9.1%)	2 (9.1%)	0 (0.0%)	6.1%
Poor	2 (9.1%)	1 (4.6%)	0 (0.0%)	4.6%
Total	22 (100%)	22 (100%)	22 (100%)	100%

Based on Table 3, in Meeting 1, there were 8 aspects that were not yet optimal (adequate, unsatisfactory, and poor categories). This occurred because the teacher was not yet optimal in providing apperception, stimulating student curiosity, directing group presentations, and guiding students to summarize the material. In Meeting 2, the teacher made improvements, reducing the sub-optimal aspects to 6. Furthermore, in Meeting 3, the teacher's performance increased significantly, with 20 aspects (90.9%) falling into the "good" and "very good" criteria, and no aspects remaining in the "unsatisfactory" or "poor" categories. Overall, the average implementation of teacher activity fell into the "good" and "very good" categories at 75.7%.

3.3.2 Student Activity Observation Results

The student activity observation sheet monitored 22 indicator aspects during the learning process. A summary of the development of student engagement is presented in Table 4.

Table 4: Percentage of Student Activity Observation Results

Evaluation Criteria	Meeting 1 (%)	Meeting 2 (%)	Meeting 3 (%)	Average (%)
Very Good	2 (9.1%)	3 (13.6%)	4 (18.2%)	13.6%
Good	11 (50.0%)	15 (68.2%)	16 (72.7%)	63.6%
Adequate	6 (27.3%)	3 (13.6%)	2 (9.1%)	16.7%
Unsatisfactory	2 (9.1%)	1 (4.6%)	0 (0.0%)	4.6%
Poor	1 (4.6%)	0 (0.0%)	0 (0.0%)	1.5%
Total	22 (100%)	22 (100%)	22 (100%)	100%

The observation results demonstrated a consistent, gradual increase in student engagement. In Meeting 1, 9 aspects of student engagement were considered sub-optimal. Students were hesitant to discuss, less responsive during apperception, and unaccustomed to presenting group outcomes. As students became accustomed to the PBL stages in Meetings 2 and 3, active involvement increased rapidly. By Meeting 3, activity aspects in the ”good” and ”very good” criteria reached 90.9% (20 aspects). The overall average percentage of student activity reached 77.2%, categorized as ”good” and ”very good”.

3.3.3 Student Learning Outcomes

The learning achievement test consisted of 5 essay items on SLETV material and was administered at the fourth meeting to 25 students who attended the evaluation. The Minimum Mastery Criteria (KKM) set for mathematics was 75.

Based on the final test data analysis, 19 students achieved scores of ≥ 75, resulting in a classical mastery rate of 76%. Meanwhile, 6 students (24%) had not achieved mastery as they scored below the KKM. These results demonstrate that student learning achievement met the established classical success indicator of $\geq 75\%$.

3.4 Reflection and Discussion

Reflection was conducted at the end of the cycle based on the analysis of teacher activity observations, student activity observations, and learning achievement test results. A summary of the action evaluation achievements is presented in Table 5.

Table 5: Summary of Action Implementation Achievements

No.	Evaluation Data Source	Achievement	Criteria / Mastery
1	Teacher Activity Observation Sheet	75.7%	Good / Very Good
2	Student Activity Observation Sheet	77.2%	Good / Very Good
3	Mathematics Learning Outcome Test	76.0%	Mastered ($\geq 75\%$)

The implementation of the Problem-Based Learning (PBL) model was gradually proven to improve the quality of the learning process in Class VIII-B at SMP Negeri 1 Suwawa. The teacher's classroom management activity showed continuous improvement, particularly in providing group guidance and facilitating discussions [14, 15]. This enhancement in teaching quality directly impacted student activity, leading students to become more confident in interacting, expressing opinions, and presenting discussion results in front of the class [5, 6, 13].

Students' active involvement in solving contextual SLETV problems on group worksheets fostered a deeper understanding of mathematical modeling and problem-solving concepts [3, 10, 12, 16]. This improvement was directly reflected in the student learning outcome test results, which achieved a classical mastery level of 76.0%, confirming that the PBL model effectively enhances student learning outcomes in mathematics [7–9]. Because all established success indicators (teacher activity, student activity, and classical learning mastery $\geq 75\%$) were achieved in Cycle I, this classroom action research was concluded and did not need to proceed to Cycle II [17, 18].

4. Conclusion

Based on the research results and discussion, it can be concluded that the implementation of the Problem-Based Learning (PBL) model on Systems of Linear Equations in Two Variables (SLETV) material successfully improved the engagement and mathematics learning outcomes of Class VIII-B students at SMP Negeri 1 Suwawa. This improvement is demonstrated by several main indicators:

- **Student Learning Outcomes:** The classical learning mastery rate reached 76.0% (19 out of 25 students achieved mastery with scores ≥ 75), meaning that it met the minimum success indicator target of 75%.
- **Teacher Activity:** The implementation of teacher activity in managing problem-based learning fell into the good/very good criteria with an average percentage of 75.7%.
- **Student Activity:** The level of student participation and active learning during the learning process reached an average percentage of 77.2%, categorized under good/very good criteria.

With all success indicators fulfilled in Cycle I, the Problem-Based Learning model is proven to be effective as an alternative interactive learning model to enhance the quality of the learning process and student learning achievements in mathematics.

Acknowledgments

The authors would like to express their sincere gratitude to all individuals and institutions who contributed to the completion of this research.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] C. E. Hmelo-Silver, "Problem-based learning: What and how do students learn?" *Educational Psychology Review*, vol. 16, no. 3, pp. 235–266, 2004, doi:10.1023/B:EDPR.0000034022.16470.f3.

[2] D. E. Allen, R. S. Donham, and S. A. Bernhardt, "Problem-based learning," *New Directions for Teaching and Learning*, no. 128, pp. 21–29, 2011, doi:10.1002/tl.465.

[3] A. Dorimana, A. Uworwabayeho, and G. Nizeyimana, "Enhancing upper secondary learners' problem-solving abilities using problem-based learning in mathematics," *International Journal of Learning, Teaching and Educational Research*, vol. 21, no. 8, pp. 235–252, 2022, doi:10.26803/ijlter.21.8.14.

[4] F. Dochy, M. Segers, P. V. den Bossche, and D. Gijbels, "Effects of problem-based learning: A meta-analysis," *Learning and Instruction*, vol. 13, no. 5, pp. 533–568, 2003, doi:10.1016/S0959-4752(02)00025-7.

[5] Hidayati, Z. Abidin, and B. I. Ansari, "Improving students' mathematical communication skills and learning interest through problem based learning model," *Journal of Physics: Conference Series*, vol. 1460, no. 1, 2020, doi:10.1088/1742-6596/1460/1/012047.

[6] S. Zamir, Z. Yang, H. Wenwu, and U. Sarwar, "Assessing the attitude and problem-based learning in mathematics through pls-sem modeling," *PLoS ONE*, vol. 17, no. 5, 2022, doi:10.1371/journal.pone.0266363.

[7] W. Malmia et al., "Problem-based learning as an effort to improve student learning outcomes," *International Journal of Scientific and Technology Research*, vol. 8, no. 9, pp. 1140–1143, 2019.

[8] E. Báró, "The effect of problem-based learning on students' learning outcomes," *Annales Mathematicae et Informaticae*, vol. 60, pp. 178–189, 2024, doi:10.33039/ami.2024.04.002.

[9] Masriah, S. Utaminingsih, and S. Utomo, "The influence of problem based learning model on mathematics learning outcomes in elementary school students," *AIP Conference Proceedings*, vol. 2733, no. 1, 2023, doi:10.1063/5.0140515.

[10] H. Damayanti and Susiswo, "Applying problem based learning to improve students' math problem-solving skills on system of linear equations with two variables," *AIP Conference Proceedings*, vol. 3049, no. 1, 2024, doi:10.1063/5.0194913.

[11] V. Mustafa, T. J. Zenku, E. Iseni, and S. Rexhepi, "Comparison of solving systems of linear equations with two variables with classic methods and application software," *International Electronic Journal of Mathematics Education*, vol. 21, no. 1, 2026, doi:10.29333/iejme/17836.

[12] A. R. Sakinah, C. Hiltrimartin, Y. Hartono, and Indaryanti, "High school students' mathematical modeling skills in problem-based learning (pbl)," *Journal of Physics: Conference Series*, vol. 1480, no. 1, 2020, doi:10.1088/1742-6596/1480/1/012041.

[13] A. S. Hidayat and D. Haryanto, "The application of problem based learning model to improve mathematical cognitive skill and students engagement toward curved-face three-dimensional objects in ix grade of smp laboratorium percontohan upi," *Journal of Physics: Conference Series*, vol. 1280, no. 4, 2019, doi:10.1088/1742-6596/1280/4/042037.

[14] D. H. J. M. Dolmans, W. D. Grave, I. H. A. P. Wolfhagen, and C. P. M. V. D. Vleuten, "Problem-based learning: Future challenges for educational practice and research," *Medical Education*, vol. 39, no. 7, pp. 732–741, 2005, doi:10.1111/j.1365-2929.2005.02205.x.

[15] R. P. Lainata, I. W. Damai, and A. Pesik, "Development of two variable linear equation system learning development with a problem-based learning model," *Journal of Physics: Conference Series*, vol. 1968, no. 1, 2021, doi:10.1088/1742-6596/1968/1/012052.

[16] S. Selfiani, T. Machmud, R. Resmawan, and Y. Ismail, "Pengaruh model problem based learning terhadap kemampuan berpikir kreatif matematis siswa pada materi kubus dan balok," *RMNS*, vol. 1, no. 2, 2022, doi:10.55657/rmns.v1i2.66.

[17] S. Arikunto, *Prosedur Penelitian Suatu Pendekatan Praktik*. Jakarta: Rineka Cipta, 2021.

[18] S. Kemmis, R. McTaggart, and R. Nixon, *The Action Research Planner: Doing Critical Participatory Action Research*. Singapore: Springer, 2014, doi:10.1007/978-981-4560-67-2.

[19] A. Sudijono, *Pengantar Evaluasi Pendidikan*. Jakarta: Rajawali Pers, 2018.