



THE EFFECT OF PROBLEM BASED LEARNING MODEL ASSISTED BY GEOGEBRA ON STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITY IN SPLDV MATERIAL OF 9TH GRADE AT STATE JUNIOR HIGH SCHOOL 45 MEDAN.

Putri Lingga Sari^{1*}, Suci Frisnoiry²

¹State University of Medan, Faculty of Mathematics and Natural Science, Indonesia;
lggsr0303@gmail.com

²State University of Medan Faculty of Mathematics and Natural Science, Indonesia;
sucifrisnoiry@unimed.ac.id

Corresponding Author*:

Putri Lingga Sari
State University of Medan
Jln. Willem Iskandar, Pasar V, Medan Estate.
lggsr0303@gmail.com
Contact Person: 0822-4425-0887

Article Info:

Received 2025-10-19
Revised 2026-01-30
Accepted 2026-04-17

How to Cite:

Sari, Putri Lingga., & Frisnoiry, Suci. (2026). The Effect Of Problem Based Learning Model Assisted By Geogebra On Students' Mathematical Problem-Solving Ability In Spldv Material Of 9th Grade At State Junior High School 45 Medan.. *Jurnal Theorems (The Original Research of Mathematics)*, 11(1), 58-72.

ABSTRACT

This study aims to determine whether students' mathematical problem-solving ability taught using the problem-based learning model assisted by GeoGebra is higher than that of students taught using conventional learning in Grade IX of State Junior High School 45 Medan in the academic year 2025/2026. The research method used was a quasi-experimental method. The sample of this study consisted of two classes, namely class IX-2 as the control class and class IX-3 as the experimental class. Based on the results of the study, it was found that the mathematical problem-solving ability of students in the experimental class showed a significant improvement with an average pretest score of 56.13 and a posttest score of 81.33. The results of the mathematical problem-solving ability test of students in the control class also showed significant improvement with an average pretest score of 57.7 and a posttest score of 73.23. Based on the t-test results, it was obtained that $t_{hitung} > t_{tabel}$ was $9.0418 > 2.002$, which means that the mathematical problem-solving ability of students taught using the problem-based learning model assisted by GeoGebra is higher than that of students taught using conventional learning

Keywords: Problem Based Learning, GeoGebra, Students Mathematical Problem-Solving Ability.

INTRODUCTION

Mathematics is a universal science that is useful for human life; it can stimulate students' thinking processes systematically and logically to solve mathematical problems as well as problems in daily life (Nurhasanah et al., 2022). Mathematics learning in school has always been inseparable from arithmetic operations, including addition, subtraction, multiplication, and division, all of which are related to number concepts (Permatasari et al., 2023). The process of learning mathematics is related to many concepts. Mathematics also has one concept that is connected to other concepts. As a result, students perceive mathematics as having an abstract nature, which leads to it being considered a difficult subject (Diro et al., 2024).

One of the goals of mathematics learning according to “Permendikbud No. 22 of 2016” and NCTM is to learn for problem-solving. Problem-solving is essential because it allows students to identify mathematical problems and solve them in a logical and structured manner. According to Rahmawati et al. (2021), mathematical problem-solving ability is essentially one of the important and essential mathematical skills that students must master, as they will be trained to think creatively, logically, critically, and systematically in solving mathematical problems. This aligns with the opinion of Sagita et al. (2023), who state that problem-solving is an important part of learning mathematics because it focuses not only on understanding concepts but also on developing thinking skills methods.

Mathematical problem-solving can be defined as a series of learning activities that emphasize the process of scientific problem-solving (Kania & Ratnawulan, 2022). In reality, many students still struggle with solving mathematical problems. This was found from the results of the Trends in International Mathematics and Science Study (TIMSS) inspection in 2018, which showed that Indonesia ranked 73rd out of 79 other countries participating in TIMSS, with an estimated average of 397. This indicates that Indonesian students' ability to solve mathematical problems is far lower than that of students in other countries. This low score indicates students' difficulty in applying mathematical concepts to practical and complex problems. Indonesia's Program for International Student Assessment (PISA) scores also did not show substantial improvement, consistently remaining below 400, which indicates that students struggle to apply mathematical knowledge to solve problems requiring critical and analytical thinking, as well as to relate mathematical concepts to real-life situations (Fauziah et al., 2022).

The researcher's initial test confirmed the low mathematical problem-solving ability. The preliminary evaluation results revealed that students were still having difficulties with all aspects of problem solving. Additionally, errors in calculating discounts and the application of inappropriate methods result in inaccurate results. Students also did not show critical reflection on the results obtained, tending to consider all results correct without evaluation. This indicates that students' ability to understand, plan, execute, and evaluate the solution of mathematical problems is still low.

One of the main causes of students' low mathematical problem-solving abilities is that mathematics learning in the classroom still uses conventional, teacher-centered instruction (Andriani & Arhasy, 2019). In practice, teachers do most of the talking while students only listen or take notes, creating a passive and rigid learning environment. This makes students feel bored, lose focus, and become less emotionally and intellectually engaged in the learning process. When learning doesn't provide challenges or connect the material to students' real-life experiences, learning motivation tends to decrease (Susanti et al., 2024).

This was also evident during observations, where in the learning process, the teacher dominated activities through lectures, examples, and exercises, while students only passively received information.

This resulted in a lack of student activity in the learning process. Additionally, the teacher also stated that throughout the learning process, they never used application-based learning media. As a result, many students have difficulty solving mathematical problems independently. This is supported by the opinion of Wijayanti et al. (2023), who stated that one of the main reasons for students' low mathematical problem-solving abilities is that most students are accustomed to being presented with routine problems.

Additionally, students are less accustomed to questions that require a thorough understanding of concepts, such as contextual or real-life-based questions, which are essentially crucial for training higher-order thinking skills. This is exacerbated by a teaching approach that is still teacher-centered, where classroom interaction is only one-way, from teacher to student, without allowing for exploration and discussion. In this case, the teaching techniques or strategies implemented have not provided students with the opportunity to actively construct their own knowledge thru meaningful learning experiences. According to research conducted by Aslan & Duruhan (2021), student-centered learning has the potential to hinder the development of problem-solving skills because students are not directly involved in the process of thinking and independently solving mathematical problems.

To solve the problems in mathematical problem-solving ability, a teaching and learning process is needed that can improve students' understanding and mathematical problem-solving abilities thru the application of various types of models, methods, strategies, and approaches. Problem-Based Learning (PBL) is a learning model that uses real-world problems as the context for students to solve problems, enabling them to make decisions about each issue and encouraging them to gather information to solve problems (Hasbi & Fitri, 2023; Muzaini et al., 2022). This aligns with the opinions of Sarah & Tasman (2022), who stated that the problem-based learning model can be used to improve mathematical problem-solving abilities because this model actively and collaboratively involves students in the learning process. Additionally, Putri et al. (2023) stated that the problem-based learning model can be used as one alternative for selecting a learning model that can actively engage students in independently exploring information, thinking critically, working together, and finding solutions to achieve learning objectives.

However, according to Ulva et al. (2020), the problem-based learning model did not have a statistically significant effect on students' mathematical problem-solving abilities in schools with medium and low levels. This could be due to students' lack of preparedness for learning methods that require active participation and critical thinking, as well as potential difficulties in understanding more complex material without adequate support. Therefore, further research is needed to reexamine the effectiveness of the problem-based learning model in improving mathematical problem-solving abilities. This research is expected to provide stronger empirical evidence regarding the significant impact of this model, particularly across different grade levels and school conditions.

Beside learning models, the use of learning media is necessary to improve students' understanding of mathematical concepts. Learning accompanied by media serves as a vehicle for conveying messages to students. One learning medium that can be used is Geogebra software (Mahardihika & Nurjanah, 2024). Geogebra is a learning tool that can stimulate students to understand mathematical concepts and problem-solving thru object visualization (Fatihah & Yahfizham, 2024). This aligns with the opinion of (Nilasari et al., 2023) who stated that Geogebra can be used as an aid in improving students' mathematical problem-solving abilities because Geogebra is a tool that can visually display mathematical ideas, thus helping students understand complex concepts.

The GeoGebra application can generate graphical representations of various mathematical topics, including geometry, algebra, and matrices, which are engaging for students. This aligns with the teaching material for linear programming, whose characteristics require the illustration of function graphs, constraints, and solution sets (Fauzy et al., 2023). Furthermore, GeoGebra supports problem-based learning (PBL) by providing students with the opportunity to actively engage in the learning process. In the context of PBL, students can use GeoGebra to identify and solve problems, which encourages them to develop more effective problem-solving strategies (Nilasari et al., 2023).

METHODS

This research is classified as quantitative research with a quasi-experimental approach, involving two sample classes: the experimental class and the control class. The experimental class received treatment using the Geogebra-assisted problem-based learning model, while the control class received direct instruction. Here is the research design that will be used.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experimen	O ₁	X ₁	O ₂
Control	O ₁	X ₂	O ₂

Description:

- O₁ = The pretest is given before the treatment begins.
- O₂ = The posttest is given after the treatment begins.
- X₁ = Learning using a problem-based learning model assisted by GeoGebra
- X₂ = Learning using conventional methods

This research is located at State Junior High School 45 Medan, which is located at Jl. Jala Raya Griya Martubung, Medan Labuhan, Medan City, North Sumatra. With the implementation period in the odd semester of the 2025/2026 academic year. The study population consisted of all ninth-grade students, while the sample for this study was selected using the Cluster Random Sampling technique. Therefore, the study sample consisted of two classes, IX-2 and IX-3, with 30 students in each class.

This study uses two variables. First, the independent variable (X) is the Problem-Based Learning model with the assistance of the GeoGebra application. Meanwhile, the dependent variable (Y) in this study is students' mathematical problem-solving ability. Then the data was collected using observation and documentation. The instrument used in the study was an essay test sheet. After the data is collected, data analysis is performed using normality tests, homogeneity tests, hypothesis tests, N-Gain tests, and effect size tests.

FINDINGS

The results of the pretest and posttest assessments in the experimental and control classes can be described as shown in the table below:

Table 2. Pretest dan Posttest of Experiment and Control Class

No	Code	Experiment		Code	Control		
		Pretest	Posttest		Pretest	Posttest	
1	S1	33	73	S1	33	63	
2	S2	70	100	S2	40	63	
3	S3	40	70	S3	43	53	
4	S4	60	100	S4	43	50	
5	S5	50	80	S5	50	63	
6	S6	43	83	S6	50	80	
7	S7	50	90	S7	50	60	
8	S8	53	83	S8	53	60	
9	S9	43	83	S9	60	73	
10	S10	60	93	S10	50	63	
11	S11	46	60	S11	53	63	
12	S12	53	90	S12	60	96	
13	S13	53	70	S13	60	96	
14	S14	50	96	S14	53	73	
15	S15	60	93	S15	70	73	
16	S16	53	63	S16	60	80	
17	S17	53	70	S17	63	93	
18	S18	53	60	S18	53	70	
19	S19	53	100	S19	53	70	
20	S20	60	70	S20	63	73	
21	S21	63	63	S21	63	70	
22	S22	40	56	S22	53	70	
23	S23	43	73	S23	70	90	
24	S24	63	83	S24	70	73	
25	S25	63	80	S25	53	90	
26	S26	70	83	S26	53	83	
27	S27	70	96	S27	73	80	
28	S28	73	93	S28	73	83	
29	S29	80	96	S29	80	60	
30	S30	83	90	S30	83	83	
		$\sum = 1684$	$\sum = 2440$			$\sum = 1731$	$\sum = 2197$
		$\bar{X} = 56,13$	$\bar{X} = 81,33$			$\bar{X} = 57,7$	$\bar{X} = 73,23$

$SD = 11,84$	$SD = 13,18$	$SD = 11,45$	$SD = 12,18$
$Var = 145,22$	$Var = 179,95$	$Var = 135,66$	$Var = 153,56$

Based on the posttest results, the average score for the experimental class was 81.33, while the average for the control class was 73.23. This average difference indicates that learning using the Geogebra-assisted problem-based learning model is better at improving students' mathematical problem-solving abilities compared to conventional learning. Pedagogically, this indicates that students in the experimental class are more capable of understanding the concept of linear equations in two variables, analyzing problems, and applying appropriate solution strategies. The visualizations provided by GeoGebra help students understand the relationships between variables and reduce conceptual errors.

Data Analysis

The data analysis for the testing is in the form of a t-test performed manually. However, before hypothesis testing is conducted, prerequisite tests are first performed, namely normality and homogeneity tests. The data analysis for the testing is in the form of a t-test performed manually. However, before hypothesis testing is conducted, prerequisite tests are first performed, namely normality and homogeneity tests.

Normality Test

Normality testing is used to test whether the research data collected is normally distributed or not. Researchers chose the Shapiro-Wilk test for this normality test because the data type for the researcher's variables is interval data. The normality test results are shown below:

Table 3. Normality Test Result

Class	Data	N	$W_{Calculated}$	W_{table}	Result
Experiment	Pretest	30	0,967	0,927	Normally
	Posttest		0,932		
Control	Pretest	30	0,962	0,927	Normally
	Posttest		0,956		

From the table, for the pretest and posttest of the experimental class, it was obtained that $W_{Calculated} > W_{table} = 0.967; 0.932 > 0.927$, and then for the pretest and posttest of the control class, it was obtained that $W_{Calculated} > W_{table} = 0.962; 0.956 > 0.927$. Based on the calculation results, it can be concluded that the pretest and posttest of the experimental and control classes come from a normally distributed population.

Homogeneity Test

The homogeneity test is used to see or prove that two or more sample data groups originating from the same population have equal variances. In this study, the F-test was used to test the homogeneity of the data. The homogeneity test results are shown below:

Table 4. Homogeneity Test Result

Group	$F_{calculated}$	F_{table}	Result
Pretest	1,072	1,861	Homogen

From the table, it is obtained that $F_{calculated} < F_{table} = 1.072 < 0.861$ at a significance level of $\alpha = 0.05$. Based on the calculation results, it can be concluded that both the experimental and control classes come from a homogeneous population.

Hypothesis Test (t-test)

Hypothesis testing was conducted using the t-test, which compares the posttest mean scores of mathematical problem-solving abilities between experimental and control class students to determine if there was a significant improvement in the mathematical problem-solving abilities of students taught using the Geogebra-assisted problem-based learning. The results of the hypothesis test calculations are presented in the following table:

Table 5 Hypothesis Test Result

Data	Mean	$t_{calculated}$	t_{table}	Conclusion
Experimental	81,33	9,418	2,002	Influential
control	73,23			

Based on the table above, the results of the hypothesis test calculation for the posttest mean scores of the experimental and control classes provided $t_{calculated} = 9.418 > t_{table} = 2.002$, with the posttest mean score in the experimental class being 81.33, categorized as high, and the control class mean being 73.23, categorized as Medium. Therefore, H_0 is rejected and H_1 is accepted. Statistically, this indicates a significant difference between the mean scores of students in the experimental and control classes.

N-Gain Test

Testing with N-Gain is a test used to measure the extent of improvement that occurs in a class before and after being given treatment by comparing pretest and posttest scores. The results of the N-Gain test calculation are presented in the following table:

Table 6. N-Gain Test Result

Class	N-Gain	Interpretation
Experiment	0,584	Medium
Control	0,338	Medium

From the N-Gain test calculations in the table above, an N-Gain score of 0.584 was obtained, which falls into the moderate category with a percentage of 58.4% (quite effective) for the experimental

class, while for the control class, an N-Gain score of 0.338 was obtained, which falls into the moderate category with a percentage of 33.8% (not effective). Therefore, the results of the N-Gain test in this study show that both the experimental and control classes fall into the moderate category, with the percentage of the experimental class being 24.6% higher than the control class, indicating moderate effectiveness for the experimental class treatment in improving students' mathematical problem-solving abilities.

Significant Impact Test

After conducting a hypothesis test and finding a difference in the average mathematical problem-solving abilities of students between the two classes, the next step is to measure the magnitude of the impact. A summary of the calculations is shown in the following table:

Table 7. Significant Impact Test

Class	Mean	Varians	Standart Devitiation	Impact (d)
Experiment	81,33	179,95	12,8	0,632
Control	73,23	153,56		

From the size of the impact test calculations in the table above, it can be seen that the result obtained is a Cohen's d value of $d \approx 0.632$, which falls into the category of a moderately large effect size.

DISCUSSION

Both the experimental and control group pretests revealed limitations in understanding the problems presented. Many students are still unable to identify key information from the questions, making it difficult for them to determine the best solution strategy. According to Jupri and Drijvers (2016) one of the most difficult stages for students when solving mathematical word problems is mathematization, which involves transforming information from the problem into an appropriate mathematical model. Additionally, according to Agusfianuddi, et.al (2024), low reading and comprehension skills also contribute to students' difficulty in extracting important information.

After the posttest was given, both the control and experimental classes showed an improvement in students' ability to understand the problems, which was evident after the students were given instruction. Students became more capable of identifying important information and determining more appropriate problem-solving strategies. However, the most significant improvement occurred in the experimental class that received problem-based learning assisted by Geogebra. This is supported by Wulandari (2023), who found that using problem-based learning assisted by Geogebra significantly improved students' problem-solving abilities. Similar findings were also presented by Suratno & Waliyanti (2023), where integrating Geogebra with problem-based learning was proven to improve students' problem-solving skills more effectively than teacher-centered learning.

This is also evident during the teaching and learning process, where in the teacher-centered control class, students are less actively involved in the learning process, tending to only listen to what the teacher explains. As stated by Ng & Karjanto (2023), in teacher-centered learning, students who only listen without active involvement tend to have lower learning outcomes compared to active learning that encourages student participation. Meanwhile, according to Cevikbas & Kaisar (2020), this concretely shows that traditionally arranged classrooms and teacher-centered teaching methods lead to minimal problem-solving activities and student interaction.

In the learning process, students can only solve problems that are almost identical to the examples. If the problems given are slightly different from the example problems, students become confused and have difficulty solving them, and only a few students are able to complete them. In this case, students are still not familiar to solving problems and their learning outcomes are less than optimal. Meanwhile, in the learning process conducted in the experimental class, it can be seen that students who were given treatment using the Geogebra-assisted problem-based learning model were more actively involved during the learning process in the classroom. This is in line with the research by Anawula et al. (2025), which shows that using the Geogebra-assisted problem-based learning model can increase student activity, especially during group discussions.

Student engagement in learning results in students being more skilled and capable of collaborating to solve problems within a group. When the teacher orients students to a problem by explaining the objectives, motivating the students, and presenting contextual problems relevant to daily life, especially those directly related to the students' spldv material, the students immediately try to identify the problem using the Geogebra application. This allows students to see the relationship between two equations more clearly, such as the number of items and the price. With the help of Geogebra, students are able to mark variables and label the values from the story problem into equations in Geogebra, making it easier for them to understand what is known and what is being asked in the problem, and facilitating their understanding of the problem situation.

This is also evident from the posttest results for the first indicator, which showed an increase from 53.33% previously to 95.00%. This increase is due to students' ability to identify and model contextual problems into mathematical equations, which is increasingly guided thru dynamic Geogebra visualization. The interactivity of the GeoGebra application allows students to explore various scenarios directly, thus strengthening their conceptual understanding of variables and relationships between equations. The collaborative process within the group also encourages in-depth discussion, where students correct and refine their mathematical models, ultimately leading to a significant improvement in mathematical problem-solving abilities on the first indicator.

Furthermore, when the students were divided into 5 groups of 6 people each. Students were seen discussing with each other, exchanging ideas, and working together to find various alternative solutions.

Thru GeoGebra with its clear algebraic display, students can see the relationships between variables, making the solution plan more focused. At this stage, students concretely formulate strategies before actually performing calculations or drawing graphs, thereby increasing their active involvement and sense of responsibility for the learning process.

Collaborative dynamics directly contributed to a significant improvement in the second indicator, which is developing a plan. Which increased from 56.30% on the pretest to 90.00% on the posttest results. This achievement demonstrates that structured group interaction enables students to systematically design strategic steps before performing the calculation process. Thru discussion, students are not only able to identify variables, but also agree on an effective order of mathematical operations. GeoGebra's features that visualize the consequences of each plan provide students with instant feedback, allowing them to evaluate and revise their strategies directly. Thus, the process of developing a plan transforms from a mere procedural routine into a deep cognitive activity, ultimately ensuring near-perfect mastery of planning indicators. At the moment, the teacher served as a facilitator, providing guidance when needed, while GeoGebra was used as a tool to conduct trials or verify the steps of the solution. This was also stated by Almulla (2020) that problem-based learning is able to increase student engagement thru various knowledge and discussions. Then, in accordance with Anzani's (2022) opinion, thru presentations and group discussions, students developed communication skills where they clearly conveyed ideas and arguments.

Implementation at this stage proved to significantly improve students' performance on the indicator of executing plans, as reflected in a 23.3% increase in pretest scores (from 64.07% to 79.26%). Although this percentage is not as high as the achievement on the previous indicator, this consistent improvement indicates that the learning guide thru GeoGebra successfully guided students in translating strategic plans into concrete actions. When students analyze the suitability between mathematical solutions and real-world problem contexts, they are indirectly self-evaluating the validity of their answers. Thus, the stage of implementing this plan serves as a bridge connecting strategic planning with critical reflection.

At the end of the learning session, a reflection is conducted by reviewing the strategies that have been used. At this moment, you can see how students are sharing opinions, providing feedback, and discussing the work of their classmates. Geogebra is used by students to double-check the results of the solutions they have obtained. The reflection process has proven to build the foundations of students' metacognitive skills, particularly in reexamining. Although the improvement in this aspect was not as significant as other indicators (from 47.22% to 57.78%), this actually confirms the complexity of self-evaluation, which requires a deep understanding that goes beyond simply finding the correct answers and moves toward verifying the process. However, the consistent improvement in this indicator shows that the structured reflection framework thru GeoGebra has successfully cultivated the seeds of metacognitive awareness.



The increase in percentage also proves that students are starting to develop the habit of reviewing their work, rechecking their solutions, and taking responsibility for their answers. This is an important stage where students no longer see mathematics as just calculation, but as a process that needs to be rationally reexamined. So, even tho the increase wasn't drastic, this change is a significant achievement in cultivating deep thinking habits for problem-solving. This aligns with Susanti's (2021) opinion, which emphasizes that reflection strategies can improve thinking errors and complete incomplete problem-solving algorithms. Similar findings were obtained from Sangpom et al. (2020), who stated that reflection supports students in developing advanced mathematical thinking thru problem-solving arranged in stages with increasing complexity.

The research results indicate that using GeoGebra in a problem-based learning model has a positive impact on students' mathematical problem-solving abilities. These research findings are clearly and significantly different from previous studies, both in terms of achievement results, research design, and application context. In terms of results, the studies by Sarah (2022) and Nisa et al. (2023), which only used the problem-based learning model without the aid of GeoGebra, showed that students' mathematical problem-solving abilities were in the range of 66-79, while the studies by Ramadani & Musdi (2023) and Anawula et al. (2025), which integrated GeoGebra, showed an increase to 69-78. In this study, the average posttest score for the experimental class reached 81.33, indicating a higher improvement compared to all relevant studies used as references.

Then, in terms of design, most previous studies used a posttest-only control design. This design is considered susceptible to bias, particularly selection bias and threats to internal validity, because it cannot control for initial differences in ability between the experimental and control groups. In line with the opinion of Capili & Anastasi (2024), who stated that the posttest-only control design has certain limitations, the absence of an initial measurement (pretest) makes it difficult to know whether the experimental and control groups were already equivalent before the treatment. This opens up the possibility of selection bias (the groups already have different abilities from the start) and without a pretest, it cannot be claimed that the observed effect is truly due to the treatment, not because of initial differences between the groups.

Conversely, this study uses a pretest-posttest control group design, which allows the researcher to compare the initial and final abilities of both groups, making the results objective, measurable, and valid. Additionally, the difference in the context of application is also an advantage of this research. This research focuses on 9th-grade middle school students learning the topic of systems of linear equations with two variables (SPLDV), which is essential material but often considered difficult by students. This difference in grade level and material broadens the scope of the scientific contribution of the Geogebra-assisted problem-based learning model in a more varied context.



And most importantly, the statement by Ulva et al. (2020) that the problem-based learning model has no significant effect serves as an important foundation. My research reinforces and provides stronger empirical evidence that the GeoGebra-assisted problem-based learning model significantly improves students' mathematical problem-solving abilities, demonstrating the effectiveness of this model when supported by stronger media and research design. However, in previous studies, the researcher used several instruments consisting of tests and non-tests, whereas this study only uses test instruments. Therefore, the previous study has more complete data compared to this study.

CONCLUSION AND SUGGESTION

Based on observations during the learning process using the Geogebra-assisted problem-based learning model, students appeared more active in discussions, were able to identify information from the problems, and were more skilled in developing problem-solving strategies compared to students in the control class who received teacher-centered learning. Based on data analysis and discussion of research findings, it is possible to conclude that the Geogebra-assisted problem-based learning model has a positive and significant effect on students' mathematical problem-solving abilities in the SPLDV material for 9th-grade students at State Junior High School 45 Medan during the 2025/2026 academic year.

ACKNOWLEDGMENTS

Praise be to God Almighty for His grace and blessings, which enabled the successful completion of this research. The author expresses sincere gratitude to the Principal of SMP Negeri 45 Medan, all teachers, staff, and school personnel who provided permission, support, and convenience in the implementation of this research. Special thanks are extended to the students who participated in the research, as well as to all parties who directly or indirectly contributed to the realization of this scientific article. Awards were also given to family and colleagues for their motivation and moral support during the research and writing process. Hopefully, the results of this research can make a significant contribution to the development of educational science and serve as a useful reference for future research.



REFERENCE

- Agusfianuddin, A., Herman, T., & Turmudi, T. (2024). Investigation of Students' Difficulties in Mathematical Language: Problem-Solving in Mathematical Word Problems at Elementary Schools. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, 10(2), 578. <https://doi.org/10.33394/jk.v10i2.11257>
- Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open*, 10(3). <https://doi.org/10.1177/2158244020938702>
- Anawula, S. R., Awaludin, A., & Zamsir, Z. (2025). Pengaruh Model Problem Based Learning Berbantuan Aplikasi Geogebra terhadap Kemampuan Pemecahan Masalah Matematis Siswa. *Jurnal Penelitian dan Pendidikan Matematika*, 13(1), 113–124. <http://dx.doi.org/10.36709/jppm.v13i1.50104>
- Andriani, T., & Arhasy, E. A. (2019). Kemampuan Pemecahan Masalah Matematik Peserta Didik Ditinjau dari Penggunaan Model Problem Based Learning (PBL) dan Model Creative Problem Solving (CPS). *Prosiding Seminar Nasional & Call For Papers*, 577–585.
- Aslan, S. A., & Duruhan, K. (2021). The effect of virtual learning environments designed according to problem-based learning approach to students' success, problem-solving skills, and motivations. In *Education and Information Technologies*, 26(7), 2253-2283. <https://doi.org/10.1007/s10639-020-10354-6>
- Capili, B., & Anastasi, J. K. (2024). An Introduction to Types of Quasi-Experimental Designs. *American Journal of Nursing*, 124(11), 50–52. <https://doi.org/10.1097/01.NAJ.0001081740.74815.20>
- Cevikbas, M., & Kaiser, G. (2020). Flipped classroom as a reform-oriented approach to teaching mathematics. *ZDM - Mathematics Education*, 52(7), 1291–1305. <https://doi.org/10.1007/s11858-020-01191-5>
- Diro, A., Saprin, M., Kodri, S., Susanti, S., Yudewinarti, Y., Herdiansyah, H., Larawati, L., & Sari, W. (2024). Probelmatika Pembelajaran Matematika Kelas Tinggi Di Sekolah Dasar. *SIGMA: jurnal Pendidikan Matematika*, 16(20), 73–83. <https://doi.org/10.26618/sigma.v16i1.14348>
- Fauziah, N., Roza, Y., & Maimunah, M. (2022). Kemampuan Matematis Pemecahan Masalah Siswa dalam Penyelesaian Soal Tipe Numerasi AKM. *Jurnal Pendidikan Matematika*, 6(3), 3241–3250. <https://doi.org/10.31004/cendekia.v6i3.1471>
- Fatihah, A., & Yahfizham, Y. (2024). Penerapan Geogebra Terhadap Kemampuan Pemecahan Masalah Matematis Siswa dalam Pembelajaran Matematika. *PENDEKAR: Jurnal Pendidikan Berkarakter*, 2(3), 117127. <https://myjms.mohe.gov.my/index.php/jdpd/article/view/10334/4888>
- Fauzy, A., Jaenal, E., Danny, F., Hidayat, W., Hendriana, H., Putra, H. D., Sugandi, A. I., Siliwangi, I., Terusan, J., Sudirman, J., Cimahi, J., & Barat, I. (2023). Bahan Ajar Berbantuan Geogebra dan Kemampuan Pemecahan Masalah Matematis: Design Research. *Teorema: Teori Dan Riset Matematika*, 8(2), 257–268. <https://dx.doi.org/10.25157/teorema.v8i2.11596>
- Hasbi, M., & Fitri. (2023). Pre-Service Teachers with Courses in Problem-Based Learning in Mathematics. *ETDC: Indonesian Journal of Research and Educational Review*, 2(2), 51–60. <https://doi.org/10.51574/ijrer.v2i2.588>



- Jupri, A., & Drijvers, P. (2016). Student difficulties in mathematizing word problems in Algebra. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(9), 2481–2502. <https://doi.org/10.12973/eurasia.2016.1299a>
- Kania, N., & Ratnawulan, N. (2022). Kompetensi Matematika: Kemampuan Pemecahan Masalah Matematis Siswa Menurut Polya. *Journal of Research in Science and Mathematics Education (J-RSME)*, 1(1), 17–26. <https://doi.org/10.56855/jrsme.v1i1.10>
- Mahardihika, G., & Nurjanah, N. (2024). Pengaruh Pembelajaran Problem Based Learning (PBL) Berbantuan Geogebra Untuk Meningkatkan Kemampuan Pemahaman Konsep Matematis Siswa. *SIGMA: Jurnal Pendidikan Matematika*, 16(2), 385-394. <https://doi.org/10.26618/sigma.v16i2.15218>
- Muzaini, M., Hasbi, M., Ernawati, E., & Kristiawati, K. (2022). The Empowerment of Problem-Based Learning Models to Improve Students' Quantitative Reasoning. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 12(1), 10–24. <https://doi.org/10.30998/formatif.v12i1.8502>
- Ng, P. K., & Karjanto, N. (2023). Enhancing academic performance: The impact of active learning in mathematical economics. 1–4. <http://arxiv.org/abs/2311.12837>
- Nilasari, N., Marlina, M., & Ayuningtyas, V. (2023). Pengaruh Model Problem Based Learning Berbantuan Software Geogebra terhadap Kemampuan Pemecahan Masalah Matematis dan Minat Belajar Matematika. 2(2), 68–77. <https://doi.org/10.31957/cjce.v2i2.3848>
- Nurhasanah, F., Sumarni, S., & Riyadi, M. (2022). Pengembangan E-Modul Materi Barisan Dan Deret Untuk Memfasilitasi Kemampuan Pemecahan Masalah Matematis. *Sigma: Jurnal Pendidikan Matematika*, 14(2), 104–117. <https://doi.org/10.26618/sigma.v14i2.9320>
- Nisa, K., Nasrullah, A., Hidayat, A., Mahuda, I., & Bhat, I. A. (2023). Problem-Based Learning in Improving Problem-Solving Ability and Interest in Learning Mathematics: An Empirical Study. *International Journal of Mathematics and Mathematics Education*, 1(3), 206–217. <https://doi.org/10.56855/ijmme.v1i3.725>
- Permatasari, A. C., Sari, J. A., Winanda, T., Saputra, R. I., Silvi, S., Annisa, P., & Fitriani, E. (2023). Analisis Kesulitan Belajar Matematika dalam Menyelesaikan Soal. *Jurnal Pendidikan Dasar Flobamorata*, 4(1), 421–423. <https://univpgri-palembang.ac.id>
- Putri, D. E. N., Maulana, M., & Irawati, R. (2023). Pengaruh Model Problem Based Learning terhadap Kemampuan Pemecahan Masalah Matematis Siswa. *Ideguru: Jurnal Karya Ilmiah Guru*, 9(3), 1797–1804. <https://doi.org/10.51169/ideguru.v9i3.1307>
- Rahmawati, A., Lukman, H. S., & Setiani, A. (2021). Analisis Kemampuan Pemecahan Masalah Matematis Siswa Sd Ditinjau Dari Tingkat Kecerdasan Intelektual. *Jurnal Ilmiah Pendidikan Matematika*, 4(2), 79–90. <http://repository.upi.edu/54235>
- Ramadani, S., & Musdi, E. (2023). Pengaruh Penerapan Model Pembelajaran Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematis Peserta Didik Kelas Viii. *Jurnal Edukasi Dan Penelitian Matematika*, 12(1), 70–76. <https://doi.org/10.24036/pmat.v12i1.14292>
- Sagita, D. K., Ermawati, D., & Riswari, L. A. (2023). Kemampuan Pemecahan Masalah Matematis Siswa Sekolah Dasar. *Jurnal Educatio FKIP UNMA*, 9(2), 431–439. <https://doi.org/10.31949/educatio.v9i2.4609>



- Sangpom, W., Suthisung, N., Kongthip, Y., & Inprasitha, M. (2020). Advanced Mathematical Thinking and Students' Mathematical Learning: Reflection from Students' Problem-Solving in Mathematics Classroom. *Journal of Education and Learning*, 5(3), 72. <https://doi.org/10.5539/jel.v5n3p72>
- Sarah, M., & Tasman, F. (2022). Pengaruh Penerapan Model Pembelajaran Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematis Peserta Didik Di Kelas VIII SMP Negeri Palupuh. *Jurnal Edukasi dan Penelitian Matematika* 11(3). 115-123. <http://dx.doi.org/10.24036/pmat.v11i3.14035>
- Suratno, J., & Waliyanti, I. K. (2023). Integration of GeoGebra in Problem-Based Learning to Improve Students' Problem-Solving Skills. *International Journal of Research in Mathematics Education*, 1(1), 63–75. <https://doi.org/10.24090/ijrme.v1i1.8514>
- Susanti, E. (2021). Reflection Strategies on Students' Thinking Structures in the Mathematical Problem Solving Steps. *Mathematics Education Journal*, 5(2), 145–158. <https://doi.org/10.22219/mej.v5i2.17249>
- Susanti, S., Aminah, F., Mumtazah Assa'idah, I., Wati Aulia, M., & Angelika, T. (2024). Dampak Negatif Metode Pengajaran Monoton Terhadap Motivasi Belajar Siswa. *Pedagogik: Jurnal Pendidikan Dan Riset*, 2(2), 86–93. <https://ejournal.edutechjaya.com/index.php/pedagogik/article/view/529>
- Ulva, E., Maimunah, M., & Murni, A. (2020). Pengaruh Model Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematis Siswa Kelas VII SMP N Se-Kabupaten Kuantan Singingi. 04(02), 1230–1238. <https://doi.org/10.31004/cendekia.v4i2>
- Wulandari, W., Misu, L., & Salim. (2023). Problem-Based Learning Model with Geogebra Support on Students' Ability to Solve Mathematical Problems. *Jurnal Amal Pendidikan*, 4(3), 240–250. <http://doi.org/10.36709/japend.v4i3.85>
- Wijayanti, N. S., Maulana, M., & Isrok'atun, I. (2023). Kemampuan Pemecahan Masalah Peserta Didik dalam Pendekatan Comprehensive Mathematics Instruction. *JNPM (Jurnal Nasional Pendidikan Matematika)*, 7(1), 55. <https://doi.org/10.33603/jnpm.v7i1.7610>