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THE EFFECT OF PROBLEM BASED LEARNING (PBL) ASSISTED BY GEOGEBRA ON MATHEMATICAL PROBLEM SOLVING ABILITY

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Abstract

This study examines the effect of implementing a GeoGebra-assisted Problem Based Learning (PBL) model on students' mathematical problem solving abilities. It was motivated by students' low initial performance in solving problems, as indicated by pretest scores below the minimum mastery criterion, highlighting the need for innovative, technology integrated instruction. This study adopted a quantitative method employing a quasi experimental design with a pretest posttest control group. The participants were 42 seventh grade students at SMP Negeri 2 Abung Surakarta, with 22 in the experimental group (Class VII A) and 20 in the control group (Class VII B), selected via purposive sampling. The intervention spanned five sessions on the topic of squares, with the experimental group receiving GeoGebra assisted PBL instruction and the control group receiving conventional teaching. Data were collected through problem solving tests and analyzed using normality and homogeneity tests, N-gain analysis, and independent samples t-tests. Results showed that the experimental group achieved a higher average N-gain (0.608) than the control group (0.444), and the t-test indicated a significant difference ($T_{count} = 3.154 > T_{table} = 2.021$, $\alpha = 0.05$). These findings confirm that the GeoGebra assisted PBL model effectively enhances students' mathematical problem solving skills and supports the use of technology integrated learning in teaching squares at the junior high school level.

Keywords: Geogebra; Mathematical Problem Solving Ability; Problem Based Learning

1. INTRODUCTION

Mathematics education aims to develop students' understanding of concepts along with their logical, critical, and problem solving abilities [1]. However, findings from the Trends in International Mathematics and Science Study (TIMSS) reveal that students in Indonesia problem solving skills remain relatively low [2]. Their mathematics scores have consistently fallen below the international benchmark of 500, with averages of 411 (2003), 397 (2007), 386 (2011), and 397 (2015), ranking 44th out of 49 participating countries, and fewer than 1% of students reaching the advanced level [3]. This situation emphasizes the importance of strengthening mathematical problem solving skills, as they are not only a central objective of mathematics learning but also motivate students to engage more seriously with problems and prepare them for real life challenges and future careers [4], [5].

Problem solving skills are the skills to solve unusual problems related to real life contexts, with learning that emphasizes thinking processes and problem solving strategies [6]. These skills enable students to understand problems comprehensively, analyze situations accurately, determine appropriate strategies, perform calculations, and evaluate results reflectively [7], as well as utilize existing knowledge to solve complex mathematical problems and develop their thinking skills [8].

Based on this explanation, problem solving ability can be concluded as an essential skill in mathematics learning, which includes the ability to understand problems, analyze information, determine answer strategies, carry out solution steps, and review results reflectively [9], [10], [11]. According to Polya [12] Problem solving skills include four indicators, that is : (1) understanding the problem, (2) designing a solution plan, (3) implementing the plan, and (4) reviewing the results of the solution.

According to [13], students' low mathematical problem solving abilities are caused by teacher centered learning that relies heavily on lectures, resulting in less active, less creative, and rarely critically thinking students. This aligns with observations and interviews at SMP Negeri 2 Abung Surakarta, where 18 out of 25 students (72%) had not reached the KKM of 75. This situation highlights the need for a learning model that promotes active student participation, enhances self confidence, and strengthens understanding of mathematical concepts [14].

Previous research has shown that Problem Based Learning (PBL) is effective in enhancing students' problem solving abilities through student centered learning, collaboration, and real world problem solving [15], [16]. GeoGebra helps students understand mathematical concepts visually and link abstract ideas to concrete representations [17], [18], [19]. Combining PBL with GeoGebra has the potential to enhance engagement and problem solving skills, but empirical evidence for middle school students is still limited, highlighting the need for further research.

To comprehend the foundation of this approach, it is important to recognize that Problem Based Learning (PBL) is an instructional model that focuses on addressing real world problems as a learning context enabling students to collaborate in addressing issues relevant to everyday life [20]. In this model, students are actively engaged rather than passively receiving information. According to [21], PBL is an innovative model that can motivate students to take an active role in the learning process. Similarly, [22] explain that PBL places placing students at the core of the learning process by involving them directly in solving problems related to real life situations [23], [24], [25], [26]. The purpose of PBL is not only to master the material but also to develop deep thinking skills, problem solving abilities, as well as essential competencies such as understanding information, collaboration, and reflective and critical thinking [27].

PBL is closely related to problem solving ability because it can enhance students' knowledge development and increase their motivation to address problems [28]. However, like other learning models, PBL has limitations. One major limitation is its difficulty in helping students understand abstract mathematical concepts. Concept representations constructed through narration or group discussion are often unclear and difficult for students to grasp [29]. This indicates the need for interactive visual media to facilitate students' comprehension of abstract concepts.

To overcome this limitation, PBL has been developed into a Problem Based Learning model assisted by GeoGebra, integrating GeoGebra into each stage of the learning process. At the problem orientation stage, the teacher presents the learning objectives and illustrates the problems using GeoGebra. During the organization and investigation stages, students are guided to explore concepts and develop solutions independently or collaboratively through construction and simulation. At the presentation stage, students present the solutions they have developed, and at the review stage, the teacher and students reflect on and verify the accuracy and effectiveness of the problem solving strategies used. The integration of GeoGebra allows students to better understand abstract concepts in a more concrete and active manner.

Earlier research has indicated that combining Problem Based Learning (PBL) with GeoGebra positively influences mathematics learning. [30] reported that PBL assisted by GeoGebra improved students understanding of mathematical concepts, while [31] found that PBL significantly enhanced students' mathematical problem solving abilities. Nevertheless, prior research has not specifically examined whether PBL assisted by GeoGebra affects students' mathematical problem solving abilities according to Polya's stages. Therefore, this study seeks to investigate the effect of Problem Based Learning assisted by GeoGebra regarding students' mathematical problem solving abilities, to determine the extent to

which GeoGebra integration supports the development of students' problem solving abilities.

2. RESEARCH METHODS

This research adopted a quantitative method utilizing a quasi experimental pretest posttest control group design. It was conducted at SMP Negeri 2 Abung Surakarta during the first semester of the 2025/2026 academic year. The participants were two seventh-grade classes: Class VII A as the experimental group with 22 students receiving GeoGebra assisted Problem Based Learning (PBL), and Class VII B as the control group with 20 students receiving conventional instruction. Classes were selected through purposive sampling based on comparable initial abilities, as determined by the pretest on mathematical problem-solving skills.

Table 1. Pretest-Posttest Control Group Design

Group	***Pretest***	**Treatment**	***Posttest***
Experiment	O_1	X	O_2
Control	O_3		O_4

Source: [32].

The data in this study were collected using pretests and posttests, each consisting of four mathematical story problems with a maximum score of 40, later converted to a 0–100 scale. Each problem was designed to assess students' mathematical problem solving skills following Polya's four steps: comprehending the problem and formulating a solution plan, implementing the plan, and reviewing the results. Scoring was based on a rubric of 1–3 for each indicator, giving a maximum of 10 points per problem. The test items were validated by mathematics lecturers at Muhammadiyah University of Kotabumi, Venty Meilasari, S.Pd., M.Pd., and Darwanto, S.Pd., M.Pd., to ensure alignment with the intended assessment indicators.

After the validation process, the instrument was pilot tested on eighth grade students to determine the quality of each item. The pilot test results were analyzed based on difficulty level, discrimination power, and reliability. The analysis showed that each item had a correlation between item score and total score in the valid category, thus all items were suitable for use as a research instrument. Furthermore, the reliability test results showed an $r_{11} = 0.145$, indicating that the test instrument as a whole had an adequate level of reliability for use in research.

The collected data were analyzed by calculating N-gain scores to measure improvements within students' problem solving abilities after instruction. In addition, hypothesis testing was performed using independent samples tests to examine the effect of GeoGebra assisted Problem Based Learning (PBL) on students' mathematical problem solving skills. Before conducting the hypothesis tests, normality and homogeneity tests were carried out to confirm that the data satisfied the requirements for parametric analysis, making the results statistically valid.

3. RESULTS AND DISCUSSION

Before conducting prerequisite and hypothesis tests, the data were processed by calculating N-gain values to assess students' progress in problem-solving. N-gain reflects changes in ability after learning, with results for the experimental and control groups shown in Table 2.

Table 2. N -Gain Value Data

Group	n	Mean N-Gain	The highest score	Lowest Value
Experiment	22	0.608	0.906	0.313
Control	20	0.444	0.639	0.036

Based on Table 2, the average N-gain for the experimental class was 0.608 and the control class was 0.444, indicating a better improvement in problem solving skills within the experimental group A normality test was then conducted as a requirement for hypothesis testing, with the results shown in Table 3.

Table 3. Summary of N-Gain Normality Test

Group	n	L_{count}	L_{table}
Experiment	22	0.130	0.186
Control	20	0.138	0.190

Table 3 indicates that the N-gain scores for both the experimental and control groups are normally distributed, as the L $L_{count} < L_{table}$ values, meeting the requirements for parametric analysis. Subsequently, a homogeneity test was performed to examine the equality of variances between the two groups, with the results shown in Table 4.

Table 4. *N-Gain* Homogeneity Test

Group	Variance	F_{count}	F_{table}	Decision
Experiment	0.028	0.882	2.144	Homogeneous
Control	0.032			

Table 4 shows that the $F_{count}(0.882) < F_{table}(2.144)$ variance values for both groups are homogeneous. This means the data meets all requirements for a t-test. Because the data are normal and homogeneous, the analysis continued using a hypothesis test (t-test) to assess whether there are significant differences between the experimental and control classes. The results of the t-test are presented in Table 5.

Table 5. Summary of the Similarity of Two Averages (T Test)

Significance Level	T_{count}	T_{table}

0.05	3.154	2.021

Table 5 shows that the data analysis results indicate a significant effect of GeoGebra assisted Problem Based Learning (PBL) on the mathematical problem solving abilities of seventh grade students at SMPN 2 Abung Surakarta. The t-test results revealed $T_{count}(3.154) > T_{table}$ (2.021), indicating that H_0 is rejected.

The analysis results showed that the average N-gain of the experimental group was 0.608, higher than the control class at 0.444. This shows that *GeoGebra*- assisted PBL learning provides a learning experience that better supports conceptual understanding through visualization, object exploration, and active student involvement.

This improvement occurred because students were exposed to contextual problems presented visually from the outset. *GeoGebra* helped students understand problem situations more concretely, identify important information, and systematically develop problem solving steps. This process encouraged students' active involvement in reasoning, reviewing results, and solving problems independently.

Additionally, students work in groups using *GeoGebra* to explore concepts through various experiments, such as moving points, observing changes in the size of shapes, and creating simple constructions. These activities encourage discussion and collaboration among students, increasing their confidence in expressing ideas and solving problems.

These learning activities are in line with the theory of social constructivism which views that knowledge is actively constructed through students' learning experiences and social interactions, where collaboration between students is an important component in the process of knowledge formation [33], [34]. In mathematics learning, *GeoGebra* as an interactive media allows students to

manipulate objects visually so that abstract concepts become more concrete and easier to understand. Research in Indonesia demonstrates that combining *GeoGebra* in problem based learning can significantly increase student activity, the quality of group discussions, and understanding of mathematical concepts [35], [36].



Figure 1. Students Activities during Group Based Learning

Figure 1 shows students working collaboratively to discuss the problem and complete a task of determining the number of floor tiles using the concept of the area of a square, supported by GeoGebra to visualize the tile arrangement and check the calculation results. Students engage in discussions and write down the solution steps.

After the exploration phase, students solved the problem of determining the number of floor tiles in a square classroom with a side of 9 meters and tiles measuring 1 m × 1 m. In the understanding stage of the problem, students were able to identify the known and the required information. Next, in the planning and implementation stage of the solution, students linked the problem to the concept of the area of a square and carried out calculations systematically to obtain the final result. These results show that the use of *Problem Based Learning* (PBL) helps students meet the problem solving ability stage. In the review stage of the results, *GeoGebra* plays an important role through the visualization of the tile arrangement, so

that students can re-check and ensure the correctness of the answer more convincingly.

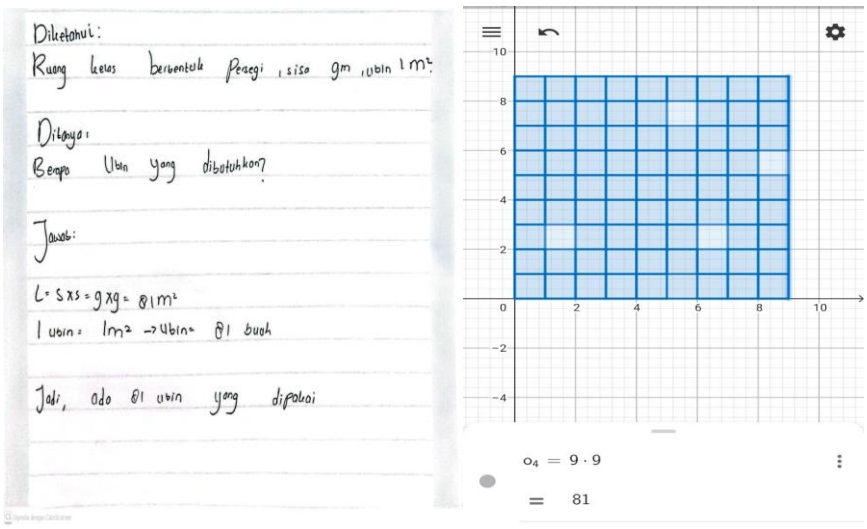


Figure 2. Manual Calculations and Students' *Geogebra Results* in Determining the Number of Floor Tiles.

Figure 2 shows that students' manual solutions match GeoGebra visualizations. Their written work reflects correct application of square area concepts, while GeoGebra provides concrete confirmation. This combination demonstrates that students meet problem solving indicators, especially in implementation and evaluation. Integrating GeoGebra-assisted PBL thus creates a more complete problem solving process, with PBL aiding understanding and planning, and GeoGebra supporting evaluation and review.

The interviews with seventh grade students revealed that GeoGebra supported their understanding of math problems by providing clear and interactive visualizations. These visuals helped them better imagine the shapes and scenarios in the problems, encouraged them to check and correct their calculations, and ultimately made their problem-solving process more focused and reflective.

The results of this study are consistent with prior research, such as [31], who investigated the effectiveness of the Problem Based Learning (PBL) model on the problem solving abilities of ninth grade students. Similar to [31] study, this research confirms that PBL can enhance students' mathematical problem solving skills . However, it differs from the study by [30], which focused on students' conceptual understanding using PBL combined with the GeoGebra application. While their study targeted high school students and emphasized conceptual understanding, the current study specifically examines seventh grade students learning about square, reporting both N-gain scores and t-test results $T_{count}(3.154) > T_{table}$ (2.021). This demonstrates that the observed improvements in the experimental class were statistically significant and attributable to the innovative and interactive PBL approach integrated with GeoGebra.

4. CONCLUSION AND SUGGESTIONS

(1) GeoGebra-assisted Problem Based Learning (PBL) significantly improves students' mathematical problem solving skills, as shown by higher N-gain scores and significant t-test results ($p < 0.05$). (2) The integration of PBL and GeoGebra promotes active participation and learning independence, while GeoGebra's interactive visualizations support clearer conceptual understanding and more systematic problem solving processes. (3) However, the implementation of GeoGebra assisted PBL requires adequate teacher readiness and technological support; therefore, further empirical studies across different mathematical topics and educational contexts are needed.

This study presents certain limitations, such as limited number of participants, the focus on only one school, and the use of a single mathematical topic. Future studies are expected to involve broader and more varied samples, apply GeoGebra assisted PBL to different

topics and educational levels, and consider additional variables such as critical thinking, creativity, and learning motivation to provide stronger evidence of its effectiveness in mathematics learning.

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