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THE EFFECTIVENESS OF THE PROBLEM-SOLVING LEARNING MODEL ASSISTED BY GEOGEBRA ON MATHEMATICAL PROBLEM-SOLVING SKILLS

Wahyu Ari Wibowo[1], Tarso[2], Deny Hadi Siswanto[3]

[1,2] Yogyakarta State University, Yogyakarta, Indonesia

[3]Ahmad Dahlan University, Yogyakarta, Indonesia

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ABSTRAK

Penelitian ini bertujuan untuk mengkaji pengaruh model pembelajaran Problem Solving berbantuan GeoGebra terhadap kemampuan pemecahan masalah matematika siswa. Desain penelitian yang digunakan adalah Posttest Only Control Group Design, yang memungkinkan evaluasi efektivitas perlakuan terhadap kelompok eksperimen dibandingkan dengan kelompok kontrol. Populasi penelitian melibatkan seluruh siswa kelas VIII SMP Muhammadiyah 1 Mlati, yang berjumlah 60 orang. Pengambilan sampel dilakukan menggunakan teknik sampling jenuh, di mana seluruh populasi dijadikan sebagai sampel penelitian dengan kelas VIII A sebagai kelas eksperimen dan VIII B sebagai kelas control. Data penelitian dikumpulkan melalui tes yang dirancang untuk mengukur kemampuan pemecahan masalah matematika siswa. Sebelum melakukan penelitian pengujian instrument tes kepada kelas IX A SMP Muhammadiyah 1 Mlati hingga data tersebut dinyatakan valid dan reliabel. Hasil penelitian menunjukkan bahwa model pembelajaran Problem Solving berbantuan GeoGebra memberikan pengaruh positif dan signifikan terhadap kemampuan pemecahan masalah matematika siswa. Hal ini terlihat dari skor tes yang lebih tinggi pada kelompok siswa yang menggunakan model pembelajaran Problem Solving berbantu GeoGebra dibandingkan dengan kelompok yang tidak menggunakan GeoGebra. Temuan ini menunjukkan bahwa penggunaan GeoGebra sebagai media pembelajaran dapat membantu siswa memahami konsep matematika secara visual, interaktif, dan efektif. Oleh karena itu, model pembelajaran Problem Solving berbantuan GeoGebra dapat dijadikan salah satu alternatif strategi pengajaran matematika untuk meningkatkan kemampuan pemecahan masalah siswa secara optimal.

ABSTRACT

This study aims to examine the effect of the Problem-Solving learning model assisted by GeoGebra on students' mathematical problem-solving abilities. The research design employed was the Posttest Only Control Group Design, which allows for the evaluation of treatment effectiveness by comparing the experimental group with the control group.The population of the study consisted of all eighth-grade students of Muhammadiyah 1 Mlati Junior High School, totaling 60 students. Sampling was conducted using a saturated sampling technique, where the entire population was included as the research sample, with class VIII A serving as the experimental group and VIII B as the control group. Research data were collected through tests designed to measure students' mathematical problem-solving skills. Prior to the research, the test instrument was validated and tested for reliability with class IX A students of Muhammadiyah 1 Mlati Junior High School. The results revealed that the Problem-Solving learning model assisted by GeoGebra had a positive and significant effect on students' mathematical problem-solving abilities. This was evident from the higher test scores of students in the experimental group compared to those in the control group. These findings indicate that the use of GeoGebra as a teaching medium helps students understand mathematical concepts in a visual, interactive, and effective manner. Therefore, the Problem-Solving learning model assisted by GeoGebra can be considered an alternative teaching strategy to optimize students' problem-solving skills in mathematics.

1. INTRODUCTION

Problem-solving is one of the primary objectives of mathematics education in schools (Rohid et al., 2019). This skill is crucial as it encourages students to think critically, reason, and draw logical conclusions. Moreover, problem-solving helps students develop the ability to articulate explanations or ideas through various forms of expression, such as writing, maps, charts, or graphs (Alkhatib, 2019; Prihandoko et al., 2023; Wakhata et al., 2023). As an in-depth learning process, problem-solving aims to

*Corresponding author.
E-mail addresses: theresearchfighter@gmail.com

train students to think independently and seek creative solutions to challenges, thereby enhancing their ability to address everyday problems.

Susanti et al. (2023) stated that problem-solving is a constructive effort to achieve solutions to challenging goals. Adeoye & Jimoh (2023) added that this process involves an individual's attempt to find answers to problems with no clear solutions. Gagne Sirait et al. (2020) even suggested that problem-solving represents the highest level of learning, involving the comprehension of techniques, rules, and the content of mathematical lessons. Thus, students are expected to apply mathematical concepts in real-world situations, making it a critical foundation in education.

However, despite its importance, many students still struggle with solving mathematical problems. Research by Dahal et al. (2023) revealed that one reason is the abstract nature of mathematics, which often makes it challenging for students to grasp basic concepts. Tambunan (2019) also highlighted that students' difficulty in understanding procedural steps is a major factor contributing to their failure in problem-solving. This underscores the need for more effective teaching approaches to support students.

Various studies have identified key factors underlying students' low problem-solving abilities. According to Siswanto & Hanama (2024), these include a lack of understanding of mathematical problems, limitations in selecting solution methods, weak critical thinking skills, and low confidence and perseverance in learning. These conditions call for innovative efforts, particularly through the active role of teachers in creating effective and meaningful learning experiences focused on skill development.

Teachers hold a strategic position in enhancing students' problem-solving abilities. The National Council of Teachers of Mathematics (2000) recommends five essential skills to be integrated into mathematics education: connection, reasoning, communication, problem-solving, and representation. This approach enables students to develop critical and creative thinking skills, preparing them to tackle mathematical problems effectively and independently.

One teaching approach considered effective in improving problem-solving abilities is the Problem-Solving model. Astiwi et al. (2024) explained that this model is designed to encourage students to observe, comprehend, analyze, and find solutions to given problems. This learning process not only teaches students to think critically but also trains them to seek and validate information from various sources. As a result, this approach helps students build deeper, contextual, and meaningful knowledge in mathematics.

The Problem-Solving model plays a significant role in developing students' abilities, with teachers acting as facilitators who stimulate critical thinking (Andriyani, 2024). In this model, students are given opportunities to actively seek solutions to problems. This process not only enhances their mathematical skills but also trains communication skills through various media, such as writing, maps, or graphs. By creating an active, effective, and innovative learning environment, teachers can make a significant positive contribution to students' success in understanding and mastering mathematics.

In addition to teaching approaches, the use of media plays a strategic role in increasing the effectiveness of mathematics teaching and learning processes. In today's era, Information and Communication Technology (ICT) has become an integral element of education. Yogyanto et al. (2024) stated that utilizing ICT holds great potential for enhancing productivity and effectiveness in learning processes. One frequently used medium in mathematics education is GeoGebra, a computer program designed to help students visualize mathematical concepts dynamically and interactively.

With GeoGebra, students can construct and visualize mathematical concepts in a way that is easier to understand through numerical, algebraic, and graphical representations (Siswanto et al., 2024). According to Bedada & Machaba (2022), the use of media such as GeoGebra has proven to increase students' interest in learning and facilitate their conceptual understanding. The combined support of the Problem-Solving model and appropriate learning media is a key factor in optimizing mathematics education. With this approach, students are expected to improve their problem-solving abilities, which is one of the primary goals of mathematics education in schools.

2. METHODS

This study employs a Posttest Only Control Group Design, an experimental design that involves measuring only the final outcomes (posttest) without any initial measurement (pretest) (Sugiyono, 2019). The purpose of this design is to evaluate the effect of a specific treatment on the experimental group by comparing its results with those of the control group, which does not receive the treatment. The study population consists of 60 eighth-grade students at SMP Muhammadiyah 1 Mlati, with class VIII A designated as the experimental group and class VIII B as the control group. The entire population was included in the study through a saturated sampling technique, considering its relatively small size, which allowed all students to be research subjects without additional selection. Data on students' mathematical

problem-solving abilities were collected through a test comprising five descriptive questions. The instrument was developed with careful consideration of its validity and reliability to ensure that the measurements align with the study's objectives.

Once the data were collected, analysis was conducted using a t-test to determine significant differences between the experimental and control groups. Prior to the t-test, prerequisite analyses were performed, including a normality test to ensure that the data followed a normal distribution and a homogeneity test to verify the equality of variances between groups. These steps are critical to ensuring that the data meet the assumptions of parametric statistical analysis, thereby making the results reliable. Through this structured approach, the study aims to produce valid and accurate findings regarding the impact of the treatment on students' mathematical problem-solving abilities.

3. RESULT AND DISCUSSION

Results

Before conducting the study, a test instrument in the form of essay questions consisting of five items was developed and piloted with class IX A at SMuhammadiyah 1 Mlati Junior High School. Below are the results of the validity test for these essay questions.

Tabel 1. Table 1. Validity Test Results

Correlations

		No1	No2	No3	No4	No5	Total
No1	Pearson Correlation	1	.063	-.072	.132	-.107	.384*
	Sig. (2-tailed)		.742	.704	.487	.579	.036
	N	30	30	30	30	29	30
No2	Pearson Correlation	.063	1	.577**	-.281	-.247	.471**
	Sig. (2-tailed)	.742		.001	.133	.196	.009
	N	30	30	30	30	29	30
No3	Pearson Correlation	-.072	.577**	1	-.045	-.191	.507**
	Sig. (2-tailed)	.704	.001		.815	.320	.004
	N	30	30	30	30	29	30
No4	Pearson Correlation	.132	-.281	-.045	1	.289	.385*
	Sig. (2-tailed)	.487	.133	.815		.128	.036
	N	30	30	30	30	29	30
No5	Pearson Correlation	-.107	-.247	-.191	.289	1	.427*
	Sig. (2-tailed)	.579	.196	.320	.128		.021
	N	29	29	29	29	29	29
Total	Pearson Correlation	.384*	.471**	.507**	.385*	.427*	1
	Sig. (2-tailed)	.036	.009	.004	.036	.021	
	N	30	30	30	30	29	30

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Based on the table above, it can be seen that all the significance values of the test items are less than 0.05, indicating that all the items are valid. Subsequently, a reliability test was conducted. Below are the results of the reliability test using SPSS-25.

Tabel 2. Reliability Test Results

Reliability Statistics

Cronbach's Alpha	N of Items
.084	5

Based on the table above, it is evident that the Cronbach's Alpha value of 0.084 > 0.05 indicates that the data is reliable. Once the instrument was deemed valid and reliable, it was subsequently

administered in the study. The instrument was tested in two classes, namely the experimental and control classes, with the results subjected to prerequisite tests, including normality and homogeneity tests. Below are the results of the normality test:

Table 3. Normality Test Results for the Experimental and Control Classes

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Experimental_Class	.112	30	.200*	.942	30	.100
Control_Class	.099	30	.200*	.957	30	.256

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on the table above, it is observed that the Shapiro-Wilk significance values are 0.100 > 0.05 for the experimental class and 0.256 > 0.05 for the control class. This indicates that both classes have a normal distribution. Subsequently, a homogeneity test was conducted for the two classes. Below are the results of the homogeneity test using SPSS-25.

Table 4. Homogeneity Test Results

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Value	Based on Mean	.801	1	58	.375
	Based on Median	.636	1	58	.428
	Based on Median and with adjusted df	.636	1	57.947	.428
	Based on trimmed mean	.776	1	58	.382

Based on the table above, it is shown that the significance value Based on Mean is 0.375 > 0.05, indicating that the two classes are homogeneous. After confirming that the data from both groups meet the requirements for normality and homogeneity, the final step is hypothesis testing. This test is designed to determine whether the mathematical problem-solving abilities of students learning with the Problem Solving model assisted by GeoGebra are superior to those of students learning with a conventional teaching model. For this purpose, a t-test using the pooled variance formula (Independent Sample t-test) was applied to analyze the hypothesis. The results of the hypothesis testing are presented in the following table:

Table 5. t-Test Results

Independent Samples Test

		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
Value	Equal variances assumed	.801	.375	3.68	58	.000	983.23	266.54	449.68	1516.7
	Equal variances not assumed			3.68	57.27	.001	983.23	266.54	449.54	1516.9

Based on the table above, it is evident that the significance value (2-tailed) is 0.000 < 0.05. Therefore, it can be concluded that the Problem Solving learning model assisted by GeoGebra has a significant effect on students' mathematical problem-solving abilities.

Discussion

The application of the Problem-Solving learning model has proven effective in developing students' skills in addressing various challenges. This aligns with the perspective of (Adeoye & Jimoh,

2023), who assert that the Problem-Solving model is a process of finding solutions to encountered problems. This model not only supports students' problem-solving abilities but also stimulates them to think logically and systematically. By presenting problems that require solutions, this model offers students opportunities to practice critical and structured thinking, which are essential skills in daily life and professional settings.

In addition to the Problem-Solving model, the experimental class utilized GeoGebra software as an effective learning medium to enrich the learning process (Susanti et al., 2023). The combination of the Problem-Solving model and relevant educational media created a more dynamic and effective learning experience. According to Qatrunnada & Syahputra (2022), computer-based learning, such as GeoGebra, aids students in understanding abstract mathematical concepts, thereby improving their overall academic performance. GeoGebra, as a type of computer program, is particularly beneficial in mathematics education, especially for visualizing shapes, solids, graphs, or curves. With its interactive features, GeoGebra serves as an invaluable tool for demonstrating, illustrating, and constructing abstract mathematical concepts, making them more concrete and comprehensible for students.

During the implementation of learning in the experimental class, students exhibited better readiness and actively engaged in every stage of the learning process (Afandi et al., 2024; Putri et al., 2024). The researcher presented material accompanied by problems related to solid geometry, enhanced by using GeoGebra to determine the surface area and volume of the solids. GeoGebra successfully captured students' attention through its ability to visualize three-dimensional shapes in an appealing and interactive manner. This tool helped students easily understand the taught geometry concepts, leading to deeper and more comprehensive understanding.

The Problem-Solving model, assisted by GeoGebra, provided beneficial visual stimulation by depicting solid geometry problems through interactive visualization. This approach allowed students to actively observe, understand, and seek solutions to the given problems (Wibowo, et al., 2024; Syah et al., 2024). The learning process encouraged students to be more involved, both individually and in group discussions. In groups, students exchanged opinions and collaborated to comprehend the problems to be solved. According to Thomas & Adebowale (2023), this approach effectively trains students' critical thinking skills and helps them solve problems more systematically. In contrast, the control class employed a conventional teaching method that was more teacher-centered. Pisriwati et al. (2024) and Widyastuti et al. (2024) describes conventional teaching as a model dominated by teacher activities, where the teacher actively explains concepts while students passively listen and take notes. This method offers fewer opportunities for students to think critically or collaborate in problem-solving activities.

The findings indicated that the Problem-Solving model assisted by GeoGebra was significantly more effective than the conventional method in enhancing students' mathematical problem-solving abilities. This distinction was evident in students' structured and logical approaches to solving mathematical problems (Pisriwati et al., 2024; Syah et al., 2024). The Problem-Solving model not only encouraged logical thinking but also emphasized the cognitive processes involved in problem-solving. Additionally, it allowed students to acquire new knowledge and broaden their perspectives independently through problem exploration.

The superiority of the Problem-Solving model is supported by Graesser et al. (2018), who states that this model equips students with the foundational knowledge required for solving problems while enhancing their cognitive abilities. This approach teaches students not only practical methods for problem-solving but also fosters a deeper understanding of problems, enabling them to develop logical and effective strategies (Tarso et al., 2024). This preparation equips students to face more complex challenges in both academic and real-world contexts.

Previous studies corroborate these findings, demonstrating the positive impact of GeoGebra-assisted learning on students' mathematical problem-solving abilities. For example, Tong et al. (2021) concluded that GeoGebra-assisted learning significantly improves the mathematical problem-solving skills of junior high school students. Similarly, Priyatno et al. (2021) found that using a Problem-Based Learning model with GeoGebra significantly enhanced the mathematical problem-solving abilities of high school students compared to conventional methods.

Amalia et al. (2020) revealed that GeoGebra-assisted realistic mathematics education improved students' mathematical communication skills more effectively than traditional methods. The use of technology-based educational media like GeoGebra enhances students' understanding and skills, particularly in mathematical communication a crucial aspect of learning. GeoGebra enables students to express their understanding visually and verbally, enriching the learning experience.

Additionally, Pratiwi (2016) found that a Learning Cycle 5E approach assisted by GeoGebra enhanced students' conceptual understanding of mathematics. By integrating GeoGebra into the learning process, students not only grasped the material more easily but also showed significant improvement in

their academic achievements. These findings affirm the benefits of using GeoGebra in mathematics education for various purposes, whether to deepen conceptual understanding, enhance mathematical communication, or develop overall problem-solving skills.

4. CONCLUSION

This research demonstrates that the application of innovative learning methods, such as the Problem-Solving model supported by GeoGebra, is effective in enhancing students' mathematical problem-solving abilities. Actively involving students in every stage of the learning process stimulates critical thinking development in solving various problems, in contrast to students who tend to remain passive. Therefore, educators should implement diverse learning models or methods relevant to 21st-century mathematics education while utilizing learning media that support the learning process and enhance students' critical thinking and problem-solving skills. One such approach is the application of the Problem-Solving Model with the assistance of GeoGebra.

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