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Enhancing problem-solving abilities through Geogebra-assisted discovery learning model for elementary school students

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ABSTRACT

The students' low problem-solving ability is due to a less meaningful learning process. This study aims to analyze the effect of applying the discovery learning model assisted by GeoGebra on the mathematical problem-solving abilities of fourth-grade elementary school students. This research employs the quasi-experimental design. The population of this study consisted of fourth-grade students at SDN Dabin III Pecangaan Jepara. The sample was taken using simple random sampling techniques. The data collecting technique used was a test. The data were analyzed using t-tests. The results of the data analysis showed that the average mathematics learning outcome of the experimental class was 81.03, which was higher than the control class (64.65). It can be concluded that using the discovery learning model with the assistance of GeoGebra significantly affects the problem-solving abilities of fourth-grade elementary school students. The implications of this research provide guidelines for curriculum innovation in facing future challenges.

Meningkatkan kemampuan pemecahan masalah melalui model *discovery learning* berbantuan geogebra pada siswa sekolah dasar

Kata Kunci:

Discovery learning
GeoGebra
Kemampuan pemecahan masalah
Pendidikan dasar

ABSTRAK

Rendahnya kemampuan pemecahan masalah peserta didik disebabkan karena proses pembelajaran yang kurang bermakna. Penelitian ini bertujuan untuk menganalisis pengaruh penerapan model pembelajaran *discovery learning* berbantuan GeoGebra pada kemampuan pemecahan masalah matematika siswa di kelas IV SD. Jenis penelitian ini quasi experimental design. Populasi penelitian ini peserta didik kelas IV SDN Dabin III Pecangaan Jepara. Pengambilan sampel menggunakan teknik *simple random sampling*. Pengumpulan data menggunakan metode tes, dan data dianalisis menggunakan uji-t. Hasil analisis data menunjukkan rata-rata hasil belajar matematika kelas eksperimen sebesar 81,03 lebih tinggi daripada kelas kontrol yang memiliki rata-rata 64,65. Dapat disimpulkan bahwa penggunaan model *discovery learning* dengan bantuan GeoGebra memiliki pengaruh yang signifikan pada kemampuan pemecahan masalah siswa di kelas IV SD. Implikasi penelitian ini memberikan panduan bagi inovasi kurikulum dalam menghadapi tantangan masa depan.

1. INTRODUCTION

Mathematics plays a vital role in human life, meeting practical needs and solving everyday problems [1], [2]. It is essential because to study other fields, it is necessary to understand the basic concepts of mathematics [3]. In its implementation, mathematics learning not only emphasizes numeracy skills but also invites students to think and reason critically, communicate, and work together so that they can solve various problems systematically [4], [5]. Thus, mathematics learning in elementary schools aims to enable students to use various mathematics concepts skillfully in everyday life [6], [7]. Mathematics has become the foundation of human thinking processes to face future challenges.

Based on the 2022 Program for International Student Assessment (PISA) survey results for mathematics literacy, Indonesia's ranking increased by five positions compared to PISA 2018. Despite the increase, Indonesia was still in the bottom 12 of the 81 participating countries [8]. It means that the results of learning mathematics in Indonesia were in the low category. It is also supported by the results of observations and interviews conducted at Elementary School 3 Karangrandu. The data showed that 32%, or 12 students, got a score higher than 65, and 68%, or 25 students, were still below the minimum standard. In Elementary School 1 Karangrandu, 45% or 15 students reached the minimum standard, and 55% or 18 students were below the minimum standard. In Elementary School 2 Pecangaan Wetan, 52% or 15 students reached the minimum standard and 48% or 14 students were below the minimum standard.

During mathematics learning, the learning activities were carried out by delivering material using the lecturing method and then giving practice questions or assignments from books. After that, the tasks were collected and discussed together. From the implementation of the learning, students listen, write, and memorize more formulas without any effort to understand the concept of the formula. When given slightly different questions, the students had difficulty formulating the problem. At the end of the lesson, there was no conclusion on the material and no self-reflection on the learning. Thus, the learning implemented conventional models with expository methods. The expository method is a method in which the teacher plays a dominant role in delivering learning material verbally with the aim that students master the material well [3], [9]. In addition, based on the observation results, students' mathematical problem-solving skills were still relatively low.

Problem-solving ability is one of the skills needed to develop understanding in STEM (Science, Technology, Engineering, and Mathematics) education. STEM education is intended so that students can face changing times, face innovative challenges, and contribute to technological developments. Teachers play an essential role in developing students' interests and encourage students to become researchers, experimenters, and problem solvers to understand STEM concepts [10]. According to Polya, there are four steps to solving a problem, which includes 1) understanding the problem, 2) making a problem-solving plan, 3) implementing the plan, and 4) considering the overall results obtained and drawing conclusions [2], [11].

There were problems found at Dabin III Elementary School Pecangaan Jepara, so it was necessary to improve learning by designing fun and more meaningful learning to achieve the learning goals optimally. In the Merdeka Curriculum, teachers are encouraged to be more creative and innovative in providing pleasant learning experiences for students [12]. The Merdeka Curriculum recommends the discovery learning model [12], [13]. The discovery learning model encourages students to actively understand and find their conclusions so that the results they get will last a long time in their memory [14], [15]. The

discovery learning model emphasizes the role of the teacher as a supervisor who provides opportunities for students to learn actively because the teaching materials used are not provided in the final form. Thus, students are directed to collect information/data and organize and conclude them themselves [16], [17]. The stages of implementing the discovery learning model include 1) the stimulation stage by providing problems that can encourage students' curiosity; 2) the identification of problems, which are written in the form of hypotheses; 3) data collection through interviews, observations, and so on; 4) data processing, which is interpreted at a certain level of confidence; 5) proof to the hypothesis based on the results of data processing; 6) conclusions of findings [18], [19]. The discovery learning model is intended to change the state of passive learning to active and student-centred. In addition, the discovery learning model can help students develop problem-solving skills because they are invited to find concepts with their groups by discussing and gathering information to solve their problems.

Learning media adapted to the material is needed to support problem-solving and facilitate students' understanding through the discovery learning model [20], [21]. GeoGebra is one of the learning media that can be used to learn mathematics. It is a dynamic and interactive mathematics application containing geometry, calculus, and algebra, which can be used for simulation, demonstration, exploration, problem-solving, and problem-proofing [22], [23].

In previous research, the GeoGebra was beneficial for students to learn geometric construction by making the construction of various 2-dimensional geometric shapes and transformations [24]. Other research revealed that GeoGebra affectsimproves student learning outcomes, especially transformation materials [25]. Other research shows that compared to conventional learning, the discovery learning model with GeoGebra media can improve students' mathematical understanding, as seen in problem-solving regarding examples and not examples of indeterminate integrals of algebraic functions [26]. Other research shows that discovery learning is more effective than the problem-solving model in improving mathematical problem-solving skills, as seen from the problem-solving in the experimental class, which is higher than that of the control class [27]. Other research revealed that the GeoGebra-assisted discovery learning model was effectively used in mathematics learning in junior high school, as seen from improved learning outcomes, observation of activities, and student responses [28].

Based on previous studies, the GeoGebra-assisted discovery learning model can be used as an innovative solution in the implementation of mathematics learning. However, no previous research specifically discusses the application of the GeoGebra-assisted discovery learning model to the ability to solve fractional problems at the elementary school level. Therefore, this study was focused on analyzing the effect of the GeoGebra-assisted discovery learning model on the ability to solve fractional problems in fourth-grade elementary school students.

Research on the application of the discovery learning model in education has been widely conducted, including studies on its application to problem-solving abilities [29], improvement of science learning motivation [30], learning outcomes in mathematics [31], [32], critical thinking skills [33], and mathematical reasoning abilities [34]. However, none of these studies have applied the discovery learning model assisted by GeoGebra. GeoGebra is a tool that can be used to enhance problem-solving skills.

This study aims to determine the effect of applying the discovery learning model assisted by GeoGebra on the ability to solve fraction problems at the elementary school level. Unlike previous studies, the discovery learning model was implemented without

educational media assistance. Therefore, using GeoGebra as a medium can significantly improve problem-solving skills.

Contribution to the literature

This study contributes to:

- Provides an understanding of the effect of applying the GeoGebra-assisted discovery learning model on problem-solving capabilities.
- Provide an understanding of the differences in the use of GeoGebra-assisted discovery learning models and the use of conventional models wit expository methods.
- Increase knowledge about innovative and fun learning models to create more meaningful student learning.

2. METHOD

This study employed the quantitative approach, a type of quasi-experimental design research. This type of research was chosen because not all external variables that affect the implementation of the experiment can be controlled [35]. The population of this study was the fourth-grade students of elementary school. The sample was taken using simple random sampling because the population data was homogeneous. The sample was carried out by the lottery technique twice. The first draw was to determine two classes as research samples, and the second was to determine the experimental and control classes. The sample taken from the fourth grade of Elementary School A, which consisted of 37 students, was obtained as an experimental class that received treatment by applying the GeoGebra-assisted discovery learning model. The control class was taken from the fourth-grade of Elementary School B, which consisted of 33 students taught using the expository method. This research was conducted in four meetings. Each meeting was conducted for two hours of learning. The research was carried out in May 2024. The teachers acted as observers during the implementation of the learning process, while the researchers acted as practitioners. The data collection instrument used was a test sheet consisting of five fractional material description questions.

Before the research was carried out, the question instrument was analyzed through the validity, reliability, difficulty, and differentiation tests. The validity test covered 1) content validity by compiling a grid of instruments to be consulted with experts in charge of mathematics. The test was tried out to the fifth-grade students because they had already studied the material tested [36]. 2) Empirical validity was carried out using the results of try-out questions with the help of the SPSS 23 application through the Analyze-Correlate-Bivarate menu, resulting in eight valid questions. Second, a reliability test was carried out with the help of the SPSS 23 application through the Cronbach Alpha model. The results stated that the questions were considered reliable. 3) the difficulty test was carried out to balance the difficulty level of the question (proportional) [37]. The analysis discovered that one question was in the easy category, and seven were in the medium category. 4) The differentiation test was used to determine the difference between high-ability and low-ability students. If a question can only be solved by high-ability students, then the question is considered good [36]. The results indicated that two questions were in the good category, three in the medium category, and three in the poor category. Therefore, the questions used for the test were five questions.

The data analysis technique used the pretest score as the initial data and the posttest score as the final data. In the initial data, before the sample was given treatment, a prerequisite test was carried out with the help of the SPSS 23, covering the normality, homogeneity, and average similarity tests. The tests aimed to find out the similarity of the initial data conditions. Furthermore, the final data was analyzed using the normality, homogeneity, hypothesis, and G-Nain tests. After the data analysis, a comparison of learning outcomes was carried out between the experimental class using the Geogebra-assisted discovery learning model and the control class using a conventional model with the expository method. The flow of this research can be seen in the following figure.

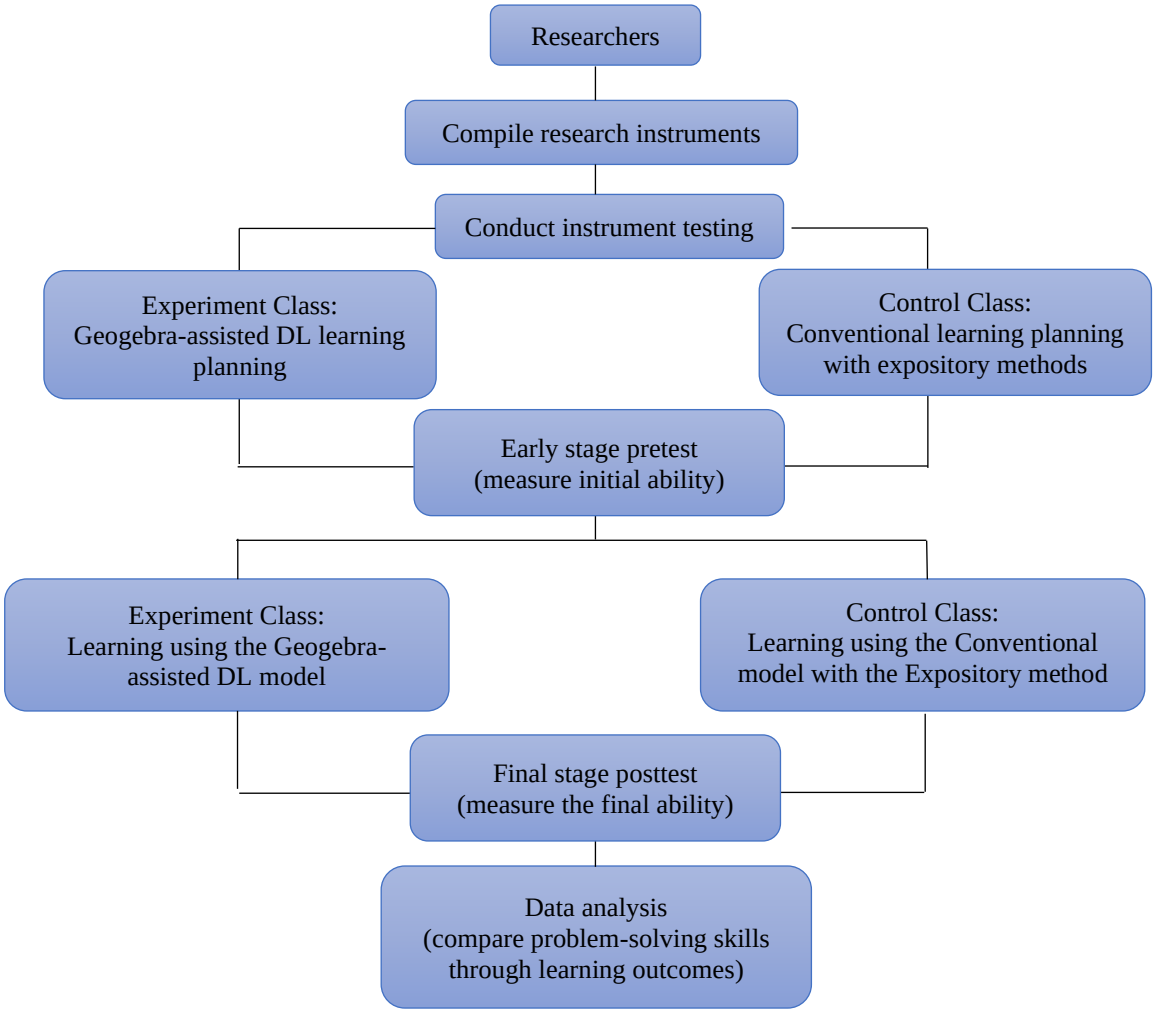


Figure 1. Research Flow

3. RESULTS AND DISCUSSION

Learning using the GeoGebra-assisted discovery learning model involved compiling teaching modules and student worksheets according to the material, creating media using the GeoGebra application, and applying this knowledge to learning and collecting data. The data collected was in the form of pretest and posttest scores, which were then analyzed using SPSS 23. This approach aimed to enhance students' conceptual understanding and problem-solving skills by actively engaging them in the learning process and using visual aids to better grasp complex mathematical concepts.

3.1 Implementation of GeoGebra-Assisted Discovery Learning Model

Table 1 shows the stages of the discovery learning model, which provides a structured approach to facilitate student engagement and understanding through guided exploration and problem-solving [16].

Table 1. Data Description of Pretest Results

Activity	Information
Introduction	The teacher prepares students to learn. The teacher gives an apperception according to the material. The teacher conveys the learning objectives.
Stimulation	The teacher provides stimulation by asking questions according to the material. The teacher explained the material as an introduction with the help of GeoGebra media.
Problem Statement	The teacher forms groups and assigns group assignments. Students identify problems with the group.
Data Collection	Students gather information to solve problems.
Data Processing	Students solve problems based on information that has been collected.
Verification	Students present the results of group work.
Generalization	Students, together with the teacher, conclude the learning.
Closing	The teacher gives individual evaluation questions. Teachers and students do self-reflection. The teacher delivered the follow-up plan.

Observers measured each stage of learning using observation sheets provided by researchers. Observers were tasked with supervising and scoring during learning activities.

3.2 GeoGebra Media

The media used to support the application of the discovery learning model was GeoGebra. This media was made using the GeoGebra application adapted to the learning material. In the first meeting, the material presented was more than one fraction. In the second meeting, the material presented was fractions of value. In the third meeting, the material presented was the addition of fractions. In the first meeting, the material presented was the subtraction of fractions. The GeoGebra media used in learning is displayed in Figure 2.

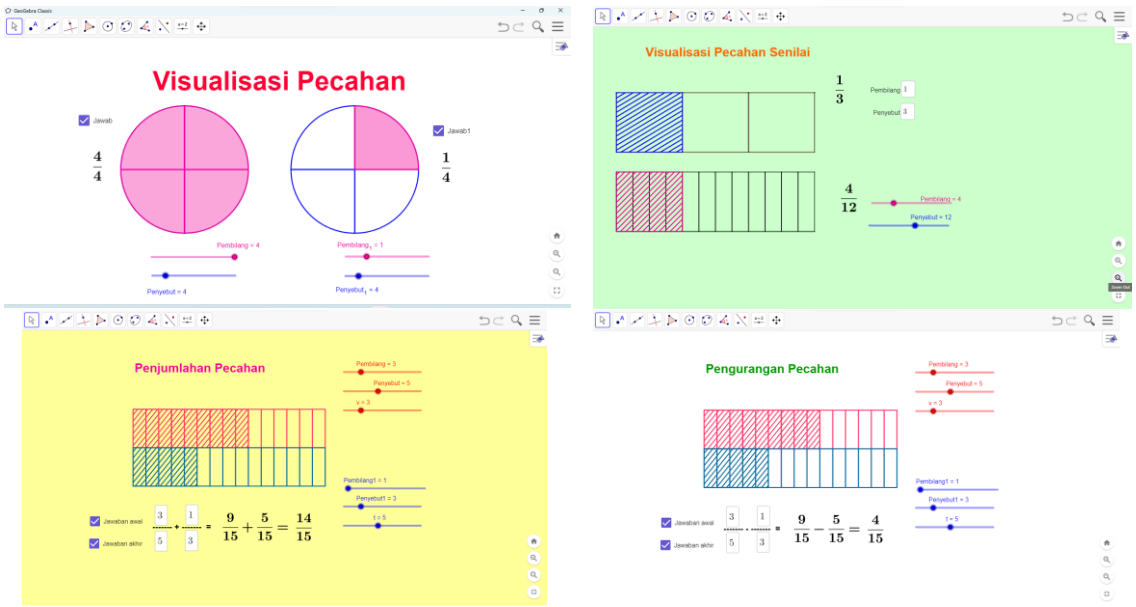


Figure 2. GeoGebra Media

3.3 Data Analysis Results

Before the treatment, the experimental and control classes were given pretest questions to determine their initial abilities. The following is a description of the pretest result data.

Table 2. Data Description of Pretest

Statistic Descriptives	Experimental Class	Control Class
Mean	35,08	31,58
Median	34,00	32,00
Std. Deviation	9,861	8,700
Minimum	16	18
Maximum	54	46
Range	38	28

Based on Table 2, the average pretest score in the experimental class reached 35.08, while in the control class reached 31.58. To prove the similarity of initial data conditions, normality, homogeneity, and average similarity tests with a significance level of 5% were carried out using SPSS 23. The test series results can be seen in Table 3, Table 4, and Table 5.

Table 3. Normality Test of Pretest Values

Tests of Normality							
	SDN	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
Pretest	1	.090	33	.200*	.951	33	.147
	3	.114	37	.200*	.967	37	.334

Table 4. Test Homogeneity of Pretest Values

Test of Homogeneity of Variances			
Pretest			
Levene Statistic	df1	df2	Sig.
.194	1	68	.661

Table 5. Equality Average Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest	Equal variances assumed	.194	.661	-1.569	68	.121	-3.505	2.235	-7.964	.954
	Equal variances not assumed.			-1.580	67.994	.119	-3.505	2.219	-7.932	.922

Based on the test results in Tables 3, 4, and 5, the significance value in each table is more significant than 0.05. The results showed that the initial data was normally distributed, had the same variance (homogeneous), and students had not much different initial abilities. Thus, the data can be processed using parametric statistics.

Furthermore, both classes were treated. After the treatment, a posttest was administered to determine the achievement of problem-solving abilities. Table 6 describes the posttest result data.

Table 6. Description of Posttest Result Data

Statistic Descriptives	Experimental class	Control class
Mean	81,03	64,85
Median	80,00	64,00
Std. Deviation	9,124	9,500
Minimum	60	50
Maximum	96	84
Range	36	34

Based on Table 6, the average posttest score in the experimental class reached 81.03, while the control class reached 64.85. The posttest score was then tested using SPSS 23, with a normality test and a homogeneity test with a significance level of 5%. The results of the normality test and homogeneity of the final data can be seen in Tables 7 and 8.

Table 7. Normality Test on the Posttest Score

Tests of Normality							
	SDN	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	Df	Sig.
Posttest	1	.111	33	.200*	.964	33	.330
	3	.100	37	.200*	.970	37	.413

Table 8. Homogeneity Test on the Pretest Score

Test of Homogeneity of Variances			
Posttest			
Levene Statistic	df1	df2	Sig.
.181	1	68	.672

Based on the test results in Tables 7 and 8, the significance value in each table is more significant than 0.05. Therefore, the final data was normally distributed and had the same variance (homogeneous).

Furthermore, a hypothesis test was carried out to determine whether there was a significant influence on the ability to solve fractional problems after the treatments were carried out in the experimental and control classes. The hypothesis test was performed using the independent sample t-test menu on SPSS 23. The results are displayed in the T-Test for Equality of Means column. H_o is accepted if the significance value is more than 0.05, and H_o is rejected if the significance value is less than 0.05. The hypotheses tested in this study were:

H_o = GeoGebra's assisted discovery learning model does not affect fractional problem-solving ability in fourth-grade elementary school students.
H_a = The GeoGebra-assisted discovery learning model significantly affects the ability of fourth-grade elementary school students to solve fractional problems.

The results of the hypothesis test can be seen in Table 9. Based on Table 9, the significance value obtained was 0.000, less than 0.05. Therefore, H_o was rejected, and H_a was accepted, which means that the students had better fractional problem-solving skills after applying the discovery learning model with the help of GeoGebra.

Table 9. Results of the Hypothesis Test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest	Equal variances assumed	.181	.672	-7.263	68	.000	-16.179	2.228	-20.623	-11.734
	Equal variances not assumed.			-7.246	66.376	.000	-16.179	2.233	-20.636	-11.721

Furthermore, the N-Gain test was performed to determine the increased problem-solving skills, characterized by increased learning outcomes after the treatment. The results of the N-Gain test can be seen in Table 10.

Table 10. N-Gain Test Results

Class	Average		Number of Graduate Participants	G	Criteria
	Pretest	Posttest			
Experiment	35,08	81,03	37	0,70	High
Control	31,58	64,85	33	0,48	Middle

Table 10 shows an increase between pretest and posttest scores in the experimental class by 0.70 with high criteria. In the control class, there was an increase of 0.48 in the medium criteria. Figure 3 contains a diagram that illustrates the increase in pretest to posttest.

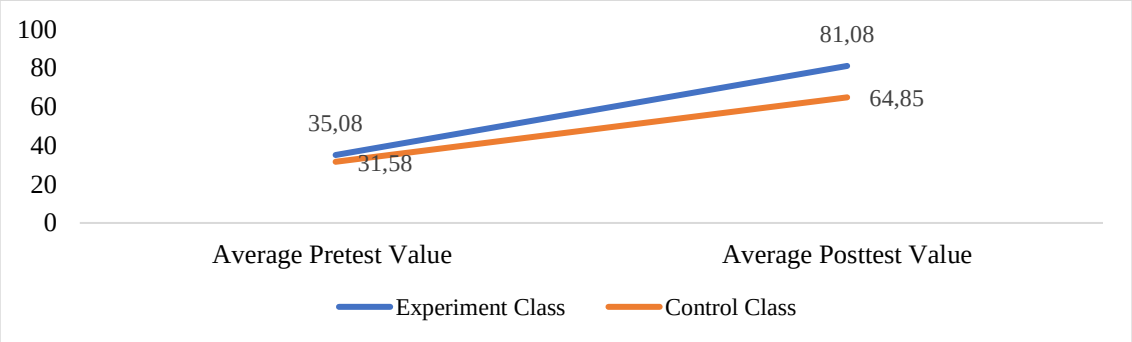
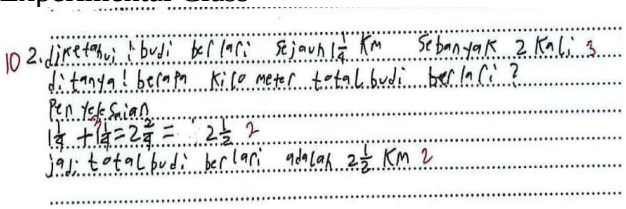


Figure 3. The Increase in Pretest and Posttest Scores

Based on the diagram above, the initial abilities of the experimental and control classes were almost the same before the treatment. However, after the treatment, the experimental class using the GeoGebra-assisted discovery learning model showed higher learning outcomes than the control class using conventional learning with the expository method. Various factors can affect student learning outcomes, grouped into internal and external factors [38]. Internal factors include ability, interest in learning, motivation, and physical or mental condition. On the other hand, the external factors include family, school, and community environment [39], [40]. In this study, the factor that affects students' pretest scores in both classes was the ability of students because they had never studied fractional material before. Therefore, the students found it difficult when doing pretest questions.

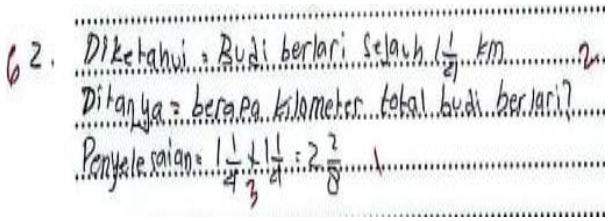
The difference in the ability to solve mathematics problems after the treatment lied in the analysis process in solving a mathematics problem. The following are the differences in the experimental and control classes' results.

Experimental Class



Given:
Budi runs $1\frac{1}{4}$ km two times.
Question:
How many kilometres does Budi run in total?
Solution
$1\frac{1}{4} + 1\frac{1}{4} = 2\frac{1}{2}$
Therefore, the total distance Budi runs is $2\frac{1}{2}$ km.

Control Class



Given: Budi runs a distance of $1\frac{1}{4}$ km
Asked: How many kilometres does Budi run in total?
Solution:
$1\frac{1}{4} + 1\frac{1}{4} = 2\frac{2}{8}$

Figure 4. The Experimental and Control Class's Answers

Based on Figure 4 above, the experimental class worked on the problem in sequence, starting from identifying the problem, planning the solution, and applying it to concluding correctly. However, in the control class, in identifying problems, the solution process was incomplete, and there was no conclusion. The application of the discovery learning model is suitable for learning mathematics because it can improve students' problem-solving skills [27], [41]. Applying the discovery learning model can also cause a sense of curiosity to investigate. Thus, it increases students' learning motivation [24], [42]. In addition, GeoGebra media can help teachers visualize material concepts so that students can easily understand the material, not just memorize the material [26], [42].

The results of data analysis show that the GeoGebra-assisted discovery learning model significantly affects problem-solving ability, marked by an increase in mathematics learning outcomes in the experimental class. The average posttest reached 81.03, while the control class reached 64.85. It was further strengthened by the results of the N-Gain test in the experimental class of 0.70 (high category) and the control class of 0.48 (medium category). Previous research revealed that discovery learning is more effective than the problem-solving model in improving mathematical problem-solving skills, as seen from the problem-solving problems in the experimental class, which is higher than that of the control class [27]. Another study revealed that the GeoGebra-assisted discovery learning model was effectively used in mathematics learning in junior high school, as seen from improved learning outcomes, observation of activities, and student responses [28]. Other research shows that, compared to conventional learning, the discovery learning model with the help of GeoGebra media can improve students' mathematical understanding, as seen in solving problems regarding examples and not examples of indeterminate integrals of algebraic functions [26]. Other research reveals that the discovery learning model with the help of audiovisual media can improve the ability to solve mathematical problems [43]. Another study also shows that discovery learning assisted by GeoGebra can improve spatial abilities [44]. The previous study and this study analyzed the influence of the discovery learning model. The differences lie in the variables, the media, and the research

sample. Furthermore, the students had differences in motivation, interests, family, and community environments, which slightly affected the students' learning outcomes.

Although there was an increase in learning outcomes, there were still several obstacles to implementing the discovery learning model in elementary schools. Not all students could make discoveries because their rational thinking skills were limited. It took a long time to find theories to solve problems [45]. In addition, not all students took part in learning with the discovery learning model because they were used to the old way of learning. Therefore, teachers must direct and guide the discovery process so students can cooperate in groups and not rely on each other.

A significant contribution from this study is the need to determine a learning model that can create a more meaningful learning atmosphere tailored to learning objectives, teaching materials, time allocation, school facilities, and creative and innovative learning media. The implication is that applying the GeoGebra-assisted discovery learning model can provide a new understanding for educators in creating more meaningful learning and consideration for educators in using innovative, engaging, and fun learning models and media. The limitations of this study include limited sample size and focus on specific schools, which may impact the generalization ability of the findings. Future research can explore the influence of Geogebra-assisted discovery learning models with larger sample sizes and in various educational contexts. Further research is recommended to investigate how the discovery learning model and GeoGebra media affect students' creativity skills, especially in primary school education.

4. CONCLUSION

This study analyzes the influence of the GeoGebra-assisted discovery learning model on the ability to solve fractional problems. It was found that the application of the GeoGebra-assisted discovery learning model had a significant influence on the problem-solving ability of the fourth-grade students of elementary school. The posttest results in the experimental class had an average of 81.03, higher than the control class, with an average of 64.65. In addition, based on the results of the N-Gain test, the increase between the pretest and posttest scores in the experimental class was in the high category, while in the control class, it was in the medium category. Therefore, the GeoGebra-assisted discovery learning model can be an alternative to choosing learning models and media that create a more meaningful learning atmosphere and improve student learning outcomes.

AUTHOR CONTRIBUTION STATEMENT

The VA contributed to writing original drafts, editing, determining research methods, conducting formal analysis, and editing. NA contributed to the formal review and analysis.

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