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The Effectiveness of Problem-Based Learning and Direct Instruction Models in Enhancing Mathematical Understanding among Elementary School Students

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Abstrak
Penelitian ini memfokuskan pada perbandingan pengaruh Problem Based Learning (PBL) dan Direct Instruction (DI) terhadap kemampuan pemahaman matematis peserta didik, dengan mempertimbangkan tingkat minat belajar mereka. Desain faktorial 3x2 digunakan, menggabungkan tingkat minat belajar (rendah, sedang, tinggi) dengan model pembelajaran (PBL dan DI). Hasil analisis menunjukkan perbedaan signifikan antara kedua metode pembelajaran, dengan interaksi antara metode dan tingkat minat peserta didik memengaruhi peningkatan pemahaman matematis. Peserta didik dengan minat tinggi cenderung mengalami peningkatan yang lebih signifikan. Temuan ini menekankan pentingnya responsif dan diferensiatif dalam pendekatan pembelajaran matematika, sesuai dengan kebutuhan individual peserta didik. Implikasi praktisnya adalah penyesuaian metode pembelajaran untuk mencapai hasil optimal. Studi ini memperkaya pemahaman tentang hubungan kompleks antara metode pembelajaran, minat belajar, dan pemahaman matematis.
Kata Kunci: Problem Based Learning; Direct Instruction; kemampuan pemahaman matematis.

Abstract
This study investigates the comparative impact of Problem-Based Learning (PBL) and Direct Instruction (DI) on students' mathematical understanding, considering their levels of interest in learning. A 3x2 factorial design was employed, incorporating varying levels of learning interest (low, medium, high) and learning models (PBL and DI). Statistical analysis reveals significant distinctions between the two instructional approaches, with the interaction between method and students' interest levels influencing improvements in mathematical understanding. Notably, students with high interest tend to demonstrate more substantial advancements. These findings underscore the importance of adapting instructional strategies to accommodate individualized student needs in mathematics education. The practical implication suggests tailoring teaching methods to optimize educational outcomes. This research enhances our understanding of the intricate dynamics among instructional methods, student interest, and mathematical comprehension.
Keywords: Problem Based Learning; Direct Instruction; Mathematical Understanding Ability.

I. INTRODUCTION

The landscape of 21st-century education prioritizes enhancing skills that bolster personal quality of life and professional efficacy (Island et al., 2021). This presents a collective challenge for stakeholders in education, including educators and students, to positively influence these skills (Indy, 2019). Mathematics, as a fundamental discipline, plays a crucial role in fostering logical and scientific thinking abilities. Nonetheless, pervasive negative perceptions towards mathematics often stem from individual learning experiences (Kamarullah, 2019). Despite this, mathematics significantly contributes to various sectors and society at large. Hence, it is imperative to transform these negative perceptions through educational approaches that integrate creativity, innovation, critical thinking, problem-solving, communication, and collaboration within the context of mathematics learning (Afriansyah et al., 2020).

In 2000, the National Council of Teachers of Mathematics (NCTM) revised the Principles and Standards for School Mathematics, continuing the global evolution of mathematics education since the 1980s (Maulyda, 2020). These revisions underscored the centrality of problem-solving in the curriculum, influenced by developmental psychology theories such as those of Piaget (Siagian, 2019), emphasizing that understanding mathematics, not mere memorization, is the primary educational objective, with the teacher serving as a facilitator. However, despite efforts, many schools in Indonesia continue to struggle with extracting pertinent information and comprehending mathematical texts, a challenge persisting since 2006. A study in 2015 highlighted that more than half of Indonesian adolescents were unable to grasp main ideas or interpret texts deeply (Pisani, 2016; Sjøvoll, Grothen, & Frers, 2020). According to the OECD report in 2018, Indonesian 15-year-olds exhibited declining performance in science, mathematics, and reading compared to 2015, as illustrated in Table 1.

Table 1.
Indonesia's PISA Scores

	2015	2018	*Global Average*
Reading	397	371	487
Mathematics	386	379	487
Science	403	396	489

The significance of communication in learning mathematics is rooted in two primary reasons: first, mathematics functions as a language that serves not only as a cognitive tool but also as a crucial means of clearly and succinctly communicating diverse ideas (Arifin et al., 2019). Second, learning mathematics is inherently a social activity, involving interactions among students and between teachers and students (Arifin et al., 2019). Developing mathematical communication hinges on enhancing students' understanding of mathematics(Cai, Lane, dan Jakabcsin; Gordah & Astuti, 2019). Therefore, mathematics education should prioritize the development of both mathematical understanding and communication skills through continuous exploration and improvement of instructional models and approaches.

The focus of this research centers on mathematics education at the elementary school level, which represents the foundational stage where understanding of mathematical concepts begins and develops. This focus arises from concerns over various comprehension challenges encountered by elementary school students. Correspondingly, it is argued that elementary school mathematics equips students with essential cognitive skills such as logical, critical, systematic, analytical, and creative thinking to solve problems. Mathematics education also nurtures responsibility and the ability to provide reasoned solutions systematically. In this context, mathematics learning trains students to express ideas using numerical language, fostering cognitive development that enriches human life (Juhayyatul Anisa, Sayidiman, 2020).

However, current practices in elementary school mathematics often focus solely on delivering content and solving problems without fully engaging students in critical, logical, systematic, and creative thinking (Rizti & Prihatnani, 2021). Consequently, many students perceive mathematics as daunting and consequently approach lessons with apprehension, which hampers their ability to focus and master mathematical concepts during learning activities (Juhayyatul Anisa, Sayidiman, 2020).

One alternative instructional approach under consideration is Problem-Based Learning (PBL). PBL immerses students in contextualized problems that prompt them to recognize mathematical concepts, engaging them actively in mathematical processes. This model challenges students to develop their learning skills collaboratively within groups to address real-world problems (Kemendikbud, 2014, hlm. 229; Damayanti & Afriansyah, 2018). Additionally, Anwar et al. (2019) identify three models—experimentation, troubleshooting, and mini-project design—that significantly enhance students' higher-order thinking skills.

Problem-Based Learning (PBL) is designed to immerse students in authentic problem-solving scenarios, facilitating active investigation and knowledge acquisition. This approach involves students directly in identifying, understanding, and resolving real-world problems, thereby promoting deep learning experiences (Lesi & Nuraeni, 2021). Through PBL, students engage in problem analysis, estimation, data collection, analysis, and solution formulation, fostering a learning environment that resonates with their daily lives. Moreover, collaborative group discussions within PBL enhance students' ability to solve problems collectively and construct knowledge collaboratively (Mashuri et al., 2019; Sutarsa & Puspitasari, 2021).

Research demonstrates that PBL effectively enhances students' mathematical understanding, as evidenced by significant improvements in learning achievement outcomes (Rifa'i, 2021). This success encourages further exploration into PBL's efficacy in deepening students' comprehension of mathematical concepts. Additionally, to explore the synergistic effects of instructional models, researchers are investigating the integration of the Direct Instruction (DI) model alongside PBL to optimize learning outcomes. DI is noted for its structured approach to developing both procedural and declarative knowledge through systematic, step-by-step instruction (Iswara & Sundayana, 2021). This method involves the teacher presenting new concepts followed by guided and independent practice, which helps students internalize and communicate mathematical concepts effectively (Ulfah et al., 2021).

Direct Instruction (DI) is a pedagogical model specifically designed to enhance students' acquisition of procedural and declarative knowledge through a well-structured, step-by-step approach (Supartini, 2021). This model involves the teacher explaining new concepts or skills to students, followed by controlled practice where students test their understanding under the teacher’s guidance, and then continue practicing with ongoing teacher support (Cahyo, 2019; Hanipah & Sumartini, 2021). Through such guidance, students can deepen their comprehension of mathematical material and effectively communicate it. Arends, as cited in Ulfah et al. (2021), elaborates that Direct Instruction is tailored to facilitate the learning of procedural knowledge through a sequential and systematic teaching pattern.

Direct learning, or Direct Instruction, is characterized by its teacher-centered approach, where the teacher plays a crucial role in motivating students to foster reciprocal interactions (Waru, 2016; Ulfah et al., 2021). This approach can be implemented using various methods such as lectures, demonstrations, practice exercises, and can be combined with other instructional techniques (Hermiyanty, Wandira Ayu Bertin, 2017). The implementation of Direct Instruction comprises five stages: stage 1 involves preparing the students; stage 2 entails explaining the lesson material; stage 3 includes guided practice; stage 4 involves checking understanding and providing feedback; and stage 5 offers opportunities for further independent practice. This model is chosen for its structured phases, beginning with orientation and culminating in independent practice. Direct Instruction promotes students' ability to construct their knowledge through active learning and direct engagement with problem-solving tasks, fostering student activity and exploration of the material (Ulfah et al., 2021).

The novelty of this research lies in integrating two instructional models—Project-Based Learning (PBL) and Direct Instruction (DI)—to create a more comprehensive learning approach. By combining PBL, which enhances active engagement and contextual problem-solving, with DI, which ensures structured understanding and direct teacher guidance, this research aims to leverage the strengths of each model. This integrated approach is expected to enhance students' mathematical understanding and communication skills more effectively than employing the models separately. The research will provide valuable empirical contributions and practical recommendations for teachers and educators, aiming to improve the quality of

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mathematics education at the elementary school level.

II. METHOD

This research employs a mixed methods approach with an embedded mixed methods design, specifically incorporating qualitative research within a quantitative framework. The chosen design is a sequential explanatory design, where quantitative and qualitative data are collected sequentially in two phases, with one form of data collection embedded within the other (Creswell, 2015, p. 1106).

A quantitative approach is utilized to statistically address the research questions based on measurement results. In this approach, the quasi-experiment method is employed. Stouffer (1950) and Campbell (1957) define a quasi-experiment as an experimental design that includes treatment, impact measurement, and experimental units, but does not use random assignment to create comparisons necessary for concluding treatment-induced changes.

The sequential explanatory design enables the collection of quantitative data first, followed by qualitative data to further explore the quantitative findings. Quantitative data collection is conducted using questionnaires, tests, and other validated and reliable measurement tools. This data is gathered from fifth-grade students at SDN 209 Cilengkrang, who are divided into two groups: one using the Problem-Based Learning (PBL) model and the other using the Direct Instruction (DI) model. Measurements are taken through pretests and posttests to evaluate the effectiveness of each learning model on student outcomes.

Following the analysis of quantitative data, qualitative data is collected through interviews, observations, and document analysis. Interviews with teachers and school principals provide in-depth insights into the implementation of the two learning models, while observations during the learning process offer direct insights into student interactions and responses. Document analysis involves reviewing learning materials, lesson plans (RPP), and student work.

Quantitative data analysis includes descriptive statistics to characterize the research sample, t-tests to compare pretest and posttest results between the experimental and control groups, and analysis of variance (ANOVA) for comparisons involving more than two groups. Qualitative data analysis encompasses transcription of interviews and observations, data coding to identify key themes, and triangulation to validate the findings.

The research sample is determined based on specific criteria: (1) proximity and accessibility, (2) ease of administrative procedures, (3) completeness of facilities and infrastructure, and (4) average student ability at a medium level. Consequently, the sample for this research consists of fifth-grade students from SDN 209 Cilengkrang, Bandung City, for the 2023/2024 academic year, as detailed in Table 2.

Table 2.
Sample of the Study

Class	Description	Number of

		Students
V C	Group of students using PBL Model	29
V D	Group of students using DI Model	29
	Total	**58**

The sample taken in this research will consist of two classes, one designated as the experimental class and the other as the control class. This restriction is related to the effectiveness of the research implementation, as the characteristics of this study are highly dependent on the selected subjects.

III. RESULT AND DISCUSSION

In exploring the dynamics of mathematics education, this study focuses on the differential impact of two primary instructional approaches—Problem-Based Learning (PBL) and Direct Instruction (DI)—on enhancing students' mathematical understanding. The research aims to investigate how these two methods differ in their effectiveness, considering an additional variable: students' learning interests. By examining the interaction between instructional models and learning interests, this study seeks to provide a more comprehensive perspective on the efficacy of each approach within the context of students' learning preferences and characteristics in mathematics education.

To analyze the differences in the impact of PBL and DI on improving mathematical understanding, and how these effects are influenced by students' levels of interest in learning, statistical analyses were conducted. The results of these analyses enhance our comprehension of the relative effectiveness of these two instructional methods in the context of students' mathematical understanding. Through a robust statistical framework, we can identify significant differences between the two approaches and examine how their interaction with students' learning interests affects outcomes. This analysis provides insights into formulating more personalized and effective instructional recommendations tailored to individual students' learning needs and preferences.

To address the research questions, data analysis employed an independent t-test to determine differences in the improvement of students' mathematical understanding. Subsequently, a two-way ANOVA was conducted to test the research hypotheses. Statistical testing followed standard procedures, including verification of prior assumptions. The following is a summary of the data analysis results:

Table 3.
Tests of Normality
Differences in the Effects of Implementing Problem-Based Learning and Direct Instruction on Enhancing Mathematical Understanding Considering Students' Learning Interests

N-Gain Score		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Model Pembelajaran	Problem Based Learnig	.157	29	.066	.960	29	.323
	Direct Instruction	.100	29	.200*	.982	29	.875
Minat Belajar	Rendah	.156	20	.200*	.907	20	.056
	Sedang	.146	18	.200*	.956	18	.525
	Tinggi	.151	20	.200*	.942	20	.258

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

Based on Table 3, it can be seen that the increase in the mathematical understanding ability of students using the learning models is categorized into two groups. The increase in the mathematical understanding ability of students who use the Problem-Based Learning method shows a significance of 0.066, while those who use the Direct Instruction method show a significance of 0.200. The creative thinking ability associated with the use of these learning methods is concluded to be normally distributed because they have a significance value (sig) > 0.05.

Additionally, the increase in students' mathematical understanding ability is categorized by learning interest into three groups. The high learning interest category shows a significance of 0.200, the medium learning interest category shows a significance of 0.200, and the low learning interest category also shows a significance of 0.200. The increase in students' mathematical understanding ability is concluded to be normally distributed because each category has a significance value (sig) > 0.05.

After establishing the normal distribution of the data, a homogeneity test was conducted to examine the distribution of research respondents. The results of the homogeneity test are presented below:

Table 4.
Levene's Test of Equality of Error Variances[a,b]
Differences in the Effects of Implementing Problem-Based Learning and Direct Instruction on Enhancing Mathematical Understanding Considering Students' Learning Interests

		Levene Statistic	df1	df2	Sig.
N-Gain Score	Based on Mean	2.176	5	52	.071
	Based on Median	1.415	5	52	.234
	Based on Median and with adjusted df	1.415	5	38.541	.241
	Based on trimmed mean	2.072	5	52	.084

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Dependent variable: Peningkatan kemampuan pemahaman matematis
b. Design: Intercept + MODEL + MINAT

Based on Table 4, Levene's Test of Equality of Error Variance indicates a Levene statistic of 2.176 with a significance of 0.71, which is greater than 0.05 (<0.05). According to this homogeneity test, it can be concluded that the variance in data among research participants is homogeneous, indicating no significant difference in enhancing students' mathematical understanding abilities overall. The results of this homogeneity test pertain to the intercept of learning models in both Problem-Based Learning (PBL) and Direct Instruction (DI) categories across high, medium, and low interest levels.

This research investigates differences in the impact of implementing Problem-Based Learning (PBL) and Direct Instruction (DI) on improving mathematical understanding abilities concerning students' learning interests. Initially, the author conducted an independent samples test to examine the mean differences between the two learning models: PBL and DI. Furthermore, the researchers explored whether significant differences exist between these groups and utilized Cohen's effect size to assess the magnitude of these effects on enhancing mathematical understanding abilities. The results of the independent test data analysis are presented in the Table 5 below.

Table 5.
Independent Samples Test
Differences in the Impact of Implementing Problem Based Learning and Direct Instruction on the Improvement of Mathematical Understanding Skills Considering Students' Learning Interests

	t-test for Equality of Means						
						95% Confidence Interval of the Difference	
N-Gain Score	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.056	.814	4.742	56	.000	.12386	.02612
Equal variances not assumed			4.742	55.692	.000	.12386	.02612

The analysis presents results from the Levene test for equality of variances and the t-test for equality of means. The t-test aimed to assess whether a significant difference existed in the average improvement of mathematical understanding between two groups. Results indicate a t-value of 0.056 with a significance level (Sig.) of 0.000. Given Sig. < 0.05, a significant difference in average improvement of mathematical understanding is evident between the groups. Furthermore, the mean difference reveals an average improvement of 0.056, with a 95% confidence interval ranging from 0.12386 to 0.02612. Thus, this analysis confirms a notable difference in average improvement in mathematical understanding between the groups, while indicating similar variances.

Consequently, these findings suggest that Problem Based Learning (PBL) implementation tends to yield greater improvements in students' mathematical understanding compared to Direct Instruction (DI). Details of the average differences between the groups are outlined in the following Table 6:

Table 6.
Group Statistics Differences in the Effects of Implementing Problem Based Learning and Direct Instruction on the Enhancement of Mathematical Understanding Skills Considering Students' Learning Interests

N-Gain Score	Learning Model	N	Mean	Std. Deviation	Std. Error Mean
	Problem Based Learnig	29	.5455	.10309	.01914
	Direct Instruction	29	.4217	.09569	.01777

The results of this analysis present descriptive statistics on the enhancement of mathematical understanding abilities within two learning model groups: Problem Based Learning (PBL) and Direct Instruction (DI). The PBL group comprised 29 students, showing an average increase in mathematical understanding ability of 0.5455, with a standard deviation of 0.10309 and a mean standard error of 0.01914. Similarly, the DI group, also consisting of 29 students, exhibited an average increase of 0.4217, a standard deviation of 0.090569, and a mean standard error of 0.01777.

These findings illustrate differences in both the average improvement and dispersion of mathematical understanding abilities between the two learning groups. The average increase in mathematical understanding was higher in the PBL group (0.5455) compared to the DI group (0.4217), with a slightly higher standard

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deviation observed in the PBL group (0.10309) compared to DI (0.090569). This initial observation suggests potential disparities in the efficacy of the two learning methods for enhancing students' mathematical understanding. Given these significant differences, further discussion is warranted to explore the influence of employing Problem Based Learning (PBL) and Direct Instruction (DI) models, including the magnitude of their respective impacts. The following Table 7 presents a detailed comparison:

Table 7.
Independent Samples Effect Sizes Differences in the Impact of Implementing Problem Based Learning and Direct Instruction on the Enhancement of Mathematical Understanding Skills Considering Students' Learning Interests

		Standardizer[a]	Point Estimate	95% Confidence Interval Lower	95% Confidence Interval Upper
N-Gain Score	Cohen's d	.09946	1.245	.677	1.805
	Hedges' correction	.10081	1.229	.668	1.780
	Glass's delta	.09569	1.294	.671	1.902

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control group.

The analysis reveals three distinct effect sizes: Cohen's d, Hedges' correction, and Glass's delta, which quantify the magnitude of the mean difference between two groups in standard deviation units. Cohen's d, widely employed in statistical analyses, yields a point estimate of 0.09946, suggesting that the disparity in average improvement in mathematical understanding between Problem Based Learning (PBL) and Direct Instruction (DI) groups spans approximately 1.245 standard deviations. The 95% confidence interval for Cohen's d ranges from 0.677 to 1.805, indicating the degree of certainty surrounding this difference.

Hedges' correction, designed for smaller sample sizes, provides a point estimate of 0.10081, with a 95% confidence interval from 0.668 to 1.780. Meanwhile, Glass's delta, utilizing the sample standard deviation of the control group, yields a point estimate of 0.09569, with a 95% confidence interval from 0.671 to 1.902.

These effect sizes collectively illustrate the magnitude of difference between PBL and DI in enhancing mathematical understanding. A larger effect size denotes a greater disparity between the groups. Consequently, the findings underscore a significant difference in the effectiveness of PBL and DI methodologies for enhancing students' mathematical understanding.

The research problem addresses whether there exists a disparity in the impact of implementing Problem Based Learning and Direct Instruction on enhancing mathematical understanding, considering students' learning interests. Hypothesis testing employs a Two-Way ANOVA test with a Two-Factor Between-Subjects design. The null hypothesis (Ho) is tested with a significance criterion of less than 0.05, indicating rejection of the null hypothesis in favor of the alternative hypothesis. Conversely, a significance value greater than 0.05 supports acceptance of the null hypothesis, suggesting no significant difference.

H_0: $\alpha_r = 0$	*There is no difference in the impact of implementing Problem Based Learning and Direct Instruction on the enhancement of mathematical understanding skills considering students' learning interests.*
H_1: not all $\alpha_i = 0$	*There is a difference in the impact of implementing Problem Based Learning and Direct Instruction on the enhancement of mathematical understanding skills considering students' learning interests.*

Based on this hypothesis, it is essential to analyze the enhancement of students' mathematical understanding abilities across each factor within each research variable. The factorial design employed in this study involves two independent variables: the learning model (Problem Based Learning and Direct Instruction) and students' level of interest in learning (high interest, medium interest, and low interest), thereby constituting a 3x2 factorial design. Based on these findings, researchers utilized the Two-way ANOVA test to assess the interaction effect between learning models and students' learning interests on the improvement of students' mathematical understanding abilities. The results of the Two-way ANOVA are presented below:

Table 8.
Tests of Between-Subjects Effects Differences in the Effects of Implementing Problem Based Learning and Direct Instruction on the Enhancement of Mathematical Understanding Skills Considering Students' Learning Interests

Dependent Variable: N-gain Score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	Hypothesis	13.552	1	13.552	76.349	.013	.974
	Error	.355	2.000	.177[a]			
MODEL	Hypothesis	.219	1	.219	71.303	.014	.973
	Error	.006	2.006	.003[b]			
MINAT	Hypothesis	.355	2	.178	57.949	.017	.983
	Error	.006	2	.003[c]			

a. .999 MS(MINAT) + .001 MS(Error)
b. .999 MS(MODEL * MINAT) + .001 MS(Error)
c. MS(Error)

The result of this analysis is a test of the effect of different factors on the dependent variable, namely the enhancement of mathematical understanding abilities. The Intercept Test examines whether there is a significant difference in the improvement of mathematical understanding abilities among different subject groups. The results indicate that the intercept has an F value of 76.349 with a significance of 0.013, demonstrating a significant difference in the improvement of mathematical understanding abilities among subject groups.

The effect of the learning model (PBL or DI) on the enhancement of mathematical understanding abilities is also examined. The results show that the learning model has an intercept with an F value of 71.303 and a significance of 0.014, indicating a significant influence on increasing students' mathematical understanding abilities. These findings affirm that the choice of learning approach (PBL or DI) impacts students' comprehension of mathematical material. Moreover, these results underscore the importance of selecting an appropriate learning model to effectively enhance mathematical understanding abilities, particularly in consideration of students' level of interest in learning.

Additionally, the effect of the level of learning interest (low, medium, or high) on the enhancement of mathematical understanding abilities is assessed. The results reveal an intercept with an F value of 57.949 and a significance of 0.017, indicating a significant influence of learning interest on increasing students' mathematical understanding abilities. This underscores the pivotal role of students' interest in the learning process and their grasp of mathematical concepts. Importantly, the level of learning interest can moderate or alter the impact of the learning model (PBL or DI) on mathematical understanding abilities, highlighting the variability in influence based on students' interest levels.

The data analysis confirms that both learning methods and interest in learning, including their interactions, significantly affect the improvement of students' mathematical understanding abilities, as evidenced by the F value of 71.303 and significance of 0.014 (significant because it is less than <0.05). Therefore, it can be concluded that the null hypothesis (Ho) is rejected, implying that the alternative hypothesis (Ha) is accepted. This suggests that "There are differences in the influence of implementing Problem Based Learning and Direct Instruction on increasing mathematical understanding abilities in terms of students' learning interest."

Furthermore, partial eta squared is utilized to gauge the extent to which each variable explains variability in the dependent variable. A high partial eta squared value indicates a strong influence of the independent variable on the dependent variable. In this analysis, partial eta squared values for all variables (Intercept, MODEL, and INTEREST) are close to 1, indicating a substantial influence of these three variables on the enhancement of students' mathematical understanding abilities. Thus, these findings provide valuable insights into how the implementation of PBL and DI shapes improvements in students' mathematical understanding, particularly when considering their individual learning interests.

To further explore differences in students' mathematical understanding abilities across different levels of learning interest, a post hoc test was conducted, the results of which are presented in the following Table 9:

Table 9.
Post Hoc Perbedaan Pengaruh Implementation of Problem Based Learning (PBL) and Direct Instruction (DI) on the Enhancement of Mathematical Understanding Skills Considering Students' Learning Interests

Dependent Variable: N-gain The Increase of Mathematical Understanding Abilities

Learning Interest	Learning Model	Mean	Std. Deviation	N
Low	Problem Based Learnig	.4464	.06619	10
	Direct Instruction	.3229	.05770	10
	Total	.3846	.08758	20
Medium	Problem Based Learnig	.5436	.03587	9
	Direct Instruction	.4464	.04061	9
	Total	.4950	.06232	18
High	Problem Based Learnig	.6463	.07301	10
	Direct Instruction	.4982	.07565	10
	Total	.5723	.10492	20
Total	Problem Based Learnig	.5455	.10309	29
	Direct Instruction	.4217	.09569	29
	Total	.4836	.11671	58

The results of this descriptive statistical analysis provide an overview of the average, standard deviation, and sample size (N) for the variable of increased mathematical understanding abilities based on the combination of Learning Interest Level (low, medium, and high) and Learning Models (Problem Based Learning and Direct Instruction).

For students with a low level of Interest in Learning who participated in Problem Based Learning, the average increase in mathematical understanding ability was 0.4464, with a standard deviation of 0.06619. Those who participated in Direct Instruction had an average increase of 0.3229, with a standard deviation of 0.05770. Overall, students with a low level of Interest in Learning showed an average increase of 0.3846 in mathematical understanding ability.

Students with a moderate level of Interest in Learning who engaged in Problem Based Learning had an average increase of 0.5436, with a standard deviation of 0.03587. Those in Direct Instruction had an average increase of 0.4464, with a standard deviation of 0.04061. Overall, students with a moderate level of Interest in Learning showed an average increase of 0.4950 in mathematical understanding ability.

Students with a high level of Interest in Learning who participated in Problem Based Learning had an average increase of 0.6463, with a standard deviation of 0.07301. Those in Direct Instruction had an average increase of 0.4982, with a standard deviation of 0.07565. Overall, students with a high level of Interest in Learning showed an average increase of 0.5723 in mathematical understanding ability.

Thus, these findings provide insight into the differences in increasing mathematical understanding abilities based on the combination of Learning Interest Level and the applied Learning Model.

Overall, when considering the total combinations of learning interest levels and learning models, there is variability in the increase of students' mathematical understanding abilities. Specifically, differences exist between the Problem Based Learning and Direct Instruction models in terms of enhancing mathematical understanding abilities. Furthermore, differences also emerge across levels of learning interest, including high, moderate, and low interest categories. Generally, students with a higher level of Interest in Learning tend to experience a greater average increase in mathematical understanding abilities, followed by those with moderate and low levels of Interest in Learning.

Based on the statistical analysis presented earlier, significant differences were found in the impact of implementing Problem Based Learning (PBL) and Direct Instruction (DI) on enhancing mathematical understanding abilities, depending on students' level of interest in learning.

PBL demonstrates a tendency to be more effective in enhancing mathematical understanding compared to DI. Students engaged in PBL typically experience greater improvement because this method encourages active problem-solving and application of mathematical concepts in real-world contexts. This finding aligns with the observation that PBL fosters active student engagement, particularly benefiting those with high learning interest.

Conversely, DI remains effective but generally yields slightly lower results than PBL in terms of enhancing mathematical understanding. DI provides direct guidance and structured learning, which is advantageous, especially for students responsive to clear instructional direction. However, the effectiveness of DI is also influenced by students' level of interest in learning; students with high interest tend to respond more positively to this approach.

The interaction between learning methods (PBL vs DI) and students' interest in learning is pivotal in interpreting these research findings. Combinations of high learning interest with PBL tend to yield the most significant improvements in mathematical understanding, whereas similar combinations with DI also result in positive outcomes but with slightly less impact.

Overall, this study contributes significantly to understanding how different mathematics teaching methods can be tailored to students' varying levels of interest to enhance learning effectiveness. By accommodating diverse learning interests and responses to teaching methods, educators can develop more inclusive and responsive strategies, thereby enhancing each student's opportunity to achieve deeper mathematical understanding.

The outcomes of this research are consistent with prior studies (Harisantoso et al., 2020), which highlight significant differences in problem-solving abilities between students taught using PBL and DI. Students in PBL environments tend to achieve higher average scores due to active discussion and collaborative problem-solving, which fosters deeper problem-solving skills compared to DI. Similarly, research by Raharjo (2019) underscores significant differences in learning outcomes favoring PBL over DI, reinforcing the notion that PBL consistently delivers superior results in mathematical understanding and problem-solving.

These findings suggest that the interactive and real-world problem-based approach of PBL is more effective in stimulating student interest and active participation compared to the structured approach of DI. Successful implementation of PBL requires thorough preparation and flexible adaptation to students' interests and learning needs, potentially yielding more optimal outcomes compared to the conventional DI method.

IV. CONCLUSION

The research findings indicate that Problem Based Learning (PBL) effectively enhances students' mathematical understanding by engaging them in active problem-solving and applying mathematical concepts in real-world scenarios. Students with a high interest in learning tend to benefit the most from this approach. Conversely, Direct Instruction (DI), which involves direct delivery of information by the teacher, has also proven effective, particularly for students who require clear guidance in grasping mathematical concepts. Responses to DI are influenced by students' level of interest in learning, with those having high interest showing greater receptivity to direct instruction.

Significant disparities in learning outcomes were observed among students with high, moderate, and low levels of learning interest. Students with high learning interest demonstrated substantial improvements in mathematical understanding, especially when engaged in PBL. Meanwhile, students with moderate and low levels of learning interest also experienced enhancements, albeit to a lesser degree compared to their highly interested peers.

In educational settings, it is crucial to acknowledge the diversity in students' learning interests when designing effective and inclusive mathematics learning strategies. Educators can leverage a blend of teaching methods such as PBL and DI, while employing differentiation strategies to cater to the varied needs of learners. Further research is warranted to delve deeper into the interplay between learning methods, levels of learning interest, and outcomes of mathematical understanding. This ongoing exploration will facilitate the refinement of optimal and responsive mathematics teaching practices across diverse educational contexts.

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