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The influence of PBL and BBL models on the acquisition and improvement of elementary school students' mathematical concept understanding abilities

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ABSTRACT

This study explores the impact of using the Problem Based Learning (PBL) and Brain Based Learning (BBL) models on the achievement and development of elementary school students' mathematical concept understanding abilities. The method applied is a quantitative approach with quasi-experimental and descriptive designs. Participants in this study included sixth-grade students from a public elementary school in Bandung, who were divided into two experimental groups: one used the PBL model, and the other applied the BBL model. The measurement tool used in this study is an essay test designed to assess the ability to understand mathematical concepts. The findings of this study indicate that the implementation of both learning methods, namely PBL and BBL, has a significant impact on students' ability to understand mathematical concepts. Although the BBL model shows a more significant improvement tendency than the PBL model, the difference in effects between the two methods in enhancing mathematical understanding is not statistically significant. This research contributes to developing innovative, appropriate, and efficient mathematics learning models for use at the elementary school level.

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ABSTRAK

Studi ini bertujuan untuk mengeksplorasi dampak penggunaan model pembelajaran Problem Based Learning (PBL) dan Brain Based Learning (BBL) terhadap pencapaian serta perkembangan kemampuan pemahaman konsep Matematika murid di sekolah dasar. Metode yang diterapkan adalah pendekatan kuantitatif dengan rancangan quasi-eksperimen dan deskriptif. Partisipan dalam penelitian ini meliputi peserta didik kelas VI dari sebuah sekolah dasar negeri di Bandung, yang dibagi menjadi dua kelompok eksperimen: satu kelompok menggunakan model PBL dan kelompok lainnya menerapkan model BBL. Alat ukur yang digunakan dalam penelitian ini adalah tes esai yang dirancang untuk menilai kemampuan pemahaman konsep Matematika. Temuan penelitian ini menunjukkan bahwa penerapan kedua metode pembelajaran, yaitu PBL dan BBL, memiliki pengaruh yang signifikan terhadap kemampuan pemahaman konsep Matematika peserta didik. Meskipun model BBL menunjukkan kecenderungan peningkatan yang lebih besar dibandingkan model PBL, perbedaan efek antara kedua metode dalam meningkatkan kemampuan pemahaman Matematika tidak signifikan secara statistik. Penelitian ini memberikan sumbangan terhadap pengembangan model pembelajaran Matematika yang inovatif, sesuai, dan efisien untuk digunakan di tingkat sekolah dasar.

Kata Kunci: *kemampuan pemahaman; konsep matematis; pembelajaran berbasis masalah; pembelajaran berbasis otak*

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INTRODUCTION

Education is one of the crucial aspects in developing human resources, including mathematics education. As an essential basic subject in the education curriculum, Mathematics has a vital role in equipping learners with the ability to understand solid concepts needed to face future challenges. However, despite its essential role, learning Mathematics is often perceived as complex and uninteresting by students. This view eventually contributes to the low interest in learning and achievement of students in Mathematics. The facts in the field show that not all students have achieved these abilities optimally and thoroughly. The Organization for Economic Co-operation and Development (OECD) in the Program for International Student Assessment (PISA) 2022 results announced on December 5, 2023, stated that the results of the PISA international survey confirmed that the mathematics skills of Indonesian students still need to be improved significantly. Only a small percentage of learners can apply basic mathematics concepts in everyday life. This data shows that the quality of Mathematics learning in Indonesia needs to be improved so that students can compete globally. Mathematics encourages learners to think systematically and analytically, not just as subjects. Through learning Mathematics, learners learn to solve problems in a structured way and can improve their critical thinking skills.

Previous research has shown that learners with a strong understanding of basic mathematical concepts can more easily analyze information and find solutions to complex problems. Mathematics is a subject and a tool for honed thinking skills and applying its concepts to other issues and daily life problems (Suryapuspitarini, 2018). Learning can use models that can help students develop their thinking skills, as Problem-Based Learning (PBL) and Brain-Based Learning (BBL).

Previous research has shown how these two learning approaches positively impact student learning outcomes. Research by Asih *et al*. (2019) shows that students who study with PBL experience a significant increase in their understanding of mathematical concepts compared to those who use traditional learning methods. This study compared the effectiveness of BBL with PBL and found that BBL had a higher impact on improving students' understanding. Based on these studies, it is known that both the PBL and BBL models positively influence the experience of Mathematics concepts of elementary school students. The PBL model improves students' critical and analytical thinking skills, while the BBL also significantly contributes to concept comprehension (Anggraini *et al*., 2020; Mareti & Hadiyanti, 2021). Previous research has shown that students' understanding of mathematical concepts greatly influences their academic achievement and critical thinking skills. On the other hand, many students, especially at the elementary school level, still have difficulty understanding mathematical concepts. This shows the need for a practical learning approach to improve students' understanding of what is meant by "understanding Mathematics." This research will implement the PBL and BBL models, two learning approaches expected to enhance students' understanding of mathematical concepts.

The PBL model allows students to learn through real problem-solving to develop critical and creative thinking skills (Amarullah *et al.*, 2025). These two models have advantages that complement each other. PBL encourages students to be actively involved in learning, while BBL helps understand how students' brains work in the learning process. Combining these two approaches is hoped to examine the application of two learning models, namely PBL and BBL, in improving elementary school students' understanding of Mathematics concepts.

This study aims to determine how the two learning models can strengthen students' understanding of mathematical concepts and develop their interest and motivation for Mathematics lessons for elementary school students. By combining the advantages of each model, where PBL encourages the active involvement of students in the learning process, and BBL understands how students' brains work, it is hoped that the characteristics of students can create more effective learning methods. The results of this research are expected to contribute to developing Mathematics learning methods that are more innovative and relevant to students' learning needs and tendencies.

LITERATURE REVIEW

Ability to Understand Mathematical Concepts

Understanding concepts is fundamental for students to have. By understanding the concept, students will find it easier to learn the material received. Swafford et al., in the book *"Adding it Up: Helping Children Learn Mathematics,"* explain that conceptual understanding is the ability to understand concepts, operations, and relationships in mathematics. Thus, understanding the concept is very important for students because it will help them solve problems with each material given to them. Understanding concepts will make it easier for students to learn the following Mathematics materials and solve more complex problems. (Rafianti *et al*., 2020). In other words, understanding mathematical concepts is the key for students to learn Mathematics meaningfully and apply it in daily life. Meanwhile, in the 2015 National Education Standards Agency, it is stated that the indicators of concept understanding consist of 1) Restating the concept; 2) Classifying objects according to specific properties; 3) Providing examples and non-examples of concepts; 4) Presenting concepts in various forms of mathematical representation; 5) Develop the necessary conditions and sufficient conditions of a concept; and 6) Using, utilizing and choosing to sort out specific operating procedures.

Problem-Based Learning (PBL) model

The Problem-Based Learning (PBL) model is used in the learning process because it has the advantage of helping students understand how to learn independently. PBL is a learning model involving students solving a real problem (Ardianti *et al*., 2021). Based on this, the primary goal of PBL is to improve students' ability to think critically to solve a problem (Angraini *et al*., 2022). PBL effectively activates early knowledge and encourages elaboration, which is essential in Mathematics learning in elementary school (Lestari *et al*., 2024). The characteristics of PBL (Barrow, 1996): 1) Student-centered learning, where students are the primary focus as learners; 2) The problems presented are authentic and are at the core of the learning process; 3) New information is obtained through independent learning, where students seek information from various sources, such as books or other references; 4) Learning is carried out in small groups; and 5) Teachers play the role of facilitators who accompany students.

PBL emphasizes students' problem-solving activities, which will trigger students' thinking skills. PBL is a learner-centered learning approach, with authentic problems as a learning trigger (Savery, 2015). Students work in small groups to find solutions, with teachers acting as facilitators who guide the learning process. PBL improves students' academic understanding and develops critical thinking skills, collaboration, and independence in learning. The PBL model has advantages in training students to think critically, actively, and independently in learning (Masrinah *et al*., 2019; Wijanarko, 2022). PBL centers on students with authentic problems as the core of learning and emphasizes group work and the role of teachers as creative and innovative facilitators (Fajriah *et al*., 2021). With the proper application, PBL can improve academic understanding, critical thinking, collaboration, and independent learning skills.

Brain-Based Learning (BBL) model

The Brain-Based Learning (BBL) model or Pembelajaran Berbasis Otak (PBO) is a learning approach that explains how the human brain processes information. This approach emphasizes the importance of creating a learning environment that is fun, challenging, and relevant to the learner's experience so that the learning process becomes more effective and meaningful. Therefore, BBL can effectively increase students' interest, understanding, and skills in learning (Damayanti & Suryadi, 2024). Education can realize the fundamental role of students, who are more dominant in learning than the role of teachers, by making learning centered on student competencies (student-centered) (Rahadian, 2016; Rochmat *et al*., 2022). Students' competencies that need to be improved are focused on 21st-century skills, namely thinking skills (Muhammad *et al*., 2021). 21st-century skills help learners adapt to various forms of change, including 1) critical thinking and problem solving, 2) communication and collaboration, and 3) creativity and innovation (Redhana, 2019). In BBL, the brain is considered the center of information processing, and each learning activity is designed to stimulate different parts of the brain, such as emotional, social, and physical, to achieve optimal learning outcomes.

The BBL model can increase learner engagement by creating fun and active learning situations. The advantages of the BBL Model include: 1) Building children's critical thinking skills; 2) Developing children's thinking skills in solving problems that occur; 3) Developing potential in children; 4) Creating a safe and fun learning atmosphere for children to provide positive energy for children; 5) Building children's motivation to learn; 6) Learning that uses this model can be used for various ways of learning because by involving the brain it will be better; 7) Learning will be modern; and 8) pay attention to the natural workings of the child's brain in the use of the BBL model (Handayani, 2021). On the other hand, there are disadvantages of the BBL model, namely 1) Many audiences do not know the BBL model, so there are not many who apply this model to learning in the classroom; 2) This model tends to take a long time to understand how the brain works, so special knowledge of neuroscience is needed; and 3) Much capital is needed in using the BBL learning model (Al-Ayyubi *et al*., 2024).

In applying a model to learning, of course, it will experience challenges. Jensen conveyed this in the book *"Teaching with the Brain in Mind," which stated that one of the biggest challenges in implementing BBL in the classroom is the availability of sufficient resources to train teachers and provide the materials and tools needed to create a learning experience that is based on* the principles of the brain. This is reinforced by Sousa's statement in his book *"How the Brain Learns Mathematics"* that a deep understanding of neurobiology is essential for teachers to optimize the application of BBL in Mathematics learning. Without a good understanding of how the brain works, educators may have difficulty designing the right learning experience. It is therefore concluded that, although BBL offers many opportunities to improve the quality of learning, success must be ensured by considering scientific understanding, facilities, and budget issues.

METHODS

This study adopted a quantitative approach by applying a quasi-experimental method. The Nonequivalent Control Group Design is used, which is divided into two groups, namely the Experiment class. The participants in this experiment are students who are taught using the Problem-Based Learning (PBL) methodology. In this strategy, learners are given various problems that require attention to increase their level of active participation in the learning process. Meanwhile, the control class is a group of students taught using the Brain-Based Learning (BBL) method. In this method, learning is designed to fit the natural workings of the brain, where learners can connect new knowledge with previous experiences. This approach activates different brain areas relevant to learning, helping learners understand concepts more deeply and improve critical thinking skills. Through an approach that involves active interaction, in-depth information processing, and authentic experience, students in the control class experienced a significant improvement in problem-solving skills and material understanding compared to students using conventional methods. The research design scheme can be seen in **Figure 1** below.

O	**X**	**O**
O	**Y**	**O**

Figure 1. Design scheme
Source: Research, 2024

Information:
O = Pre-test (before treatment) and Post-test (after treatment)
X = Problem-Based Learning (PBL) learning treatment
Y = Brain-Based Learning (BBL) learning treatment

The population in this study is all 6th-grade students in one of the elementary schools in Bandung. The research sample consisted of two classes selected by purposive sampling: the experimental class with 25 students and the control class with 25 students. Several techniques were used to collect data, namely the initial test (pre-test), the treatment (the application of the PBL model in several meetings), and the final test (post-test). Data analysis was carried out using the Paired t-test to compare the pre-test and post-test results in each group, the Independent t-test to compare the results between the experimental and control groups, and the N-Gain to evaluate the improvement of understanding of mathematical concepts. Field, in the book *"Discovering Statistics using IBM SPSS Statistics,"* explains the importance of checking the normality of data before applying paired t-tests and independent t-tests in quantitative research. In this context, paired t-test analysis is used to test for changes in pre-test and post-test results in the experimental group. In contrast, the independent t-test helps compare the differences between the experimental and control groups. Field also explained how N-Gain can be used to measure how much students' understanding of concepts improves after treatment.

RESULTS AND DISCUSSION

Student Scores of Kemampuan Pemahaman Konsep Matematis (KPKM) through PBL and BBL Learning

The description of the KPKM score of students who study with PBL and BBL represents results that describe the level of understanding of Mathematics concepts of students after they participate in learning using the PBL and BBL models. This score reflects the ability of students to understand, connect, and apply Mathematics concepts in depth, according to the learning characteristics of each model. PBL focuses on practical problem solving, while BBL optimizes how students' brains process and remember information, so these two approaches are expected to improve students' understanding of mathematics comprehensively.

Table 1. Descriptive Statistics Output of Learning with PBL and BBL

Descriptives

			Statistic	Std. Error
Posttest_pbl	Mean		78.21	3.034
	95% Confidence Interval for Mean	Lower Bound	71.93	
		Upper Bound	84.48	
	5% Trimmed Mean		78.59	
	Median		81.00	
	Variance		220.868	
	Std. Deviation		14.862	
	Minimum		50	
	Maximum		100	
	Range		50	
	Interquartile Range		23	
	Skewness		-.614	.472
	Kurtosis		-.868	.918

Postest_bbl	Mean		80.75	2.886
	95% Confidence Interval for Mean	Lower Bound	74.78	
		Upper Bound	86.72	
	5% Trimmed Mean		81.25	
	Median		82.00	
	Variance		199.935	
	Std. Deviation		14.140	
	Minimum		53	
	Maximum		100	
	Range		47	
	Interquartile Range		17	
	Skewness		-.911	.472
	Kurtosis		-.054	.918

Source: Research, 2024

Based on a descriptive analysis of the scores of students who learn using the PBL and BBL models, several findings are obtained that are important to understand. The average score of students who used BBL (80.75) was higher than that of students who used PBL (78.21). This shows that, in general, students who study with the BBL approach have a better understanding of Mathematics concepts than students who use the PBL approach. However, this difference is not too significant. The standard deviation shows the difference in the distribution of scores between the two groups. The standard deviation score in the PBL group (14,862) was higher than that in the BBL (14,140), indicating that the score distribution in the PBL group was more dispersed. This means that the variation or difference in scores between students in the PBL group is more significant, with some students getting very high or very low scores. In contrast, student scores are more concentrated or homogeneous in the BBL group. The skewness in both groups showed negative values, namely in PBL (-0.614) and BBL (-0.911), which indicates that the score distribution tends to shift towards higher scores. Thus, most learners in both groups obtained relatively high scores, although the distribution was not entirely symmetrical. Overall, these results show that both PBL and BBL effectively improve understanding of mathematics concepts, but BBL tends to be more consistent in providing even results among students.

The Impact of PBL on the Acquisition of KPKM in Students

Table 2. Output Statistics of the Paired Samples T-Test on Students' Learning with PBL

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PBL_pretest	31.04	25	6.509	1.302
	PBL_postest	78.52	25	14.632	2.926

Paired Samples Correlations

				Significance	
		N	Correlation	One-Sided p	Two-Sided p
Pair 1	PBL_pretest & PBL_postest	25	.462	.010	.020

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	PBL_pretest - PBL_postest	-47.480	12.978	2.596	-52.837	-42.123	-18.293	24	<.001	<.001

Paired Samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval	
					Lower	Upper
Pair 1	PBL_pretest - PBL_postest	Cohen's d	12.978	-3.659	-4.753	-2.553
		Hedges' correction	13.402	-3.543	-4.603	-2.472

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Source: Research, 2024

Based on the paired sample t-test results in **Table 2,** there was a significant positive relationship between pre-test and post-test scores with a correlation value of 0.462 (p = 0.020). This suggests that about 21% of the variation in post-test scores can be explained by pre-test scores. PBL significantly influences students' ability to understand Mathematics concepts with a significance level of p < 0.001. Nonetheless, the effect of PBL on students' understanding of mathematical concepts had a low effect size, indicated by Cohen's value d of -3.659, below the low effect threshold (< 0.2). This indicates that although PBL is effective, its impact on improving the ability to understand Mathematics concepts is still limited. The PBL model effectively improves students' mathematical problem-solving skills (Paillin et al., 2024). PBL encourages learners to be more active and critical in learning, contributing to a deeper understanding of concepts.

The Impact of BBL on the Acquisition of Kemampuan Pemahaman Konsep Matematis (KPKM) in Students

Table 3. Paired Sample T-Test on Students' Learning with BBL

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	BBL_pretest	28.08	25	4.856	.971
	BBL_postest	79.84	25	14.571	2.914

Paired Samples Correlations

		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	BBL_pretest & BBL_postest	25	.835	<.001	<.001

Paired Samples Test

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	BBL_pretest - BBL_postest	-51.760	10.852	2.170	-56.240	-47.280	-23.847	24	<.001	<.001

Paired Samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval	
					Lower	Upper
Pair 1	BBL_pretest - BBL_postest	Cohen's d	10.852	-4.769	-6.161	-3.368
		Hedges' correction	11.207	-4.619	-5.966	-3.262

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Source: Research, 2024

Based on the paired sample t-test results, as seen in **Table 3**, there is a robust correlation between pre-test and post-test scores, with a correlation value of 0.835 ($p < 0.001$). This shows that pre-test scores contribute 69% to the variation in post-test scores. BBL significantly affects the students' Mathematical Concept Comprehension Ability, with a significance level of $p < 0.001$. However, the influence of BBL on Understanding Mathematical Concepts is in the low category, as shown by Cohen's value of d of -4.769, below the low effect threshold (< 0.2). Although BBL has an impact on improving the ability to understand Mathematics concepts, its effectiveness in bringing about significant changes is still limited.

The Difference in the Impact of PBL and BBL on the Acquisition of Kemampuan Pemahaman Konsep Matematis (KPKM) in Students

Table 4. Independent Sample T-Test Statistics on the Acquisition of Kemampuan Pemahaman Konsep Matematis (KPKM) in Students.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Postest	Equal variances assumed	.068	.795	-.320	48	.375	.751	-1.320	4.130	-9.624	6.984
	Equal variances not assumed			-.320	47.999	.375	.751	-1.320	4.130	-9.624	6.984

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Postest	Cohen's d	14.601	-.090	-.645	.465
	Hedges' correction	14.835	-.089	-.634	.457
	Glass's delta	14.571	-.091	-.645	.465

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.

Source: Research, 2024

The results of the independent sample t-test in **Table 4** showed no significant difference between the PBL model and the BBL model on the KPKM of students, with a significance value of $p = 0.751$. The effect size of the two learning models was in the low category, with Cohen's d value of -0.90 (< 0.2). The low Cohen's d indicates that applying the two learning models has a relatively similar influence on the KPKM of students.

Criteria for the Improvement of Kemampuan Pemahaman Konsep Matematis (KPKM) in Students' Learning with the PBL Model

Table 5. Output Descriptive Statistics of the Improvement of Kemampuan Pemahaman Konsep Matematis (KPKM) in Students' Learning with the PBL Model

Descriptives

	model			Statistic	Std. Error
NGain	pbl	Mean		.6954	.04035
		95% Confidence Interval for Mean	Lower Bound	.6121	
			Upper Bound	.7787	
		5% Trimmed Mean		.7029	
		Median		.7654	
		Variance		.041	
		Std. Deviation		.20173	
		Minimum		.25	
		Maximum		1.00	
		Range		.75	
		Interquartile Range		.30	
		Skewness		-.775	.464
		Kurtosis		-.428	.902

Source: Research, 2024

The following description of the findings: The average increase in students' ability (N-Gain) in the PBL model is 0.6954, which is classified as moderate based on Melzer's classification. Melzer's classification is divided into three categories: high, medium, and low. In the high category, the N-Gain value > 0.70s shows that the learning method effectively improves students' understanding. Then, in the low category, the N-Gain value < 0.30 shows that learning methods are less effective in improving students' understanding. Meanwhile, for the medium category, the N-Gain value is in the range of 0.30 - 0.70. This moderate category shows that the learning method is quite effective, but can still be further improved

This shows that applying the PBL model has a practical impact on improving students' abilities. The distribution of student scores showed a pattern that tended to be negatively skewed, with a skewness value of -0.775. This indicates that the majority of learners have scores that are concentrated in relatively high grades. The PBL model effectively improves students' higher-order thinking Skills (HOTS) (Sunarti *et al*., 2024). Their study showed that students with the PBL model had better high-level thinking skills than those taught with conventional methods.

The Difference in the Impact of PBL and BBL Implementation on the Acquisition of Kemampuan Pemahaman Konsep Matematis (KPKM).

Table 6. Output Statistics of the Independent Sample T-Test on the Improvement of Kemampuan Pemahaman Konsep Matematis (KPKM) in Students.

Group Statistics

	model	N	Mean	Std. Deviation	Std. Error Mean
NGain	pbl	25	.6954	.20173	.04035
	bbl	25	.7291	.18193	.03639

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
NGain	Equal variances assumed	.413	.523	-.619	48	.269	.539	-.03366	.05433	-.14290	.07558
	Equal variances not assumed			-.619	47.497	.269	.539	-.03366	.05433	-.14293	.07561

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
NGain	Cohen's d	.19209	-.175	-.730	.381
	Hedges' correction	.19515	-.172	-.718	.375
	Glass's delta	.18193	-.185	-.740	.374

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.

Source: Research, 2024

The independent sample t-test results showed no significant difference in the increase in KPKM between students who learned using the PBL model and the BBL model, with a significance value of p = 0.539. The effect size of the difference between the two learning models was in the low category, with Cohen's d value of -0.175 (< 0.2). This shows that the difference in influence between PBL and BBL on the increase in student KPKM is minimal and less meaningful practically.

Discussion

The results showed that the Brain-Based Learning (BBL) model had a higher average post-test score than the Problem-Based Learning (PBL) model, which descriptively indicated the superiority of BBL in improving the Mathematical Concept Comprehension Ability (KPKM) of elementary school students. However, the Independent Sample T-Test results produced a significance value of 0.751 (> 0.05), meaning there is no statistically significant difference between the two models. The effect size value of -0.90 was in the low category, indicating that despite the difference in average, the influence of the two models on the increase in KPKM was still statistically weak.

BBL focuses on the principle of how the brain works in processing material. Caine and Caine explain in their book *"Making Connections: Teaching and the Human Brain"* that the BBL model is based on the principle that effective learning involves the entire brain, combining cognitive, emotional, and social aspects in an integrated manner. Jensen, in the book *"Brain-based Learning: The New Paradigm of Teaching,"* also explains that BBL is designed to create a safe, challenging, and meaningful learning environment, which triggers the activation of important neurological pathways in the learning process. This aligns with MacLean's Triune Brain Theory, which Sousa stated in the book *"How the Brain Learns Mathematics,"* that emotions and a sense of security are fundamental prerequisites for activating the cortex in logical and conceptual thinking. Therefore, BBL is one of the superior models for improving KPKM.

The study results show that BBL is effective as one of the models that can help students improve mathematical thinking skills because of its nature, which focuses on adjusting to the way the brain works. BBL can significantly improve mathematical problem-solving ability in the high category (Subekti & Halimah, 2017). In this case, BBL improves students' mathematical literacy by activating real experiences and mathematical visualization (Rosalina *et al*., 2019).

Meanwhile, the PBL model is firmly rooted in Vygotsky's social-constructivist learning theory in the book *"Mind in Society: The Development of Higher Psychological Processes,"* specifically in the Zone of Proximal Development (ZPD) concept. According to this theory, learners will learn more effectively when guided to complete tasks that are more difficult than they could do on their own with the help of a teacher or peers. PBL facilitates these conditions through group work, discussions, and independent investigations, encouraging students to achieve their learning potential optimally.

In this study, although PBL did not produce post-test scores as high as BBL, the standard deviation in the PBL group was smaller, which indicated an equitable distribution of learning outcomes at various levels of students' abilities. This reinforces that PBL effectively reaches students with varying initial abilities (Sari *et al*., 2021). Bruner, in the book *"Toward a Theory of Instruction,"* also explains that effective learning must involve enactive (action-based), iconic (image-based), and symbolic (language/mathematics-based) learning representations. PBL is more prominent in symbolic and metacognitive aspects because it trains students to formulate solutions and reflect on their thinking processes.

PBL emphasizes the process of dealing with a problem and the efforts to solve it for students. This will undoubtedly trigger students' critical thinking skills in a systematic and structured manner. PBL assisted by manipulative media can significantly improve the understanding of geometric concepts (Martiasari & Kelana, 2022). The effectiveness of BBL and PBL is highly dependent on the creativity factor of students, where students with high creativity show better achievements when using BBL. However, PBL is still effective for students with good collaboration and self-regulation skills (Adiansha *et al*., 2021).

Information Processing Theory explains that the learning process involves three main stages, namely input (stimulus), internalization process (memory processing), and output (learning response). The BBL model contributes to strengthening long-term memory through structured elaboration and repetition techniques, as described by Gagné in the book *"The Conditions of Learning and Theory of Instruction."* Meanwhile, Slavin, in the book *"Educational Psychology: Theory and Practice,"* emphasized that the PBL model tends to focus on information management training through self-search activities, information organization, and synthesis of new concepts. These two models support the efficiency of memory working systems and form deeper conceptual understanding through active and contextual learning strategies.

Based on this description, although statistically, this study does not show a significant difference between BBL and PBL, this finding confirms that the success of learning does not depend only on the model used but also on the interaction between the model, student characteristics, teacher skills, and learning environment support. Both BBL and PBL have strong potential to improve KPKM if implemented with the right strategies and approaches to the needs of students and the learning context.

These results have important implications for learning practices in primary schools. First, teachers must realize that no one learning model is superior, but must be adjusted to the student's profile, learning objectives, and classroom context. Because its nature is based on brain performance (Nahdi, 2015), the BBL model will be more appropriately applied to students who need emotional, visual, and multisensory stimulation. Meanwhile, PBL effectively trains students with good exploration and collaboration capacity. This is because PBL emphasizes collaboration and the application of knowledge in solving problems (Ndraha *et al*., 2024).

Second, these results confirm the importance of teachers as facilitators who can create an adaptive learning environment. The effectiveness of BBL and PBL is greatly influenced by how teachers arrange learning activities, provide scaffolding, and adjust the approach to the social-emotional conditions of students. Teachers are facilitators who present all the learning needs (facilities) needed in the learning process (Yuniar *et al*, 2022). Third, schools and educational institutions need to provide training to teachers in differentiating pedagogic strategies, the use of manipulative media, and active classroom management so that the implementation of the BBL and PBL models can be carried out optimally. Training for teachers is needed to help teachers apply learning models to be more effective in the classroom and daily learning practices (Lestari & Kurnia, 2023). With these three important implications, implementing PBL and BBL in elementary learning practices to improve KPKM for students will take place well (effectively).

CONCLUSION

Based on research conducted in the sixth grade at one of the public elementary schools in Bandung with a focus on Fractional material, it was found that students' average understanding of mathematical concepts showed variations in the distribution of their grades. Students who followed the Problem-Based Learning (PBL) approach had a more significant score variation than students who learn through Brain-Based Learning (BBL). A negative score distribution pattern for both learning methods indicates that most students get high scores.

This study also revealed that the improvement of students' understanding of mathematical concepts, according to Hake's criteria, was included in the low category for both learning methods. However, PBL and BBL significantly impact students' mathematical understanding of fractional material. However, when these two approaches were compared, no significant differences were found in the results or improvement of students' ability to understand mathematical concepts for the Fraction and Speed materials. These findings show that the effectiveness of the two learning methods is almost the same in improving students' understanding of mathematical concepts.

Based on the findings of this study, some of the recommended suggestions are as follows: The application of PB and BBL can be used to improve students' understanding of mathematical concepts. Selection of Math Content When implementing PBL and BBL, it is important to tailor the teaching material to the characteristics of each approach. For PBL, it is recommended to use problem-based materials that are relevant to students' daily lives. Selecting the right teaching materials can increase the meaning of the learning process. Given the absence of significant differences between PBL and BBL in improving understanding of mathematical concepts, future research could investigate these two models in other mathematical aspects, such as problem-solving ability, mathematical representations, or other relevant matters. This research has several limitations that can be an opportunity for deeper exploration. The development of similar research will help expand understanding of the effectiveness of PBL and BBL in various aspects of Mathematics learning.

AUTHOR'S NOTE

The author declares that there is no conflict of interest related to the publication of this article and emphasizes that the data and content of the article are free from plagiarism.

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