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The Effectiveness of the Problem-Based Learning Model with Metacognition Strategies in Terms of Junior High School Student's Problem Solving Ability and Self-Efficacy

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Abstract

This study aims to describe the effectiveness of the Problem-Based Learning model with metacognition strategies on junior high school students' problem-solving abilities and self-efficacy in statistics. This study is a quasi-experimental study with a non-equivalent control group pretest-posttest design, so there are experimental and control classes. The experimental class uses the Problem-Based Learning model with metacognition strategies, while the control class uses the Problem-Based Learning model. The research population is eighth-grade students at SMPN 2 Mlati with purposive sampling. The research instruments were observation sheets, pretest-posttest problem-solving skills, and self-efficacy questionnaires, which had been validated. The data analysis used was Hotteling's T2 multivariate difference test, one sample t-test, and independent sample t-test. The results of the study with α=0.05 showed that: (1) the PBL model with metacognition strategies applied at SMPN 2 Mlati in statistics material was effective in terms of problem-solving skills and self-efficacy; (2) the PBL model applied at SMPN 2 Mlati in statistics material was effective in terms of problem-solving skills and self-efficacy; (3) the PBL model with metacognition strategies applied at SMPN 2 Mlati in statistics material is more effective than the PBL model in terms of problem-solving skills and self-efficacy.

Keywords: *Problem Solving; Self-Efficacy; Problem-Based Learning; Metacognition Strategies*

Introduction

Globalization has brought significant changes to education systems around the world. Education is no longer understood solely as a means of transferring knowledge, but also plays an important role in preparing students to respond to rapid changes in various aspects of life (Sokol, 2023). Therefore, the education system is required to instill reflective and adaptive thinking skills, as well as careful decision-making abilities, to prepare students to face current and future challenges (Maśloch, 2024). Thus, the urgency of implementing 21st-century learning has become increasingly clear (Voogt & Roblin, 2012).

21st-century learning emphasizes four key competencies, namely critical thinking, creativity, communication, and collaboration (Kayyali & Christiansen, 2024). These competencies form the basis for students to deal with real-world problems logically and systematically. In this case, teachers act as facilitators who encourage problem-based learning, open discussion, and active student involvement (Rostoka et al., 2024). This approach is believed to be effective in fostering lifelong learning awareness (Sarr et al., 2025).

In the national context, the urgency of developing thinking and problem-solving skills is emphasized in the Minister of Education and Culture Regulation No. 21 of 2016 concerning Basic and Secondary Education Content Standards. This regulation mandates that every subject, including mathematics, should be directed towards developing students who think logically, critically, and systematically. Mathematics itself has a strategic role in training thinking and problem-solving skills, which are an important part of 21st-century competencies (Klang et al., 2021). In line with this, the National Council of Teachers of Mathematics (NCTM, 2000) emphasizes five process standards in mathematics learning, one of which is problem solving, which is considered fundamental in mastering mathematical concepts and life skills (Palmér & Van Bommel, 2023).

However, various studies and international evaluations show that Indonesian students’ problem-solving skills are still low. The results of the 2012 Programme for International Student Assessment (PISA) placed Indonesia with an average score of 375 points, far below the OECD average of 494 points (Scherer & Beckmann, 2014). The majority of students are only able to solve simple routine problems, while they experience significant difficulties with more complex non-routine problems (Siswanto & Meiliasari, 2024). A similar situation can be seen in academic achievement in junior high schools, such as SMPN 2 Mlati, Yogyakarta, where the average midterm score for mathematics was only 48.468, far below the Learning Objective Achievement Criteria (KKTP) of 70.

Previous studies have shown that students' low problem-solving abilities are caused by various factors, including difficulty understanding questions, misreading information, failure to identify important data, inappropriate use of formulas, and inability to represent results correctly (Arfiana & Wijaya, 2018; Kenney & Ntow, 2024; Valdez & Taganap, 2024). These errors indicate the weakness of students' problem-solving strategies. In fact, the right strategies in understanding problems, identifying information, planning solutions, and evaluating results are the keys to successful problem solving (Chytrý et al., 2020; Retnawati et al., 2018).

In addition to cognitive factors, affective aspects, particularly self-efficacy, also greatly influence student success. Self-efficacy is defined as a person's belief in their ability to complete a particular task (Bandura, 1977). Liu et al. (2024) and Pereira et al. (2022) state that self-confidence is a strong predictor of problem-solving ability and a strong determinant of student success in completing mathematical tasks. When students have good self-efficacy, they are not afraid to take on challenging tasks and are more confident in using their cognitive strategies when faced with obstacles or challenges in solving problems (Hatlevik et al., 2018). In other words, students with high self-efficacy are more committed to achieving any goal, while students with low self-efficacy do not try optimally to achieve a goal (Duman & Özçelik, 2018). This is because someone who is confident and believes that if they work hard, they will succeed in completing the task (Roberts, 2022).

However, a number of other studies show that students' self-efficacy is still low. Ramlan et al. (2021) reported that most students feel unable to solve math problems even before trying. Nurani et al. (2021) also found that many students doubted their ability to deal with mathematical problems. Fitri et al. (2017) showed indications of low self-efficacy from the behavior of students who preferred to copy their homework from friends. Students with low self-efficacy tend to give up easily, be passive, and lack the courage to face challenges (Zimmerman, 2000; Usher & Pajares, 2008). This has a negative impact on their motivation, effort, and learning outcomes (Hamidy et al., 2023; Zetriuslita et al., 2020).

Students' low problem-solving skills and self-efficacy are influenced by a lack of support in the learning environment and teaching methods that do not encourage self-confidence. Hardiyanto & Santoso (2018) show that students tend to rely on memorizing formulas, making it difficult for them to solve problems that differ from the examples given. Erayani & Jampel (2022) also found that theory-focused learning makes students passive and only copy material without deep understanding. This condition limits students' experience in dealing with real problems, thereby hindering the development of problem-solving skills and weakening their self-efficacy.

To overcome these problems, teachers need to introduce learning innovations that can develop problem-solving skills while increasing students' self-efficacy. One potential alternative is the implementation of the Problem-Based Learning (PBL) model. This model emphasizes learning through contextual real-world problem solving, thereby encouraging students' active involvement in the process of searching for information, analyzing, identifying the core of the problem, and solving the problem (Hmelo-Silver, 2004; Delisle, 1997). A number of previous studies have proven that Problem-Based Learning is effective in improving students' problem-solving skills and self-efficacy, such as the study by Rosmita et al. (2020), which found that the Problem-Based Learning model is effective in improving problem-solving skills. Then, a study by Hardiyanto & Santoso (2018) showed that the Problem-Based Learning model is effective in terms of student self-efficacy. Furthermore, research by Pratama (2024) found that the Problem-Based Learning model is effective in improving students' problem-solving skills and self-efficacy.

Marthaliakirana et al. (2022) state that through the stages of Problem-Based Learning, which encourage students to actively engage in formulating, investigating, and evaluating solutions to given problems, students gain direct experience in solving problems independently and in groups. These experiences become one of the main sources in developing self-efficacy, as emphasized by Bandura (1997), that success in facing challenges through real experiences contributes greatly to the formation of self-confidence in individual abilities. This shows that the Problem-Based Learning model has the potential to help students improve their problem-solving skills and self-efficacy.

In addition to learning models, learning strategies also play an important role in supporting the success of the learning process. Hardiyanto et al. (2018) emphasize that the effectiveness of a model will increase when combined with the right strategy. One strategy that is relevant to combine with Problem-Based Learning is the metacognition strategy. Aleven & Koedinger (2002) recommend this strategy because it has been proven to increase student understanding and engagement. Flavell (1979a) defines metacognition as a person's awareness of their thinking process as well as their ability to regulate themselves while thinking. Thus, metacognition strategies help students understand how they learn, become aware of their knowledge, and plan the steps needed to acquire new information (Wilson & Bai, 2010).

Research by Zhao et al. (2019) shows that metacognition strategies have a positive effect on problem solving. Salsabila and Widjajanti (2025) also found that these strategies are effective in improving critical thinking skills and problem-solving abilities. In addition to their impact on cognitive aspects, metacognition strategies are also closely related to non-cognitive aspects, especially self-efficacy. Polrak, Kedcham, & Chansari (2024) emphasize that metacognition strategies not only help regulate thinking but also strengthen students' self-confidence. This is in line with Šafranj's (2019) findings, which explain that self-efficacy influences how individuals think, feel, and behave, which in turn affects their ability to regulate their own thoughts, for example, in the problem-solving process.

Based on the above description, the application of the Problem-Based Learning model with metacognition strategies is believed to be an effective alternative for developing junior high school students' problem-solving skills and self-efficacy. Although a number of previous studies have examined the effectiveness of both, studies combining PBL with metacognition strategies are still limited. Therefore, this study was conducted to fill this gap with the title “The Effectiveness of the Problem-Based Learning Model with Metacognition Strategies in Terms of Middle School Students' Problem-Solving Skills and Self-Efficacy.”

Method

This research is a quasi-experimental study with a pretest-posttest nonequivalent control group design, involving two classes, namely the experimental class and the control class. The research population consisted of eighth-grade students at SMPN 2 Mlati in the 2025/2026 academic year studying Statistics. The research sample was selected using purposive sampling, so that class VIII C was designated as the experimental class that received treatment using the PBL model with metacognition strategies, while class VIII D was designated as the control class with the PBL model without metacognition strategies. The research was conducted over four meetings, including pretest, posttest, initial questionnaire, and final questionnaire, with a time allocation of 2 JP (2 × 45 minutes) for each meeting.

The independent variable in this study was the learning model, namely the PBL model with metacognition strategies, while the dependent variables consisted of students' problem-solving abilities and self-efficacy. Research data were collected through several techniques, namely tests in the form of pretest and posttest of problem-solving abilities, student self-efficacy questionnaires, and observations of learning implementation. The instruments used had undergone validity testing with expert judgment and reliability estimation. The pretest and initial questionnaire were given to both classes before the treatment, while the posttest and final questionnaire were given after the treatment.

The problem-solving ability test instrument consists of three essay questions, which are compiled in accordance with the problem-solving indicators, namely: (1) understanding the problem, (2) developing a strategy, (3) implementing the strategy, and (4) reviewing. Meanwhile, the non-test instrument in the form of a self-efficacy questionnaire consists of 24 statements, namely 12 positive statements and 12 negative statements. The self-efficacy questionnaire statements are compiled based on self-efficacy indicators, namely level, strength, and generality. The learning implementation observation sheet is in the form of a checklist that refers to the PBL stages with metacognition strategies for the experimental class and PBL without metacognition strategies for the control class.

The data obtained were analyzed using descriptive and inferential analysis. Descriptive analysis was used to describe the mean, highest score, lowest score, and standard deviation of students' problem-solving abilities and self-efficacy. Learning was declared effective descriptively if the average problem-solving ability score reached the Learning Objective Completion Criteria (KKTP) ≥ 70 and the average student self-efficacy score was in the high category $(X > 80)$.

Meanwhile, inferential analysis was used to test the research hypothesis. Assumption tests included normality and homogeneity tests on the research data. Next, hypothesis testing was conducted using Hotelling's T^2 multivariate test, independent sample t-test, and one sample t-test. Hotelling's T^2 test is used to determine the difference in the mean pretest and posttest scores between classes in terms of problem-solving skills and self-efficacy before and after the treatment. If there is a significant difference in the posttest scores, then an independent sample t-test is conducted to compare the effectiveness of the two learning models. The one sample t-test was used to test whether the average posttest problem-solving ability of students was ≥ 70 and the average final self-efficacy questionnaire score of students reached the high category $(X > 80)$. Learning was declared inferentially effective if the significance value was < 0.05 at a 5% significance level.

Results and Discussion

Results

a. Implementation of Learning

Learning in both the experimental and control classes was conducted four times with a total duration of 8 JP x 45 minutes. Before the learning process began, students were given a pretest before learning and a posttest after learning, each lasting 2 JP x 45 minutes. During the implementation of learning in the experimental and control classes, there were observers who observed the implementation of learning. The assessment of the implementation of learning used an observation sheet that referred to the stages of the PBL model with metacognition strategies in the experimental class and the stages of the PBL model without metacognition strategies in the control class. The results of the implementation of learning in both classes are presented in Table 1.

Table 1. Results of Learning Implementation

Meeting	Percentage of Learning Implementation			
	Experimental Class		Control Class	
	Teacher Activities	Student Activities	Teacher Activities	Student Activities
Meeting 2	92%	88%	85%	80%
Meeting 3	96%	88%	90%	85%
Meeting 4	96%	92%	90%	90%
Meeting 5	96%	95%	95%	95%
Average	95%	91%	90%	88%

Based on Table 1, it can be seen that the implementation of learning in each meeting in both the experimental and control classes met the criteria for very good. The average implementation of teacher activities in the experimental class was 95% and student activities was 91%, while in the control class, teacher implementation reached 90% and student implementation was 88%. When compared to the learning effectiveness criteria, namely when the average implementation reaches $\geq 80\%$, the results obtained from both classes show that learning has been carried out effectively. Thus, it can be concluded that both the PBL model with metacognition strategies and PBL without metacognition strategies were implemented in accordance with the planned learning stages.

b. Problem-Solving Ability Data

Data on the problem-solving abilities of students in both groups was obtained from pretest results administered before the treatment and posttest results administered after the treatment. The results of descriptive statistical analysis of problem-solving ability data are presented in Table 2.

Table 2. Descriptive Statistics of Students' Problem-Solving Ability

Description	**Experimental Class**		**Control Class**	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Number of Students	32	32	32	32
Ideal Maximum Score	100	100	100	100
Maximum Score	41,667	100	41,667	100
Ideal Minimum Score	0	0	0	0
Minimum Score	16,667	60,416	16,667	52,083
Mean	31,380	82,617	23,307	76,757
Variance	41,705	121,090	40,667	116,238
Standard Deviation	6,457	11,004	6,374	10,781

Based on Table 2, it can be seen that the average problem-solving ability of students in both classes increased after the treatment. In the experimental class where the PBL model with metacognition strategies was applied, the average score increased from 31.380 to 82.617, with an increase of 51.237 points. Meanwhile, in the control class, which applied the PBL model without metacognition strategies, the average score increased from 23.307 to 76.757, an increase of 53.450 points. This shows that both learning models are effective in improving students' problem-solving skills, but the improvement in the experimental class that applied the Problem-Based Learning model with metacognition strategies was higher than in the control class that only applied the Problem-Based Learning model.

c. Self-Efficacy Data

The self-efficacy data of students in both classes were obtained from the prescale administered before the treatment and the postscale administered after the treatment. The results of the descriptive statistical analysis of self-efficacy data are presented in the following table 3.

Table 3. Descriptive Statistics of Student Self-efficacy

Description	**Experimental Class**		**Control Class**	
	Prescale	***Postscale***	***Prescale***	***Postscale***
Number of Students	32	32	32	32
Ideal Maximum Score	120	120	120	120
Maximum Score	80	110	80	107
Ideal Minimum Score	24	24	24	24
Minimum Score	53	77	50	79
Mean	67,125	96,625	65,03	90,469
Variance	43,338	80,048	50,095	60,708
Standard Deviation	6,583	8,946	7,077	7,791

Based on Table 3, it is known that the average self-efficacy of students in both classes increased after the treatment was given. In the experimental class where the PBL model with metacognition strategies was applied, the average score increased from 67.125 to 96.625, with an increase of 29.500 points. Meanwhile, in the control class, which applied the PBL model without metacognition strategies, the average self-efficacy increased from 65.03 to 90.469, an increase of 25.439 points. When viewed from the average score after treatment (posttest), the experimental class obtained a higher self-efficacy score than the control class. This shows that the application of the Problem-Based Learning (PBL) model with metacognition strategies is more effective in increasing student self-efficacy than PBL without metacognition strategies.

d. Assumption Testing

1. Normality Testing

Normality testing was conducted in two stages, namely multivariate and univariate. Multivariate normality testing using Henze-Zirkler was applied to the pretest and posttest data of both classes with the criterion of normal data if the $p-value > 0{,}05$. Meanwhile, the univariate normality test uses Shapiro-Wilk on posttest data, with data considered normal if the $p-value > 0{,}05$. The results of the multivariate normality test are presented in Table 4, while the results of the univariate normality test are shown in Table 5.

Table 4. Results of Multivariate Normality Test of Pretest–Posttest Data

Class	Variable	*Henze-Zirkler*	*p-value*	Decision
Experimental	Before Treatment	0,345	0,715	Normal
	After Treatment	0,501	0,346	Normal
Control	Before Treatment	0,416	0,533	Normal
	After Treatment	0,625	0,167	Normal

The Henze-Zirkler test shows that all pretest and posttest data, both in the experimental class and the control class, have a $p-value > 0{,}05$. This means that the data are normally distributed in a multivariate manner, so the assumption of multivariate normality is satisfied.

Table 5. Results of Univariate Normality Test of Pretest–Posttest Data

Class	Data	Variable	*Shapiro-Wilk*	*p-value*	Decision
Experimental	*Pretest*	Problem-Solving	0,948	0,130	Normal
	Prescale	*Self-Efficacy*	0,981	0,851	Normal
	Posttest	Problem-Solving	0,963	0,347	Normal
	Postscale	*Self-Efficacy*	0,942	0,086	Normal
Control	*Pretest*	Problem-Solving	0,970	0,507	Normal
	Prescale	*Self-Efficacy*	0,983	0,898	Normal
	Posttest	Problem-Solving	0,965	0,388	Normal
	Postscale	*Self-Efficacy*	0,953	0,178	Normal

Based on the results of the Shapiro-Wilk test on the variables of problem solving and self-efficacy, both in the pretest and posttest data in both classes, all showed a $p-value > 0{,}05$. Thus, the data were univariately normally distributed.

2. Homogeneity Test

A homogeneity test is conducted to ensure the similarity of data diversity between groups. Variance homogeneity is tested using Levene's Test, while variance-covariance matrix homogeneity is tested using Box's M Test. Data is declared homogeneous if the $p-value\ is > 0{,}05$.

Table 6. Results of Homogeneity Test of Covariance Matrices

Data	*Box's M*	*p-value*	Decision
Before Treatment	2,411	0,491	Homogen
After Treatment	1,200	0,753	Homogen

Based on Table 6, the results of the covariance matrix homogeneity test using Box's M Test show that the $p-value > 0{,}05$ both before and after treatment. This means that the assumption of covariance matrix homogeneity is fulfilled.

Table 7. Results of Univariate Homogeneity Test

Data	Variable	*Levene test*	*p-value*	Decision
Pretest	Problem-Solving	0,037	0,847	Homogen
Postest		0,174	0,681	Homogen
Prescale	*Self-efficacy*	0,257	0,613	Homogen
Postscale		0,350	0,556	Homogen

Based on Table 7, the results of the covariance matrix homogeneity test using the Levene test show that the $p - value > 0{,}05$. Thus, the data for each dependent variable, both before and after treatment, meet the assumption of variance homogeneity.

e. Testing the effectiveness of learning

1. Testing the Average Vector of Ability before Treatment

After the assumption test was fulfilled, the average vector test was conducted using Hotteling's T^2 to test the difference in the average problem-solving ability and self-efficacy in both classes before treatment. The decision criterion in this test is that if the $p - value > 0{,}05$, then there is no difference in the initial average ability of students in both the experimental and control classes. The results of the initial average ability vector test are presented in the following table 8.

Table 8. Results of Mean Vector Test Before Treatment

Data	**F**	**df**	**Error df**	***p-value***
Before Treatment	5,5831	2	61	0,072

Based on Table 8, the results of the mean vector test conducted using Hotelling's Trace show that the $p - value = 0{,}072 > 0{,}05$, so H_0 is accepted. This means that there is no difference in the mean initial ability of students in both the experimental and control classes before the treatment was given.

2. Testing the Effectiveness of the PBL Learning Model with Metacognition Strategies

After determining that the initial abilities of both classes were relatively the same, the next step was to test the effectiveness of learning through a one-sample t-test. The Problem-Based Learning model with metacognition strategies was declared effective if it met two criteria, namely: (1) the average problem-solving score reached a minimum of 70, and (2) the average self-efficacy score was in the high category $(X > 80)$. The one-sample t-test was conducted on the posttest data in the experimental class with the following decision criteria: if the $p - value < 0{,}05$, then H_0 is rejected, which means that the average score meets the effectiveness criteria. The test results are presented in the following table 9.

Table 9. Results of One-Sample t-test

Class	**Data**	T_{value}	**df**	***p-value***	t_{table}
Experimental	Problem-Solving	5,984	31	0,000	2,040
	Self-efficacy	7,982	31	0,000	

Based on Table 9, the results of the one-sample t-test for problem-solving ability show a $p - value = 0{,}000 < 0{,}05$ and $t_{value} = 5{,}984 > t_{table} = 2{,}040$, so H_0 is rejected. This means that the average problem-solving ability has reached KKTP (≥ 70), so the learning is declared effective. Furthermore, for self-efficacy, the $p - value = 0{,}000 < 0{,}05$ and $t_{value} = 7{,}982 > t_{table} = 2{,}040$, so H_0 is rejected. This means that the average self-efficacy of students is in the high category $(X > 80)$ and meets the criteria for effectiveness. Thus, Problem-Based Learning with a metacognition strategy applied in the experimental class is effective in terms of junior high school students' problem-solving abilities and self-efficacy.

3. Testing the Effectiveness of the PBL Learning Model without Metacognition Strategies

The second hypothesis states that the Problem-Based Learning model is effective in terms of junior high school students' problem-solving abilities and self-efficacy. This effectiveness is determined based on two criteria, namely: (1) the average problem-solving ability score reaches a minimum of 70, and (2) the average self-efficacy score is in the high category $(X > 80)$. To test this hypothesis, a one-sample t-test was used on the posttest data in the experimental class. The decision criterion was that if the $p - value < 0{,}05$, then H_0 was rejected, which meant that the average student score met the learning effectiveness criteria. The test results are presented in Table 10 below.

Table 10. Results of One-Sample t-test

Class	Data	T_{value}	df	*p-value*	T_{table}
Control	Problem-Solving	3,545	31	0,001	2,040
	Self-efficacy	4,696	31	0,000	

Based on Table 10, the results of the one-sample t-test for problem-solving ability show a $p - value = 0{,}001 < 0.05$ and $t_{value} = 3{,}545 > t_{table} = 2{,}040$, so H_0 is rejected. This means that the average problem-solving ability has reached KKTP (≥70), so the learning is declared effective. Furthermore, for self-efficacy, the $p - value = 0{,}000 < 0{,}05$ and $t_{value} = 4.696 > t_{table} = 2{,}040$, so H_0 is rejected. This means that the average self-efficacy of students is in the high category $(X > 80)$ and meets the criteria for effectiveness. Thus, Problem-Based Learning without metacognition strategies applied to the control class is effective in terms of junior high school students' problem-solving abilities and self-efficacy.

4. Testing for More Effective Learning

Once learning has been proven effective, the next step is to conduct an independent sample t-test to determine which learning model is more effective: PBL with metacognition strategies or PBL without metacognition strategies. Before conducting the independent sample t-test, a mean vector test using Hotelling's T^2 was first conducted to test whether there were differences in students' problem-solving abilities and self-efficacy after the treatment. The decision criterion for both Hotelling's T^2 test and independent sample t-test is that if the $p - value < 0{,}05$, there is a significant difference between the two groups. The results of the Hotelling's T^2 mean vector test after treatment are presented in Table 11 below.

Table 11. Results of Mean Vector Test After Treatment

Data	F	df	Error df	*p-value*
After Treatment	10,773	2	61	0,0075

Based on Table 11, the results of the average final ability vector test with Hotelling's Trace show a $p - value = 0{,}0075 < 0{,}05$, so H_0 is rejected. This means that there is a difference in the average problem-solving ability and self-efficacy in the experimental and control classes after treatment.

5. Independent Sample T-Test

The results of the Hotteling trace test show that there is a difference in the average problem-solving ability and self-efficacy of students after treatment, so a follow-up test is conducted, namely an independent sample t-test to examine which learning is more effective in terms of problem-solving ability and self-efficacy. The results of the independent sample t-test are presented in Table 12 below.

Table 12. Results of the Independent Sample t-test

Variable	**df**	t_{value}	***p-value***	t_{table}
Problem solving	62	2,193	0,032	2,000
Self-efficacy	62	2,935	0,004	

Based on Table 12, the results show that for the problem-solving ability variable, the $t_{value} = 2{,}193 > t_{table} = 2{,}000$ with a $p-value = 0{,}032 < 0{,}05$. Meanwhile, for the self-efficacy variable, the $t_{value} = 2{,}935 > t_{table} = 2{,}000$ with a $p-value = 0{,}004 < 0{,}05$. Thus, for both dependent variables, the condition $t_{value} > t_{table} = 2{,}000$ and $p-value < 0.05$ applies, so H_0 is rejected. This means that there is a significant difference between the experimental class that uses the Problem-Based Learning model with metacognition strategies and the control class that uses the Problem-Based Learning model without metacognition strategies, in terms of students' problem-solving abilities and self-efficacy after treatment. Thus, it can be concluded that the Problem-Based Learning model with metacognition strategies is more effective than the Problem-Based Learning model without metacognition strategies in improving junior high school students' problem-solving abilities and self-efficacy.

Discussion

The purpose of this study was to describe the effectiveness of the Problem-Based Learning model with metacognition strategies in terms of problem-solving skills and self-efficacy, describe the effectiveness of the Problem-Based Learning model in terms of problem-solving skills and self-efficacy, and describe which is more effective between the Problem-Based Learning model -Based Learning model with metacognition strategies and the Problem-Based Learning model in terms of students' problem-solving abilities and self-efficacy.

The PBL model with metacognition strategies applied in the experimental class proved to be effective in terms of problem-solving abilities and self-efficacy. This was proven by the results of the one-sample t-test, which showed that for the problem-solving ability variable, the $t_{value} = 5{,}984 > t_{table} = 2{,}040$ and the $p-value < 0.05$, and for the self-efficacy variable, the $t_{value} = 7{,}982 > t_{table} = 2{,}040$ and the $p-value < 0{,}05$. This shows that PBL learning with metacognition strategies has met the established effectiveness criteria, namely an average problem-solving ability score of at least 70 and an average self-efficacy score in the high category $(X > 80)$. Thus, the PBL model with metacognition strategies is effective in terms of problem-solving ability and self-efficacy.

In addition, PBL learning without metacognition strategies applied in the control class proved to be effective in terms of students' problem-solving abilities and self-efficacy. This was proven by the results of the one-sample t-test, which showed that for the problem-solving ability variable, the $t_{value} = 3{,}545 > t_{table} = 2{,}040$ and the $p-value < 0{,}05$, and for the self-efficacy variable, the $t_{value} = 4{,}696 > t_{table} = 2{,}040$ and the $p-value < 0{,}05$. This shows that PBL learning has met the established effectiveness criteria, namely an average problem-solving ability score of at least 70 and an average self-efficacy score in the high category $(X > 80)$. Thus, the PBL model with metacognition strategies is effective in terms of problem-solving ability and self-efficacy.

Although both PBL models with metacognition strategies and PBL models without metacognition strategies proved to be effective. However, based on the descriptive statistics of problem-solving ability and self-efficacy data, the average problem-solving ability and self-efficacy of students in the experimental class were superior to those in the control class. This indicates that the PBL model with metacognition strategies is more effective than the PBL model without metacognition strategies. This superiority was proven by the results of a follow-up test using an independent sample t-test, which showed that $t_{value} = 2{,}193 > t_{table} = 2{,}000$ or $p - value = 0{,}032 < 0{,}05$. This means that the Problem-Based Learning model with metacognition strategies is more effective than the PBL model in terms of problem-solving skills.

Both classes applied Problem-Based Learning with a focus on contextual problems. However, in the experimental class, the initial stage of learning was reinforced with a metacognition question column that helped students identify their prior knowledge and predict the steps to solve the problem. Before systematically solving the problem, students were directed to write down their initial strategies in the column so that the thinking process was more structured and monitored. Next, through investigation accompanied by metacognition questions, students analyze information, connect concepts, design strategies, and review the solutions they have obtained.

Reflective questions in metacognition strategies train students to evaluate their thinking processes. With metacognition questions at each stage of problem solving through metacognition strategies in Problem-Based Learning, students in the experimental class were better trained in designing, applying, and evaluating problem-solving strategies. This contributes to an improvement in students' problem-solving abilities compared to the control class, which only applied Problem-Based Learning without metacognition strategies, as stated by Schoenfeld (1985), who emphasized the importance of awareness in choosing and evaluating problem-solving strategies.

These findings are supported by research conducted by Mohamed et al. (2025), which shows that Problem-Based Learning with metacognition strategies significantly improves students' thinking awareness, and Paudel (2025), which proves that integrating metacognition strategies into Problem-Based Learning can improve critical thinking and problem-solving skills. Then, based on the results of the independent sample t-test on the self-efficacy variable, it was found that the $t_{value} = 2{,}935 > t_{table} = 2{,}000$ or the $p - value = 0{,}004 < 0{,}05$. This means that the Problem-Based Learning model with metacognition strategies is more effective than the PBL model in terms of self-efficacy.

This shows that integrating metacognition strategies into the PBL stages makes students more aware of their progress and able to improve their problem-solving processes. This builds students' self-confidence in learning mathematics, in accordance with Bandura's (1997) concept of self-efficacy. In addition, the experience of success in completing group tasks serves as a mastery experience, which is one of the main sources of self-efficacy, because students obtain concrete evidence that they are capable of facing challenges. These findings are supported by research by Monica et al. (2019), which reveals that the application of the Problem-Based Learning model is effective in increasing students' self-efficacy. Furthermore, these findings are also supported by research by Yıldız & Akdağ (2017), which shows that the use of metacognition strategies significantly increases self-efficacy.

Conclusion

Based on the results of the analysis and discussion described in the previous chapter, the following are three conclusions from this study: (1) Problem-Based Learning with metacognition strategies applied at SMPN 2 Mlati in statistics material is effective in terms of problem-solving skills and self-efficacy; (2) Problem-Based Learning -Based Learning model applied at SMPN 2 Mlati in statistics material is effective in terms of problem-solving skills and self-efficacy; and (3) The Problem-Based

Learning model with metacognition strategies applied at SMPN 2 Mlati in statistics material is more effective than the Problem-Based Learning model without metacognition strategies in terms of problem-solving skills and self-efficacy.

Based on the research conducted, the researcher suggests that future research should conduct further research on the Problem-Based Learning model with metacognition strategies, examining different materials or different dependent variables so that the research results can be comprehensive or comparable.

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