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Influence of Problem-Based Learning Model on Students' Critical Thinking Ability and Learning Motivation in Mathematics Learning

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Abstract

This study aims to determine the effect of the problem-based learning (PBL) model on critical thinking skills and students' motivation to learn mathematics. This type of research is a quasi-experiment. The design model uses a pre-test-post-test control group design. The population of this study was all students of class VII SMP Kesatria Medan in the 2023/2024 academic year, consisting of 30 students. Sampling was conducted using a random sampling technique, and the research sample was obtained, namely VII-1, totalling 16 students as the control class and 14 students as VII-2 as the experimental class. The research instrument used tests in the form of essays. Data analysis techniques used descriptive analysis, including normality tests, homogeneity tests and hypothesis tests, namely the t-test (paired sample t-test). The results of the study show the sig. (2-tailed) of 0.000 < 0.05, it can be concluded that students who get the problem-based learning model are better than students who use conventional learning models.

INTRODUCTION

Education is an essential human activity that is constructive in human life. This means that education plays an essential role in determining the development and improvement of the quality of human resources. Therefore, as educators, we must be able to hold learning activities in the form of assessments so that students can be accountable for the actions done, namely educating and being educated. An individual's quality depends on the quality of education he obtains and sees the current condition of education, namely the weak learning process [1]–[3]. Education is all learning experiences in all environments and throughout life. Education is any life situation that affects individual growth [4].

In education, mathematics is one of the basic sciences that is important to be taught to students because mathematics can train a student to think logically and responsibly, have a good personality, and have problem-solving skills in everyday life. This shows that mathematics is essential in improving human resources [5], [6]. Mathematics is a science that underlies technological developments that play an essential role in various disciplines and advance human thinking. Mathematics exists at every level of education, from elementary school to college. Mathematics lessons must be given to all students from elementary school to college to equip

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them with logical, analytical, systematic, critical, and creative thinking skills and the ability to work together. Therefore, mathematics is essential in various aspects of life [5], [7]–[9].

One of the thinking skills demanded in higher-order learning is the ability to think critically. Thinking critically is a competency that must be achieved through learning [10]. The ability to think critically mathematically emphasizes not only students' ability to solve problems but also their ability to evaluate problem-solving. Critical thinking is critical in solving a problem and making the right decision by considering the impact of the actions [11]. In addition, critical thinking can bring creative ideas to face life so that they can make the right decision every time they act.. Critical thinking is reasoning and gathering as much information as possible before deciding or taking action [12]. Furthermore, critical thinkers are characterized by someone who can connect ideas systematically, formulate ideas briefly and precisely, and evaluate each argument carefully, or critical thinkers who can think openly and see gaps in gray areas [13].

However, it shows that mathematics learning in Indonesia is generally carried out mechanically and tends to be taught using practical formulas, so it does not involve a construction process that can improve students' critical thinking skills (Arisetyawan & Supriadi, 2020). The results of PISA 2018 and TIMSS 2015 show the same results: students' ability level, especially in mathematics in Indonesia, is still at the level of understanding until application but has not yet reached the aspect of critical thinking skills [14], [15]. Similarly, at SMPS Kesatria Medan, after being given a critical thinking questionnaire from 24 students, only six students had high critical thinking skills; from these results, it can be stated that mathematics learning tends to be one-way (teacher-oriented), so that student involvement during learning is very minimal, which has an impact on their critical thinking skills. Another indication can be seen in the evaluation questions, given that they still understand the application.

Several factors cause low critical thinking skills and student learning motivation, including learning that occurs in schools, which is still teacher-centred. According to Oktavia and Ridlo, the study's results stated that students' critical thinking skills are still relatively low, which is caused by mathematics teachers who still apply the principle of transfer of knowledge [16]. This results in one-way learning, namely teachers as informers and students as recipients of information, so learning becomes rigid and teacher-centred, and students become passive [17]. In research conducted, Cristillo explained that almost 48.7% of educators in Indonesia use this teacher-centred learning model, and, unsurprisingly, this can hinder the development of students' understanding of the next level of cognitive abilities. Of course, many students have low critical thinking skills [18].

However, departing from these problems, teachers need to innovate habits, perceptions, pleasures, interests, social adjustments, types of skills, ideals, desires, and expectations, not just mastery of subject theory concepts [19]. This follows government policy regarding the duties of teachers regulated in Law No. 14 of 2005 Calm Teachers and Lecturers, which states that teachers must be active in planning learning, preparing teaching models and methods, implementing quality learning processes, and assessing and evaluating learning outcomes.

A strategy in learning that can improve students' ability to solve problems, especially in mathematics lessons, is the problem-based learning (PBL) model. Problem-based learning is a student-centred learning approach that forms small learning groups to keep the learning process focused and active. This problem-based learning approach exposes students to real problems in

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small groups. Teachers can help students focus on real problem-solving contexts, motivating them to consider the right situation in determining solutions [20]. PBL can optimize students' thinking skills through a systematic group work process so that students can empower, hone, test, and develop thinking skills continuously. PBL is a suitable learning model for achieving mathematics learning goals, and it can solve problems creatively [21], [22].

Various problems related to learning models on critical thinking skills and student learning motivation are common problems experienced by schools in Indonesia. One is research conducted by Dino Steven at SMPN 2 Kendari, published in September 2019. Some factors can cause low critical thinking skills in students, including using less innovative learning models. A learning model that can help students related to mathematical critical thinking skills is the Problem-Based Learning model or problem-based learning. Using the Problem-Based Learning model in grade VIII of SMP Negeri 2 Kendari, the learning process is categorized as good to very good. Overall, the percentage of learning implementation rate by teachers in 6 consecutive meetings was 88%, 88%, 92%, 96%, 92%, and 96%. At the same time, the percentage of student activity rate in 6 consecutive meetings is 80%, 80%, 88%, 88%, 84%, and 88%. The PBL model positively influences students' mathematical critical thinking skills [14].

Based on this description, researchers are interested in determining the influence of problem-based learning (PBL) learning models on students' critical thinking skills and learning motivation in mathematics learning.

METHODS

This research was carried out in the odd semester of the 2023/2024 academic year at SMPS Kesatria Medan. The population in this study was all students of grades VII-3. Sugiyono (2017: 81) states that the researcher can process data by determining the population. To facilitate data processing, the author will take part in the number and characteristics of the population called the sample. By using samples, researchers will process data more efficiently, and the results obtained will be more credible. The sampling technique in this study is simple random sampling. Probability sampling provides equal opportunities for each element or member of the population to be selected as a sample [23]. Probability sampling consists of simple random sampling, proponate stratified random sampling, disproportionate stratified random, and sampling area (cluster) sampling. In this study, researchers used simple random sampling then. According to Sugiyono [23], Simple Random Sampling is the taking of sample members from a population that is carried out randomly without paying attention to the strata in that population.

This type of research is quasi-experimental research. Sugiyono states that pseudo-experiments are research that is close to natural experiments [23]. This study aims to directly test the influence of one variable on other variables and test the hypothesis of cause-and-effect relationships. Pseudo-experimental research tests hypotheses about the presence or absence of influence on an action. This study was conducted to determine the critical thinking skills and motivation of students who apply the Problem-Based Learning learning model. The research design used is a Matching post-test Control Group Design. In the Matching pre-test and post-test Control Group Design, two classes are selected directly and then given a pre-test to determine the initial state. Is there a difference between the experimental and control classes? The

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experimental class was treated using PBL, while the control class continued to use the lecture method. After completion of treatment, both classes were given a post-test.

The steps in this study start with research preparation, namely preparing the necessary learning tools such as RPP, LKS, Learning Motivation Questionnaire, and Critical Thinking Ability Questions. This activity is continued with the implementation of initial research on providing pre-test questions to students, where this test is given before teaching begins and aims to determine the extent of students' mastery of the teaching material (knowledge and skills) to be taught. In this case, the function of the pre-test is to see to what extent the teaching effectiveness will be compared with the post-test after the pre-test results. Then, learning activities are carried out using the PBL model. It then ends with administering a post-test, which is given at the end of the teaching unit program. This post-test aims to determine how students achieve teaching materials (knowledge and skills) after experiencing a learning activity.

Data analysis on every aspect of research activities was carried out from the beginning of the study. Researchers can also directly analyze what is observed, the classroom or field's situation and atmosphere, and the educators' relationship with students and other friends. Data analysis is an effort to summarize the data collected in a reliable, accurate, and correct manner. From the description above, it can be concluded that data analysis is an effort to summarize the data collected in research and can be done with quantitative and qualitative data descriptive techniques that are interpreted in the form of descriptions. Descriptive analysis is data analysis using respondents' identities and decision-making processes [23]. This analysis is grouped based on the same answer, followed by a percentage based on the number of respondents. The most significant percentage is the dominant factor of each variable studied. This analysis is the activity of collecting, processing and describing the collected data.

RESULTS AND DISCUSSION

Result

Researchers tested the validity of 20 statements from critical thinking and learning motivation questionnaires. The result of the validity test is that out of 20 statements, all statements are considered valid.

Table 1. Validity Test Results

Variable		R-count		R-correlation	Information
Critical Thinking	$X_{1.1}$	0.435	>	0.300	Valid
	$X_{1.2}$	0.533	>	0.300	Valid
	$X_{1.3}$	0.528	>	0.300	Valid
	$X_{1.4}$	0.664	>	0.300	Valid
	$X_{1.5}$	0.526	>	0.300	Valid
	$X_{1.6}$	0.521	>	0.300	Valid
	$X_{1.7}$	0.551	>	0.300	Valid
	$X_{1.8}$	0.608	>	0.300	Valid
	$X_{1.9}$	0.461	>	0.300	Valid
	$X_{1.10}$	0.567	>	0.300	Valid
Learning	$X_{2.1}$	0.491	>	0.300	Valid
	$X_{2.2}$	0.522	>	0.300	Valid
	$X_{2.3}$	0.546	>	0.300	Valid

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Variable		R-count		R-correlation	Information
Motivation	$X_{2.4}$	0.601	>	0.300	Valid
	$X_{2.5}$	0.621	>	0.300	Valid
	$X_{2.6}$	0.467	>	0.300	Valid
	$X_{2.7}$	0.644	>	0.300	Valid
	$X_{2.8}$	0.589	>	0.300	Valid
	$X_{2.9}$	0.673	>	0.300	Valid
	$X_{2.10}$	0.591	>	0.300	Valid

Based on Table 1 of the validity test results, it can be seen that all question items or variable indicators of critical thinking and learning motivation are declared valid because of the correlation results between the results of respondents' answers to each question item or indicator with a total score, significant results are obtained, namely calculated > correlation values. (0.300).

Then, for the question test instrument, a reliability test is carried out to determine whether the question is reliable—data processing using Cronbach Alpha with SPSS 26. The results of the reliability test are in Table 2.

Table 2. Reliability Test Results

Variable	*Cronbach's Alpha*	Interpretation
Critical Thinking	0.756	High
Learning Motivation	0.722	High

The results of the reliability test show that the value of Cronbach's Alpha for all variables is 0.700 with high interpretation, so it can be concluded that the variables critical thinking and learning motivation are reliable to be used as variable measuring tools. The data from this study were obtained from pre-test and post-test scores, which showed increased students' critical thinking skills and mathematical learning motivation. The data will be analyzed using normality tests, homogeneity tests, and hypothesis tests, while the data results regarding pre-test and post-test critical thinking skills and mathematical motivation of students from each class in Table 3.

Table 3. Descriptive Statistics of Pre-Test and Post-Test Data (Critical Thinking)

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Eksperimen	30	35	75	62.34	6.685
Pos-Test Eksperimen	30	65	95	87.41	4.102
Pre-Test Kontrol	30	38	75	64.73	6.096
Pos-Test Kontrol	30	50	60	56.91	5.675
Valid N (listwise)	30				

Based on the table above, it can be seen from the analysis results that the experimental and control class pre-test minimum value is 35, and the maximum is 75. Analysis of the experimental class post-test results: The minimum value is 65, and the maximum is 95. Meanwhile, the post-test control class results have a minimum value of 50 and a maximum of 60.

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Table 4. Descriptive Statistics of Pre-Test and Post-Test Data (Learning Motivation)

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Eksperimen	30	30	75	60.56	6.432
Pos-Test Eksperimen	30	60	85	72.89	4.087
Pre-Test Kontrol	30	35	70	59.78	5.921
Pos-Test Kontrol	30	40	65	61.88	6.277
Valid N (listwise)	30				

Table 4 shows that the experimental and control class pre-test has a minimum value of 30 and a maximum of 75. Analysis of the post-test results of the experimental class shows that the minimum value is 60 and the maximum is 85. Meanwhile, the post-test control class results have a minimum value of 40 and a maximum of 65.

Before conducting the t-test analysis technique, researchers ensure that the data is or is not normally distributed through a normality test. The normality test used in this study used Kolmogorov Smirnov with SPSS 26. The normality test in this study was carried out to understand whether the data obtained was distributed normally (Sugiyono, 2018). The normality test was run on the pre-test and post-test values of the control and experimental classes utilizing Kolmogorov Smirnov.

Table 5. Kolmogorov Smirnov Normality Test

	Class	Kolmogorov-Smirnov[a]		
		Statistics	Df	Sig.
Students' Mathematical Critical Thinking	Pre-Test Eskperimen (PBL)	.153	30	.073
	Post-Test Eksperimen (PBL)	.159	30	.052
	Pre-Test Kontrol (Konvensional)	.210	30	.002
	Pre-Test Kontrol (Konvensional)	.173	30	.022

The table above shows the value of sig. Pre-test experimental class 0.120 > 0.05 and SIG scores. Post-test experimental class 0.200 > 0.05. So is the sig value. Pre-test and post-test control class 0.200 > 0.05, then Ho was accepted. In conclusion, pre-tests and post-tests in experimental and control classes are normally distributed. Because the research data is normally distributed, we can use the homogeneity test using the Levene Statistic test with the help of SPSS 26 Software to find out whether the data obtained is homogeneous or not.

A homogeneity test is carried out after the pre-test data is declared normal. The homogeneity test is carried out to determine the similarity of two states or populations. In this study, the homogeneity test aims to determine whether the variance of experimental class post-test data (PBL) and control class post-test data (Conventional) is homogeneous.

Table 6. Homogeneity Test

Levene Statistic	Df_1	Df_2	Sig.
3.875	1	56.784	.54

Based on the table above, the value of sig is known. 0.250 > 0.05. So, it can be concluded that the variance of experimental and control class post-test data is homogeneous or equal. Next, test the hypothesis using a t-test (paired sample t-test). The hypothesis test results are carried out

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after the normality and homogeneity tests. Test the hypothesis in this study using a paired sample t-test, which is used to determine whether there is an average difference between two paired samples. In this study, the paired sample t-test test is used to answer the formulation of the problem, namely whether the problem-based learning model improves the critical thinking skills and mathematical motivation of students of SMP Kestaria grade VIII.

Table 7. Paired Sample T-Test

	Std. Deviation	T	df	Sig. (2-tailed)
Pre Test Eksperimen-Post Test Eksperimen	8.061	-13.386	29	.000

Based on the table above, the sig value is obtained. (2-tailed) of 0.000 < 0.05, it can be concluded that there is a difference in the average mathematical critical thinking of students of SMP Kesatria class VII with students who get a problem-based learning model better than students who use conventional learning models.

Discussion

Based on the results of the analysis conducted, namely the effect of using the problem-based learning model on critical thinking and student learning motivation in mathematics lessons of grade VII students of Kestaria Junior High School for the 2023/2024 academic year, it shows that respondents' responses regarding problem-based learning variables have a moderate level of (21.52) and learning motivation variables also have a medium level of (21.20).

The normality test results using chi-square from the pre-test and post-test data of critical thinking variables show customarily distributed residuals. This normality test is normal because the significant level of $\alpha = 5\%$ is known as the Asymp value. Sig (2-sided) Pearson chi-square from the pre-test and post-test data of learning motivation variables is 0.000 < 0.05. Therefore, it can be concluded that the pre-test and post-test data of critical thinking variables used in this study are normally distributed. Critical thinking skills can be improved with the PBL model. PBL model is a teaching model characterized by real problems as a context for students to learn critical thinking and problem-solving skills and acquire knowledge [21], [24], [25], [25]. The results of this study show that the problem-based learning model can improve students' critical thinking skills in mathematics learning and increase their understanding of the material studied.

The analysis results with the paired sample t-test showed a positive count value of 22.710 > table 13.386 and the Sig, (2-tailed) value from the pre-test and post-test data of critical thinking variables was 0.000 < 0.05, then H0 was rejected, and H_1 was accepted. So it can be concluded that there is an average difference between pre-test and post-test critical thinking, which means that there is an effective increase in the use of problem-based learning models in increasing critical thinking and learning motivation of grade VII students of SMP Kesatria for the 2023/2024 academic year. So the hypothesis that reads "There is an influence of the Problem-based learning model on critical thinking and student learning motivation in mathematics lessons", can be accepted.

Based on the results of research that show that the problem-based learning model can improve critical thinking and student learning motivation and the problem-based learning model

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has a significant influence on student's critical thinking, this means that problem-based learning can create activities that stimulate students' curiosity when participating in classroom learning by providing related problems With daily life in students, with group work, making works or making reports and being able to present them. With this activity, the problem-based learning model is preferred by students so that they are more motivated to follow the learning process when learning in class.

Students become interested in the activities carried out during the learning process and in the problems given by the teacher, making students challenged to solve these problems. Students and their groups try their best to do the assignment because they want to succeed in the task given by the teacher. When teachers provide opportunities for presentations, group representatives scramble to present their work in front of the class. The teacher will give students who can respond to presentations from other groups their rewards and grades. Here, the teacher always chooses students so as not to cause jealousy in students. This problem-based learning model can increase student learning activity. Besides that, it is also more fun and liked by students. Students can develop their ability to think critically, and it can provide opportunities for them to apply their knowledge to the real world [26].

The PBL model can increase student motivation because the learning utilizes the effects of curiosity, challenge, authentic assignment, and engagement. In addition, working together to solve a problem can motivate one to engage in a task, increase opportunities for joint inquiry and dialogue, develop thinking skills, and give rise to a high sense of sociality [27]. The results of this study are relevant to the research conducted by Risnawati [28], which showed that the problem-based learning model could increase student learning motivation and significantly influence learning motivation.

CONCLUSION

The sig value can be obtained based on the research results from the discussion above. (2-tailed) of $0.000 < 0.05$, then there is a difference in the average mathematical critical thinking of SMP Kesatria Medan grade VII students. The conclusion is that the results show that the problem-based learning model has a significant influence on improving the mathematical critical thinking skills of grade VII students of SMP Kesatria Medan.

This study suggests that educators pay more attention to things in learning, especially mathematics, such as material that is easy for students to understand, learning methods, and strategies to attract students' attention and be pleased. In learning, teachers must also be able to involve students so that learning is not only centred on the teacher, while students only receive lessons passively. Researchers also advise further researchers on applying problem-based learning models to improve students' mathematical and creative thinking skills.

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