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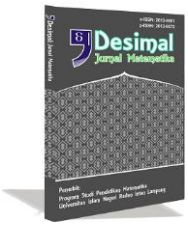

Problem based learning and self-regulated learning: Impact on mathematical reasoning ability in the circle material

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ABSTRACT

This research aims to see the effect of the problem-based learning model on mathematical reasoning abilities based on students' self-regulated learning on the circle material. The method used in this research is an experimental method (quantitative) with a 2×3 *factorial design. The sampling technique in this research is cluster random sampling. Data collection techniques used in this research include tests to measure mathematical reasoning abilities and questionnaires to measure self-regulated learning. Based on the results of the research data analysis, it was concluded that there was an effect of the PBL model on students' mathematical reasoning abilities which was carried out through the overall final test and there were differences in the results of the reasoning ability tests and SRL given the PBL and conventional models. There are differences in mathematical reasoning abilities based on self-regulated learning, from the results of calculations using the two-way ANOVA test, while the interaction between the learning model and self-regulated learning of SMP Negeri 15 Palembang students is not found or there is no interaction.*

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INTRODUCTION

Mathematics is a compulsory subject that is learned by students from elementary to high school. This is in accordance with the assessment submitted by Komariyah et al. (2018) who observed that mathematics is a valuable illustration to be given to all students because considering the development of developing innovations, what is needed now is individuals who can think critically, validly, and coherently.

In the 21st century learning, learning is designed to keep up with the latest technological developments, thus students are required to master four skills, namely: creative and innovative, cooperation, communication, critical thinking, and problem-solving. These skills can help students in terms of mathematical thinking, especially in reasoning (Trisnawati & Sari, 2019).

Reasoning ability is a logical thinking process in gathering facts to draw conclusions. Reasoning ability is not only a goal of learning mathematics but is an

important activity in learning mathematics. This opinion is also supported by Dalimunthe & Siregar (2022) who stated that mathematical reasoning abilities are interrelated in problem-solving that can be sharpened by learning mathematics. This is supported by the theory of Burais et al. (2016) which stated that when students are given the opportunity to reason in conducting analysis or conjectures based on their own experience, what happens is that students will easily understand concepts.

In addition to reasoning abilities, there are also skills that are expected to be mastered by students, namely independent learning or self-regulated learning. Self-regulated learning is the ability to control one's own behavior in learning. According to Rachmayani (2014), self-regulated learning is a process of designing and self-monitoring cognitive and affective processes to solve a problem or academic task.

Self-regulated learning is important to be developed for students when learning mathematics because if students already have independent learning, students can regulate and direct their desire to learn without being influenced by others. Those who have independent learning tend not to depend on others and have the initiative to solve problems they will face on their own without waiting for help from others. This is in line with research conducted by Kurnia & Warmi (2019) which stated that students who have learning independence tend not to depend on others and have the initiative to solve problems that will be faced by themselves without waiting for help from others.

Therefore, to improve students' mathematics learning outcomes, the role of the teachers is very important to determine learning methods. Learning methods that are in accordance with the material presented. With a learning model to support capacity in the learning process, the appropriate or significant learning model that will be applied in this research is the problem-based learning (PBL) model.

Problem-based learning is a model that provides problems to be solved by students. Problem-based learning models help students to apply concepts or designs, by first providing a problem at the beginning of learning to be discussed and solved with groups or together. This is in line with the theory put forward by Ariandi (2016) which stated that with the problem-based learning model students are required to be more active in developing reasoning abilities and finding solutions to any problems or problems in real life.

In this research, the material used is circle material. Because according to Gusnarsi et al. (2017) which states that students have difficulty in learning because students easily forget the material that has been taught and do not have ideas for solving problems, are less thorough in understanding the problems and formulas to be used and do not understand the concept circle material. Therefore, this research uses the PBL model with students' reasoning abilities and student learning independence, whereas previous researchers only used the PBL model on reasoning abilities, not with SRL.

Based on this background, researchers are interested in conducting research on the effect of problem-based learning models on mathematical reasoning abilities based on self-regulated learning for Class VIII Junior High School students.

METHOD

The method used in this research is a quantitative method with a 2×3 factorial design, with the aim of knowing students' self-regulated learning (high, medium, low) on mathematical reasoning abilities as in Table 1.

Table 1. 2 x 3 Factorial Design

Reasoning Ability (A)	*Self-regulated Learning* (B)		
	High (B1)	Medium (B2)	Low (B3)
Problem-based Learning Model (A1)	(A1B1)	(A1B2)	(A1B3)
Conventional Learning Model (A2)	(A2B1)	(A2B2)	(A2B3)

Remarks :
A : Reasoning Ability
B : Self-regulated
A1 : Problem-based Learning Model
A2 : Conventional Learning Model
B1 : High Level Self-regulated Learning
B2 : Medium Level Self-regulated Learning
B3 : Low Level Self-regulated Learning
A1B1 : High level self-regulated learning through problem-based learning models
A1B2 : Medium level self-regulated learning through problem-based learning models
A1B3 : Low level self-regulated learning through problem-based learning models
A2B1 : High level self-regulated learning through conventional models
A2B2 : Medium level self-regulated learning through conventional models
A2B3 : Low level self-regulated learning through conventional models

This research is conducted in the even semester of the 2021/2022 academic year, where the research is carried out at SMP Negeri 15 Palembang. This research used two samples, namely the experimental class and the control class. The experimental class used a problem-based learning model while the control class used a conventional learning model. The moderator variable in this research applies three levels, namely: Self-regulated learning (high, medium, low). The population in this research was all class VIII SMP Negeri 15 Palembang in the 2021/2022 academic year. as in Table 2.

Table 2. Research Population

No.	Class	Male	Female	Total
1	8.1	13	17	30
2	8.2	15	15	30
3	8.3	13	17	30
4	8.4	18	12	30
5	8.5	14	17	31
6	8.6	10	19	29
7	8.7	13	15	28

(Source : Administrative Staff of SMP Negeri 15 Palembang)

The sampling technique used is a random sampling technique, especially with a sampling area (Cluster sampling) taken in 2 classes. The sample in this research consisted of two classes, namely the experiment class and the control class, then both classes were given tests in the form of numeric thinking and self-regulated learning.

Table 3. Research Sample

No.	Class	Male	Female	Total
1	8.1	13	17	30
2	8.2	15	15	30

The treatment design in this research was the researcher applied the Posttest-Only Control Design where there were two groups chosen randomly.

In this design, there are two groups of research subjects selected randomly. Then at the end of the meeting, each group is given a final test. Data collection techniques using tests and questionnaires, tests are used to determine mathematical reasoning abilities after using learning models on circle material.

Table 4. Test Question Scoring Guidelines

Indicator	Action Against Problem	Score
Analyzing mathematical situations	No answer	0
	Unable to analyze known and asked mathematical situations	1
	Able to analyze mathematical situations from problems	2
	Understand the problem analysis	3
Planning the completion process	No answer	0
	Unable to make the completion process	1
	Able to make the completion process but not correct	2
	Solve the problem correctly	3
Solve problems with systematic steps	No answer	0
	Solve irrelevant problems	1
	Solving problems with systematic steps but cannot be solved	2
	Solving problems with systematic steps and correct answers	3
Draw conclusions by making reasons at each step of completion	No answer	0
	Not giving conclusions and making reasons in answers	1
	Giving conclusions with no reasons	2
	Giving conclusions with the right reasons	3

Questionnaires are used to determine students' self-regulated learning. The questionnaire was carried out in the experimental class and the control class, this questionnaire contains a number of statements related to self-regulated learning to determine the scale of students' self-regulated learning. The scale set is the Likert scale, which consists of four choices, namely: SS (Strongly Agree), S (Agree), TS (Disagree), and STS (Strongly Disagree) without neutral options with positive statements and negative statements.

Table 5. Questionnaire Answer Scale

No.	Statement	Option	Score
1	Positive Statement	SS (Strongly Agree)	4
		S (Agree)	3
		TS (Disagree)	2
		STS (Strongly Disagree)	1
2	Negative Statement	SS (Strongly Agree)	1
		S (Agree)	2
		TS (Disagree)	3
		STS (Strongly Disagree)	4

Table 6. Questionnaire Grid

No.	Indicator	Statement (+)	Statement (-)
1	Not depend on other people	6, 16, 21	1, 4
2	Have confidence	8, 17	10, 22
3	Behave discipline	11, 18	12, 23, 24
4	Have a sense of responsibility	7, 14, 25, 26	13,27
5	Behave according to one's own initiative	2, 3, 20, 28	5
6	Doing self-control	9, 19	15, 29, 30
	Total	**17**	**13**

The score of the self-regulated learning questionnaire value obtained is then qualified with the following conditions.

Table 7. Questionnaire Answer Category

Criteria	Category
Score $\geq \bar{x} + s$	High Group Students
$\bar{x} - s \leq Score < \bar{x} + s$	Medium Group Students
Score $< \bar{x} - s$	Low Group Students

The categories of self-regulated learning questionnaire results were obtained with 30 statements as in Table 8.

Table 8. Category of Self-Regulated Learning Questionnaire Results

Questionnaire Score	Category
Score $\geq$ 88	High Group Students
63 $\leq$ Score $<$ 88	Medium Group Students
Score < 63	Low Group Students

RESULTS AND DISCUSSION

The research instrument used in this research has been validated by two validators and is declared valid. So, for the number of reasoning ability test questions as many as 5 questions, and the number of self-regulated learning questionnaire statements as many as 30 items consisting of positive statements and negative statements. Before analyzing the collected data, the normality test and homogeneity test were first carried out with a significant level of 0.05, with the basis of decision making, namely if the value of sig $\geq$ 0.05 then the data were normally distributed and homogeneous, to determine whether the data were normally distributed or not and homogeneous or not. So, it can be concluded what tests should be used in the subsequent data analysis. Normality test using SPSS One-Sample Kolmogorov-Smirnov that distributed data comes from data that is normally distributed. The results of the normality test as in Table 9.

Table 9. Test Data Normality Test

Class	Kolmogorov-Smirnova		
	Statistic	df	Sig.
Experiment	.153	30	.072
Control	.146	30	.100

Based on the results of the normality test with the One-Sample Kolmogorov-Smirnov test, it is known that the significant value of the experimental class is 0.072 > 0.05 and the significant value of the control class is 0.100 > 0.05, it can be concluded that the data is normally distributed.

Table 10. Questionnaire Normality Test

Class	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Experiment	.147	30	.099
Control	.158	30	.053

Based on the results of the normality test with the One-Sample Kolmogorov-Smirnov questionnaire, it is known that the significant value of the experimental class is 0.099 > 0.05 and the significant value of the control class is 0.053 > 0.05, it can be concluded that the data is normally distributed.

The results of the homogeneity test of test data and questionnaires with SPSS (One Way ANOVA) using Levene's Test as shown in Table 11.

Table 11. Test Homogeneity Test

Levene Statistic	df1	df2	Sig.
2.371	1	58	.129

Based on the results of the homogeneity test with SPSS (One Way ANOVA) using Levene's Test, it is known that the significant value is 0.129 > 0.05. So, it can be concluded that the data is homogeneous.

Table 12. Questionnaire Homogeneity Test

Levene Statistic	df1	df2	Sig.
.004	1	58	.950

Based on the results of the homogeneity test with SPSS (One Way ANOVA) using Levene's Test it is known that the significant value is 0.950 > 0.05. So, it can be concluded that the data is homogeneous.

If the data has been obtained with a normal distribution and the data is homogeneous, then hypothesis testing is carried out, hypothesis testing in this study uses SPSS-assisted Two Way ANOVA. The criteria for testing the hypothesis in this research, namely :
H_o is rejected if $F_{calculated} > F_{table}$
H_o is accepted if $F_{calculated} \leq F_{table}$
where $\alpha = 5\%$ or 0.05.

The results of hypothesis testing using two-way ANOVA are as in Table 13.

Table 13. Two Way ANOVA Test Results

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5326.915[a]	5	1065.383	44.638	.000
Intercept	188382.686	1	188382.686	7.893E3	.000
MODEL	101.585	1	101.585	4.256	.044
SRL	4566.768	2	2283.384	95.671	.000
MODEL * SRL	10.282	2	5.141	.215	.807
Error	1288.818	54	23.867		
Total	350748.000	60			
Corrected Total	6615.733	59			

The results of the calculation of the two-way ANOVA test are as follows :

1. Significant value = 0.044 < 0.05, then Ho is rejected by PBL on the mathematical thinking skills of students in class VIII SMP Negeri 15 Palembang. The results obtained are in line with research conducted by Vatillah et al. (2020) based on the results of their research, it is concluded that there is a tremendous impact between the PBL model to further develop students' numerical thinking skills, and the final results obtained with the PBL model have a higher value than students who were given the conventional model. These results are also strengthened by research of Simatupang & Surya (2017), their research which concludes that there is a massive impact of the PBL model on remembering that the ability of students who use PBL is better than students who use conventional learning.
2. Significant value = 0.000 < 0.05 then Ho is rejected with the difference in extraordinary thinking abilities based on students' completeness scores in class VIII SMP Negeri 15 Palembang. This is in accordance with research directed by Nawastiti et al. (2018) that the difference between students who are given a learning model and the treatment given by a traditional model has high-level self-regulated learning. These results are enhanced by the consequences of exploration directed by Julia (2019) who stated that there were differences between students who were taught using PBL and students who received guided learning.
3. Significant value = 0.807 > 0.05, so Ho is accepted, thus there is no significant interaction between problem-based learning and self-regulated learning models on the mathematical reasoning abilities of students in class VIII SMP Negeri 15 Palembang. These results are in line with and reinforced by research conducted by Julia (2019) whose research results show that there is no interaction between learning models and initial mathematical abilities on students' mathematical reasoning abilities.

It can be seen that there is no significant interaction between learning models and self-regulated learning on students' mathematical reasoning abilities. It can be seen in Figure 1.

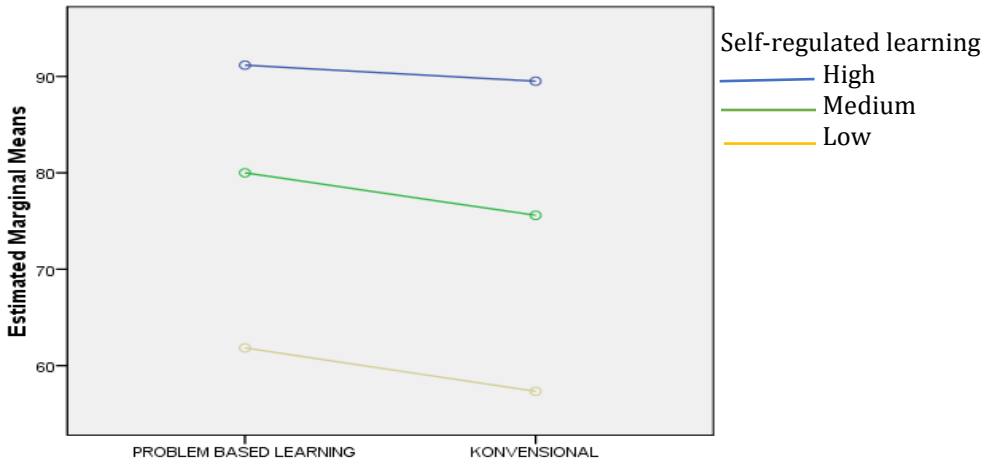

Figure 1. Interaction

Furthermore, the Scheffé test is carried out. The Scheffé test is carried out if the test results with ANOVA show that Ho is rejected and is useful for knowing which pairs of sample groups have significant average differences. In the ANOVA test, for the hypothesis that Ho is rejected, thus there are differences in mathematical reasoning abilities based on self-regulated learning (high, medium, low) of class VIII SMP Negeri 15 Palembang. The following is the test criteria:

If the probability value (significant) < α, where $\alpha = 0.05$. So, Ho is rejected.

If the probability value (significant) > α, where $\alpha = 0.05$. So, Ho is accepted.

Based on the calculations in Table 14, the following results are obtained :

1. Between medium self-regulated learning and high self-regulated learning, the significant value is 0.000 <0.05, so Ho is rejected. Thus, there is a significant difference in mathematical reasoning ability between students who have medium and high self-regulated learning in students who get problem-based learning models and conventional learning models.
2. Between low self-regulated learning and high self-regulated learning, the significant value is 0.000 <0.05, so Ho is rejected. Thus, there is a significant difference in mathematical reasoning ability between students who have low and high self-regulated learning in students who get problem-based learning models and conventional learning models.
3. Between low self-regulated learning and medium self-regulated learning, the significant value is 0.000 <0.05, so Ho is rejected. Thus, there is a significant difference in mathematical reasoning ability between students having low and medium self-regulated learning in students who get problem-based learning models and conventional learning models.

The research data described include three variables, namely the problem-based learning treatment variable, the dependent variable on mathematical reasoning ability, and the moderator variable, namely self-regulated learning. The experimental class was treated with the PBL model and the control class with the lecture or conventional method. Then the two classes were given a posttest in the form of a reasoning test with the instrument used in the form of a questionnaire to assess SRL (High,

Medium, Low). The results of the analysis through the final test show that there are differences between the results of the experimental class test with the PBL and conventional models.

Table 14. Scheffé Test Results

(I) Self-regulated learning	(J) Self-regulated learning	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
High	Medium	12.538*	2.140	.000	8.247	16.829
	Low	30.750*	2.443	.000	25.853	35.647
Medium	High	-12.538*	2.140	.000	-16.829	-8.247
	Low	18.212*	1.610	.000	14.985	21.440
Low	High	-30.750*	2.443	.000	-35.647	-25.853
	Medium	-18.212*	1.610	.000	-21.440	-14.985

In the PBL model students are trained to solve existing problems individually to determine, formulate, and get results, so that the PBL model becomes a learning that can improve students' mathematical reasoning abilities. Research conducted by Palobo & Nur'aini (2017) stated that learning by using a problem-based learning model on curved side space constructs effectively improves students' mathematical reasoning abilities. Research conducted also by Nanang (2016) stated that problem-based learning or problem-based learning has a much better impact in terms of achieving creative thinking skills and student learning independence which is influenced by various factors. This is supported by the theory of Burais et al. (2016) which stated that when students are given the opportunity to reason based on their own experience, students will easily understand concepts. Previous research using representation abilities conducted by Nurfitriyanti et al. (2020) concluded that the PBL model has a different effect from direct learning on students' mathematical representation abilities. There is also research from research conducted by Munawaroh et al. (2018) concluded that the mathematical reasoning ability of students who were given a problem-based learning model was higher than students who were treated with scientific learning.

Students' mathematical reasoning abilities based on SRL (High, Medium, Low) have differences, this is in line with research conducted by Nawastiti et al. (2018) that there are differences in mathematical reasoning abilities among students who are treated with PBL and conventional models in the group with high SRL. Previous research using multimedia and subject matter of colloidal systems conducted by Fitriani et al. (2019) concluded that the combination of PBL and SRL models that use multimedia has a better and significant effect on student learning outcomes.

The research conducted by Astikawati et al. (2020) stated that the average value and learning independence or self-regulated learning of experimental class students who studied with the problem-based learning (PBL) model were higher when compared to the average value of control class who learns using direct instruction. The research conducted by Ansori et al. (2019) concluded that there is a significant influence on student learning independence with students' mathematical reasoning abilities so student learning independence has a very positive effect on students' mathematical reasoning abilities which are affected by factors other than independent learning or self-regulated learning. In research conducted by Sabina (2019), it was found

that there was an increase in the ability to understand concepts and mathematical reasoning abilities that are given the discovery learning model with a scientific approach, and there was an effect of increasing SRL.

There is also research conducted by Afinnas et al. (2018), the results obtained are higher, namely by learning using the SRL model and description of mathematical reasoning abilities, so that subjects are able to perform sub-criteria for students' mathematical reasoning abilities. The research conducted by Cahya et al. (2021) concluded that SRL had a positive influence on students' mathematical reasoning ability variables. Research conducted by Syaripuddin et al. (2020) concluded that students' mathematical reasoning abilities are very low, so learning requires a metacognitive approach to improve students' mathematical reasoning abilities. Research conducted by Ulfadilah et al. (2022) concluded that mathematical reasoning abilities that have high SRL and are meeting the indicators of mathematical reasoning ability are different from mathematical reasoning abilities that have low SRL and only meet one indicator of mathematical reasoning ability. There is also research conducted by Shora & Kartono (2020) which stated that students with high SRL met all indicators of reasoning ability, students with medium SRL met two indicators of reasoning ability, and students with low SRL met one indicator of reasoning ability.

CONCLUSIONS AND SUGGESTIONS

Based on the research and discussion that has been described, several conclusions can be drawn, namely: There is an effect of the problem-based learning model on the numerical reasoning abilities of students in class VIII at SMP Negeri 15 Palembang. And there is an alteration of numerical reasoning ability based on self-regulated learning (High, Medium, Low) of class VIII students of SMP Negeri 15 Palembang. Then for the interactions obtained in this study, there is no interaction between the learning model and self-regulated learning (High, Medium, Low) of students on the mathematical reasoning abilities of students in class VIII at SMP Negeri 15 Palembang.

Because the purpose of this research is to see the effect of the problem-based learning model on the numerical reasoning ability based on self-regulated learning of SMP Class VIII students. Based on what is obtained from the results of this study, the researcher suggests that further research can continue this research in different materials or with different abilities.

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