Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika
Volume 5, Issue 2, 207-225, December 2023
e-ISSN: 2715-6109 | p-ISSN: 2715-6095
https://journal.ibrahimy.ac.id/index.php/Alifmatika

Analysis of the problem-based learning (PBL) models on geometry material in improving students' mathematics learning outcomes

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Received: July 12, 2023 | Revised: October 24, 2023 | Accepted: November 15, 2023 | December 15, 2023
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Abstract:
This study aimed to describe the increase in students' learning outcomes of geometry material at MTs Nuris Jember used a problem-based learning model. This type of research was classroom action research with a model design consisting of four steps: planning, acting, observing, and reflecting. Data collection techniques used tests and observations. The instruments used essay questions and checklists of student activities in class. Thirty students of class VII at MTs Nuris Jember served as the subjects, and samples were collected using purposive random sampling. In this study, descriptive and inferential statistics were employed in the data analysis for this investigation. It could be seen from the research results that the initial condition of the average test score was 61.33, meaning that 30% of students had passed the learning in the pre-cycle. In standard Cycle I, the average test score was 66.83, and 47% of students had reached standard learning. In Cycle II, the average score of students' tests was 71.67, and 83% of students had reached the standard learning. The significance test results of the average value showed a significant difference in average test results between students' mathematics learning outcomes in Cycle I and Cycle II, with a significance value of 0.000, which is less than 0.05. Based on the observation result of students' activity in the second Cycle, the average observation result for students' activities was 79,45% in the good category and got an alphabet score of B.

Keywords: Problem-Based Learning; Mathematics Learning; Student Learning Outcomes.

How to Cite: Bhary, F., Maswar, M., Atikurrahman, M., & Afandi, A. (2023). Analysis of the problem-based learning (PBL) models on geometry material in improving students' mathematics learning outcomes. *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika*, 5(2), 207-225. https://doi.org/10.35316/alifmatika.2023.v5i2.207-225

Introduction

A learning model is a form of learning that diagrams from start to finish, especially introduced by teachers in the classroom. Learning models have a hierarchy of goals to achieve student performance, starting with learning approaches (student- or teacher-centred), learning strategies (exposure-finding learning or individual group learning),

learning methods (lectures, discussions, simulations, etc.), and learning techniques and tactics (specific, person-centred, and unique). Regarding learning models, Joyce & Marsha Weil (2011) propose four groups of learning models, namely: (1) the Social interaction model; (2) the Information processing model; (3) the personal and humanitarian model; and (4) the Behavior modification model. There is now another model, problem-based learning. Problem-based learning (hereafter abbreviated as PBL) is an innovative learning model that can provide students with active learning conditions. PBL is a learning model in which students solve problems through stages of the scientific method, allowing students to develop problem-solving skills while learning problem-related cognitions (Kartini et al., 2021; Masliah et al., 2023).

In developing and improving MCTS, researchers working with mathematics teachers chose problem-based learning (PBL) as a solution to increase students' low MCTS. PBL is student-centred learning that enables students to explore, combine theory and practice, and apply knowledge and skills to identify the best solutions to specific problems, which can develop problem-solving, critical thinking, communication, and collaboration skills. The PBL process consists of several steps, namely: (1) directing students to a problem, (2) managing students, (3) directing research, (4) developing and presenting work, and (5) analyzing and evaluating problem-solving processes. The choice of PBL as a solution stems from the fact that PBL planning can develop and improve students' critical thinking so that PBL can shape students into critical individuals who can analyze, verify, and justify the truth and validity of the information received so that they can adapt to different conditions and situations. Therefore, PBL is adopted as a model of learning mathematics at various levels of formal education to develop and improve students' MCT (Suparman & Tamur, 2021; Yasin & Novaliyosi, 2023).

Problem-based learning (PBL) is a learning model that can encourage students' competencies and skills to welcome the 21st Century through problem-solving and applying knowledge in everyday situations (Amaringga et al., 2021; Yulianti et al., 2019). Furthermore, the characteristics of the PBL model are learning centred on fact and authentic problems and encouraging students to be actively involved in problem-solving (Atikurrahman & Yuliati, 2019; Hung, 2011; Kazemi & Ghoraishi, 2012). In PBL learning, the student's task is not as simple as collecting facts; on the contrary, students must be actively involved, so that it influences problem-solving abilities, information acquisition, discussion skills, cooperation, mathematical communication, critical thinking skills, and generates students' creative ideas (Carlgren, 2013; Herutomo et al., 2020; Rambe & Nurwahidah, 2023). According to Tan et al. (2016), Problem-Based Learning is an innovation in learning because, in PBM, students' thinking abilities are optimized through group processes or systematic teamwork, enabling them to continue strengthening, perfecting, testing, and developing their thinking skills. Boud and Feletti then proposed that problem-based learning was the most significant innovation in education (Abdullah et al., 2019).

Problem-based learning begins by presenting problem situations and dividing students into study groups. Student groups are asked to plan and conduct research to find possible solutions. Student progress is monitored by teachers and students when the survey is opened. Finally, groups demonstrate their learning and engage in reflection and leadership (Alizadeh et al., 2017). The use of PBL in learning mathematics is designed to help students actively learn to build mathematical knowledge. By using PBL in learning mathematics, students can develop thinking skills, solve problems, and deepen their understanding of mathematical concepts.

In contrast, PBL encourages students to learn and gives them confidence in their math skills. One type of question that can be present in PBL is open-ended questions. PBL learning syntax consists of identifying student problems, organizing student learning, managing individual or group research, developing and delivering work products, as well as analyzing and evaluating problem-solving processes (Masitoh & Fitriyani, 2018; Organista-Labrado et al., 2023; Sa'o et al., 2023; Zulfa et al., 2023).

Problem-Based Learning Learning Model (PBL) can be defined as a series of learning activities that emphasize the process of problem-solving. Through the solving of mathematical problems in PBL, students are directed to develop their ability to build new knowledge, solve problems in various contexts related to mathematics, and apply International Journal of Sciences: Basic and Applied Research (IJSBAR) (2017) Volume 33, No 2, pp 321-331 324 various strategies as needed, in reflecting on the mathematical problem-solving process (Simamora et al., 2017). In addition, problem-solving activities can be viewed as an activity that allow students to build and experience the influence or impact of mathematics. Problem-solving activities are also an approach that allows students and teachers to learn and apply mathematical knowledge. The syntax for problem-based learning can be seen in Table 1 below.

Table 1. Syntax of Problem-Based Learning (PBL)

Phases	Teacher Behavior
Phase 1 Student orientation to the problem	• Explain the purpose of learning • Describes the required logistics • motivate students to be actively involved in solving the selected problem
Phase 2 Organize Students	• Help students define and organize learning tasks related to the problem
Phase 3 Individual and group research guide	• Encourage students to gather appropriate information • Encourage students to carry out experiments from explanations and problem-solving
Phase 4 Develop and present the work	• Assist students in planning and preparing suitable works such as reports, models, and sharing assignments with friends
Phase 5 Analyze and evaluate the problem-solving process	• Evaluate learning outcomes about the material that has been studied/ask for group presentation of the work

Not all teachers understand the PBL concept well due to a lack of desire and motivation to improve the quality of science and a lack of system support to improve the scientific quality of teaching staff. Based on the description above, applying the learning model student-centered support students' mathematical learning outcomes is necessary. Learning must be problem-oriented and demands active student involvement. Two things are very closely related characteristics of the PBL model. The PBL model is a student-centred, problem-based learning process (Herutomo et al., 2020; Nau et al., 2023). With the PBL teaching method, the class is not only the lecturer, but everyone actively participates in learning. In implementing PBL, the teacher only acts as a guide, inviting students to class so that students can improve their ability to learn independently and integrate new experiences and knowledge. During the problem-solving process, students integrate the new experiences and knowledge they acquire in class and then integrate them into their skills (Hsu & Hsu, 2020; Prastyo, 2020; Yudha et al., 2023). Of course, it is necessary to do research that examines in depth what and how problem-based learning is applied in the learning process and its effect on student learning outcomes in mathematics. This is because math problems involve mathematical concepts that require indirect solutions. Problem-solving is at the heart of math instruction. Therefore, every student is taught problem-solving problems. Nowadays, in the industrial revolution 4.0, the problem-solving process has been massively replaced by several applications where users or students no longer need to pay attention to the mathematics process. It is not enough for an authentic teacher to only look at the result, not the ability of students to solve problems (Tohir et al., 2020).

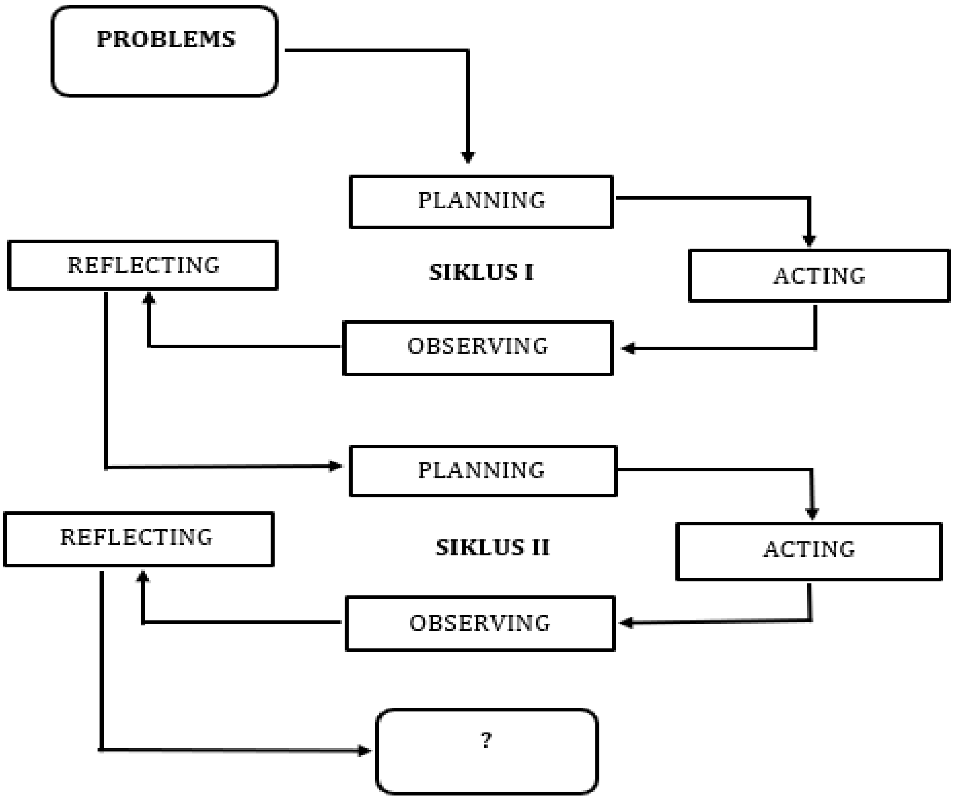
The results of previous research by Nurhidayah and Waskitoningtyas (2023) show that the PBL learning model can improve students' mathematical concept understanding tests with SPLDV material for Class X IPA SMA AL-Hassan Balik Papan. The test results for understanding the mathematical concepts of the SPLDV material in the first cycle were above 65 by 90%, and in the second cycle, scores above 65 reached 100%. Thus, the novelty of this study is an analysis of problem-based learning focused on the study of geometric material for students, assuming that it can improve student learning outcomes in students' cognitive and affective domains.

Research Methods

This research was classroom action research (CAR). It has two approaches there were quantitative and qualitative research approaches. A quantitative approach identifies and describes student learning outcomes focusing on the cognitive domain through math test scores. Quantitative research focuses on measuring and analyzing causal relationships between different variables, not a process. This research is seen in a value-free framework (Yilmaz, 2013). A qualitative approach identifies and describes student learning outcomes that focus on the affective and psychomotor areas when learning occurs in the classroom according to student performance scores. Quantitative research aims to reveal phenomena comprehensively and contextually by gathering information from natural backgrounds, using itself as the main tool of researchers (Priadana & Sunarsi, 2021). The method used in this research was testing, observation, and documentation. The data collection instruments were the learning class's description questions, checklists, and photo forms.

The location of this research was at the school of MTs Nuris Jember. It is located in the Antirogo Village, Sumbersari District, Jember Regency. This research was conducted in the even semester of the 2022/2023 academic year, from March 16 to April 15, 2023, to be precise. The object studied was the results of learning mathematics for class VII C on students’ subjects of square and rectangular shapes. Selection of Jember students for the 2022-2023 school year. The class determination was taken with purposive sampling. It was based on several basic reasons and recommendations from the mathematics teacher in the class. Apart from that, the class was given shaped material, and the average ability of students in that class was better than in other classes, even though the learning that was carried out was still centred on the teacher, namely using the lecture method. The students studied in this research were 30 students.

In general, the classroom activity survey (CAR) procedure used in this study was designed by Kurt Lewin. It consists of multiple cycles or repetitions of cycles. Each cycle consists of 4 steps/phases: (1) planning; (2) Acting; (3) observing; and (4) reflecting. The four phases are the elements that make up a cycle, a series of sequential activities. Therefore, the form of action research in the classroom was never a one-off activity but a series of activities that returned to the original form: a cycle (Checkland & Poulter, 2020; Coghlan, 2011; Messiou et al., 2016). Overall, the classroom action research (CAR) procedure can be observed in the following flowchart.



Picture 1. The Cycles of Classroom Action Research (Arikunto, 2019)

In the classroom, action research describes the causes and consequences of treatment, what happens when treatment is administered, and the entire process from initiation of treatment to its effect on the object of action (Arikunto, 2019). Planning: At this stage, the researcher, in consultation with the mathematics teacher, developed a lesson plan based on the syllabus, adapted the topics to the material, and prepared the materials to be used in this cycle. The researcher also made an evaluation form to determine student achievement at the end of this cycle. *Acting*: In this phase, researchers and observers collaborate to carry out planned actions. Researchers explain how the steps of the learning method are based on the problem. First, provide orientation on algebraic math problems to students. Secondly, they organized students to research. Thirdly, students should be encouraged to investigate algebraic mathematical problems independently or in groups. Fourthly, preparing students to develop and present investigative results. Fifth, analyze and evaluate the problem-solving process carried out by students. *Observing*: In this phase, researchers observed student responses, participation, and achievements during teaching and learning. Sometimes, observers ask students' opinions about the teaching and learning process using outdoor activities. Researchers also take observational notes to write down the actual situation when the action occurred. *Reflecting*: In this phase, researchers and observers collaborate to identify the problems found by looking at the results of observations that must be solved. Then, it is used to plan the next cycle and fix the weaknesses.

Action research methods are widely used in educational research. This study leveraged action research by integrating PBL instruction and situational case studies into adult education to explore student learning outcomes through planning, action, observation, and reflection (Hsu & Hsu, 2020). This research aims to use her PBL as a mainstay of curriculum implementation and improve the discussion and participation of MTs Nuris Jember students in the classroom through innovative teaching methods. The results validate the effectiveness of her PBL in improving students' mathematics learning outcomes.

The instruments used essay questions and checklists of student activities in class. Thirty students of class VII at MTs Nuris Jember served as the subjects, and samples were collected using purposive random sampling. In this study, descriptive and inferential statistics were employed in the data analysis for this investigation. Descriptive statistical analysis is not used to perform limited calculations on collected data or reach general conclusions (inferences). Meanwhile, inferential statistical analysis is the opposite of descriptive statistical analysis, which performs calculations on the data collected to make general conclusions. Some descriptive statistical analysis techniques commonly used in quantitative research include (1) presenting the data in the form of a table or histogram; (2) calculating the magnitude of the central tendency (central tendency) of the data in the form of sum, mean, median, mode; and (3) calculated data spread measures in the form of standard deviation, variance, range, minimum, maximum, and standard error; and 4) distribution of data in the form of skewness and kurtosis. Inference analysis techniques now include correlation analysis, regression, chi-square, Wilcoxon, split coefficient, t-test, f-test, univariate, multivariate, and more (Maswar, 2017).

In this study, researchers focused only on (1) displaying data in the form of tables or histograms of achievement rates for learning outcomes; (2) calculating the central tendency of test scores and student activity data in the form of sum, mean, median, mode; and (3) calculate data spread in terms of standard deviation, variance, minimum, maximum, and S.E.mean. The inference analysis method then focuses on testing the difference between cycle I and cycle II mean test scores using the t-significance test.

Formula and criteria: Students are said to have completed individually if the test scores obtained equal or exceed the minimum passing grade criteria set by the MTs Nuris Jember school for mathematics, which is 70. Then, classical completeness is equal to or exceeds the percentage of 70%. The techniques used in analyzing the data and determining the percentage of student learning completeness by using the formula as follow (Anam et al., 2020).

$$Classical\ Mastery\ (CM) = \frac{Many\ Students\ Complete}{All\ Students} x100\%$$

A class is said to have completed classical learning if the percentage is achieved at least 65%. But, for MTs, Nuris Jember has set classical mastery at least 70%. Then, the average comparison test uses the t-significance test, with a 95% confidence level or an alpha of 0.05. First criteria: For values of Z count > Z table or Z count < -Z table, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. It shows that two variables have a large impact. Conversely, for values of Z count ≤ Z table or Z count ≥-Z table, the null hypothesis (H_0) is accepted, and the alternative hypothesis (H_1) is rejected. It indicates that the two variables do not have a large effect. The second criterion: If the significance test results in Z (Asymp. Sig. Z) ≤ 0.05, then the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. It indicates a significant effect between the two variables tested. On the other hand, if the significance test yields z count (Aaymp. Sig. Z) > 0.05, then the null hypothesis (H_0) is accepted, and the alternative hypothesis (H_1) is rejected. It means no significant effect exists between the two variables tested (Asari et al., 2023).

Results and Discussions

Pre-Cycle

Study beginning: What did the researcher do before acting for cycle good, cycle One, or cycle two was observation? This research took place from March 20 to 28, 2023. The researcher enters room class VII C as a subject study when the process learns how to teach. The data information that the researcher gets is outlined as follows:

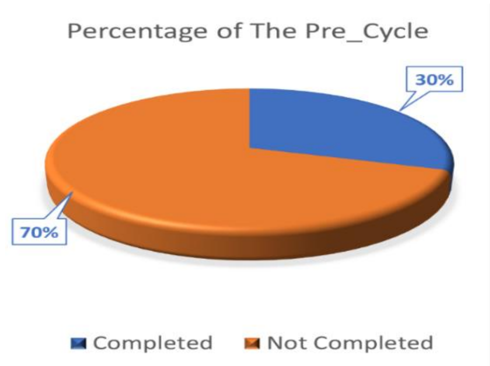
a. The subject teachers' learning method at MTs Nuris Jember is still dominantly focused on teachers in lectures. These question, answer, and assignment methods cause students to lack freedom in thinking and reasoning.
b. Students are less focused on the learning process being carried out
c. Many students are still busy with personal activities that have nothing to do with the lesson, do not pay attention to the teaching material delivered by the teacher, or do not respond to other students' questions
d. Students lack the courage to ask or express their opinions related to the teaching material delivered by the teacher
e. There are still many students who are not able to repeat the teaching material presented by the teacher
f. The students' mathematical abilities on the pre-cycle test were still less than the minimum standard of completeness set by the school.

Based on the results of preliminary data mining conducted by researchers, it was revealed that the tendency of students to learn was passive; only a few students were active in the learning process. When the teacher asks a question, only a number of people answer the question. The results or scores obtained. Many have not reached the minimum passing grade standard, as shown in Table 2.

Table 2. The Pre-Cycle Cognitive Aspect Student's Learning Outcomes

Descriptive Statistics									
	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Completed	9	15	70	85	710	78.89	1.620	4.859	23.611
Not Completed	21	25	40	65	1130	53.81	1.823	8.352	69.762
All Results	30	45	40	85	1840	61.33	2.525	13.830	191.264

Overall, the percentage results between students who completed and did not complete the passing grade standard by the school set in the field of mathematics in pre-cycle activities are as follows.



Picture 2. The Pre-Cycle of Learning Outcomes Percentage of Student's Completeness On The Minimum Passing Grade Standard

Based on the table and diagram above, it can be seen that the level of mastery of the area of squares and rectangles learning objectives for MTs Nuris Jember students has not been reached. Only nine students, or 30%, achieved the passing grade standard in the school setting, and as many as 21 students, or 70%, have yet to graduate. Based on the pre-cycle test results, action research should be done in at least two cycles of action design. Action activities are performed using problem-based learning treatment. This learning method is more student-focused, and the instructor takes on the role of facilitator.

The First Cycle (Cycle I)

Student learning outcomes in the cognitive aspects carried out in the first cycle are presented in Table 3.

Table 3. The First Cycle of Cognitive Aspect Student Learning Outcomes

Descriptive Statistics									
	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Completed	14	20	70	90	1075	76.79	1.933	7.234	52.335
Not Competed	16	20	45	65	930	58.13	1.930	7.719	59.583
All Results	30	45	45	90	2005	66.83	2.190	11.997	143.937

Explanation diagram of the percentage results between students who completed and did not complete the passing grade standard set by the school in the field of mathematics in cycle one activities, as follow.

Picture 3. The First Cycle of Learning Outcomes Percentage of Student's Completeness On The Minimum Passing Grade Standart

Based on Table 2 and Picture 3 above, it is known that the results of students' mathematics learning in learning using problem-based learning models still have not reached the targeted learning objectives because only 14 students have completed and 16 students have not completed according to the minimum passing grade standard of the school set of MT Nuris Jember if the percentage of learning outcomes reaches 47% of students in the complete category, and 53% of students in the not complete category.

Table 4. The Observation Result of Student's Activity in the First Cycle

Number	Aspects Observed	Percentage of Action Success
1	Students show discipline by coming on time to class	66.67%
2	Students concentrate and are not noisy in the learning process	60.00%
3	Students show curiosity by asking questions of teachers or friends if any material is not understood	33.33%
4	Students are active in answering any questions the teacher opens the question, and when the discussion	26.67%
5	Students brave enough to convey their ideas in group discussion	20.00%
6	Students work on tasks assigned by the teacher	40.00%
	Sum	**246.67%**
	Average	**41.11%**

Meanwhile, based on the observations in the first Cycle (Cycle I) regarding student learning activities directly when applying the problem-based learning models, information was obtained that as many as 20 students or (66.67%) completed aspect in number 1) Students show discipline by coming on time to the class, 18 students or (60.00%) completed aspect in number 2) Students concentrate and not noisy in the learning process, ten students or (33.33%) completed aspect in number 3) Students show curiosity by asking questions to teacher or friends if any material is not understood, eight students or (26.67%) completed aspect in number 4) Students active to answer any questions teacher an open question and when the discussion, six students or (20.00%) completed aspect in number 5) Students brave to convey their ideas in group discussion, and 12 students or (40.00%) completed aspect in number 6) Students work on tasks assigned by the teacher.

Table 5. The result of Score Range, Categories Student's Activity, and Alphabets Score

Number	Score Range (%)	Categories	Alphabets Score
1	85 - 100	Very Good	A
2	70 - 84	Good	B
3	55 - 69	Enough	C
4	40 - 54	Less	D
5	0 - 39	Very Less	E

Based on the observation results of students' activity in the second cycle, the sum and average of observation results of student activity are 246.67 and 41,11%, respectively. Thus, we can not say the grade standard of MT Nuris Jember is ≥70%. According to Table 4, we will know that students achieved 41,11% in less category and got alphabet score of D.

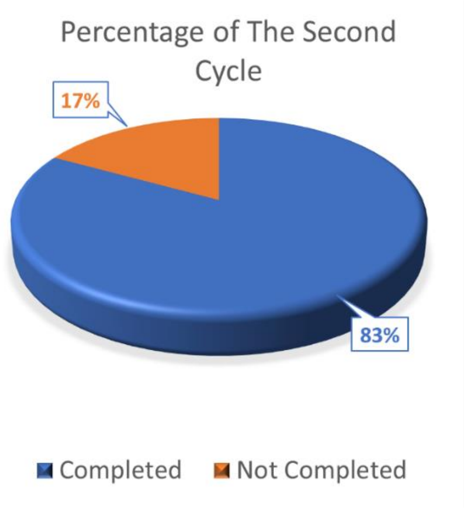
The Second Cycle (Cycle II)

Table 6. The Second Cycle of Cognitive Aspect Student Learning Outcomes

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Completed	25	20	70	90	1875	75.00	1.291	6.455	41.667
Not Completed	5	15	50	65	275	55.00	3.162	7.071	50.000
All Results	30	40	50	90	2150	71.67	1.815	9.942	98.851

Explanation of the percentage results diagram between students who completed and did not complete the KKM set by the Unggulan Nuris Jember MTs school in the field of mathematics in the second cycle of activities, as follow.



Picture 4. The Second Cycle of Learning Outcomes Percentage of Student's Completeness on The Minimum Passing Grade Standart

Based on Table 6 and Figure 4 above, it is known that students' mathematics learning outcomes using problem-based learning models have increased and have achieved the targeted learning objectives of 70%. The results in this second cycle were 25 students who passed and five students who did not complete according to the minimum passing grade standard by the school set of MTs Jember MTs if the percentage of learning outcomes reaches 83% of students in the complete category, and 17% of students in the incomplete category.

Table 7. The Observation Result of Student's Activity in the Second Cycle

Number	Aspects Observed	Percentage of Action Success
1	Students show discipline by coming on time to class	93.33%
2	Students concentrate and are not noisy in the learning process	90.00%
3	Students show curiosity by asking questions of teachers or friends if any material is not understood	66.67%
4	Students are active in answering any questions the teacher opens the question, and when the discussion	60.00%
5	Students brave enough to convey their ideas in group discussion	86.67%
6	Students work on tasks assigned by the teacher	80.00%
	Sum	**476.67%**
	Average	**79,45%**

Meanwhile, based on the observations in the first cycle (cycle I) regarding student learning activities directly when applying the problem-based learning model, information was obtained that as many as 28 students, or (93.33%) completed aspect in number (1) Students show discipline by coming on time to the class, 27 students or (90.00%) completed aspect in number; (2) Students concentrate and not noisy in learning process, 20 students or (66.00%) completed aspect in number; (3) Students show curiosity by asking questions to teacher or friends if any material is not understood, 18 students or (60.00%) completed aspect in number; (4) Students active to answer any questions teacher opens question and when the discussion, 26 students or (86.67%) completed aspect in number; (5) Students brave to convey their ideas in group discussion, and 24 students or (80.00%) completed aspect in number; and (6) Students work on tasks assigned by teacher.

Based on the observation results of students' activity in the second cycle, the sum and average of observation results are 476,67% and 79,45%. Thus, it is completed because the minimum passing grade standard of MTs Nuris Jember is ≥ 70%. According to Table 4, students achieved 79,45% in the good category and got an alphabet score of B. Furthermore, based on observations in the second cycle of student learning activities directly when applying problem-based learning methods, information was obtained that as many as one student, or (3%) was in the less category, eight students, or (27%) were in enough category, and 21 students or (70%) in the good category. The differences in student learning outcomes in the pre-cycle, the first cycle, and the second cycle, based on test results in the field of mathematics on the subject of square and rectangular shapes, can be seen in the table below.

Table 8. Comparison of Learning Outcomes in Pre-Cycle, First Cycle (Cycle I), and Second Cycle (Cycle II)

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Pre_Cycle	30	45	40	85	1840	61.33	2.525	13.830	191.264
Cycle I	30	45	45	90	2005	66.83	2.190	11.997	143.937
Cycle II	30	40	50	90	2150	71.67	1.815	9.942	98.851

From the table above, it is known that the average learning outcomes of 30 students in the pre-cycle is 61.33, with a minimum data of 40, a maximum of 85 data, a total of 1,840, a standard error of 2.525, a standard deviation of 13.830, and a variance of 191.264. Furthermore, the average learning outcomes of 30 students in cycle 1 was 66.83, with minimum data of 45, maximum data of 90, total of 2,005, standard error of 2.190, standard deviation of 11.997, and variance of 143.937. Then, the average learning outcomes of 30 students in cycle 2 were 71.33, with minimum data of 50, maximum data of 90, total of 2,150, standard error of 1.815, standard deviation of 9.815, and variance of 98.851.

Judging from the data, it is known that there is an increase in the average value of 5.5 points from the pre-cycle with an average value of 61.33 to cycle I with an average value of 66.83. Meanwhile, from the data, it was also known that there was an increase in the average value of 4.83 points from cycle I, with an average value of 66.83, to cycle II, with an average value of 71.67. Directly, the average increase from pre-cycle to cycle II without going through cycle I is 10.34 points.

Table 9. Test of Normality Based on Mean

Tests of Normality

Learning Outcomes	Cycles	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	Cycle I	0.129	30	0.200*	0.957	30	0.256
	Cycle II	0.267	30	0.000	0.887	30	0.004

The analysis results show that based on the significance of the Shapiro-Wilk value, it is 0.256 for cycle I > 0.005 and 0.004 for cycle II < 0.005. From these results, it can be concluded that the data on student test results in cycle II is normal, but in cycle I, it is not normal.

Table 10. Test of Homogeneity of Variances Based on Mean

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Learning Outcomes	**Based on Mean**	1.655	1	58	0.203
	Based on Median	1.613	1	58	0.209
	Based on Median and with adjusted df	1.613	1	57.904	0.209
	Based on trimmed mean	1.628	1	58	0.207

The learning outcomes analysis results show that based on the mean, the Levene Statistical value is 1,655 with a sig. 0.203 > 0.005. From these results, it can be concluded that the data on student test results in cycle I and cycle II are homogeneous. In other words, they have the same variance. Because one data does not meet the normality requirements, even though the two groups of data in cycles 1 and 2 are equally homogeneous, the appropriate test used to determine the significance level of the comparison of the two data is non-parametric inferential statistics in the form of the Wilcoxon test.

Table 11. The results of the significance test of the average student learning outcomes

Test Statistics[a]

	Cycle II - Cycle I
Z	-3.830[b]
Asymp. Sig. (2-tailed)	0.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

The Wilcoxon Signed Rank test results yield a Z-score of -3.830 and an Asymp-Sig score. (2-sided) 0.000 is less than the alpha value of 0.05 or (5%), thereby rejecting the null hypothesis and accepting the alternative hypothesis. It means that the average student learning outcomes differ significantly between cycles I and II when associated with the problem-based learning model.

The results showed that the application of a problem-based learning model could significantly improve student learning outcomes at MTs Nuris Jember. These results are very important for teachers and education practitioners to apply this PBL model in every learning process in the school class. It has been proven that PBL can improve student learning outcomes both in the cognitive domain obtained through test scores and the affective domains obtained from the value of observing student activities in the learning class. These results are relevant to those carried out by Zaduqisti (2010), who found that the Problem-Based Learning Model improves students' psychological aspects; this paper focuses on increasing learning achievement results and motivation.

The results of this study are also related to those by Juandi and Tamur, in which the MA study provides the following information: (1) PBL implementation has a strong positive effect on a student's improvement in her MCTS, as evidenced by a synthesis of 17 relevant primary studies; and (2) publication characteristics are one of the factors influencing heterogeneous effect size data. This MA study, therefore, provides mathematics teachers or lecturers with information that PBL is an alternative learning that effectively solves problems associated with low MCTS in students. Therefore, we can consider her PBL as an alternative solution to improve the student's low MCTS (Suparman & Tamur, 2021).

PBL applies to students and can be used as a model to increase adult learning enthusiasm and motivation. This is consistent with research conducted by Hsu and Hsu (2020), which found that participants' attitudes toward learning changed significantly, becoming more positive and self-directed. This conclusion mirrors that of his M.S. He proposed the adult learning theory. Knowles Further, M.S. Knowles found that adult learning orientations are life and problem-oriented. The autonomous learning emphasized in PBL is well-suited for adult education. The results of this study also demonstrate learning outcomes for adult learners through PBL. Learning by applying the PBL model increases students' learning activity, making them more disciplined, more focused on learning, and more serious about their answers in class; they dare to explore their ideas in group discussions, are more active in asking questions, and so on. Not only that, but the application of PBL also makes learning more enjoyable for teachers and more flexible for observing student performance in teams and getting good experience. Research by McLoone et al. (2016) has shown that the PBL model also provides students with valuable opportunities to learn various skills such as teamwork, leadership, communication, research, time management, and project management. The moderator also liked the experience and noticed that the students were very motivated in their project work.

A higher student-to-teacher ratio was associated with better student mathematics performance at the school level. In summary, students' mathematics performance should be viewed in the context of psychological, social, and academic factors, not just mathematics teaching. Further research is needed to capture the impact of other variables and compare results between schools in different provinces of Indonesia. Nevertheless, these findings will help Indonesian education policymakers address this issue for society's current and future development. PBL can be used not only in mathematics classes but also in other learning classes. It is related to the results of research conducted by Sudareny (2023). The increase in student learning outcomes in economics learning by applying the problem-based learning model shows that the model positively contributes to the learning process and student learning outcomes. Moreover, this learning model is often used to improve the quality of learning in secondary schools, especially in economics subjects. Problem-based learning (PBL) models can be used to develop policies that improve school learning quality (Sudareny, 2023).

Conclusions and Suggestions

The results of this study show that the application of the problem-based learning models has been shown to improve student's learning outcomes at MTs Nuris Jember. The geometry, especially flat shapes that is the focus of your study in this action research course consists of square and rectangular planar shapes. This increase in learning outcomes can also be seen in student test results. Students' average scores improved from 61.33 in Pre-Cycle I to 66.83 in Cycle I and 71.67 in Cycle, meaning that problem-based learning is an effective model to enhance student learning outcomes. Applying PBL showed a significant increase from cycle I to cycle II, with The results of the Wilcoxon Signed Rank test yielding a Z-score of -3.830 and an Asymp-Sig score (2-sided) 0.000 is less than the alpha value of 0.05 or (5%), thereby rejecting the null hypothesis and accepting the alternative hypothesis. It means that the average student learning outcomes differ significantly between cycles I and II when associated with the problem-based learning model. According to the findings observed for thirty subjects in standard cycle II, the average observation result for students' activities was 79,45%, in the good category, and got an alphabet score of B.

Acknowledgements

We would like to thank the supervisor and mathematics teacher at MTs Nuris Jember, who helped researchers complete this scientific work and supported and guided us during writing, and all parties who helped learn and collect research data. PBL models must be applied collaboratively or in teams, not only in groups of students but also in teams of math teachers and researchers.

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