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Application of Problem-Based Learning to Enhance Mathematical Reasoning Skills of Phase E Students in Class X-3 SMAN 6 Pekanbaru

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A B S T R A C T

This study aims to enhance the learning process and improve students' Mathematical Reasoning Skills (MRS) through the implementation of the Problem-Based Learning (PBL) model. The initial MRS test results for Class X-3 at SMAN 6 Pekanbaru were relatively low, with an average score of 46.07%. This was attributed to students' unfamiliarity with reasoning-based questions, insufficient understanding of the material, and a learning process that failed to actively engage students. The research, conducted as classroom action research, consisted of two cycles involving 35 students during the first semester of the 2024/2025 academic year, focusing on sequences and series topics. Research instruments included teaching modules and student worksheets, along with observation sheets and MRS tests for data collection. Qualitative data from observations indicated a progressive improvement in learning quality across meetings, with students becoming more active and capable of constructing their knowledge. Quantitative data from the MRS tests showed an N-Gain score improvement from 0.44 in the first cycle to 0.68 in the second cycle, categorized as a moderate increase. The findings suggest that the PBL model effectively improves the learning process and enhances students' MRS, fostering a more engaging and interactive learning environment.

1. Introduction

One of the abilities that students must have is related to the objectives of learning mathematics, namely the ability to reason and prove mathematics. Mathematical reasoning can be used as a foundation for understanding and solving mathematics as well as an integral part of problem solving (Basir, 2015). Mathematical Reasoning Skills (MRS) according to Akuba, Purnamasari, and Firdaus (2020) is a thinking process carried out by drawing conclusions that can be accounted for. According to Khainingsih, F.G., Maimunah., and Roza, Y. (2020) Reasoning ability is the ability to think in mathematics which is a thought process in connecting various known facts so that conclusions can be obtained.

Reasoning abilities are needed in every aspect of life, including in the field of mathematics, so that a person can analyze every problem that arises carefully, can solve problems well, can assess things critically and objectively, and can express opinions and ideas logically (Badjeber, 2017). Linola, Marsitin, and Wulandari (2017) say that mathematical reasoning skills are very important because reasoning abilities can directly improve students' learning outcomes. Mathematical reasoning skills can create students with the ability to analyze, understand, collect evidence and make conclusions so that they can solve problems appropriately and relevantly. Based on this opinion, it can be concluded that mathematical reasoning skills must be a concern in the mathematics learning process because they have a very important role in building students' understanding of concepts. Indicators of Mathematical Reasoning Skills, namely: presenting mathematical statements in writing or pictorially, proposing conjectures, compiling evidence by providing reasons or evidence for the correctness of the solution, and drawing conclusions.

However, in reality, students' mathematical reasoning skills are still relatively low, as evidenced by research by Rosaliana, D., Muhtadi, D., and Setiawati, T., (2019) which states that students' level of mastery of mathematical reasoning skills is still low in all indicators, seen from the results of his research, it was stated that the mastery stage in the indicator of presenting mathematical statements verbally, in writing, with pictures and graphs was 33.75%, the indicator of compiling evidence was 26.75%, and the indicator of drawing conclusions was 26.75%. 25.62%. The cause of low mathematical reasoning skills is because students are unable to find information from the problems given because students are not used to working on problems that require reasoning, do not master concepts, and have difficulty understanding problems. Apart from that, students are not used to solving problems that require reasoning abilities and lack mastery of material concepts that have been studied for a long time.

Based on observations, it can be seen that the learning process is not in accordance with Permendikbudristek No.16 of 2022, where learning strategies are designed to provide a quality learning experience, giving students the opportunity to actively participate in learning. During learning, teachers have not implemented a learning atmosphere that is interactive, inspiring, challenging, motivating for students, and provides sufficient space to increase students' creativity, independence, interest and physical development, as well as psychology. Students are also not able to find information from the problems given because students are not used to working on problems related to reasoning, do not master the concepts so it is difficult to understand the problems.

Based on the results of interviews with teachers, information was obtained that the low ability of students to solve contextual problems was because students were less active and did not participate enough in the learning process. When the teacher explained in front, only some of the students listened seriously, the rest were sleeping and playing. Students are only able to work on questions using the same model as the example given by the teacher. In delivering the material, the teacher has provided an understanding of the concept of the material and also

contextual problems, but students are still not used to working on problems that require reasoning skills to solve them.

The researcher also gave a reasoning ability test to students of class X-3 SMAN 6 Pekanbaru. The initial test consisted of 2 questions about number patterns which were material that had been studied in junior high school for 35 students. The percentage of initial mathematical reasoning ability test scores for each indicator in class X-3 SMAN 6 Pekanbaru was as follows: for the indicator of presenting mathematical statements 49.75%; for the indicator of making guesses 47%; for the indicator of compiling evidence 47.5%; and for the indicator of drawing conclusions 25%. Based on the results of the initial mathematical reasoning skills test that the researcher conducted in class, it showed the percentage of scores obtained by students for each indicator of reasoning ability on questions number 1 and question number 2, students were still unable to solve contextual problems correctly on each indicator.

Thus, students' mathematical reasoning skills need to be improved, namely through the application of a learning model that can increase students' activeness in learning, stimulate students to understand concepts to solve mathematical problems. Problem Based Learning is learning that begins by exposing students to a problem that exists in everyday life and guides them to be able to solve the problem through activities or learning experiences carried out during the learning process (Isrok'atun & Amelia in Kotto, Babys, and Gella, (2022) a similar opinion was also expressed by Ulva, E., Maimunah, and Murni, A, (2020), namely that PBL is a learning model that starts learning activities by giving problems to students and involving students and solving these problems. PBL directs students to find their own answers to solving problems. The PBL model can help students be actively involved in the learning process, namely students are required to be active in thinking, reasoning, communicating, searching for data and processing data, and finally drawing conclusions. (Abidah, Hakim, and Wijayanti, 2021 in Kotto, Babys, and Gella, 2022). The problem based learning model is related to mathematical reasoning because the reasoning process requires the ability to connect facts to solve problems.

In this study, researchers measured students' mathematical reasoning skills on sequences and series material. Sequences and series are material that is widely applied in everyday life so that in the learning process teachers can use various learning models which can provide opportunities for students to find answers for themselves according to their experiences (Rizkiana, W., 2024). For example, we can use arithmetic sequences and series to calculate the amount of savings in several years if we save at a bank with a fixed difference in the increase in nominal savings each month. The applications of sequences and series are generally directly related to everyday life. The presentation of sequence and series material that is directly related to real life is expected to foster independence in solving problems that train mathematical reasoning skills. Therefore, it is very important for students to understand and master the material on arithmetic sequences and series (Annisa, R and Kartini, 2021).

Based on this explanation, researchers see the need for improvements in the learning process by implementing a learning model that can increase the mathematical reasoning skills of class X-3 students at SMAN Pekanbaru. This is what prompted researchers to conduct research entitled "Application of the Problem Based Learning Model to Improve the Mathematical Reasoning Skills of Phase E Students in Class X-3 SMAN 6 Pekanbaru". Researchers conduct research on sequence and series material.

2. Methodology

The type of research carried out is Classroom Action Research (PTK) Muhammad Djajadi (2019) states that the meaning of Classroom Action Research (PTK) is carried out in 2 cycles. According to Muchlisin Riadi (2019), Classroom Action Research (CAR) is a form of research that occurs in the classroom in the form of certain actions taken to improve the teaching and learning process in order to improve learning outcomes that are better than before. The research was carried out collaboratively between researchers as research implementers, and teachers as observers. This classroom action research aims to improve the process and increase the mathematical reasoning skills of class X-3 students at SMAN 6 Pekanbaru by taking action in the form of applying the problem based learning (PBL) model. Muhammad Djajadi 2019 (Prasetyo 2021) stated that the steps taken in the first and subsequent cycles were: (1) Action Planning, (2) Action Implementation, (3) Observation, (4) Reflection. This research was carried out in class 56 of 2022 concerning guidelines for implementing curriculum in the context of learning recovery, contains a teaching module containing all plans that describe learning procedures for 5 meetings using the PBL model with an attached Student Worksheet (LKPD) which is a guide for students to use in investigation activities and problem solving that contains PBL syntax and formative assessment. Data collection instruments used observation sheets of teacher and student activities and also tests of students' reasoning abilities. The technique used to collect data on teacher and student activities is observation techniques, while the technique used to collect data on students' mathematics learning outcomes is a written test in the form of a 5-item Mathematical Reasoning Skills test. The data obtained from the test instrument was analyzed to determine the increase in mathematical reasoning skills based on the mathematical reasoning skills assessment rubric in table 1.

The analytical techniques used are descriptive narrative data analysis techniques and descriptive statistical data analysis. The data obtained from the observation sheet is qualitative data and is analyzed using descriptive quantitative analysis techniques which are carried out in 3 stages, namely data reduction, data exposure and drawing conclusions. The analysis technique for student mathematical reasoning skills test results in cycle I and cycle II is analyzed quantitatively to determine the student's initial mathematical reasoning skills level. Test data processing is carried out by providing scores in accordance with scoring guidelines which are converted to a scale of 0-100, creating a mathematical reasoning skills score table to determine students' mathematical reasoning skills

improvement scores. Conversion of students' mathematical reasoning skills scores uses the formula: the student's final score is the score obtained by the student (individual) divided by the maximum score multiplied by 100.

Table 1. Guidelines for Scoring Students' Mathematical Reasoning Skils

Indicators	Criteria	Score
Present mathematical statements in writing or in pictures	• Present mathematical statements correctly and completely	4
	• Presents mathematical statements correctly but incompletely	3
	• Presenting inaccurate mathematical statements	2
	• Presenting incorrect mathematical statements	1
	• Presents no statement or no answer	0
Making allegations	• Submit allegations correctly and completely	4
	• Submit allegations correctly but incompletely	3
	• Making inaccurate allegations	2
	• Making false allegations	1
	• Don't ask for guesses or empty answers	0
Compile evidence	• Compile evidence correctly and completely	4
	• Compile correct but incomplete evidence	3
	• Arranging inaccurate evidence	2
	• Arranging faulty evidence	1
	• No answer	0
Draw a conclusion	• Draw conclusions, listen correctly and completely	4
	• Draws conclusions but is incomplete	3
	• Draw conclusions but are not precise	2
	• Drawing wrong conclusions	1
	• No conclusions or no answers	0

Source: Modification from Setiawati,T., Muhtadi,D., & Rosaliana,D. (2019). and Vebrian et al., (2021)

There are three categories of Mathematical Reasoning Skills, namely the low category with a final score of less than 60, the medium category with a final score ranging from 60 to less than 80, and the high category with a final score of 80 to 100 according to Wirawan, N., Yuhana, Y ., and Fatah, A (2023). The increase in test results can be calculated using the N-Gain test which comes from the pretest and posttest scores. According to Eka, L.K. and Yudhanegara, M.R. (2017). the amount of increase can be calculated using the normalized gain formula as follows: The N-Gain value is (post-test score - pre-test score) divided by (ideal maximum score - pre-test score). The categorization of the N-gain score can be determined based on the N-gain value. The division of categories for obtaining N-gain values is the high category with N-Gain obtaining more than 0.70, the medium category with obtaining N-Gain values more than 0.30 and less than or equal to 0.70, and the low category with obtaining values N-Gain is less than or equal to 0.30.

Based on the N-Gain score criteria, it is said to increase if a student's mathematical reasoning skills results obtain an N-Gain score $\geq$ 0.30 in the medium or high category. The criteria for the success of the action in this research are that there is an improvement in the learning process if the learning process carried out in cycle 1 and cycle 2 is in accordance with the steps in implementing

the planned PBL model and an increase in student mathematical reasoning skills is said to have increased if the number of students who obtain the N-qualification Medium and high gains increased from cycle 1 to 2 and the number of learners who obtained low qualifications decreased.

3. Results and Discussion

The research took place over 9 meetings, of which 2 meetings were for conducting a pre-test, 2 meetings were for conducting a post-test, and 5 meetings were for carrying out actions in cycle 1 and cycle 2. Data on the results of classroom action research were obtained from classroom action research carried out in class X-3 SMA N 6 Pekanbaru. Research was carried out through 3 stages, namely planning, implementation and reflection. Teacher and student activity data were analyzed to see improvements in the learning process after implementing actions by implementing the planned PBL model in the implementation of learning. The suitability of the steps in implementing the planned PBL model with the implementation of the learning process actions can be seen from the observation sheet at each meeting. The data obtained was analyzed again. Analysis of teacher and student activity data for each preliminary activity, core activity and closing activity.

Cycle 1 contains preliminary, core and closing activities for meetings 1 and 2. The first meeting was quite good even though there were still many students who did not pay attention to the teacher's instructions and were not enthusiastic about answering the teacher, were embarrassed to ask questions, and were not quick enough to move when forming groups. The second meeting of cycle 1 was better than meeting 1, students had the courage to ask questions, more and more people were paying attention to the teacher, students were also willing to respond even though there were still some things that were careless or less serious, but when group formation only improved slightly from the meeting First. Students are also less active in their groups, some work on their own LKPD, some just copy, and some even look at other groups.

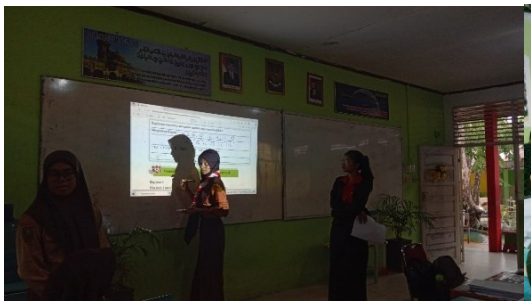

Figure 1. Group Presentation

Figure 2. Guiding individual and group inquiry

Cycle 2 in the introductory, core and closing activities for meetings 3, 4 and 5 was better than cycle 1, it was seen that students were paying close attention to the teacher, were getting used to asking the teacher about things they didn't

understand, starting to have the courage to express opinions, and easier to direct when forming groups. Students have also begun to get used to group discussions, as can be seen from their diverse opinions and presenting the results of group discussions well.

Based on the activities described in the implementation of cycle 1 and cycle 2 actions, it can be seen that there have been changes in students for the better during the learning process. It can be seen that the participation of the majority of students is increasingly active during the problem solving process. The application of the PBL model by researchers has had a positive impact on the implementation of learning. Students are also trained to build their own knowledge so that learning becomes more meaningful and sticks in students' minds. This is very helpful in increasing students' mathematical reasoning skills. The deficiencies and weaknesses that occur in the learning process become fewer and fewer as the actions in cycle 1 and cycle 2 are implemented so that the learning process improves until the end of cycle 2. Analysis of the mathematical reasoning skills of students in class and series.

During the research, there were several obstacles. These obstacles cannot be separated from the researchers' shortcomings in the learning process, including in cycle 1 the planned learning process was not carried out well. Students are not yet familiar with the steps of the PBL model. The shortcomings in cycle 1 became material for researchers to improve the learning process in cycle 2, so that in cycle 2 the researchers had almost implemented the learning plan well and students were already familiar with the PBL model. In cycle 2 the researcher was only a facilitator, different from cycle 1. In the learning process in cycle 2 the stages of the PBL model were implemented better with each meeting. The shortcomings that occur cannot be separated from the researcher's role as a teacher during research. We always strive to improve deficiencies at the previous meeting at the next meeting.

The following is an analysis of the increase in students' mathematical reasoning skills before and after applying the PBL model to sequence and series material.

Table 2. Mathematical Reasoning Skills Achievements in Cycles 1 and 2

Cycle 1			**Cycle 2**		
Average		***N-Gain***	Average		***N-Gain***
Pretes	*Postes*		*Pretes*	*Postes*	
16,41	53,29	0,44	24,24	75,01	0,68

Table 3. Increase in Mathematical Reasoning Skills Value for Each Indicator

No.	**Indicator**	**First Test**	**Cycle 1**	**Cycle 2**
1.	Present mathematical statements in writing or in pictures	49,75	80,5	94,75
2.	Making allegations	47	30,75	74,9
3.	Compile evidence	47,5	42,5	79,42
4.	Draw a conclusion	25	39,5	50,75

Based on the data in Table 3 and Table 4, information is obtained that by applying the Problem Based Learning model, students' mathematical reasoning skills in problems with each indicator of students' mathematical reasoning skills increase in the first and second cycles.

The average N-Gain of students' overall mathematical reasoning skills in the first cycle was 0.44 with a moderate increase category. Meanwhile, in the second cycle the average N-Gain of students' overall Mathematical Reasoning Skills was 0.68 with a moderate improvement category. Student mathematical reasoning skills has increased as seen from the number of students who obtained N-Gain scores in the low category, decreasing from cycle 1 of 13 students to cycle 2 to 1 student, and the number of students in the medium category in cycle 1 to cycle 2 remained the same. as many as 13 students and the high category increased from cycle 1 with 9 students to cycle 2 to 21 students. The overall increase in student mathematical reasoning skills in cycle 1 was 0.44 in the medium category to 0.68 in cycle 2 in the medium category. This shows that PBL can increase mathematical reasoning skills just like the research results of Kotto, M.A., Babys, U., and Gella , N.J.M (2022) shows that there is an increase in students' mathematical reasoning after learning with the PBL model. The results of the gain score analysis also show that students' mathematical reasoning skills in learning using the PBL model are in the high category with an average gain score of 0.71. Rahman (2019) research concluded that implementing a problem-based learning model can improve students' mathematical reasoning skills. This means that implementing PBL is indeed suitable for increasing students' mathematical reasoning skills.

Based on the description above, the application of the problem based learning model is increasingly in accordance with learning planning and the learning process is also getting better. It can be seen from the participation of some students who are increasingly active in the learning process and completing LKPD in their groups. The implementation of learning using the problem based learning model has provided opportunities for students to actively respond to the perceptions given by the teacher, understand the material being studied better, be trained to solve problems in the form of mathematical reasoning, and provide opinions or questions if there is something they do not understand. So, the results of this action analysis support the proposed action hypothesis, namely that if the problem based learning model is applied to mathematics learning, it can improve the learning process and increase the mathematical reasoning skills of students in class Rows and Series.

4. Conclusion

Based on the data analysis and discussion, it can be concluded that the implementation of the Problem-Based Learning (PBL) model can improves the mathematics learning process in Class X-3 at SMAN 6 Pekanbaru during the odd semester of the 2024/2025 academic year, focusing on sequences and series. The improvements in the learning process that happen after application of problem based learning model significantly enhance the mathematical reasoning skills of

the students in Class X-3. Consequently, this classroom action research serves as a useful reference and recommendation for future studies aiming to further enhance the learning process and outcomes in similar educational settings.

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