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HOTS *PROBLEM-BASED LEARNING DESIGN TO ENHANCE MATHEMATICAL REASONING ABILITIES*

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ABSTRAK

Penelitian ini bertujuan untuk mengetahui apakah *Problem-Based Learning* (PBL) berbasis HOTS efektif pada kemampuan penalaran matematis siswa. Penelitian ini, eksperimen semu dilakukan dengan menggunakan rancangan *posttest only control group design*. Rencana Pelaksanaan Pembelajaran (RPP) dan Lembar Kegiatan Siswa (LAS) digunakan untuk acuan kegiatan pembelajaran, sedangkan Instrumen penelitian terdiri dari lembar observasi dan soal tes penalaran matematis yang dikembangkan berdasarkan indikator kemampuan penalaran matematis dengan kategori C4, C5 dan C6 berdasarkan *Bloom's Taxonomy.* Sebelum diterapkan, semua instrumen divalidasi oleh ahli untuk selanjutnya dianalisis menggunakan menggunakan kategori validitas. Instrumen yang telah divalidasi diterapkan di kelas VIII-I sebagai kelas eksperimen dan VIII-J sebagai kelas kontrol berdasarkan teknik pemilihan sample *simple random sampling.* Menurut hasil penelitian, kemampuan penalaran matematis siswa di kelas eksperimen memperoleh kategori sangat tinggi pada indikator mengajukan sebuah dugaan dan menemukan pola berdasarkan masalah yang diberikan. Sedangkan pada indikator kemampuan penalaran matematis lainnya memperoleh kategori tinggi. Secara deskriptif, skor posttest siswa di kelas eksperimen lebih tinggi dibandingkan skor posttest siswa di kelas kontrol. Hal ini diperkuat melalui hasil analisis data menggunakan uji *t-independent sample* yang menunjukkan bahwa terdapat perbedaan rata-rata penalaran matematis siswa antara yang menggunakan model PBL berbasis HOTS dengan model konvensional. Berdasarkan uji *t-one sampel* dapat diketahui bahwa model PBL berbasis HOTS efektif terhadap kemampuan penalaran matematis siswa. Model pembelajaran PBL berbasis HOTS ini dapat diterapkan oleh pendidik untuk melatih kemampuan penalaran matematis siswa dan kemampuan siswa dalam menyelesaikan soal HOTS ataupun sebagai ide kreatif dalam pelaksanaan pembelajaran dengan *setting* model PBL.
Kata Kunci: HOTS, Kemampuan Penalaran Matematis, Model Pembelajaran, Problem Based Learning.

ABSTRACT

This study aims to determine whether HOTS Problem Based Learning has an effect on mathematical reasoning skills. Quasi-experimental design was used with a *posttest-only control group design*. Learning Implementation Plan (RPP) and Student Activity Sheets (LAS) are used as references for learning activities, while the research instruments consist of observation sheets and mathematical reasoning test questions which were developed based on mathematical reasoning indicators ability with categories C4, C5, and C6 based on *Bloom's Taxonomy*. Before being applied, all instruments were validated by experts for further analysis. Validated instruments were applied to VIII-I class as experimental class and VIII-J as control class based on the *simple random sampling* technique. The findings demonstrate that students' capacity for mathematical thinking in the experimental class obtained a very high category on the indicator of making an assumption and finding patterns based on the given problems. Meanwhile, the others mathematical reasoning abilities indicator are in the high

category. Descriptively, the experimental class students' posttest scores outperformed those of the control class students. This is reinforced through the results of data analysis using independent sample t-test which shows that there is a difference in the average mathematical reasoning abilities in both classes. Based on one sample t-test, HOTS-PBL model is effective on students' mathematical reasoning abilities. This HOTS-PBL model can be applied by teachers to enhance students' mathematical reasoning abilities and students' abilities in solving HOTS question or as creative ideas in implementing learning by setting PBL model.
Keywords: Learning model, problem based learning, HOTS, Mathematical reasoning ability.

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INTRODUCTION

One of the standard processes in learning mathematics stated by NCTM is that students have critical, logical, creative thinking skills, mathematical, systematic, and analytical reasoning in solving everyday problems (Wedekaningsih et al., 2019). Mathematical reasoning is a person's ability to compile and draw conclusions about ideas or ideas based on previously proven truths (Oktaviana & Aini, 2021). It is impossible to separate mathematics from mathematical reasoning as two vital components, namely where mathematics can be understood with mathematical reasoning, while mathematical reasoning can be understood and trained by learning mathematics (Rahman et al., 2019). To determine mathematical reasoning ability, can be identified through indicators of mathematical reasoning ability, is (1) submitting an allegation, (2) carrying out mathematical manipulation efforts, (3) finding a pattern in a mathematical problem and make generalizations (4) construct a proof, and give reasons for the solution, (5) draw a conclusion from a statement, and (6) verify the veracity of a claim (NCTM, 2000; Ariati & Juandi, 2022).

The importance of mathematical reasoning skills is not accompanied by facts about low mathematical reasoning abilities as evidenced by the 2015 and 2018 PISA results. The results of this measurement show that mathematics scores in Indonesian students get the lowest 8th rank out of 70 countries. In 2018, it can be seen that there has been a decline in ranking, namely Indonesia is ranked 73rd out of 79 countries. Additionally, based on the results of previous research conducted by (Asdarina & Ridha, 2020), it can be seen that the level of mathematical reasoning of 30 students is in a very low category, this is discovered from the results of the analysis on test indicator making conjectures there are only 6 students, indicator doing mathematical manipulation there are 10 students, indicator compiling evidence or giving reasons there were 4 students, and indicator drawing conclusions from the statement there were 5 students who were able to answer correctly. The results of the preliminary research conducted on October 13, 2021 by giving test questions containing several indicators of mathematical reasoning to 31 class VIII students at MTsN 3 Nganjuk, obtained there were 27 students who were still unable to solve questions containing indicators of mathematical reasoning. There were 15 of students who were unable to demonstrate mathematical reasoning abilities according to indicator I, there were 12 of students who were unable to demonstrate mathematical reasoning abilities according to indicator II, there were 5 of students who were not able to demonstrate mathematical reasoning abilities according to indicator III, there were 8 students who were unable to demonstrate mathematical reasoning abilities according to indicator IV, and on indicator V there were 13 of students. It can be stated that students at MTsN 3 Nganjuk possess low mathematical reasoning skills.

The low level of students' mathematical reasoning was reinforced by data from interviews conducted on October 22, 2021 with the mathematics teacher at MTsN 3 Nganjuk who said that students' general abilities in geometric material, especially prisms and pyramids, included (1) students had difficulty using formulas, (2) students have difficulty determining the elements being asked and what is known in story-shaped questions, (3) students are also not able to identify and write down what formulas are used to solve the story-shaped questions, (4) there are still many students who make mistakes when carrying out mathematical arithmetic operations, such as wrong calculations, wrong giving units at the end of the answer, even students who have not been able to grasp the concept to solve the problem, (5) students have not been able to manipulate and draw a conclusion from the information provided.

Based on the case above, a solution is needed in the form of a learning model that may motivate students to take an active role, as well as train students' mathematical reasoning in prism and pyramid material, namely the HOTS (Higher Order Thinking Skills) Based PBL (*Problem Based Learning*) learning model. This learning model is one of the efforts to fulfill the learning model recommended in the 2013 curriculum which is contained in Permendikbud No 103 of 2014. Based on Tan Oon Seng's research, the PBL learning model can foster the process of thinking skills and knowledge of students individually or in groups must be able to solve contextual problems given at the beginning of each lesson (Jailani et al., 2018). The implementation of the PBL model can be carried out in stages (1) introducing students to an issue, (2) planning student learning activities, (3) assisting students in autonomous or group investigations, (4) developing and presenting a student's work, (5) analyze and evaluate the process of solving problems, (Arends, 2012; Nurdyansyah & Fahyuni, 2016).

HOTS is an ability to manipulate, connect, and change existing knowledge to think at a high level critically and creatively when solving a problem (Masitoh & Aedi, 2020). Anderson and Krathwohl argued, cognitive processes in Bloom's Taxonomy to be achieved by students in the learning process there are six levels such as remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating or assessing (C5), and create or create (C6) (Anderson & Krathwohl, 2001). Thinking levels C1, C2, and C3 are part of lower order thinking skills or LOTS (Lower Order Thinking Skills). While the C4, C5, and C6 thinking levels are part of higher order thinking skills or HOTS (Saraswati & Agustika, 2020).

To motivate pupils to take an active part and enhance their mathematical reasoning in light of the above description, research was carried out using the HOTS-based PBL model. The PBL model is carried out through stages, namely (1) orienting students on a problem, (2) organizing student learning activities, (3) guiding students in investigations either individually or in groups, (4) creating and delivering a student's work, (5) analyze and assess a method of problem-solving. Meanwhile, HOTS is a form of questions that will be presented to students with high level abilities in the form of questions C4, C5, C6. The results of previous studies put forward by (Harahap et al., 2020) stated that with the PBL model, the scores of students at SMKN 1 Batang Angkola increased better than before, meaning that the PBL model was effective for students' mathematical reasoning. In line with the results of research from (Khaeroh et al., 2020) that the mathematical reasoning ability of students with the PBL models is higher than students who use the expository model. In addition, previous research that has examined HOTS shows that students who are given a variety of HOTS-based questions will be trained to be able to think critically, creatively, analytically, and logically (Ma'ruf et al., 2019; Herman et al., 2022) .

Based on the explanation above, the purpose of this research is to find out, 1) how is the mathematical reasoning ability of students using the HOTS-based PBL models; 2) how is the mathematical reasoning ability of students using conventional learning models; and 3) what is the problem model HOTS-based based learning has effective on students' mathematical reasoning abilities in class VIII at MTsN 3 Nganjuk.

METHODS

To answer the research objectives, the study employed a posttest-only control group design and a quasi-experimental methodology. The following design will be used in this study namely: (Fraenkel et al., 2023; Creswell, 2012)

Table 1. Research Design

Class	Treatment	*Posttest*
I	X_1	O_I
J	X_2	O_J

Keterangan:

I = Experiment Class

J = Control Class

X_1 = Experimental class treatment (with Problem Based Learning models HOTS based)

X_2 = Control class treatment (with conventional learning models)

O_A = *posttest* in the experimental class

O_B = *posttest* in the control class

In this design both classes have the same characteristics, which are then given a treatment. Experimental class engaged in learning activities using the HOTS-based PBL models. While the control class applied the conventional model. After the treatment, the two classes were given the same posttest questions to be compared.

This research was conducted at MTsN 3 Nganjuk, with a population of 10 graders in class VIII at MTsN 3 Nganjuk for the 2021/2022 academic year. Class sample selection used simple random sampling technique, namely determining the class sample randomly (Hardani, 2020). The two samples are class VIII-I for the experimental class and class VIII-J for the control class, each class consisting of 33 students. Data collection methods are observation dan test. The procedures in this research were:

1. Preparation of research instruments

The research instruments used were lesson plans with regard to the experimental and control classes, Student Activity Sheets (LAS) for the experimental and control classes, observation sheets for the experimental class and control class, and posttest question sheets. RPP is used as a learning tool that contains objectives and steps according to the learning model used. Student Activity Sheets (LAS) are used as a means to assist in the process of learning activities carried out during research, by loading several problems for students to solve. The observation sheet is used as a guide for observing and assessing the implementation of the learning process in the research that has been done. While the posttest questions are used to measure and compare the results of students' mathematical reasoning abilities after being given treatment.

2. Perform validation

Validation in this study was given to 3 experts, namely 2 mathematics lecturers and 1 mathematics teacher who is competent in his field. The validation was carried out on previously designed research instruments such as lesson plans, LAS, observation sheets, and posttest questions. The RPP is validated by experts by considering several aspects of the assessment, namely the quality of the RPP format, materials, language, and the presentation process which contains the phases in HOTS-based PBL. In the Student Activity Sheet (LAS), the validator provides an assessment based on aspects of instructions, language and content related to the suitability of the material in LAS with KD, learning objectives, and activities that contain phases of HOTS-based PBL. The observation sheet is validated based on the aspects of instructions, language, and teacher and student activities according to the stages in the lesson plan. While the posttest questions were analyzed through validity tests, reliability tests, difficulty levels, and discriminating power. As for the validation test on the posttest questions, it is validated by considering the assessment aspects of the material, construction, and language where each item contains indicators of students' mathematical reasoning and is included in the HOTS question category, namely C4, C5, and C6. Furthermore, after obtaining validation results by 3 experts, then the validity scores on all research instruments will be converted into 5 categories, namely invalid, less valid, moderately valid, valid, and very valid.

3. Carry out revision

The revision process is used as a process of improving the research instrument based on suggestions or input from the 3 validators, so that the research instrument is feasible for use in research.

4. Carry out research

This research was conducted at MTsN 3 Nganjuk in class VIII for the 2021/2022 academic year. The sample chosen in this study was class VIII-I as the experimental class and class VIII-J as the control class. Prisms and pyramids were used in this study to see whether the HOTS-based problem-based learning approach had an impact on the mathematical reasoning skills of class VIII pupils at MTsN 3 Nganjuk.

5. Carry out data analysis

The data analyzed were posttest result data which were conducted in the experimental class and control class after being treated, using a descriptive analysis test, as well as the *t-test*. The descriptive data shows how the posttest questions were utilized to calculate the students' scores for their propensity for mathematical reasoning in the experimental class and the control class, which are then converted into five categories namely, very low, low, medium, high and very high. The five categories used to measure scores of mathematical reasoning abilities are:

Table 2. Mathematical reasoning score categories for each student

Score	Category
$X < 20{,}012$	Very low
$20{,}012 \leq X \leq 40{,}004$	Low
$40{,}004 < X \leq 59{,}996$	Medium
$59{,}996 < X \leq 79{,}988$	High
$X > 79{,}988$	Very high

Table 3. The category of mathematical reasoning scores for all students

Score	Category
$X < 660$	Very low
$660 \leq X \leq 1.320$	Low
$1.320 < X \leq 1.980$	Medium
$1.980 < X \leq 2.640$	High
$X > 2.640$	Very high

Table 4. Category of score students mathematical reasoning indicator 1 and 4

Score	Category
$X < 99$	Very low
$99 \leq X \leq 198$	Low
$198 < X \leq 297$	Medium
$297 < X \leq 396$	High
$X > 396$	Very high

Table 5. Category of score students mathematical reasoning indicator 2,3 and 5

Score	Category
$X < 132$	Very low
$132 \leq X \leq 264$	Low
$264 < X \leq 396$	Medium
$396 < X \leq 528$	High
$X > 528$	Very high

Table 6. Category of score students mathematical reasoning indicator 6

Score	Category
$X < 66$	Very low
$66 \leq X \leq 132$	Low
$132 < X \leq 198$	Medium
$198 < X \leq 264$	High
$X > 264$	Very high

Next, the data is processed by normality, homogeneity and *t-test* to state a conclusion from the existing hypothesis in the study. The *independent sample t-test* and the *one sample t-test* were applied to conduct the *t-test*. The first hypothesis was made using the *independent sample t-test*, namely whether there is a difference in the average mathematical reasoning abilities of students with the experimental and control classes. Meanwhile, the *one sample t-test* was used to state the second hypothesis, namely whether the HOTS-based PBL model was effective on students' mathematical reasoning abilities.

RESULT AND DISCUSSION

After the researcher carried out the learning activities using the HOTS-based PBL model, the researcher conducted the research by providing 5 posttest questions containing HOTS questions in the form of C4, C5, and C6 level questions, and containing indicators of mathematical reasoning, namely (1) making a conjecture, (2) doing mathematical manipulation efforts, (3) finding patterns of mathematical problems, (4) compiling a proof and giving reasons for the truth of the solution, (5) drawing a conclusion from a statement, (6) examining the veracity of a claim. Furthermore, the results of student scores from the post-test questions will be tested for data analysis to state a conclusion from the purpose of this study. The study's findings and analysis are:

1. **The Results of Students' Mathematical Reasoning Abilities with The Problem-based Learning HOTS-based Model (experimental class)**

Posttest results data in the experimental class are presented through descriptive statistical tests, namely:

Table 7. *Posttest* Class Experiment Result

Descriptive Statistics							
	N	**Min**	**Max**	**Sum**	**Mean**	**Std. Deviation**	**Variance**
Experimental Class Posttest Value	33	67	88	2.544	77,09	5,180	26,835
Valid N (listwise)	33						

Table 7 above shows the total *posttest* scores of all students in the experimental class of 2.544, with a minimum score of 67, a maximum score of 88, and a mean rating of 77,09.

Table 8. Category Posttest Scores for All Experimental Class Students

Score	Category	Frequency	Percentage
$X < 20{,}012$	Very low	-	-
$20{,}012 \leq X \leq 40{,}004$	Low	-	-
$40{,}004 < X \leq 59{,}996$	Medium	-	-
$59{,}996 < X \leq 79{,}988$	High	21 student	64%
$X > 79{,}988$	Very high	12 student	36%

Table 8 shows that the posttest scores of 21 students reached the high category, and 12 students achieved scores that were in the very high category.

In addition, data from the posttest results of mathematical reasoning abilities were analyzed based on the indicators of mathematical reasoning. Mathematical reasoning ability is said to be good if students get scores on each indicator at least in the high category. The mathematical reasoning posttest scores of the experimental class are presented in Table 9.

In Table 9, indicator 1 is proposing a very high-category of conjecture, indicator 2 is making high category mathematical manipulation efforts, indicator 3 is finding patterns from mathematical problems to make generalizations of a very high category, indicator 4 is compiling evidence and gives reasons for the truth of the solution is in the high category, on indicator 5 is concluding a statement in the high category, and on indicator 6 is checking the validity of an argument in the high category. Therefore, the level of students' mathematical reasoning can be said to be good and overall students have been able to apply the six indicators of mathematical reasoning. Consequently, the HOTS-based PBL paradigm can be used to help students' mathematical reasoning. The findings of this study are consistent with those of earlier investigations, that the student's mathematical reasoning has increased with the application of the PBL models (Abidah et al., 2021; Septianawati & Abdilah, 2021; Kotto et al., 2022).

Table 9. Category of Students' Mathematical Reasoning Score in Experiment Class

Indicator of Mathematical Reasoning	Score					Total score	Category
	Question 1	Question 2	Question 3	Question 4	Question 5		
Indicator 1	76	93	83	96	89	437	Very High
Indicator 2	92	64	106	72	74	408	High
Indicator 3	116	132	132	132	116	628	Very high
Indicator 4	163	0	113	0	103	379	High
Indicator 5	89	112	102	100	86	489	High
Indicator 6	107	0	96	0	0	203	High

2. **Results of Students' Mathematical Reasoning Abilities Between Conventional Learning Models (control class)**

Posttest score data in the control class were analyzed descriptively. Here are the details:

Table 10. *Posttest* Class Control Result

Descriptive Statistics							
	N	Min	Max	Sum	Mean	Std. Deviation	Variance
Control Class Posttest Value	33	52	79	2.233	67,67	7,016	49,229
Valid N (listwise)	33						

In Table 10, the total posttest scores of all students in the control class are 2.233, with a minimum score of 52, a maximum score of 79, and an average score of 67,67.

Table 11. Category Posttest Scores for All Control Class Students

Score	Category	Frequency	Percentage
$X < 20{,}012$	Very low	-	-
$20{,}012 \leq X \leq 40{,}004$	Low	-	-
$40{,}004 < X \leq 59{,}996$	Medium	4 student	12%
$59{,}996 < X \leq 79{,}988$	High	29 student	88%
$X > 79{,}988$	Very high	-	-

Table 11 shows that the post-test scores of 4 students reach the medium category, and 29 students reached the high category.

In addition, the data from the post-test results were analyzed based on the indicators of mathematical reasoning. Mathematical reasoning ability is said to be good, if students' scores on each indicator at least reach the high category. The acquisition of mathematical reasoning scores for all students in the control class is as follows:

Table 12. Category of scores students mathematical reasoning

Indicator of Mathematical Reasoning	Score					Total score	Category
	Question 1	Question 2	Question 3	Question 4	Question 5		
Indicator 1	70	80	74	92	93	409	Very high
Indicator 2	72	64	82	22	58	298	Medium
Indicator 3	116	117	132	126	113	604	Very high
Indicator 4	149	0	115	0	83	347	High
Indicator 5	86	68	82	83	62	381	Medium
Indicator 6	100	0	94	0	0	194	Medium

In Table 12, the mathematical reasoning ability in the control class on indicator 1 is to propose a very high category of conjecture, on indicator 2 is to make efforts to manipulate mathematics in the moderate category, on indicator 3 is to find patterns from mathematical problems to make generalizations in the very high category, on indicator 4 namely compiling evidence and giving reasons for the truth of the solution in the high category, on indicator 5 namely concluding a statement in the moderate category, and on indicator 6 namely checking the validity of an argument in the moderate category. Therefore, overall students in the control class were declared unable to apply the six indicators of mathematical reasoning, and the level of students' mathematical reasoning on indicator 2, indicator 5, and indicator 6 needed to be further improved.

3. The Effective of HOTS-Based PBL Models on Students' Mathematical Reasoning Ability

Based on the description of students' mathematical reasoning abilities, it is known that students in the experimental class have been able to apply all the indicators of mathematical reasoning used. Meanwhile, students in the control class were stated to be unable to apply all the indicators of mathematical reasoning used. Additionally, students in the experimental class performed better on posttests on average than students in the control group did. Thus, the HOTS-based PBL paradigm has an impact on students' mathematical reasoning. Researchers conducted data analysis to draw a conclusion from this study using the t-test after the data were examined for normality using *Kolmogorov-Smirnov* and homogeneity using *Levene Statistics*. According to the Kolmogorov-Smirnov test in the experimental class $> 0{,}05$ $[0{,}200 > 0{,}05]$, and result in Sig. in the control class $> 0{,}05$ $[0{,}200 > 0{,}05]$. Depending on decision making if the value of Sig. $> 0{,}05$, So H_0 accepted and H_1 rejected. So, the two samples come from normally distributed populations. Hence, the homogeneity test with Levene Statistics is worth more than 0.05. Therefore, the variance between the experimental and control groups is the same or similar.

First hypothesis is used to state whether there is an average difference in the mathematical reasoning abilities of students who use the HOTS-based PBL and conventional models. The first hypothesis was tested with an independent sample t-test. Following are the results of the first hypothesis test:

Table 13. the results of the first hypothesis test

Independent Samples t-Test						
		t-test for Means of Equality				
		t	Df	Sig.(2-tailed)	Mean Difference	Std.Error Difference
Posttest Result	Equal variances assumed	6,207	64	,000	9,42424	1,51822
	Equal variances not assumed	6,207	58,895	,000	9,42424	1,51822

From Table 13 above, the Sig. (2-tailed) is obtained more than 0.05, namely $[0.000 < 0.05]$, then H_0 is rejected. That is, there is an average difference with students' mathematical reasoning applied to the HOTS-based PBL model and that applied to the conventional model.

Meanwhile, the second hypothesis test is used to state whether the HOTS-based PBL models is effective on students' mathematical reasoning abilities. If the average score of students' mathematical reasoning falls into the high category, which is greater than 60, the HOTS-based PBL methodology is deemed effective. This second hypothesis test is analyzed using the one sample t-test and a significance level of 0.05 or 5%. The following are the results of the second hypothesis test:

Table 14. Second Hypothesis Test Results

One-Sample t-Test						
	Test Value = 60					
	t	Df	Sig.(2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Experiment Class Posttest Results	18,953	32	,000	17,0909	15,254	18,928

From Table 14, the value of Sig. (2-tailed) obtained more than 0.05 is $[0{,}000 < 0{,}05]$, so H_0 rejected. That is, the mean posttest of students using the HOTS-based PBL models is more than 60. Thus, it can be said that the HOTS-based PBL paradigm improves students' capacity for mathematical reasoning.

Based on the results of the first hypothesis test, it has been stated that there is a difference in the average mathematical reasoning of students using the HOTS-based PBL model and the conventional model. The average mathematical reasoning ability with the HOTS-based PBL learning model is higher than students who use the conventional models, namely the posttest experimental class gets an average score of 79,09, whereas the control class posttest gets an average score of 67,67. Additionally, based on the findings of the second hypothesis test, it is also stated that the average posttest score of students utilizing the HOTS-based PBL model is greater than 60, indicating that the model is successful in improving students' mathematical reasoning.

Thus, the results of this research can be states that the use of the HOTS-based problem-based learning models is effective on students’ mathematical reasoning abilities. This matter is also in line with prior investigation that treatment with the PBL models had an effect on the results of students' mathematical reasoning abilities (Farida et al., 2018; Rohmatullah et al., 2022). In addition, the research results found by (Rlisya et al., 2022) that questions that use the HOTS (Higher Order Thinking Skills) type can support students' mathematical reasoning abilities, because with HOTS questions students will be required to think at a higher level and also involve their reasoning processes, such as students applying various knowledge that has been previously learned into a new context. or a more complex way.

CONCLUSION

Based on the previous justification, it has been concluded, Posttest results for experimental class students obtained a total score of 2.544, with a minimum score of 67, a maximum score of 88, and an average score of 77,09. While the results of students' mathematical reasoning were obtained on indicator 1 and indicator 3, which were in the very high category. Indicator 2, indicator 4, indicator 5, and indicator 6 are in the high category. So that overall students have been able to apply the six indicators of mathematical reasoning.

The posttest results in the control class show that the total posttest scores of all students in the control class are 2.233, with a minimum score of 52, a maximum score of 79, and an average score of 67,67. Meanwhile, the result of reasoning. Mathematical students in the control class on indicator 1 and indicator 3 are in the very high category. Indicator 4 is in the high category. Meanwhile, indicator 2, indicator 5 and indicator 6 are in the moderate category. Therefore, overall students in the control class were declared unable to apply the six indicators of mathematical reasoning.

The results of the first hypothesis test show that there is a difference in the average ability reasoning mathematics between students who use the HOTS-based PBL and conventional learning models. The findings of the second hypothesis test, however, revealed that the HOTS-based problem-based learning approach was successful in enhancing students' capacities for mathematical reasoning. So, It can be concluded from this study that the HOTS-based problem-based learning approach has an impact on ability. The material of the flat sides of prisms and pyramids is the subject of mathematical argumentation in class VIII MTsN 3 Nganjuk.

Based on the conclusions above, to be able to develop reasoning abilities. students' mathematics, there are suggestions from researchers namely: 1) When learning, the teacher should use the HOTS-based PBL models to improve students' mathematical reasoning. Because the HOTS-based PBL model is more student-centered. 2) Students are urged to participate more actively in the learning process in order to enhance their capacity for mathematical thinking. 3) The research process carried out certainly has limitations, such as limitations on time and learning materials. Thus, for further research that examines students' mathematical reasoning with the HOTS-based PBL learning model, it is suggested that it be carried out with a longer time and the material provided is more complete, so that students' mathematical reasoning abilities can continue to increase and be of good quality.

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REFERENCES

Abidah, N., Hakim, L. El, & Wijayanti, D. A. (2021). Upaya meningkatkan kemampuan penalaran matematis siswa melalui model problem based learning pada materi aritmetika sosial. *Jurnal Riset Pendidikan Matematika Jakarta*, *3*(1), 58–66. http://journal.unj.ac.id/unj/index.php/jrpmj/article/view/15524

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching and assessing: a revision of bloom's taxonomy of educational objectives: Complete edition*. Longman

Arends, R. I. (2012). *Learning to teach* (9th ed.). Mc Graw Hill.

Ariati, C., & Juandi, D. (2022). Kemampuan penalaran matematis: Systematic literature review. *LEMMA: Letters Of Mathematics Education*, *8*(2), 61–75.

Asdarina, O., & Ridha, M. (2020). Analisis kemampuan penalaran matematis siswa dalam menyelesaikan soal setara PISA konten geometri. *Jurnal Numeracy*, *7*(2), 192–206.

Creswell, J. W. (2012). *Educational Research* (4 th). Pearson.

Farida, A. R., Caswita, & Gunawibowo, P. (2018). Pengaruh model problem based learning terhadap kemampuan penalaran matematis siswa. *Jurnal Pendidikan Matematika Unila*, *6*(7), 644–654.

Fraenkel, J. R., Wallen, N., & Hyun, H. H. (2023). *How to design and evaluate research in education* (11 th). Mc.Graw Hill.

Harahap, N., Siregar, E. Y., & Harahap, S. D. (2020). Efektivitas penggunaan model pembelajaran problem based learning (pbl) ditinjau dari kemampuan penalaran matematis siswa. *Jurnal MathEdu*, *3*(1), 69–78. http://journal.ipts.ac.id/index.php/MathEdu/article/view/1157

Hardani. (2020). Metode penelitian kualitatif & kuantitatif. Pustaka Ilmu.

Herman, T., Hasanah, A., Candra Nugraha, R., Harningsih, E., Aghniya Ghassani, D., Marasabessy, R., & Studi Pendidikan Matematika, P. (2022). pembelajaran berbasis masalah-high order thinking skill (HOTS) pada materi translasi. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *06*(01), 1131–1150.

Jailani, Sugiman, Retnawati, H., Bukhori, Apino, E., Djidu, H., & Arifin, Z. (2018). *Desain pembelajaran matematika untuk melatihkan higher order thinking skills*. UNY PRESS.

Khaeroh, A., Anriani, N., & Mutaqin, A. (2020). Pengaruh model pembelajaran problem based learning terhadap kemampuan penalaran matematis. *TIRTAMATH: Jurnal Penelitian Dan Pengajaran Matematika*, *2*(1), 73–85. https://doi.org/10.48181/tirtamath.v2i1.8570

Kotto, M. A., Babys, U., & Gella, N. J. M. (2022). Meningkatkan kemampuan penalaran matematika siswa melalui model PBL (problem based learning). *Jurnal Sains Dan Edukasi Sains*, *5*(1), 24–27.

Ma'ruf, A. H., Syafi'i, M., & Kusuma, A. P. (2019). Pengaruh model pembelajaran mind mapping berbasis hots terhadap motivasi dan hasil belajar siswa. *Mosharafa: Jurnal Pendidikan Matematik*, *8*(3), 503–514.

Masitoh, L. F., & Aedi, W. G. (2020). pengembangan instrumen asesmen higher order thinking skills (HOTS) matematika di SMP kelas VII. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *4*(2), 886–897. https://doi.org/10.31004/cendekia.v4i2.328

NCTM. (2000). *Principles and standards for school mathematics*. National Council of Teachers of Mathematics.

Nurdyansyah, & Fahyuni, E. F. (2016). Inovasi model pembelajaran sesuai kurikulum 2013 (1th ed.). Nizamial Learning Center.

Oktaviana, V., & Aini, I. N. (2021). Deskripsi kemampuan penalaran matematis siswa SMP kelas VIII. *JPMI: Jurnal Pembelajaran Matematika Inovatif*, *4*(3), 587–600. https://doi.org/10.22460/jpmi.v4i3.587-600

Rahman, L., Fitraini, D., & Fitri, I. (2019). Pengaruh penerapan model discovery learning terhadap kemampuan penalaran matematis ditinjau dari pengetahuan awal siswa SMP Negeri 3 Tambang Kabupaten Kampar. *JURING (Journal for Research in Mathematics Learning)*, *2*(1), 001–010. https://doi.org/10.24014/juring.v2i1.7467

Rlisya, I. P., Fonna, M., & Listiana, Y. (2022). Analisis soal–soal tipe HOTS tingkat SMP untuk mendukung kemampuan penalaran matematis siswa. *Jurnal Pendidikan Matematika*, *2*(2), 64–71.

Rohmatullah, Syamsuri, Nindiasari, H., & Fatah, A. (2022). Analisis meta: Pengaruh model pembelajaran problem based learning (pbl) terhadap kemampuan penalaran matematis siswa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *06*(02), 1558–1568.

Saraswati, P. M. S., & Agustika, G. N. S. (2020). Kemampuan berpikir tingkat tinggi dalam menyelesaikan soal HOTS mata pelajaran matematika. *Jurnal Ilmiah Sekolah Dasar*, *4*(2), 257–269. https://doi.org/10.23887/jisd.v4i2.25336

Septianawati, E., & Abdilah, E. (2021). Kemampuan penalaran matematis ditinjau dari model problem based learning dengan contextual teaching and learning. *Kontinu: Jurnal Penelitian Didaktik Matematika*, *5*(2), 80–87.

Sugiyono. (2013). Metode penelitian kuantitatif, kualitatif, dan R & D. Alfabeta.

Wedekaningsih, A., Koeswati, H. D., & Giarti, S. (2019). Penerapan model discovery learning untuk meningkatkan keterampilan berpikir kritis dan hasil belajar matematika. *Jurnal Basicedu*, *3*(1), 21–26. https://doi.org/10.31004/basicedu.v3i1.62