Asian Journal of Education and Social Studies

Volume 48, Issue 2, Page 78-91, 2023; Article no.AJESS.103956
ISSN: 2581-6268

The Effect of Inquiry and Problem-Based Learning Models on Understanding of Mathematics Concepts Viewed from Student Learning Motivation

Desi Wahyuni Nurlaili [a++*], Zurweni [b] and Syaiful [b]

[a] *State Senior High School, Tanjung Jabung Timur, Indonesia.*
[b] *Department of Education, Universitas Jambi, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJESS/2023/v48i21054

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103956

Original Research Article

Received: 29/05/2023
Accepted: 03/08/2023
Published: 12/08/2023

ABSTRACT

This study aims to find out The Effect of Inquiry and Problem-Based Learning (PBL) Models on Understanding of Mathematics Concepts Viewed from Student Learning Motivation. The study employed the quantitative research approach with a quasi-experimental design. Data obtained with the pattern of pretest and posttest. Based on data analysis and discussion, it was be concluded that: (1) there is an influence of Inquiry and PBL learning models on students' understanding of mathematical concepts. This is because the Inquiry and Problem-Based Learning (PBL) model syntax can help students develop their ability to understand mathematical concepts, (2) there is an effect of high learning motivation, moderate learning motivation, and low learning motivation on

[++] *Professional Teacher;*
**Corresponding author: Email: nurlailidesiwahyuni@gmail.com;*

students' understanding of mathematical concepts after applying the learning model, (3) there is the interaction between the Inquiry learning model, the Problem-Based Learning (PBL) learning model, and Direct Instruction (DI) with learning motivation in influencing the ability to understand mathematical concepts. Therefore, mathematics teachers should pay attention to students' learning motivation towards their abilities and apply Inquiry or Problem-Based Learning (PBL) learning models that help increase students' understanding of mathematical concepts.

Keywords: Inquiry; problem based learning; mathematics concepts; learning motivation.

1. INTRODUCTION

Mathematics is a field of study that has a very important role in 21st-century [1]. Given the important role of mathematics, efforts to improve the mathematics teaching system have always been a concern of many parties. According to Jonsson et al. [2] and Wardhani [3], one of the general goals of mathematics education in schools is to understand mathematical concepts, explain the interrelationships between concepts, and apply concepts or algorithms in a flexible, accurate, efficient, and precise manner in understanding concepts. In line with this, reforms in centralized mathematics education began to shift from teacher-centered to student-centered classroom teaching practices [4].

The ability to understand mathematical concepts is one of the important goals in learning mathematics [5-7]. In addition, the National Council of Teachers of Mathematics [7] also states that the vision of school mathematics is based on students' learning mathematics accompanied by understanding. With an understanding of the concept, students will try to find problems and solve them [8-10], (Minarni et al., 2016; Utami et al., 2017).

In general, the ability of mathematics in Indonesia is low. Based on research that was conducted by Astrianal et al. [11] found problems with understanding concepts in learning mathematics. These problems include students still having difficulty presenting a concept with various forms of representation, for example, students still have difficulty understanding word problems, so students tend to still be wrong in writing in the form of mathematical models. In addition, based on the results of the initial observations that the researchers conducted on class XI students at Tanjung Jabung Timur 1 Public High School on March 4, 2022, it was found that student's understanding of concepts was still relatively low.

Several factors influence the low understanding of students' mathematical concepts, namely psychological factors that exist within individual students. Psychological factors will create a desire, encouragement, and enthusiasm for learning, or move students to study more actively. These psychological factors include learning motivation [12]. The motivation to learn determines the extent of choice, involvement, effort, and persistence of students [13]. “Learning motivation is one of the factors that influence learning effectiveness” [14]. “Motivation to learn makes a good contribution to understanding the concept. Students who have high learning motivation, the higher mathematics learning outcomes” [15].

To help students to be more active, teachers can make various changes or add new things in teaching mathematics by trying to choose various learning models that can increase students' understanding of mathematical concepts. By the explanation of Annajmi, [16] which explains that the teacher is a motivator and an example for students, what is done by the teacher will be imitated by students. Therefore, the teacher must be professional in his field. Professional teachers must master the subject matter and curriculum as well as know and be able to use learning models to maximize student learning outcomes.

According to Yanda et al. (2019) and Gunur et al. [17] that one way to help students understand mathematical concepts as well as generate motivation is by applying the Inquiry learning model, this model encourages an active role and supports student activity in understanding a material that leads to expanding understanding of mathematical concepts rather than rote memorization. which leads to mere mastery of formulas. Meanwhile Risnawati [18] explained that the Inquiry learning model is a learning model that can improve students' understanding of mathematical concepts by involving students to be independent, creative, and more active. The Inquiry learning model has main characteristics that emphasize student activities to seek and find their answers to something in question so that they can develop their potential such as thinking systematically, logically, and critically [19].

According to Daryanto [20], “the Inquiry learning model emphasizes the development of cognitive, affective, and psychomotor aspects in a balanced way”. With their learning style and can serve the needs of students who have abilities above average. This is in line with Pratiwi et al. [21] argument that there are advantages to the Inquiry model, namely learning becomes meaningful and can be embedded in the minds of students because students are allowed to do, try, and experience for themselves and not even just be passive listeners, and the teacher does not only transferring knowledge to students, but students are also directly involved in the learning process. This is supported by previous research conducted by Warmi [22], which stated that “learning using the Inquiry model is better than the direct learning model”.

The other learning model that can be used to improve understanding of mathematical concepts and students' learning motivation is the PBL model. According to research by Yanda et al. (2019) and Handayani [23], the PBL model is effective in increasing understanding of mathematical concepts as well as arousing student motivation. Ariandy [24] also found that the PBL model helps students to increase their understanding of a concept. Arends [25] also states that “the PBL model is a learning model in which students are faced with authentic (real) problems that require an understanding of concepts”.

Based on the explanation above, further research is needed. In line with this problem, the researcher determined the research title, namely "The Influence of Inquiry and Problem-Based Learning Models on Understanding Mathematical Concepts Given the Learning Motivation of High School Students". Thus this study aims to (1) determine the effect of applying Inquiry, Problem-Based Learning, and Direct Instruction learning models on students' understanding of mathematical concepts, (2) determine the effect of learning motivation on students' understanding of mathematical concepts, and (3) to determine the interaction between learning using the Inquiry, PBL, and Direct Instruction (DI) models with learning motivation on the ability to understand students' mathematical concepts.

2. METHODS

The research method used is quantitative research, with the type of research used is Quasi-Experimental. This is by what was stated by Sugiyono [26] that a quasi-experiment is a study that is close to a real experiment. This experimental research used the Nonequivalent Control Group Design. Namely dividing the research group into an experimental group and a control group, then giving a treatment, and after that giving a Posttest understanding of mathematical concepts. In experimental group 1 the Inquiry learning model was applied and in experimental group 2 the PBL model was applied to see the ability to understand mathematical concepts a comparison group was needed without special treatment, namely, the control group with Direct Instruction (DI) applied.

To determine the effect of the Inquiry and PBL learning models on the ability to understand mathematical concepts in terms of students' learning motivation, the research design is used which is contained in the following Table 1.

The instruments used in this study were learning devices, observation sheets, learning motivation questionnaire instruments, and mathematical concept understanding test instruments. The observation sheets in this study consisted of two kinds, namely student observation sheets and teacher observation sheets. Observation sheets are used to measure or assess the learning process, namely the activities of students during learning and teacher activities during teaching. Filling in the observation sheet is done by placing a check mark (√) in the answer column of the teacher and student observation sheet. Teacher activity observation sheets are used to monitor teachers and measure the quality of teaching and learning processes. The student activity observation sheet in this study consisted of student activity observation sheets using the Inquiry, PBL, and DI learning models.

In addition to the observation sheet, another instrument used in this research is test questions. In this study, the test used to determine the ability to understand students' mathematical concepts is a description test. The concept understanding test is used when carrying out the Pretest and Posttest. While the questionnaire used in this study was closed.

Table 1. Research design

Group Selection	Pretest	Treatment	Posttest
Experiment 1 (Inquiry)	O_1	X_1	O_2
Experiment 2 (PBL)	O_3	X_2	O_4
Control (Direct Instruction)	O_5	$-$	O_6

Information:
O_1, O_3, O_5: Pretest experimental group 1, experimental group 2, and control group
O_2, O_4, O_6: Posttest experimental group 1, experimental group 2, and control group.
X_1: Treatment of Inquiry learning model
X_2: Implementation of the PBL learning model

3. RESULTS

3.1 Data on Student Learning Motivation

Data on students' learning motivation was obtained through a questionnaire on students' learning motivation which was given at the beginning of learning in the experimental class I, experiment II, and control class. The results of the learning motivation questionnaire that has been filled in by students can be presented in Table 2 as follows:

3.2 Data Analysis Ability to Understand Mathematical Concepts

Data on students' conceptual understanding abilities were obtained from the results of the Posttest that students worked on after being given treatment in the experimental class and the control class. The test questions given are about the material for sequences and series. Posttest data descriptions can be seen in Table 3.

Based on Table 3 it can be seen that the minimum score in experimental class 1 is 73, in experiment II it is 68 and in the same control class it is 63. The maximum value in the experimental class I, experiment II, and control class is 88, 93, and 90 respectively. The mean value for class experiment I was 79.53. The average value for the experimental class II is 79.23. And the average value for the control class is 75.82.

3.3 Normality Test

Before entering into hypothesis testing, first, perform a prerequisite analysis test for the Posttest value data by testing its normality and homogeneity. The normality test results for students' Posttest scores are shown in the following Table 4.

Based on the decision-making criteria, if the significance value is ≥ 0.05 then $H0$ is accepted, and if the significance value is <0.05 then $H0$ is rejected. The table shows that for the experimental class I, experimental class II, and control class the significance value is greater than 0.05. So it can be concluded that $H0$ is accepted, namely the Posttest value data for the experimental class I, experimental class II, and the control class is normally distributed.

3.4 Homogeneity Test

After the data is tested for normality, then the Posttest data is tested for homogeneity. The results of the homogeneity test of students' Posttest scores can be seen in Table 5.

Based on the decision-making criteria, if the significance value ≥ 0.05 then $H0$ is accepted, but if the significance value is < 0.05 then $H0$ is rejected. Based on Table 5 above, it can be seen that the significance value is ≥ 0.05, so $H0$ is accepted, that is, the students' Posttest value data have the same or homogeneous variance.

3.5 Test Dependent Sample T-Test

After carrying out the normality test and homogeneity test on the Posttest data, the dependent sample t-test is then carried out. The results of the dependent sample t-test for the three classes can be seen in Table 6.

Based on decision making where the value of Sig. (2-tailed) ≥ 0.05 then there is a significant difference, otherwise if the value of Sig. (2-tailed) < 0.05 There is no significant difference in the Pretest and Posttest data. It is known from Table 6 the dependent sample t-test above that for the experimental class I the value of Sig. (2-tailed) ie 0.000 < 0.05. The experimental class II got a Sig. (2-tailed) 0.000 < 0.05. The control class also got the same significance value as the experimental class I and experimental class II, namely Sig. (2-tailed) 0.000 < 0.05. Because it is known the value of Sig. (2-tailed) for the three classes is

0.000 where the value is 0.000 <0.05, so it can be understood that there is a significant or real difference between the Pretest scores and Posttest scores for understanding mathematical concepts.

3.6 N-Gain Test

In this study a gain normalization test or n-gain test was also carried out, this test aims to see the effectiveness of using the Inquiry, PBL, and DI learning models for understanding mathematical concepts. The results of the n-gain test can be seen in Table 7.

Based on the results of the N-gain test in Table 7, it can be seen that:

1. The results of the calculation of the N-gain test show that the average N-gain score for the experimental class I with the Inquiry learning model is 58.36%. Based on the table of categories for interpreting the effectiveness of N-gain in percent form, this value is included in the moderately effective category.
2. The results of the N-gain test calculations show that the average N-gain score for experimental class II with the PBL learning model is 58.73%. Based on the table of categories for interpreting the effectiveness of N-gain in percent form, this value is included in the less effective category.
3. The results of the calculation of the N-gain test show that the average value of the N-gain score in the control class with the DI learning model is 48.90%. Based on the table of categories for interpreting the effectiveness of N-gain in percent form, this value is included in the less effective category. So, it can be understood that the class that was given the treatment of Inquiry and PBL learning models was quite effective in increasing understanding of mathematical concepts while classes with the DI learning model were less effective in increasing understanding of mathematical concepts.

Table 2. Student learning motivation questionnaire results

Learning motivation	**Learning model**					
	Inquiry	**Percentage**	**PBL**	**Percentage**	**DI**	**Percentage**
High	17	53,12%	15	50%	10	29,41%
Moderate	12	37,5%	9	30%	19	55,89%
Low	3	9,38%	6	20%	5	14,7%
Total	32	100%	30	100%	34	100%

Table 3. Posttest value data description understanding mathematical concepts

Descriptive statistics					
	N	**Mean**	**Std. deviation**	**Minimum**	**Maximum**
INQUIRY	32	79.53	4.572	73	88
PBL	30	79.23	5.703	68	93
DI	34	75.82	7.346	63	90

Table 4. Posttest data normality test for understanding mathematical concepts

One-Sample Kolmogorov-Smirnov Test				
		INQUIRY	**PBL**	**DI**
N		32	30	34
Normal parameters a, b	Mean	79.53	79.23	75.82
	Std. Deviation	4.572	5.703	7.346
Most extreme differences	Absolute	.147	.112	.146
	Positive	.147	.104	.092
	Negative	-.093	-.112	-.146
Test statistic		.147	.112	.146
Asymp. Sig. (2-tailed)		.078c	.200c,d	.064c

Table 5. Posttest data homogeneity ability to understand mathematical concepts

Test of homogeneity of variance					
		Levene statistic	**df1**	**df2**	**Sig.**
Post-Test	Based on Mean	4.692	2	93	.011
	Based on Median	3.523	2	93	.034
	Based on the Median and with adjusted df	3.523	2	77.819	.034
	Based on trimmed mean	4.699	2	93	.011

Table 6. Dependent sample T-test

Paired Samples Test									
		Paired Differences					**t**	**Df**	**Sig. (2-tailed)**
		Mean	**Std. deviation**	**Std. error mean**	**95% confidence interval of the difference**				
					Lower	**Upper**			
Pair 1	Pre-Test Inquiry Post-Test Inquiry	-28.688	11.591	2.049	-32.866	-24.509	-14.001	31	.000
Pair 2	Pre-Test PBL Post-Test PBL	-29.567	10.631	1.941	-33.536	-25.597	-15.233	29	.000
Pair 3	Pre-Test DI Post-Test DI	-23.147	13.324	2.285	-27.796	-18.498	-10.130	33	.000

Table 7. N-Gain test results

Class	**Mean**		**N-Gain %**	**Category normalized**	**Effectiveness category**
	Pre-test	**Post-test**			
Inquiry	50.84	79.53	58,36	Moderate	Effective enough
PBL	49.67	79.23	58,73	Moderate	Effective enough
DI	52.68	75.82	48,90	Moderate	Effective enough

Table 8. Two-way ANOVA hypothesis test results

Tests of between-subjects effects						
Dependent variable: Concept understanding						
Source	**Type III Sum of squares**	**df**	**Mean square**	**F**	**Sig.**	**Partial Eta squared**
Corrected model	2770.069a	8	346.259	34.138	.000	.758
Intercept	404389.539	1	404389.539	39869.297	.000	.998
Model	115.826	2	57.913	5.710	.005	.116
Motivation	2293.757	2	1146.878	113.072	.000	.722
Model * Motivation	143.408	4	35.852	3.535	.010	.140
Error	882.431	87	10.143			
Total	589590.000	96				
Corrected Total	3652.500	95				

a. R Squared = .758 (Adjusted R Squared = .736)

3.7 Hypothesis Test

After fulfilling the assumptions for testing the hypothesis, then testing the hypothesis using a two-way ANOVA test and further testing. Hypothesis testing using SPSS 25 software with a confidence level of 95%, if the significance level ≥ 0.05 then $H0$ is accepted. The results of testing the hypothesis using Two Way ANOVA are as follows:

Based on Table 8, the following results are obtained:

3.7.1 First hypothesis

$H0$: There is no effect of applying the Inquiry and PBL learning models on the ability to understand students' mathematical concepts.
$H1$: There is an effect of applying the Inquiry and PBL learning models to the ability to understand students' mathematical concepts.

3.7.2 Second hypothesis

$H0$: There is no effect of learning motivation on understanding mathematical concepts after applying the learning model.
$H1$: There is an influence of learning motivation on students' understanding of mathematical concepts after applying the learning model.

3.7.3 Third hypothesis

$H0$: There is no interaction between the Inquiry and PBL learning models with learning motivation on students' understanding of mathematical concepts.
$H1$: There is an interaction between the Inquiry and PBL learning models with learning motivation toward students' understanding of mathematical concepts.

There is an interaction between the Inquiry and PBL learning models with learning motivation toward students' understanding of mathematical concepts, it is necessary to carry out further tests, namely the Tukey test. Tukey's test was carried out to see Tukey's follow-up test was carried out to find out the differences in each class variable. Significant differences are marked with a * sign. The results of the follow-up test from the two-way ANOVA test above are as follows:

In Table 9 it can be seen that:

1. The average posttest results for students' understanding of mathematical concepts taught using Inquiry and PBL learning models have a difference of 0.29 points, where students' understanding of mathematical concepts taught using Inquiry learning is 0.29 points greater than students' understanding of mathematical concepts taught with the PBL model.
2. The average post-test results for students' understanding of mathematical concepts taught using the Inquiry learning model and the DI learning model have a difference of 3.70, where the student's understanding of mathematical concepts taught using Inquiry learning is 3.70 points greater than the participants' understanding of mathematical concepts students taught with the DI model.
3. The average posttest results for students' understanding of mathematical concepts taught by the PBL model and the DI model have a difference of 3.40, where the understanding of mathematical concepts of students taught by the PBL learning model is 3.40 points greater than the understanding of mathematical concepts of students taught by the model DI learning.

4. DISCUSSION OF RESEARCH RESULTS

After testing and based on the results of the two-way ANOVA that has been carried out on the results of the Posttest understanding of mathematical concepts of students in experimental class 1 after being taught with Inquiry learning and experimental class 2 with PBL learning on the ability to understand mathematical concepts, the significance value is 0.005 or <0.05, so $H0$ is rejected and $H1$ is accepted, in other words, there is an influence of the Inquiry and PBL learning models on students' understanding of mathematical concepts. This is in line with the results of research that has been conducted by Oktinasari & Prahmana [27] which states that Inquiry learning prioritizes teachers guiding students to find concepts through inquiry activities by asking initial questions and directing students in a discussion so that the ability to understand concepts will increase. Furthermore, according to Tanjung et al. [28] the ability to understand concepts increases because in the experimental class, students are more involved in the learning process and do more than just listen to the teacher's explanation so that learning is more meaningful. Then according to Mohammad et al. [29] stated that “learning models that use real problems in everyday life have a good impact on the learning process. This is because learning is more contextual and makes students more enthusiastic and able to discover the concepts of learning mathematics for themselves”.

Table 9. Class variable further tests

Multiple comparisons							
Dependent variable: Concept understanding							
	(I) Class Code	**(J) class code**	**Mean difference (I-J)**	**Std. error**	**Sig.**	**95% confidence interval**	
						Lower bound	**Upper bound**
Tukey HSD	Inquiry	PBL	.2979	.80936	.928	-1.6320	2.2278
		DI	3.7077*	.78440	.000	1.8373	5.5781
	PBL	Inquiry	-.2979	.80936	.928	-2.2278	1.6320
		DI	3.4098*	.79776	.000	1.5076	5.3120
	DI	Inquiry	-3.7077*	.78440	.000	-5.5781	-1.8373
		PBL	-3.4098*	.79776	.000	-5.3120	-1.5076
Bonferroni	Inquiry	PBL	.2979	.80936	1.000	-1.6778	2.2737
		DI	3.7077*	.78440	.000	1.7929	5.6226
	PBL	Inquiry	-.2979	.80936	1.000	-2.2737	1.6778
		DI	3.4098*	.79776	.000	1.4624	5.3572
	DI	Inquiry	-3.7077*	.78440	.000	-5.6226	-1.7929
		PBL	-3.4098*	.79776	.000	-5.3572	-1.4624

Based on observed means.
The error term is Mean Square (Error) = 10.143.
**. The mean difference is significant at the,05 levels.*

In experimental class 1 which uses the Inquiry learning model, the teacher starts the learning activity by giving student worksheets to students with learning steps based on the Inquiry learning model that has been compiled. This worksheet presents problems in everyday life related to material on sequences and series. Learning is done by using the method of group discussion which is divided heterogeneously. Using group discussions, it is hoped that students can support each other and exchange information and can work together in solving problems according to the syntax of the Inquiry learning model. Students use their learning abilities and experiences to find concepts according to the learning steps that have been made on the worksheet.

In Inquiry learning, the ability to understand concepts can be developed at the stage of problem orientation and formulating problems. In the problem orientation phase, students will understand the problem given, and write down what is known, and what is asked of the problem. Then students will explore ideas to get a method that can be used to solve the problem. Each student will have different ideas to solve the problem. Then in the problem formulation phase, students will determine the most suitable idea or method to solve the problem obtained from the previous stage. At this stage, students formulate problems or questions related to the problem orientation stage that has been carried out. At this stage, it trains students in the process of solving problems so that students can solve problems systematically and get the right solution. At the stage of formulating the problem, the teacher presents a problem by giving several daily life problems related to sequences and series that are often found in Inquiry-based worksheets, then the teacher asks students to determine the purpose of the problem.

The next stage is the stage of making a hypothesis and exploration (gathering information or data). At this stage, students make hypotheses that are by previous observations. Furthermore, the teacher gives students the freedom to determine the method used to get a solution to a given problem given the existing stimulations. This is in line with Noviwati et al. [30] who state “the advantages of the Inquiry model in this stage which emphasizes the development of cognitive, affective, and psychomotor aspects in a balanced way, so that inquiry learning is considered more meaningful; provide space for students to learn with their learning style; is a strategy that is considered by the development of modern learning psychology which is considered learning is a process of changing behavior thanks to experience; can serve the needs of students who have abilities above average”.

The next stage is exploration (gathering information or data). At this stage, the teacher directs students to use the information or data obtained to solve the problem. At this stage, the teacher also guides students to be able to gather as much information as possible in solving the problems to be solved. That way students will create solutions to the problems given and make conclusions for these problems and to be presented later.

The next stage is testing the hypothesis and making conclusions. At this stage, the teacher provides opportunities for students to present the results or solutions to existing problems. After the students' presentations, the teacher guides the students to exchange opinions to evaluate the results of the discussion and closes with the feedback given by the teacher for the student's work in completing the worksheet. These Inquiry learning steps can involve active students in the learning process as well as being able to improve their understanding of mathematical concepts. Overall learning has been running according to the average percentage of implementation, which is more than 85%, so it can be concluded that the Inquiry model is implemented in a good category.

In the experimental class using the PBL model, it was carried out with 5 steps or stages namely: student orientation to problems, organizing students to learn, guiding individual and group investigations, developing and presenting work, and analyzing and evaluating. In the early stages, namely the orientation of students to the problem, the teacher provides worksheets with PBL stages which contain problems related to sequences and series material, then at this stage the teacher asks students to understand the problems in the worksheet and discuss them in their respective groups.

The next stage is to organize students to learn. The teacher encourages students to define and find any information or facts related to the sequences and series on the worksheet, and the teacher will help exemplify what information can be taken from various sources related to the problem on the worksheet. By the opinion of Mustaffa et al. [31] stated that their findings indicate a positive impact on learning mathematics through PBL in schools. Learners deal with everyday life mathematical ideas. Thus, learning mathematics at school becomes meaningful and allows students to improve their thinking skills.

In the stage of guiding individual and group investigations, the teacher encourages students to obtain appropriate information, build ideas, and carry out experiments that can support completion activities and understanding of concepts on worksheets. Then at the stage of developing and presenting the results of the work, the teacher assists students in planning and preparing the results of their discussions to share with other friends. And in the last stage, namely the stage of analyzing and evaluating the process of understanding concepts, the teacher helps students to evaluate their investigations and their processes. Do not forget that the teacher reinforces the material that has been discussed so that students understand the concept of the material that has been studied.

In the entire learning process both in Inquiry and PBL classes, students seemed more active in the process of learning activities. Students can work together and argue in solving problems or completing worksheets that have been given. In addition, students are very enthusiastic about finding information and learning resources in solving the problems that have been given. This is also in line with research conducted by Marliana et al. [32], namely stating that the PBL model creates learning conditions that are not teacher-oriented because it makes students more active in learning activities so that after conducting research there is an influence of the PBL model on the ability to understand students' mathematical concepts.

Inquiry and PBL learning affect the understanding of mathematical concepts because in this learning syntax requires students to develop the ability to understand mathematical concepts that each student has. This is in line with the opinion of Karima et al. [33] said that students' understanding of mathematical concepts by using the Inquiry learning model is getting better. Also strengthened by the opinion of Yusri (2018), Siagan et al. (2019) that in applying the PBL learning model students better understand problems, plan problems, solve problems according to plan, and re-check or interpret solutions. Meanwhile, different things happened in the control class with DI learning, the teacher became a facilitator, and the learning process focused on delivering material from the teacher to the students.

After the learning process is carried out, students are then given Posttest questions which can improve the ability to understand students' mathematical concepts. This is because students are asked to solve problems with steps to understand mathematical concepts. Furthermore, students can use the appropriate steps in solving the problems given, namely in the tenth question above, students have written down the steps for solving the problem according to the indicators of understanding the concept. Students provide answers by restating the concept of arithmetic sequences correctly and solving these problems with correct calculations and finally students also complete them by restating the answers obtained with the questions given.

In the learning process in the PBL class, namely experiment 2, the teacher also provided a worksheet when PBL learning began. The worksheet provided is by the learning steps in the PBL model. Based on the student's answers to question number six, it was found that students could restate the given problem by rewriting the existing concepts in their sentences. Then students can classify problems with the steps that will be taken to solve them. Furthermore, students can make plans to solve problems with the concept of material for arithmetic sequences correctly. Students can use the right steps in solving these problems with correct mathematical calculations. However, at the time of solving the problem, students did not provide answers that match the problems given and did not state the answers obtained with the existing questions. So, the ability of students on all indicators of understanding the concept has not been fulfilled completely.

In the control class, students were also given worksheets according to DI learning. Students do not understand the problem, make plans, and check again, but students immediately carry out plans or implement strategies. Even so, students have been able to carry out completing answers slightly leading to answers that might be correct. When compared between the experimental class and the control class, the level of understanding of concepts in the experimental class is indeed superior to the control class, so it can be seen that the Inquiry I and PBL learning models have a positive effect on students' understanding of mathematical concepts.

Based on the description of the results of the completion of the Posttest students with indicators of understanding mathematical concepts that are by the real world make it easier for students to solve the problems given. According to Kesumawati. [34]; Lan et al., (2021); Warinangin et al. (2019) in a study to measure the ability to understand mathematical concepts students were given a concept understanding test in the form of questions about the material being taught according to indicators of understanding the concept. Therefore, a learning model is needed with a learning syntax that is by the indicators of understanding the concept to improve the ability to understand students' mathematical concepts. The Inquiry and PBL learning model are appropriate. This was confirmed by Barbieri et al. (2022), and Bigi et al. (2020) that the Inquiry learning model is a learning model that is oriented towards understanding concepts. Whereas Hsu et al. (2018), and Retnawati [35] that "PBL is a learning model that involves students solving problems through the stages of the scientific method so that students can learn knowledge related to these problems and at the same time have the skills to solve problems. From the research above, the application of Inquiry and PBL learning models in learning is feasible to increase students' understanding of mathematical concepts".

In addition, based on the results of the two-way ANOVA that has been carried out on the Posttest results of the ability to understand mathematical concepts of students in class XI IPA 1, XI IPA 2, and XI IPA 3 after being taught with Inquiry, PBL, and DI learning, it is obtained that the significance value for learning motivation is 0.000 (> 0.05), then $H0$ is rejected. In other words, there is an influence of high learning motivation, moderate learning motivation, and low learning motivation on student's ability to understand mathematical concepts after applying the learning model. This is in line with research by Diaz-Granados et al. [36] that students with high motivation usually like to do mathematics. E. A. Wulandari et al. [37] and Bjorklund [38] also state that learning motivation contributes to the ability to understand students' mathematical concepts. Furthermore, Maisyaroh Agsya et al. [39] said that learning motivation is a factor that causes the emergence of a desire from within students to carry out learning activities without coercion to get maximum learning results.

According to Lugosi & Urible [40], this is due to the enthusiasm of students in solving problems. Students become more enthusiastic about solving problems if there is encouragement for students to take action. This shows that the ability to understand students' mathematical concepts is influenced by learning motivation. Therefore, if students have maximum learning motivation, it is hoped that it will also have a positive impact on their ability to understand mathematical concepts. Because with the motivation to learn students will be motivated, interested, and more diligent in learning mathematics to improve their ability to understand mathematical concepts.

Another fact obtained in this study is that based on the results of a two-way ANOVA that has been carried out on the results of the Posttest students' ability to understand mathematical concepts and learning motivation is high, medium, and low in experimental 1, experiment 2, and control classes. For the interaction between the Inquiry, PBL, and DI learning models with high, medium, and low learning motivation on the ability to understand mathematical concepts of students in all sample classes, the significance value of the interaction between the learning model and learning motivation obtained a significance of 0.01 or <0.05, so $H0$ is rejected and $H1$ is accepted, in other words, there is an interaction between the Inquiry, PBL and DI learning models with high, medium, low learning motivation in influencing students' ability to understand mathematical concepts.

In the implementation of learning in the classroom, learning models with learning motivation have a dependence on each other in influencing the ability to understand students' mathematical concepts. This is in line with Wulandari et al. [37]; Yunus et al., [41] which says that learning motivation contributes to the ability to understand students' mathematical concepts. That is, if learning motivation is high, then the ability to understand concepts is also high, so learning motivation is one of the supporting factors that cannot be ignored in achieving students' ability to understand mathematical concepts. This is also reinforced by the statement of Deli (2015), and Corebima et al. (2017) which state that Inquiry learning can increase students' motivation to learn mathematics. Firmansyah et al. (2020), Sarmiento-Rojas et al. (2022) stated that PBL learning can be an alternative model that can improve students' mathematical solving abilities and learning motivation. This is because PBL learning prioritizes how students solve problems using their knowledge [42-45].

Based on the results of research that has been done previously, this proves that the Inquiry and PBL learning models and learning motivation can also affect the ability to understand mathematical concepts [46-50]. Based on the existing descriptions, it can be said that the learning model and learning motivation are dependent on each other in influencing the ability to understand students' mathematical concepts [50-54].

5. CONCLUSION

Based on data analysis and discussion, the following conclusions are obtained:

1. The average concept understanding ability of the experimental class I with the Inquiry learning model was 79.53 and for the experimental class II with the PBL learning model, the average was 79.23. Whereas the control class with DI learning obtained an average of 75.82. This shows that the Inquiry learning model produces a higher ability to understand mathematical concepts compared to the PBL and DI learning models. Also, the results of data analysis obtained $p - value$ 0.005 (< 0.05), then $H0$ is rejected or accepts $H1$ which means that there is an influence of Inquiry and PBL learning models on students' understanding of mathematical concepts. This is because the Inquiry and PBL model syntax can help students develop the ability to understand mathematical concepts. So learning that applies the Inquiry and PBL learning models can be said to be feasible to use to improve the ability to understand mathematical concepts.
2. The significance value for learning motivation was 0.000 (> 0.05), then $H0$ was rejected. In other words, there is an influence of high learning motivation, moderate learning motivation, and low learning motivation on students' understanding of mathematical concepts after applying the learning model. This is due to the enthusiasm of students in solving problems. Students become more enthusiastic about solving problems if there is encouragement for students to take action.
3. Interaction between the Inquiry learning model, the PBL learning model, and DI with learning motivation in influencing the ability to understand mathematical concepts. Based on the two-way ANOVA test, the significance value of the interaction between the learning model and learning motivation obtained a significance of 0.01 or <0.05, so $H0$ was rejected and $H1$ was accepted. This means that the

ability to understand mathematical concepts is influenced by the learning model and learning motivation carried out together. This is because the learning model and learning motivation are dependent on each other in influencing the ability to understand students' mathematical concepts.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dewanti SS, Kartowagiran B, Jailani J, Retnawati H. Lecturers' experience in assessing 21st-century mathematics competency in Indonesia. Problems of Education in the 21st Century, 2020;78(4):500–515. Available:https://doi.org/10.33225/pec/20.78.500
2. Jonsson B, Norqvist M, Liljekvist Y, Lithner J. Learning mathematics through algorithmic and creative reasoning. Journal of Mathematical Behavior. 2014;36:20–32. Available:https://doi.org/10.1016/j.jmathb.2014.08.003
3. Wardhani S. Analysis of SI and SKL mathematics subjects for SMP/MTs for optimizing achievement of goals. Center for Development and Empowerment of Mathematics Educators and Education Personnel; 2008.
4. Legesse M, Luneta K, Ejigu T. Analyzing the effects of mathematical discourse-based instruction on eleventh-grade students' procedural and conceptual understanding of probability and statistics. Studies in Educationa l Evaluation. 2020;67. Available:https://doi.org/10.1016/j.stueduc.2020.100918
5. Murizal A, Yarman Yerizon. Understanding mathematical concepts and quantum teaching learning models. Journal of Mathematics Education. 2012;1(1):19–23.
6. Abramovich S, Grinshpan AZ, Milligan DL. Teaching mathematics through concept motivation and action learning. Education Research International; 2019. Available:https://doi.org/10.1155/2019/3745406
7. Allen CE, Froustet ME, LeBlanc JF, Payne JN, Priest A, Reed JF, Worth JE, Thomason GM, Robinson B, Payne JN. National council of teachers of mathematics. The Arithmetic Teacher. 2020;29(5):59. Available:https://doi.org/10.5951/at.29.5.0059
8. Leong KE. Factors that influence the understanding of good mathematics teaching. Eurasia Journal of Mathematics, Science and Technology Education. 2013;9(3):319–328. Available:https://doi.org/10.12973/eurasia.2013.939a
9. Lin YW, Tseng CL, Chiang PJ. The effect of blended learning in a mathematics course. Eurasia Journal of Mathematics, Science and Technology Education. 2017;13(3):741–770. Available:https://doi.org/10.12973/eurasia.2017.00641a
10. Michael I. Factors leading to poor performance in mathematics. Open University of Tanzania. 2015;88.
11. Astrianal A, Waluyo SB, Siswanto B. Efforts to increase the ability to understand mathematical concepts and curiosity of class X MIPA 9 SMA N 4 semarang through the problem based learning model assisted by question cards. PRISMA, Proceedings of the National Seminar on Mathematics. 2019;2(1):893–898. ISSN 2613-9189
12. Ketren Ocmita Yanda, Jumroh DO. The influence of the inquiry learning model on concept understanding ability in view of student learning motivation. 2019;2(1):58–67. Available:https://doi.org/10.31851/indiktika.v2i1.3428
13. Dornyei Z, Ushioda E. Teaching and researching motivation (2nd, illustrated ed.). Longman; 2011.
14. Hendrayana A. The effect of Rigorous Mathematical Thinking (RMT) approach learning on middle school students' mathematical conceptual understanding. Journal of Mathematics Education Research. 2017;4(2):186–199. Available:https://doi.org/Prefix 10.21831 2356-2684 (Print) | 2477-1503 (Online)

15. Meshack EO. The role of school and motivational factors in mathematics achievement and self-efficacy: A multi-level analysis. ProQuest LLC; 2013.
16. Annajmi. Improving the ability to understand mathematics concepts for middle school students through the guided discovery method assisted by geogebra software. MES Journal (Journal of Mathematics Education and Science), 2016;2(1):1–10.
    ISSN: 2528-4363
17. Gunur B, Lalus E, Ali FA, Studies P, Mathematics P, Catholic U, Santu I. Understanding of students' mathematical concepts through the application of the guided inquiry learning model students' understanding of mathematical concepts through the guided inquiry learning. 2019;09(October).
18. Risnawati. Mathematics Learning Strategy. Suska Press; 2008.
19. Fatonah DSR, Ashadi A, Haryono H. Comparative study of chemistry learning using Inquiry Based Learning (IBL) and Problem Based Learning (PBL) models on thermochemistry materials class Xi high school N …. Journal of Chemistry Education. 2016;5(2):36–43.
20. Daryanto. Learning and teaching. CV Yrama Widya; 2010.
21. Pratiwi, CO, Sujana A, Jayadinata AK. Application of the inquiry learning model to improve student learning outcomes in class V on simple plane material. Journal of the Scientific Pen. 2017;2(1):291–300.
22. Warmi A. The effect of using inquiry learning strategies on students' mathematical understanding ability. Journal of Pendas Cakrawala. 2016;2(1):70–82.
23. Handayani E. Application of the problem based learning model to improve the ability to understand multiplication of numbers. Brilliant: Research and Conceptual Journal. 2017;2(3):319.
    Available:https://doi.org/10.28926/brilliant.v2i3.75
24. Ariandy Y. Analysis of problem solving ability based on learning activities in the PBL learning model. Proceedings of the National Mathematics Seminar X Semarang State University; 2016.
25. Arends RI. Learning to Teach (9th ed.). McGraw Hill Co; 2012.
26. Sugiyono. Metode Penelitian Kombinasi (Mix Methods). Alfabeta; 2015.
27. Oktinasari H, Prahmana RCI. The role of guided inquiry in understanding the concepts of class VIII students in learning the Pythagorean theorem. Journal of Honai Math. 2020;3(2):111–122.
    Available:https://doi.org/10.30862/jhm.v3i2.117
28. Tanjung IK, Simamora Y, Saragih RMB. Pengaruh model pembelajaran inquiry berbantuan geogebra terhadap kemampuan pemahaman konsep matematis siswa. Journal on Education. 2023;6(1):475–486.
29. Mohammad H, Redzuan Haji, Botty. The implementation of Problem-Based Learning (PBL) in a year 9 mathematics classroom: A Stu udy in Brunei Darussalam. 2016:34–47.
30. Noviwati N, Mursalin M, Odja AH. Application of the inquiry learning learning model to improve student learning outcomes of the concept of temperature and heat. Luminous Journal: Scientific Research in Physics Education. 2023;4(1):1–6.
    Available:https://doi.org/10.31851/luminous.v4i1.9193
31. Mustaffa N, Ismail Z, Tasir Z, Said MNHM. The impacts of implementing Problem-Based Learning (PBL) in mathematics: A review of literature. International Journal of Academic Research in Business and Social Sciences. 2016;6(12):490–503.
    Available:https://doi.org/10.6007/ijarbss/v6-i12/2513
32. Mariana P, Sunaryo Y, Zamnah LN. Pengaruh model pembelajaran problem based learning terhadap kemampuan pemahaman konsep matematis siswa. J-KIP (Jurnal Keguruan Dan Ilmu Pendidikan). 2023;4(1):183–190.
33. Karima R, Aniswita A, Firmanti P. Students' mathematical problem solving ability using the search solve create and share learning model in class VIII daughters of modern diniyyah pasia islamic boarding school. JURING (Journal for Research in Mathematics Learning). 2019;2(3):265.
    Available:https://doi.org/10.24014/juring.v2i3.7746
34. Kesumawati N. Improving the ability of comprehension, problem solving, and mathematical disposition of middle school students through a realistic mathematics education approach. Indonesian Education University; 2010.

35. Retnawati D. Mathematics learning design to train higher order thinking skills. UNY Press; 2018.
36. Diazgranados Ferráns S, Lee J, Ohanyido C, Hoyer K, Miheretu A. The cost-effectiveness of an accelerated learning program on the literacy, numeracy and social-emotional learning outcomes of out-of-school children in Northeast Nigeria: Evidence from a mixed methods randomized controlled trial. Journal of Research on Educational Effectiveness. 2022;15(4):655–686. Available:https://doi.org/10.1080/19345747.2022.2037799
37. Wulandari EA, Azhar E, Jusra H. Relationship between learning motivation and students' mathematical problem solving ability in class VII. Mathematics Education ka. 2018;01:397–405.
38. Bjorklund DF. Children's evolved learning abilities and their implications for education. In Educational Psychology Review. Springer US. 2022;34(4). Available:https://doi.org/10.1007/s10648-022-09688-z
39. Maisyaroh Agsya F, Maimunah M, Roza Y. Analisis Kemampuan Pemecahan Masalah Ditinjau Dari Motivasi Belajar Siswa Mts. Symmetry: Pasundan Journal of Research in Mathematics Learning and Education. 2019;4:31–44. Available:https://doi.org/10.23969/symmetry.v4i2.2003
40. Lugosi E, Urible G. Active learning strategies with positive effects on students' achievements in undergraduate mathematics education. International Journal of Mathematical Education in Science and Technology. 2022;53(2):403–424.
41. Yunus M, Setyosari P, Utaya S, Kuswandi D. The influence of online project collaborative learning and achievement motivation on problem-solving ability. European Journal of Educational Research. 2021;10(2):813–823. Available:https://doi.org/10.12973/EU-JER.10.2.813
42. Arikunto S. Research procedures a practice approach. Rineka Cipta; 2017.
43. Sudiarta GP. Application of problem solving oriented learning strategies with a metacognitive approach to improve concept understanding and student learning outcomes in statistics courses. Journal of Education and Teaching UNDIKSHA. 2007;40(3):590.
44. Jamaris M. New orientations in educational psychology. Pure Penamas Foundation; 2010.
45. Karim. 21st Century Learning. Gava Media; 2017.
46. Lestari KE, Yudhanegara MR. Penelitian pendidikan matematika. Refika Aditama; 2015.
47. Margono S. Metodologi Penelitian Pendidikan. PT Rineka Cipta; 2014.
48. Mullis IVS, Martin MO, Foy P, Hooper M. TIMSS 2015 International Results in Mathematics; 2015.
49. Ningsih YL, Paradesa R. Improving students' understanding of mathematical concepts using maple. Journal of Physics: Conference Series. 2018;948(1). Available:https://doi.org/10.1088/1742-6596/948/1/012034
50. OECD. PISA for Development Assessment and Analytical Framework. OECD Publishing; 2017.
51. Pattinson RC. Antenatal detection of small-for-gestational-age babies. Choice of a symphysis-fundus growth curve. South African Medical Journal. 1988;74(6):282–283.
52. Siagian MD. Mathematical connection ability in mathematics learning. MES (Journal of Mathematics Education and Science). 2016;2(1):58–67.
53. Siregar S. Quantitative research methods. PT Fajar Interpratama Mandiri; 2013.
54. Umam MA, Zulkarnaen R. Analysis of students' ability to understand mathematical concepts in material system of linear equations of two variables. Journal of Education FKIP UNMA. 2022;8(1):303–312. Available:https://doi.org/10.31949/educatio.v8i1.1993

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/103956