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The influence of the problem based instruction learning model on reasoning ability and mathematics learning outcomes on the system of linear equations with two variables

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ABSTRACT

This study aims to see the influence of the problem-based teaching learning model on reasoning abilities and the results of mathematical learning in the materials of the two-variable linear equation system in class X of SMK Swasta Dewi Sartika Bilah. This research is quantitative research with a Quasi-experimental approach using a Pre-Test-Post-Test Control Group Design research design. The population in this study is all students of class X which consists of 3 classes namely X-TBSM, X-TKJ, While the sample in this study is class X-TKJ which consists of 30 students as an experimental class, and class X-OTKP. consisting of 30 students as a control class with a sampling technique that is Simple Random Sampling. The data collection technique used in this research is a test to obtain data on mathematical reasoning abilities and mathematical learning outcomes. The results of the data analysis process prove that there is a significant influence with the application of the problem-based teaching learning model on reasoning abilities and the results of mathematical learning in the materials of the two-variable linear equation system.

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INTRODUCTION

Education is a conscious and planned effort to create an environment and learning process where students actively develop their potential to become religious, self-controlled, personable, intelligent, virtuous, and the skills needed for themselves and society. Education is a communication process that includes the transformation of knowledge, values and skills, both inside and outside the classroom (Refiyeti, 2022). As a subject, mathematics has an important role in shaping the character and way of thinking of students. It is very inaccurate to say that mathematics lives for itself, but mathematics has a universal role in other sciences and in the development of modern technology Jeheman, Gunur, & Jelatu, 2019). Among the many important roles in mathematics, the reality is that mathematics is still considered difficult for many students (Raharjo et al., 2021).

Mathematics is a science that aims to improve thinking abilities, such as higher level thinking abilities. In human life there are many relationships with mathematics. So, mathematics must be taught in school. Students' anxiety about mathematics affects students' ability to solve mathematical problems (Adhimah & Ekawati, 2020). Anxiety in learning causes students to have difficulty in the learning process (Irfan, 2017). (Azizah et al., 2018) stated that in the implementation of mathematics learning, it is not enough to simply provide information in the form of memorized theories or concepts, but it also needs to be oriented towards the development of skills required in problem solving. This is done to give students the ability to solve problems faced in their lives (Nasution, 2019).

One of the abilities that students must have when learning mathematics is the ability to reason, because mathematics is a science that is learned through reasoning. The goal of learning mathematics is for students to be able to use reasoning to make generalizations, organize proofs, or explain mathematical concepts and statements. To achieve the goal of improving students' reasoning abilities, new innovations are needed in learning mathematics through various methods (Nurlina et al., 2021). (Sulistiawati, 2014), one of the reasons is that students' low mathematical reasoning ability is caused by learning mathematics that does not involve students. According to (Agustin, 2016) Mathematical reasoning is not only important for proving or checking programs, but also for inference in artificial intelligence systems.

In developing mastery of concepts, student reasoning is needed to provide meaning in the independent learning process (Hermawan & Hidayat, 2018). According to (MA Basir, 2015) mathematical reasoning can be used as a basis in understanding and doing mathematics as well as an important part of problem solving. Reasoning is different from thinking, mathematical reasoning is the most important part of thinking that involves forming generalizations and making valid conclusions about ideas and how these ideas are related. (M Ario, 2016) states that generally mathematical reasoning can be classified into two types, namely inductive reasoning and deductive reasoning. Inductive reasoning is reasoning based on a limited number of observed cases or examples.

Ministerial Regulation No. 21 of 2016 on content standards emphasizes that reasoning ability is one of the competencies that students must have when learning mathematics (KH Izzah & M Azizah, 2019). This shows that mathematical reasoning ability has a very important role in learning mathematics. Therefore, every student must have mathematical reasoning abilities, but in reality there is still a lot of learning in schools that has not been able to develop students' mathematical reasoning abilities, resulting in low students' mathematical reasoning abilities (Rismawati, 2019). According to (Sufri & Idrus, 2015) the low mathematical reasoning ability of students will affect the quality of student learning, which also affects the results of low student mathematics learning in school. This opinion confirms that mathematical reasoning abilities and students' mathematical learning outcomes are interrelated.

Based on the results of observations made by the researcher at SMK Swasta Dewi Sartika Bilah through interviews with teachers and students, data was obtained that many students could not understand the meaning of the questions given by the teacher and changed the questions into mathematical form. . Students cannot draw conclusions from a problem. Also, most students just memorize formulas to solve problems. In analyzing and solving questions that use many formulas, most students cannot solve them well. Students do not master the material provided by the teacher in solving problems. Students are unable to connect the concept with the given problem. Students also tend to dislike math lessons. This happens because students consider mathematics as a difficult subject. Students also think that mathematics is just a subject that involves memorizing formulas. Learning outcomes, especially the average daily test scores for class X students are still low, i.e. 33% of students have difficulty solving math problems. This is due to the low reasoning ability of students, that is, students are still unable to apply the concept of mathematical calculations in their daily lives.

According to (Susanto, 2016) the learning outcomes of students are the knowledge, skills and abilities possessed by students, as a result of the learning they have experienced. Learning outcomes can be measured from the mathematics learning process, there are many factors that can influence the learning outcomes obtained by students. Learning is an activity carried out by individuals to gain knowledge so that individuals can experience change (Kasyadi et al, 2018). According to (Susanto, 2016) this factor can arise from within the student (internal) or outside the student (external). Internal factors include intelligence, motivation, habits, concerns, activities, interests and so on. While the external factors include the family environment, community environment, school environment, social conditions and so on.

The use of mathematical learning models used is less varied. The teacher still applies conventional learning, which means that the student's learning is only focused on the teacher's discussion. One of the causes of student reasoning and low math learning outcomes is that the learning process is normal and still centered on the teacher. Students are not much involved in building their knowledge, only receiving the information presented according to the teacher's instructions. Often students cannot answer questions that differ from the examples given by the teacher. (Sitanggang, 2018) says that teachers are required to know, understand, choose and apply learning models that are considered effective in order to create a conducive classroom atmosphere to support the optimal learning process.

Problem-Based Instruction is a problem-based learning model. In this learning model, students are faced with problems that are relevant to everyday life. In general, there are five levels of learning activities oriented to the problem-based teaching model (CM Zubainur et al., 2020), which are as follows. (1) Student orientation towards problems. (2) Encouraging students to study. (3) Guiding individual and group investigations. (4) Develop and present work results. (5) Analyze and evaluate the problem solving process. Each learning model has its own characteristics. The same is true in the Problem-Based Instruction model. According to (Nurazizah, 2018) the characteristics of the Problem-Based Instruction model are: asking questions or problems, focusing on interdisciplinary relationships, authentic investigators, Problem-Based Instruction requires students to conduct authentic investigations to find solutions to real problems, produce products and exhibit them, (Fauzia et al., 2018). Problem-Based Instruction is also able to encourage students to optimize their ability to extract information to analyze problems.

This study aims to examine the influence of the Problem-Based Instructional Learning Model on reasoning abilities and mathematical learning outcomes in the Material System of Linear Equations in Two Variables (SPLDV) at class X Private SMK Dewi Sartika Bilah. This research aims to explore the difference between students' reasoning abilities and mathematics learning outcomes before and after implementing the PBI learning model, compared between the experimental class (which implemented PBI) and the control class (which followed conventional learning).

METHOD

This type of research is quantitative research with a quasi-experimental approach using a Pretest-Posttest Control Group Design study design. The time to carry out this research is in April, even semester of the academic year 2023/2024, which is carried out in class X-TKJ and class X- OTKP. The location of the research is Dewi Sartika Bilah Private SMK located on Jalan Protokol Negeri Lama, Bilah Hilir District, Labuhanbatu Regency.

The population in this study is all class X students which consists of 3 classes namely X-TBSM, X-TKJ, X-OTKP, the sample in this study is the X-TKJ class which consists of 30 students as an experimental class, and class X -OTKP consisting of 30 students as a control class with a sampling technique that is Simple Random Sampling. According to (Sugiyono, 2017) Simple Random Sampling is a sampling technique that is planned through the population with members of the sample taken randomly without considering the specific criteria of the population. This research contains 3 variables, one independent (free) variable which is the problem-based teaching learning model X and two dependent (bound) variables which are Y1 (reasoning ability) and Y2 (learning outcomes).

The research design uses Pretest-Posttest control group design. The research design can be seen more clearly in Table 1.

Tabel 1. *Pretest-Posttest Control Group Design*

Sample	Initial Test	Treatment	Final Test
R	O_1	X	O_2
R	O_3	-	O_4

Information:
R = Random sampling
X = Treatment in the experimental class
O_1 = Experimental class pretest
O_2 = Experimental class posttest
O_3 = Pretest control class
O_4 = Control class posttest

The instrument used in this research is a test to obtain data on students' mathematical reasoning abilities and mathematical learning outcomes. The test in this study consists of 4 essay questions to measure mathematical reasoning abilities and 8 multiple choice questions to measure student learning outcomes. Pre-test and post-test questions are made the same. Before being used in research, tests are tested for validity and reliability. Analysis for hypothesis testing uses an inferential statistical test, which is an independent sample t-test to determine whether there is a statistically significant difference between the means of two unrelated groups. However, before running the t-test, the normality test and the homogeneity test were first conducted using the SPSS version 23 program.

RESULTS AND DISCUSSION

The data analyzed in this research is quantitative data obtained from the results of the pre-test (initial test) and post-test (final test) of students' reasoning abilities and mathematics learning outcomes. This test was given to 60 people who were divided into 2 classes, which were 30 people from the experimental class and 30 people from the control class. Pre-test and post-test data were obtained by giving tests to obtain data on students' mathematical reasoning abilities and mathematical learning outcomes related to the Linear Equation Material System in Two Variables. Nevertheless, before the post-test was conducted, the teacher carried out learning activities in 2 meetings, namely the experimental class using the Problem Based Instruction learning model, while the control class used the direct or conventional learning model.

Results of Descriptive Analysis of Students' Mathematical Reasoning Ability in Experimental and Control Classes

Based on the results of descriptive analysis of pre-test and post-test scores on students' reasoning abilities and mathematics learning outcomes using the SPSS version 23 application, data on the reasoning abilities and mathematics learning outcomes of experimental class and control class students have been presented. in Table 2.

Table 2. Descriptive Data

Class	Statistics	*Pre-test*	*Post-test*
Eksperimental	*Mean*	21,37	71,87
	Standard Deviation	6,970	6,257
	Variance	48,585	39,154
	Maksimum	40	80
	Minimum	10	60
Conrol	*Mean*	17,83	67,17
	Standard Deviation	5,253	7,368
	Variance	27,592	54,282
	Maksimum	30	80
	Minimum	10	50

Based on Table 2, it can be seen that the results of the descriptive analysis show that there is a difference in the calculation of descriptive statistics between the two classes with the same sample size of 30. Based on this table, it is known that in the experimental class. the average value of the pretest results is 21.37, the standard deviation of the data is 6.970, the variance data is 48.585, the maximum value is 40 and the minimum value is 10. The average of the posttest results is 71.87, the standard deviation data is 6.257, the data variance is 39.154, the maximum value is 80 and the minimum value is 60.

While for the control class the average value of the pre-test results is 17.83, the standard deviation of the data is 5.253, the variance of the data is 27.592, the maximum value is 30 and the minimum value is 10. The average value of the post-test results is 67.17, the standard deviation of the data is 7.368, the variance of the data is 54.282, the maximum score is 80 and the minimum score is 50. This shows that the mathematical reasoning ability of experimental class students is greater than the control class. This difference arises because the control class only uses a conventional learning model while the experimental class uses a problem-based teaching learning model.

Normality test

The normality test is used to determine whether the data about students' mathematical reasoning abilities and the results of mathematical learning for both classes are normally distributed or not. Decision-making data are normally distributed if the sig value > significance level ($\alpha = 0.05$). To test whether the data is normally distributed or not, the Kolmogorov Smirnov test statistic was used using the SPSS version 23 application.

Table 3. Reasoning Ability Normality Test

Class	Kolmogorov-Smirnov	Decision
	Sig	
Experiment	0,127	Normal data
Control	0,108	Normal data

Table 4. Normality Test Results of Student Mathematics Learning

Class	Kolmogorov-Smirnov	Decision
	Sig	
Experiment	0,191	Normal data
Control	0,083	Normal data

Based on Table 3, in the calculation results of the normality test for mathematical reasoning ability using Kolmogorov-Smirnov, it can be seen that there is significance in the score data for the experimental class and the control class. In the experimental class was 0.127 and 0.108 in the control class. This data is normally distributed data with a significance level greater than 0.05. The same thing is also shown in table 4 of the normality test of mathematics learning results, the significance value is 0.191 for the experimental class and 0.083 for the control class. With the results of the data it can be seen that the data has a significant influence, so it can be concluded that the two classes have a normal distribution.

Homogeneity Test

Once it is known that the sample is in the normal distribution table, proceed with the homogeneity test. If the value of sig. > significance level ($\alpha = 0.05$), then the data is homogeneous, and the results of Analysis of Variance (ANOVA) can be tested with the SPSS decision-making program. Tables 5 and 6 show the calculation of homogeneity test results

Table 5. Results of the Homogeneity Test of Mathematical Reasoning Ability

Statistics	Results
Sig	0,432
Levene's Test.	Sig. > 0,05
Decision	Normal data

Table 6. Homogeneity Test Results for Mathematics Learning Results

Statistics	Results
Sig	0,097
Levene's Test.	Sig. > 0,05
Decision	Normal data

Hypothesis testing

Both samples are in a normal and homogeneous position, according to the data analysis prerequisite table. Therefore, the SPSS analysis calculation uses the t-test Paired Sample Test. If sig value > significance level ($\alpha = 0.05$) then Ho is rejected and Hα is accepted. It can be said that the problem-based teaching learning model has an impact on the mastery of reasoning skills in the Material System of Linear Equations in Two Variables. The results of the hypothesis test can be seen in Table 7.

Table 7. Hypothesis Test Results Paired Sample t-test Pre-test and Post-test Data

Hypothesis Test Paired Sample T-Test	Results
Sig. (2-tailed)	0,000
Criteria	Sig. > 0,05
T table value	0,361
Calculated t value	63,083
Decision	Ha accepted

Based on the results of the t-test calculation, the calculated value is 63.083, while the t_{table} value is 0.361. Because $t_{test} > t_{table}$, Ho is rejected and Ha is accepted. With that, it can be concluded that the average value of reasoning ability in mathematics learning for students given a problem-based teaching learning model is greater than the average value of reasoning ability in mathematics learning for students given a conventional learning model. So, there is an influence on the results of reasoning abilities in learning mathematics for the subject System of Linear Equations in Two Variables for students who are taught using a problem-based teaching learning model. Based on the formulation, it can be said that in this research the problem-based teaching learning model is better than the conventional learning model.

Students who are treated with a problem-based teaching learning model, both high and low performing students, participate actively in learning. The phases in the problem-based teaching learning model involve students actively finding solutions to problems given with the student's knowledge reasoning abilities. Students can analyze the problems presented individually and in groups.

The problems presented in problem-based teaching learning are problems that exist in real life so that students will begin to think of concepts from the knowledge they have to solve the problem. The questions presented will instruct students to start using thinking and reasoning skills in solving problems. Students will estimate the answer, carry out calculations based on certain rules and be able to draw conclusions based on the data that has been analyzed. Students will also exchange opinions about guesses so that they are more active and hopefully students' reasoning abilities in learning mathematics will also increase.

The significant difference between the group that participates in learning with the Problem Based Instruction learning model and the group that participates in learning with the conventional model is due to the difference in behavior in the learning steps and the material delivery process. Learning with the Problem-Based Teaching model emphasizes the activities of teachers and students through the following steps: 1) Orienting students to problems, 2) Organizing students to learn, 3) Guiding individual and group investigations, 4) Developing and presenting work results, and 5) Analyze and evaluate the problem solving process. Learning with the Problem-Based Instruction model emphasizes student activity more than the teacher through group learning by providing problems related to everyday life. In addition, learning with the Problem Based Instruction model, students can share knowledge with each other and try to explore information independently and students are seen as learning subjects while the teacher only acts as a facilitator and motivator.

This is different from conventional learning which makes students learn mathematics more conceptually. In this study, the teacher dominates the learning activities. Students act as passive listeners and do what the teacher tells them to do and follow the example. Contextual math problems are usually used to test students' understanding of concepts learned and are usually given at the end of the material discussion. In addition, in learning with conventional teaching, students are rarely given the opportunity to explore a problem by using their own way of thinking. This kind of learning causes students to not be trained to investigate and will only wait for the teacher's instructions. Conventional learning rarely involves the activation of existing knowledge and rarely motivates students to process their knowledge.

According to (Darmana et al., 2013) the difference in learning methods between learning using the Problem-Based Teaching model and conventional learning certainly has a different effect on students' problem-solving abilities in learning Mathematics. The use of the Problem-Based Teaching model in learning allows students to know the benefits of the material they learn for their lives, to be active in learning activities, to discover the concepts learned by themselves without having to always depend on the teacher, to be able to solve problems related to the concepts learned, to work together with other students , and dare to express an opinion.

According to the results of the study conducted by the researcher, information has been gathered that students have good enough reasoning abilities and mathematical learning outcomes given by the researcher. This is because the learning procedure by applying the problem-based teaching learning model is a suitable technique to learn reasoning and learning outcomes, especially in learning mathematics to learn problems in everyday life. In the material, systems of linear equations in two variables can be more quickly understood and solved by students, both individually and in groups, using problem-based teaching.

The results of this research are in line with the results of research from (M Warohmah & A Masruroh, 2019) with data processing, $t_{test} = 4.29 > t_{table} = 2.00$, meaning that there is an influence of the problem-based teaching learning model on reasoning. ability in learning mathematics. The most important thing is that students will be given the opportunity to develop problem-solving and inventive abilities through problems that are intentionally presented by the teacher or that arise from the students themselves. This process will result in stronger internalization and retention of concepts after the facts obtained are then matched with learning resources. Students become more challenged to learn and try to solve all Mathematical problems faced, so that the knowledge gained is more meaningful for students. Thus, the reasoning abilities of students in Mathematics learning taught using the Problem-Based Instruction model will be better than students taught using conventional learning.

CONCLUSIONS AND SUGGESTIONS

Based on the results of analysis and hypothesis testing, it shows that there is an influence of the application of the Problem Based Instruction learning model on reasoning abilities and mathematics learning outcomes. Reasoning abilities and learning outcomes in mathematics learning taught using a problem-based teaching learning model are better than those taught using a conventional learning model. Management of previous data, the results showed that both scores before and after treatment increased. The results of the prerequisite test show a homogeneous and normal distribution. Using the Paired Sample T-Test, the hypothesis was tested. The results show that the value of sig. (2 tails) of 0.000 and the value of sig. (2-tailed) < 0.05, and the calculated t value > t table, which is 63.083 is greater than 0.361. Therefore, Ha is accepted and Ho is rejected. Therefore, the problem-based instructional learning model affects reasoning abilities and mathematical learning outcomes, especially materials on systems of two-variable linear equations.

Learning mathematics for students, especially at the upper secondary level, should involve regular practice to improve reasoning abilities and mathematical learning outcomes. Mathematics teachers as educators are advised when learning to apply a problem-based teaching model as an option to foster students' mathematical reasoning. So, in order to improve reasoning abilities and mathematical learning outcomes, in the future there should be research that produces innovations, discoveries, strategies and solutions.

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