THE EFFECT OF "*PROBLEM BASED LEARNING*" APPLICATION ON THE REASONING ABILITY OF XI IPA STUDENTS IN SMAN 7 PADANG ACADEMIC YEAR 2019/2020

ESSAY

Submitted As One of the Requirements to Obtain Bachelor of Education Degree

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2020

ABSTRACT

Hafiza: The Effect of Problem Based Learning Application on the Reasoning Ability of Class XI IPA Students in SMAN 7 Padang Academic Year 2019/2020

One of the objectives of learning mathematics which is expected in Senior High School is that students have good reasoning skills. However, according to the results of tests conducted at SMAN 7 Padang, it was found that students' mathematical reasoning abilities were still low. This is because students are accustomed to doing routine questions and the learning model used is less able to improve their reasoning abilities. If the ability to reason is low, students will have difficulty doing activities that require reasoning skills.

The purpose of research used is *quasy-experimental* with *Randomized Control-Group Only Design*. The population in this study was students of class XI IPA SMAN 7 Padang 2019/2020 Academic Year. The sample was taken using *Simple Random Sampling* technique, so that the class XI IPA was selected4 as an experimental class and XI IPA5as a control class. The instrument used is a matter of mathematical reasoning ability in the form of essays. The data obtained were analyzed by normality test, homogeneity test and t test.

Based on the analysis of the results of the students' mathematical reasoning ability test, it was found that the *P-value* = 0.003 was less than = 0.05; it means that the mathematical reasoning abilities of students whose learning with the application of the PBL model is better than the mathematical reasoning abilities of students whose learning uses the direct learning model. The results of the quiz and test obtained showed that PBL had an effect on improving students' mathematical reasoning abilities for each indicator in class XI at SMAN 7 Padang.

Keywords - Problem Based Learning (PBL), Direct Learning Model, Mathematical reasoning abilities.

PREFACE

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Praise and gratitude are expressed for the presence of Allah SWT who has bestowed His grace and gifts so that the author can complete the thesis entitled **"The Effect of the Problem Based Learning Application on the Reasoning Ability of Class XI IPA Students of SMAN 7 Padang Academic Year 2019/2020".** This thesis is structured to fulfill one of the requirements in obtaining a Bachelor of Education degree at the Mathematics Department, Faculty of Mathematics and Sciences, Padang State University. In addition, thesis writing is an additional insight for students in conducting research and making research reports.

This thesis can be completed properly with the help and cooperation of various parties. Therefore, the researchers would like to thank:

1. Mrs. Dr. Armiati, M.Pd., Academic Advisor and Advisor
2. Mr Drs. H. Mukhni, M.Pd, Mr. Dr. H. Edwin Musdi, M.Pd, as Examiners.
3. Mr Drs. Hendra Syarifuddin, M.Si, Ph.D, Chair of the Mathematics Department and Chair of the Mathematics Education Study Program of FMIPA UNP.
4. Mr. Muhammad Subhan, M.Sc., Secretary of the Department of Mathematics, FMIPA UNP.
5. Teaching staff of the Department of Mathematics, State University of Padang,
6. Mrs. Dra.Enny Sasmita, M.Pd, The Principal of SMA Negeri 7 Padang and Mr / Ms Deputy Principal,
7. Mrs. Yundriani, S.Pd and the Council of Teachers and Administrative Staff at SMA Negeri 7 Padang, as well
8. All parties who have helped in completing this thesis which cannot be mentioned one by one.

Thanks to all the support, assistance and guidance that are given to complete this thesis will be good deeds and rewarded a reward by Allah SWT. The author realizes that this thesis is not perfect. Therefore, constructive criticism and suggestions from all sides are expected. Hopefully, this thesis can give a broader insight in an effort to improve the quality of education. Aamiin.

Padang, January 2020

Author

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CHAPTER 1

INTRODUCTION

A. Background

The development of science and technology increase significantly, the results have influenced almost all aspects of human life. There have been many conveniences and pleasures for humans who have been obtained from the development of science and technology, although this has had its own impact on life, especially in the field of education. It takes an attitude and ability to think critically, creatively, and logically in choosing and utilizing the technology used. One of the sciences that can help develop such thinking skills is mathematics.

Elea Tinggih quoted by Suherman (2003: 16) says that mathematics can be said to be a science that grows and develops because of a thought process that involves ideas, processes, and reasoning. The word mathematics means "knowledge acquired by reason". This does not mean that other sciences are not obtained through reasoning, but in mathematics it emphasizes activity in the world of ratio (reasoning), whereas in other sciences it emphasizes the results of observations or experiments in addition to reasoning.

Based on Permendikbud No. 59 of 2014, one of the objectives of learning mathematics is to train how to think and reason in drawing conclusions. This means that reasoning abilities include mathematical abilities that need to be improved, so that students are required to have good reasoning. This makes mathematics a compulsory subject at every education level. However, in reality the ability of mathematical reasoning in Indonesia is still low. This is indicated by the results of the 2015 Program for International Student Assessment (PISA) study, Indonesia was only ranked 63rd out of 70 countries. The low results are due to the fact that students are accustomed to doing routine questions, lack of practicing non-routine questions and PISA study questions, where these questions measure more reasoning skills. Reminding the importance of reasoning abilities for students, the learning that is carried out needs to be planned, therefore students' mathematical reasoning abilities increase.

Based on the results of observations at SMA Negeri 7 Padang, on September 8-13 2019, it is known that the learning model commonly used is a direct learning model with a scientific approach. The teacher opens the lesson by checking student attendance. Then if there is an assignment, the teacher asks if there are any problems with the assignment. The teacher will ask several students to work on the assignment on the blackboard to be corrected together. After that, the teacher continues learning by providing perceptions and motivation to students, and conveying learning objectives at the meeting. At the time of learning, the teacher provides questions to be worked on and discussed by students in front of the class. It is hoped that the provision of practice questions can make students more familiar with the material being taught. Only a few students were able to solve the given questions. When doing the exercises, some students ask their smart friends, while others just copy their friends' work. Another problem in the learning process is that students tend to accept what the teacher said and were reluctant to ask questions or express opinions.

According to the results of midterm tests of XI IPA students at SMAN 7 Padang, it was found that students had difficulty working on questions related to reasoning abilities. This could be seen from the results of the initial test of reasoning abilities, which were given to 4 out of 6 classes of students in XI IPA at SMAN 7 Padang. The test contains the material which has been studied, namely operations on the matrix. The test results can be seen in Table 1 below:

Table 1. The Results of Students' Mathematical Reasoning Ability Tests

No.	Class	Students	Completed Students	
			The number of students	Percentage
1	XI IPA 1	36	3	8.33%
2	XI IPA 3	36	4	11.11%
3	XI IPA 4	35	6	17.14%
4	XI IPA 5	33	3	9.09%

Table 1 shows that the percentage of student completeness for each class is low. The following questions contain indicators of mathematical reasoning;

1. *Specify* A^{2009}, *if known matric* $A = \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

2. *If A and B are square matrices, then*

   $(A + B)(A - B) = A^2 + B^2$

   Check the truth of the statement above

The questions above represent several indicators of mathematical reasoning abilities which are: providing an alternative to an argument and finding patterns in a mathematical phenomenon (question no.1), Giving alternatives and drawing conclusions from a statement (question no.2). Following are the students' answers.

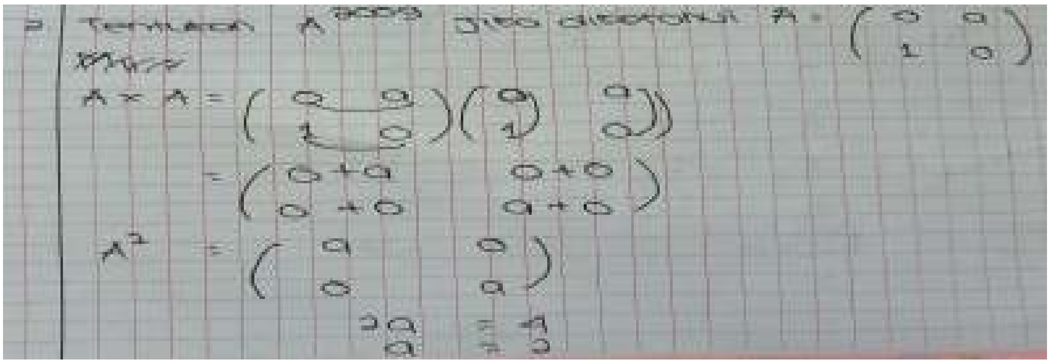


Figure 1. Students' answer to question number 1

Based on Figure 1, it can be seen that students have provided an alternative, namely by multiplying the two matrices, but students have not found a pattern from the questions given. Students should look for $A^2,\ A^3,\ A^4, A^5$ so it is found that pattern $A^n = \begin{pmatrix} a^{\frac{n}{2}} & 0 \\ 0 & a^{\frac{n}{2}} \end{pmatrix}$ for *n* is even and $A^n = \begin{pmatrix} 0 & a^{\frac{n+1}{2}} \\ a^{\frac{n-1}{2}} & 0 \end{pmatrix}$ for *n* is odd. Students who are able to get a score of 4 are 5% out of 140 people.

The following is the correct answer for question number 1:

Known: $matric\ A = \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

Asked: *Specify* A^{2009}

Solution:

$matriks\ A = \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

$A^2 = \begin{pmatrix} a & 0 \\ 0 & a \end{pmatrix}$

$A^3 = \begin{pmatrix} a & 0 \\ 0 & a \end{pmatrix} . \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

$= \begin{pmatrix} 0 & a^2 \\ a & 0 \end{pmatrix}$

$A^4 = \begin{pmatrix} 0 & a^2 \\ a & 0 \end{pmatrix} . \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

$= \begin{pmatrix} a^2 & 0 \\ 0 & a^2 \end{pmatrix}$

$A^5 = \begin{pmatrix} a^2 & 0 \\ 0 & a^2 \end{pmatrix} . \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

$A^6 = \begin{pmatrix} 0 & a^3 \\ a^2 & 0 \end{pmatrix} . \begin{pmatrix} 0 & a \\ 1 & 0 \end{pmatrix}$

$$= \begin{pmatrix} 0 & a^3 \\ a^2 & 0 \end{pmatrix} \qquad\qquad = \begin{pmatrix} a^3 & 0 \\ 0 & a^3 \end{pmatrix}$$

From the description above, a pattern was found

$A^n = \begin{pmatrix} a^{\frac{n}{2}} & 0 \\ 0 & a^{\frac{n}{2}} \end{pmatrix}$ for n even dan $A^n = \begin{pmatrix} 0 & a^{\frac{n+1}{2}} \\ a^{\frac{n-1}{2}} & 0 \end{pmatrix}$ for n odd

Since 2009 is an odd number, it was obtained

$$A^{2009} = \begin{pmatrix} 0 & a^{\frac{2009+1}{2}} \\ a^{\frac{2009-1}{2}} & 0 \end{pmatrix}$$

$$= \begin{pmatrix} 0 & a^{1005} \\ a^{1004} & 0 \end{pmatrix}$$

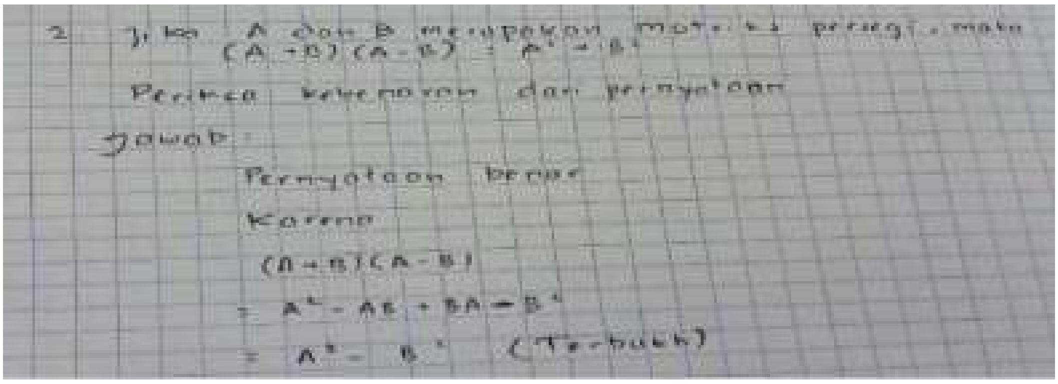


Figure 2. Students' answers to question number 2

In the second student's answer to question number 2, it appears that the students are still unable to make correct guesses, as a result students cannot make alternative answers and draw conclusions according to the indicators of mathematical reasoning ability. Students who are able to get a score of 4 are 7% out of 140 people.

The following is the correct answer for question number 1:

Known: *A and B are square matrices then*

$$(A + B)(A - B) = A^2 + B^2$$

Asked: *Check the truth of the statement above*

Solution:

A and B are square matrices, using the distributive property

$(A + B)(A - B) = A^2 - AB + BA + B^2$

On matrix multiplication $AB \neq BA$

So the statement $(A + B)(A - B) = A^2 + B^2$ wrong

Based on this evidence, it appears that students are still violating the indicators of mathematical reasoning. Students still have difficulty in finding patterns, proposing conjectures, providing alternatives to a problem, drawing conclusions from a statement. This shows that the mathematical reasoning abilities of students in these schools are still low.

If the problem of students' low mathematical reasoning ability is not resolved, then one of the objectives of learning mathematics cannot be achieved. As a result, there will be very few students who are able to think logically and have good reasoning skills. If the ability of reasoning is low, the students will find it difficult to carry out daily activities that require reasoning skills.

The solution that the author offers from this problem is the application of a problem-based learning model. The reason for choosing the Problem Based Learning (PBL) is because students will get a deeper understanding of the subject and will be more interested in the lesson if the learning is designed with problems which lead students to get the knowledge needed. According to observations at SMA Negeri 7 Padang, students like to work in groups, some students have high curiosity, and students are enthusiastic to learn. Therefore, the researcher offers this Problem Based Learning as a solution.

The Problem Based Learning (PBL) learning consists of several stages;

1. **Student orientation to the problem**. at this stage, the teacher conveys learning objectives, explains the logistics needed, proposes phenomena or demonstrations or stories to raise problems, and motivates students to be involved in solving the selected problem.
2. **Organizing students to learn.** at this time, the teacher helps students define and organize learning tasks related to these problems.
3. **Guiding individual and group investigations**. At this stage, the teacher encourages students to collect appropriate information, carry out experiments to get explanations and problem solving.
4. **Developing and presenting the work**. The teacher helps students plan and prepare appropriate work such as reports, videos, and models and helps them to share assignments with their friends
5. **Analyzing and evaluating the problem solving process**. The teacher helps students to reflect or evaluate their investigations and the processes they use.

Using the steps of the PBL learning model students' mathematical reasoning abilities can be developed. This is because there is a relationship between indicators of mathematical reasoning ability and the Problem Based Learning (PBL), as in table 2 below:

Table 2. The Relationship between Mathematical Reasoning Ability Indicators and the *Problem Based Learning* (PBL)

No.	Reasoning Ability Indicator	PBL syntax
1.	Make a guess	Student orientation to the problem
2.	Find a pattern in a symptom mathematical	Organizing students for study Guiding individual investigations and groups
3.	Provide an alternative to a argument	Guiding individual investigations and groups Develop and present masterpiece
4.	Draw conclusions from a statement	Analyze and evaluate problem solving process

In table 2, it can be seen that indicators of proposing allegations can be developed at the student orientation stage of the problem because at this stage the teacher proposes phenomena or stories to raise problems, students are asked to suspect and then prove it by displaying various concepts mastered by students that have something to do with the problems given. The indicators find a pattern in a mathematical phenomenon found at the stage of organizing students to learn and guiding individual and group investigations. At this stage the teacher helps students organize learning tasks, encourages students to collect appropriate information, and carries out experiments and students will find patterns in a mathematical phenomenon.

Indicators provide an alternative argument to be found at the stage of guiding individual or group investigations and developing and presenting the work. Indicators for making conclusions can develop at the stage of analyzing and evaluating the problem-solving process. At this stage, the teacher helps students to evaluate the investigation and the processes used when learning and later students can make conclusions.

From the description above, it can be seen that each phase in the Problem Based Learning (PBL) has steps and procedures that can help students achieve indicators of mathematical reasoning abilities. Based on the background stated above, a study was conducted with the title **"The Effect of *Problem Based Learning* (PBL) Application on the Mathematical Reasoning Ability of Students in XI IPA at SMA Negeri 7 Padang ".**

B. Identification of Problem

Problem identification based on the background described above is as follows.

1. Students' mathematical reasoning ability is still low
2. Students tend to be passive during the learning process
3. The learning process is still teacher-centered

C. Scope of Problem

Based on problem identification, the problem to be studied is limited to the low mathematical reasoning ability of class XI students of SMA Negeri 7 Padang.

D. Formulation of Problem

Based on the background and limitation of the problems above, the problem formulations in this study are as follows.

1. Is the mathematical reasoning ability of students who learn using *Problem Based Learning* (PBL) better than the mathematical reasoning abilities of students who learn using the direct learning model?
2. What is the students' mathematical reasoning ability for each indicator during utilizing Problem Based Learning (PBL) model?

E. Purpose of Research

Based on the problem formulation above, the purpose of this study are as follows.

1. To find out and describe whether the mathematical reasoning abilities of students who learn using the Problem Based Learning (PBL) are better than the mathematical reasoning abilities of students who learn using the direct learning model.
2. To find out and describe how the students' reasoning abilities for each indicator during using the Problem Based Learning (PBL).

F. Benefits of Research

The expected benefits of doing this research are as follows.

1. For researchers as additional insights and experiences as prospective professional educators.
2. For mathematics teachers as input and a source of innovation in planning the learning process to increase creativity in developing attractive learning models.

3. For the principal, it is an illustration to always provide guidance to educators and seek innovations for development and progress of school quality in order to achieve school goals and educational goals.
4. For students have the opportunity to learn more meaningfully to improve their mathematical reasoning skills.
5. For other researchers as motivation to further develop broadly similar research.

CHAPTER II

THEORETICAL FRAMEWORK

A. Theory Study

1. Problem Based Learning

Problem Based Learning (PBL) is defined as a problem-based learning. PBL learning model is a learning model that uses problems as a first step to gain new knowledge. According to Suyatno in Permendikbud No. 59 of 2014 that "Problem based learning model is a learning process that begins based on problems in real life. Students are stimulated to study problems based on the knowledge and experience they have previously (prior knowledge) to form new knowledge and experiences ".

According to Ridwan (2015: 127) "PBL is learning which is conveyed by presenting a problem, asking questions, facilitating investigations, and opening a dialogue". PBL can make students learn, through structured problem solving efforts can improve students' thinking skills. This learning requires students to take an active role while the teacher acts as a facilitator or guide. The expected result is that students are able to master the material, problem-solving skills, and attitude change in behavior.

The PBL learning has characteristics, according to Arends in Trianto (2012: 93), which are as follows:

a. Asking questions or problems.

Problem Based Learning (PBL) organizes socially important and personally meaningful learning for students

b. Focus on interdisciplinary link

Although Problem Based Learning (PBL) is centered on certain subjects (science, mathematics, and social studies), the problems to be investigated are real so that in solving them students review the problem from many subjects.

c. Authentic investigation

Problem Based Learning (PBL) requires students to commit authentic investigations to find real solutions to real problems

d. Produce a product and show it off

Problem Based Learning (PBL) requires students to produce certain products in the form of real works that represent the form of solving the problems they specify

e. Collaboration

Problem Based Learning (PBL) is characterized in students working together with one another, most often in pairs or in small groups.

Then according to Arends in Warsono (2012: 147) which cites the results of research by experts including Vanderbilt, Krajick and Czerniak, Slavian and others, it is concluded that there are five characteristics of PBL:

a. developed from a question or problem;
b. focus on interdisciplinary;
c. authentic inquiry;
d. produce artifacts; and
e. there is collaboration

Based on the description of the characteristics of PBL, it is known that the problem is the most important thing in this application. The role of educators in PBL is to provide authentic problems, facilitate students in identifying problems, and support the learning that is being carried out. Problems given to students must be problems that challenge students to master new knowledge.

The learning model has advantages and disadvantages. The advantages of the PBL model according to Sanjaya (2006: 220-221) are as follows:

a. helping students to better understand the content of the lesson;
b. challenging students' abilities and provide satisfaction to discover new knowledge;
c. increasing learning activities for students;
d. assisting students in transferring knowledge to understand real world problems; and
e. encouraging students to do evaluation.

The disadvantages of the PBL model:

a. Students will be lazy to solve problems if they do not know the usefulness of the efforts they will do.
b. Taking much time to prepare and implement PBL.

In the implementation of the PBL learning, there are several things that need to be considered. Absolutely, every model has weaknesses, so an effort is needed to overcome them. As in the PBL learning, students will be lazy to solve problems if they do not know their usefulness, so the implementation of PBL will not have a good impact on students. This PBL weakness can be overcome if educators are able to prepare challenging problems and to motivate students. In addition, PBL will be carried out well if educators are able to manage time.

PBL steps according to Ibrahim (2000: 13) are as in the following table 3:

Table 3. PBL Syntax and Teacher Behavior

No.	Syntax	Teacher Behavior
1.	Orientation students on problem	The teacher conveys the learning objectives, explain logistics that needed, propose phenomenon or demonstration or stories to raise trouble, motivate students to engage in problem solving selected.
2.	Organizing students to learn	The teacher helps students to define and organize assignments related to the problem.
3.	Guide investigations individually as well as group	Teachers encourage students to collect appropriate information, carry out experiments for getting explanations and problem solutions
4.	Develop and present the work	Teachers help students in planning and preparing applications such as reports, videos, and models as well as helping them to share tasks with friends
5.	Analyze and evaluate the process solution to problem	Teachers help students to commit reflection or evaluation of their investigations and processes they use.

According to Arends in Hosnan (2014: 296) questions and problems proposed in PBL must meet the following criteria:

a. *Authentic*, the problem must have its roots in the student's real life rather than be rooted in the principles of a particular other discipline.

b. *Clear*, the problem is clearly formulated in the sense that it does not cause new problems for students in the end
c. *Easy to understand,* the problem given should be easy for students to understand. Moreover, problems are arranged and made according to the level of student development.
d. *Broad and in accordance with learning objectives,* the problems which are compiled and formulated should be broad, it is meant that the problem includes all subject matter that will be taught in accordance with the available time, space and resources. Therefore, the problems which have been arranged must be based on predetermined learning objectives.
e. *Helpful,* problems that have been compiled and formulated must be useful, both for students as problem solvers and for teachers as problem makers. The worthy problems are problems which can improve students' problem-solving thinking skills, as well arouse student motivation.

In practice, the PBL learning model will be implemented with Student Worksheets (LKPD). In this case, the given LKPD has been made in such a way based on the PBL model steps, such as questions and directions to guide students in developing mathematical reasoning skills. Students are given several problems related to mathematical reasoning abilities. Then students are required to solve the problems given.

In the end, educators provide students with exercises to evaluate theory obtained by students. In the PBL model, students not only know how to solve mathematical reasoning problems but also understand the process of obtaining how to solve them. Therefore, by applying this model it is expected to improve students' mathematical reasoning skills.

2. Mathematical Reasoning Ability

Reasoning according to Keraf (Sadiq, 2004: 2) is a thinking process which tries to link facts or evidences to a conclusion. Meanwhile, Shadiq (2004: 2) says that reasoning is an activity, a process or a thinking activity to draw conclusions or make a new true statement based on several statements whose truth has been proven or assumed previously. In general, reasoning is a logical, structured, orderly, and rational thought process to draw a conclusion.

The importance of mathematical reasoning is also recognized by Ball, Lewis & Thamel in Riyanto & Siroj (2011: 113) stating that *"mathematical reasoning is the foundation for the construction of mathematical knowledge*". This means that mathematical reasoning is the foundation for constructing mathematical knowledge. This is supported by the opinion of the Ministry of National Education (Sadiq, 2004: 3) which states that mathematics topic is understood through reasoning and reasoning is understood, and trained through learning math material. From the definition above, it can be seen that reasoning is the process of thinking to draw conclusions from ones facts existing or make a new statement which is true based on some facts have been proven or assumed previous.

Mathematics learning objectives formulated in the National Council *of Teacher of Mathematics* (NCTM, 2000), one of which is learning for reasoning (mathematical reasoning). According to the document of the Regulation of the General Director of Primary and Secondary Education No. 506 / C / PP / 2004 that the indicators show reasoning (TIM PPPG Mathematics, 2005), as follow:

a. Presenting math statements of oral, written, picture and diagram.
b. Conjectures
c. Performing mathematical manipulations.
d. Drawing conclusions compiling evidence, providing reasons or evidence for several solutions.
e. Drawing conclusions from statements.
f. Checking the validity of an argument.
g. Finding patterns or properties of mathematical phenomena to make generalizations.

In the meantime, according to the Regulation of the Minister of Education and Culture No. 59 of 2014 that it is included in the indicators of ability mathematical reasoning, namely:

a. Proposing a conjecture
b. drawing conclusions from a statement
c. providing an alternative to an argument
d. finding a pattern in a mathematical phenomenon

In this study, indicators of mathematical reasoning ability used are indicators according to the Regulation of the Minister of Education and Culture No. 59 of 2014.

Students' mathematical reasoning abilities are expressed by grades through a rubric for assessing reasoning indicators. The rubric is a scale 4 analytic rubric which can be seen in Table 4.

Table 4. Scoring Rubric for Mathematical Reasoning Ability

Indicator	Scale 0	1	2	3	4
Apply conjecture	No Answer	Giving Incorrect presumption	Giving correct presumption but no explanation for answer	Giving correct presumption but incorrect explanation	Giving correct presumption and correct explanation
Drawing conclusion from statement	No Answer	Conclusion and process in drawing conclusion that given Incorrect	incorrect Conclusion , however process in drawing conclusion in a half of part Correct	Correct conclusion , however a little error process in drawing conclusion	Conclusion and process in drawing conclusion has been correct
Giving alternative for an argument	No Answer	Giving Incorrect Answer	Incorrect answer, however Correct reason	Correct Answer, however reason that is given less precise	Could give an alternative argument using right facts and linking in finishing the question
Finding pattern on a symptom mathematical	No Answer	There is answer, however cannot find the pattern	cannot find the pattern but giving correct reason	can find correct pattern, but reason is given not correct	can find pattern with correct reason and facts

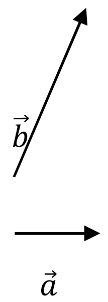
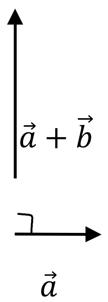
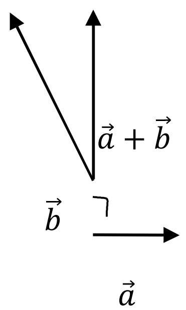
Source: Modified from Iryanti (2004: 13)

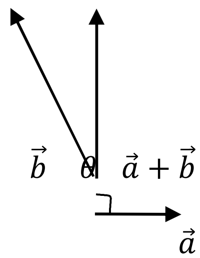
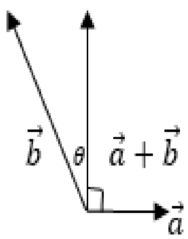
Examples of question and answer by matching the scoring used

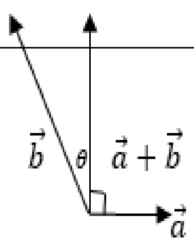
1. It is known that $\vec{a}$ and $\vec{b}$ is vectors on a flat plane such that $\vec{a}$ vertical $\vec{a} + \vec{b}$. If $\vec{a} : \vec{b}$ = 1 : 2, determine the angle between $\vec{a}$ dan $\vec{b}$.

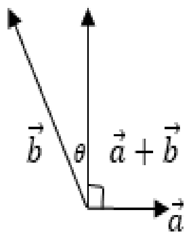
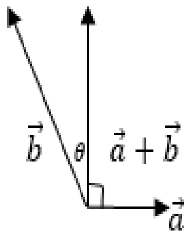
2. It is known that ABCDEF is a regular hexagon. If $\overrightarrow{CB} = \vec{u}$ dan $\overrightarrow{CD} = \vec{v}$. decide $\overrightarrow{DF}$.

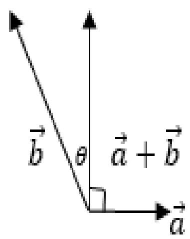
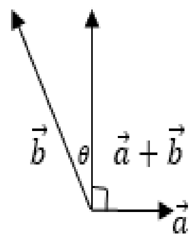
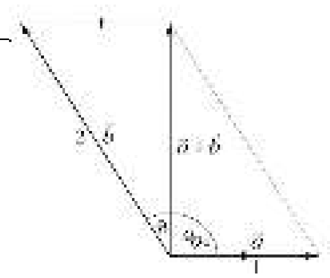
Table 5. Answers According to the Scoring Used

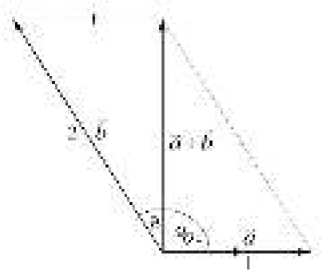
No	Score	Answer Key	Indicator
1	0	No Answer	Making a guess
	1		
	2		
	3	 The angle between $\vec{a}$ and $\vec{a}+\vec{b}$ is right angle.	

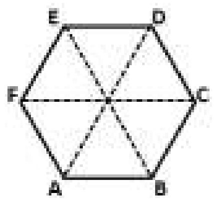
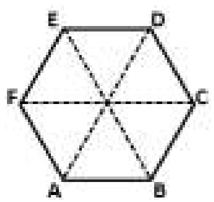
	4	 because $\vec{a}$ perpendicular with $\vec{a}+\vec{b}$, so the angle between them is 90°	
	0	No Answer	Providing an alternative of a statement
	1	 The angle between $\vec{a}$ and $\vec{b}$ is obtuse angle.	
	2		

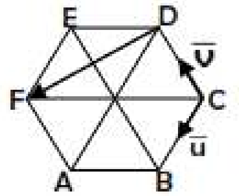


		The angle between $\vec{a}$ and $\vec{b}$ is obtuse angle because the angle is greater than 90°	
	3	 The angle between $\vec{a}$ and $\vec{b}$ is $90° + \theta$ because the angle is obtuse angle.	
	4	 Because $\vec{a}$ is upright $\vec{a} + \vec{b}$, the angle between them	

		is 90°. The angle between $\vec{b}$ and $\vec{a} + \vec{b}$ is θ. Based on the picture above, the angle between $\vec{a}$ and $\vec{b}$ is $90° + \theta$	
	0	No Answer	Finding pattern on a symptom mathematical
	1		
	2	 To find θ angle the using trigonometry Pattern	
			

	3	By using the rules Parallelogram	
	4	 Based on picture above, By using the rules Parallelogram then : $\sin\theta = \frac{1}{2}$ $\theta = 30°$ So the angle between $\vec{a}$ and $\vec{b}$ is $90° + 30° = 120°$	
2	0	No Answer	

	1	$\overrightarrow{CB} = \vec{u}$ dan $\overrightarrow{CD} = \vec{v}$ $\overrightarrow{DF} = \overrightarrow{CD} + \overrightarrow{CF}$ $= \vec{u} + 2\vec{v}$ then $\overrightarrow{DF} = \vec{u} + 2\vec{v}$	
	2	 $\overrightarrow{CB} = \vec{u}$ and $\overrightarrow{CD} = \vec{v}$ $\overrightarrow{DF} = \overrightarrow{DE} + \overrightarrow{EF}$ $\overrightarrow{DE} = \vec{v}$ $\overrightarrow{EF} = \vec{u}$ So, $\overrightarrow{DF} = \vec{u} + \vec{v}$	Drawing conclusion of a statement
	3	 $\overrightarrow{CB} = \vec{u}$ and $\overrightarrow{CD} = \vec{v}$	

		$\overrightarrow{AB} = \vec{u} + \vec{v}$ $\overrightarrow{EF} = \vec{u}$ So, $\overrightarrow{DF} = 2\vec{u} + \vec{v}$	
	4	 $\overrightarrow{CB} = \vec{u}$ and $\overrightarrow{CD} = \vec{v}$ $\overrightarrow{DA} = 2\overrightarrow{CB} = 2\vec{u}$ $\overrightarrow{AF} = \overrightarrow{DC} = \vec{v}$ So, $\overrightarrow{DF} = \overrightarrow{DA} + \overrightarrow{AF}$ $= 2\vec{u} + \vec{v}$	

3. Direct Learning Model

The direct learning model is a learning model specifically designed to support the learning process related to systematic declarative knowledge and procedural knowledge. The direct learning model emphasizes mastery of concepts with a deductive approach. Direct learning is not the same as the lectures method, but lectures and recitation (checking understanding with questions and answers) closely related to the direct learning model. Educators act as conveyors of information and in this case, educator should utilize a variety of appropriate media such as films, tape recorders, pictures, demonstrations, and so on.

The characteristics of Direct Teaching in accordance with Permendikbud No.59 of 2014 are as follows:

a. The existence of learning objectives and learning outcome assessment procedures.

b. Syntax or all of patterns and plot of learning activities.

c. Management systems and learning environments which support teaching progress and success.

Table 6. Stages of Direct Learning Model

Step	Role of Educator
Step 1 Convey goals and prepare students	Educator explains information of teaching background, the importance of lessons, and prepares students to learn.
Step 2 Demonstrate knowledge and skills	Educator demonstrates skills correctly or presents information step by step.
Step 3 Guiding training	Educator plan and give initial training guidance.
Step 4 Check understanding and provide feedback	Educator checks whether students have managed to do a job well and give feedback.
Step 5 Give opportunity to advanced training and application	Educator gives chance to commit advanced training, with special attention to application to more complex situations and everyday life.

Source: Trianto (2009: 43)

B. Relevant Research

Based on the literature study that has been conducted, there are several studies that are relevant to the research to be carried out. The relevant research comes from national research and some from international research.

Research conducted by Armiati (2011) entitled The Impact of Problem-Based Learning on Students' Mathematical Reasoning Ability based on Biggs and Collis Levels stated that the application of problem-based learning in the mathematics learning process was effective for developing mathematical reasoning abilities. The percentage of students' mathematical reasoning abilities who learn with PBL is higher than students who learn using conventional learning. Armiati said that problem-based learning is learning based on a constructivist approach, where students are faced with cognitive conflicts. This condition requires them to commit an analysis before giving answers; therefore, it can trigger the development of students' mathematical reasoning abilities. This research has in common is that it both examines the effect of Problem Based Learning (PBL) on mathematical reasoning abilities, but the difference is at the level of education, where researchers are at the high school level.

The relevant research conducted by Rahmi Hijri in 2015 explained that the average reasoning ability of students in the experimental class was greater than the control class, because the Problem Based Learning (PBL) used real problems as stimuli in learning. Presentation of real problems will provoke the curiosity of students. In addition, solving problem that is not single allows the emergence of creative ideas from students, and finds a conclusion as a solution to the problem. This study both uses PBL for student reasoning. The difference lies in the population, namely class X SMA N 5 Bukittinggi. While the research will be conducted in class X SMA Negeri 7 Padang.

In (2015), Desi Suryaningsih's research entitled "The Application of Problem Based Learning (PBL) Model to Improve Students' Mathematical Reasoning Ability on the Subject of Straight Line Equation at Class VIII C SMP Negeri 13 Jember" and explained the results of percentage study of total score aspects on students' mathematics reasoning ability had increased from 62.15% to 74.58%. This was because the Problem Based Learning (PBL) model used questions related to everyday life, and then it motivated students to know how to solve it reasonably. However, PBL learning requires more time with the result that teachers must be able to allocate time properly so that learning can be carried out more optimally. The similarity with this research is that both of them examine mathematical reasoning abilities using the *Problem Based Learning* (PBL). The differentiation of this research is the school level.

Lutfiah Fatimah, et al (2017) conducted a study that explained Problem Based Learning (PBL) with "MURDER" strategy which had positive effect towards students' mathematical reasoning abilities. This could be seen based on the results of the data processing of the students' mathematical reasoning ability test, that the average pretest and posttest scores in the experimental class experienced differences, the difference obtained was that the posttest average score in the experimental class had increased. MURDER (Mood-Understand-Recall-Detect-Elaborate-Review) is a type of cooperative learning that develops based on a cognitive psychology perspective. The "MURDER" strategy in the application of Problem Based Learning (PBL) can help students to understand any solutions or solutions to problems in the long term. This is related to the learning steps contained in the Problem Based Learning (PBL) approach where students are directly involved in solving any problems that occur and are strengthened by the steps contained in the "MURDER" strategy. From the results of research conducted by Lutfiah Fatimah, et al, which stated that there was an increase in mathematical reasoning abilities, the researchers conducted research by applying the PBL model in class XI IPA at SMAN 7 Padang.

The similarity of this study with research conducted by Lutfiah Fatimah, et al, is that both of them examine mathematical reasoning abilities using the *Problem Based Learning* (PBL) Model. However, the research conducted by Lutfiah Fatimah, et al. saw the difference between the Problem Based Learning (PBL) and the MURDER strategy, while the research carried out saw the difference between the *Problem Based Learning* (PBL) and the direct learning model.

Relevant research by Yanto Permana and Utari Sumarmo in 2007, explained that the reasoning abilities and mathematical connections of students who receive problem-based learning are greater than students' mathematical reasoning through ordinary learning. This could be seen from the achievement of scores in the experimental class of 72.5% of the ideal score, greater than the achievement of the score of the control class, which was 63.7% of the ideal score; there was a difference of 8.8%. The equation of this research was that both use the Problem Based Learning (PBL).

The relevant research by Alias Masek and Sulaiman Yamin in 2011 entitled "The Effect of Problem Based Learning on Critical Thinking Ability: A Theoretical And Empirical Review" states that the process in PBL theoretically supported the development of students' critical thinking according to the applied design. This was because in the PBL model the teacher as a facilitator monitors the progress of the group through direct observation and formative assessment. Direct observation involved coaching roles, such as probing and questioning, to trigger student meta-cognition. The facilitator, then, provides feedback by providing a formative assessment. The similarity with this research is that both use the *Problem Based*

Learning (PBL) Model. The difference is situated in the place of research and the dependent variable, where the dependent variable for research was about mathematical reasoning abilities.

Relevant research by Siti Mudhiah and Ali Shodikin in 2019 explained that problem-based learning models on the ability to understand concepts and reasoning in geometry material have a positive impact on student reasoning because teachers provided opportunities for students to issue various ideas in solving a mathematical problem. The theory that supports the problem-based learning model is Jean Piaget, this is because new knowledge is not given to students in a finished form, but students build and develop their own knowledge from the results of interactions with their environment. So it can be concluded that the reasoning ability of students getting a problem-based learning model is better than the reasoning ability of students who get a conventional learning model. These studies use PBL for student reasoning while the difference is situated in the place of research.

Relevant research by Rosmita Sari. S in 2019 entitled "Development of Learning Devices Based on Problem Based Learning to Improve Mathematical Reasoning Ability" explained that an alternative to improve reasoning skills required problem-based learning tools. This is because problem-based learning is a learning innovation because students' thinking abilities are truly optimized through a systematic group work process, so that students can empower, hone, test, and develop thinking abilities continuously. The improvement of mathematical reasoning skills using learning tools based on problem-based learning is seen from the *N-gain* value of 0.61 which means that it is in the "medium" category. These studies utilize PBL for student reasoning while the difference is situated in the level of education and the place of research.

Relevant research by Ade Mulyana in 2015 explained that there was an increase in mathematical reasoning abilities and student learning independence through problem-based learning. One of the factors that support the improvement of students' reasoning abilities is to be given a problem (question) that stimulates student knowledge. Providing varied and challenging practice questions will lead students to provide reasons for the problem solving process. The independence of student learning in problem-based learning is quite good, while the learning independence of students in conventional classes is classified as medium. In addition, there is a strong association between mathematical reasoning abilities and student learning independence. Both of studies use PBL for student reasoning.

Relevant research by Tatang Herman in 2007, explained that opened and structured problem-based learning is significantly better than conventional learning in improving students' high-level thinking skills, it can be seen in school qualifications or gender differences. Thus learning based on a potential problem is applied in the field to improve the quality of education. This study both uses PBL for student reasoning. While the difference lies in the place of research.

C. Conceptual Framework

One of the abilities that students must have in order to achieve mathematical goals is mathematical reasoning skills, where students are expected to be able to connect known facts to a conclusion. If students are able to make conclusions with the knowledge they have, learning will be meaningful. However, the learning process committed in the classroom has not been able to stimulate and motivate students to learn independently. Therefore, students are less motivation to propose their ideas. Another factor that makes students' low reasoning abilities is that students are accustomed to working on questions according to the concepts given by the teacher. If the questions given are questions of reasoning ability, students are confused about doing them.

To overcome this problem so as students 'reasoning abilities increase is to apply the *Problem Based Learning* (PBL) because the steps in this model can achieve the expected indicators of students' mathematical reasoning abilities. Starting from the teacher conveying learning objectives, explaining the material needed, proposing phenomena or stories to raise problems, motivating students to be involved in problem solving. The teacher also organizes student learning assignments. Then students are expected to be able to collect appropriate information, develop and present the work to get conclusions. In the final stage, students and teachers evaluate the processes and results which have been conducted.

With the application of the Problem Based Learning (PBL) in the learning process, it is expected that students' mathematical reasoning abilities will increase.

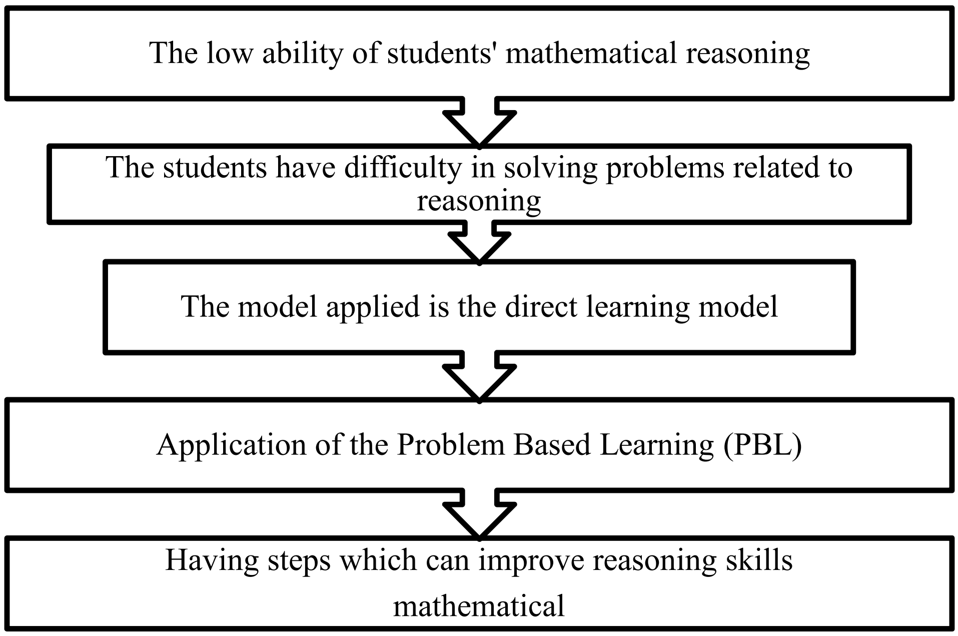


Figure 3. Conceptual framework

D. Research Hypothesis

According to the problem formulation and theoretical study which has been stated previously, the hypothesis of this study is that the mathematical reasoning ability of students who learn to apply the problem based learning (PBL) learning model is greater than the mathematical reasoning abilities of students who learn using the direct learning model in XI SMA Negeri 7 Padang for the 2019/2020 year academic.

CHAPTER III

RESEARCH METHODOLOGY

A. Types and Research Design

1. Type of Research

In accordance with the problem formulation previously stated, the type of research used is *quasy-experimental* and descriptive research. This study used two classes, namely the experimental class and the control class. The experimental class is a class that learns with the Problem Based Learning (PBL) and the control class is a class that learns with the Direct Learning Model.

The *quasy-experimental* aims to determine whether the mathematical reasoning abilities of students whose learning with the application of the Problem Based Learning (PBL) is better than the mathematical reasoning abilities of students learning by applying the Direct Learning Model. Meanwhile, descriptive research is used to describe the development of mathematical reasoning abilities of class XI IPA students during the application of the Problem Based Learning (PBL) Model in the learning process.

2. Research Design

This research design model used a *Randomized Control-Group Only Design* as shown in the following table.

Table 7. Research Design *Randomized Control-Group Only Design*

Group	Treatment	Posttest
Experiment	X	T
Control	-	T

Source: Suryabrata (2004: 104)

Information:
X : *Problem Based Learning*
T : Mathematical Reasoning Ability Test
− : Direct Learning Model

B. Population and Sample

1. Population

The population is a group of subjects to be studied. The population in this study was all students of XI IPA at SMAN 7 Padang. The population can be seen in Table 8.

Table 8. Population of XI IPA Students of SMA Negeri 7 Padang

No.	Class	The number of students
1.	XI IPA 1	36
2.	XI IPA 2	35
3.	XI IPA 3	36
4.	XI IPA 4	35
5.	XI IPA 5	33
6.	XI IPA 6	32
Total		207

Source: Administration of SMA Negeri 7 Padang

2. Samples

In accordance with the problem studied and the research method used, two classes were needed as samples, namely the experimental class and the control class. In this study, researchers used *simple random sampling technique* to take a representative sample.

Before taking the sample, the first step which is conducted is the normality test, homogeneity test and average similarity test for each sample in the population. The steps used in sampling are as follows:

a. Request the results of mid-semester math tests from teachers who teach in XI IPA Class at SMAN 7 Padang for the 2019/2020 academic year

b. Population normality test

Normality testing is performed to determine whether a data distribution is normal or not. In this study, the test used was the *Anderson-Darling test*. The steps in the normality test are as follows:

1) The hypotheses tested are:

H0 : Population is normally distributed

H1 : The population is not normally distributed

2) Determine statistical hypothesis testing using *Minitab software*.

After testing using *Minitab software* with the interpretation of P-value, that is, the data is normally distributed if the P-value obtained is greater than the level (α) which is set (= 0.05). The *P-value* in each class can be seen in table 9 below:

Table 9. Population Normality Test Results

Class	P-value	Information
XI IPA 1	0.369	Data is normally distributed
XI IPA 2	0.391	Data is normally distributed
XI IPA 3	0.314	Data is normally distributed
XI IPA 4	0.525	Data is normally distributed
XI IPA 5	0.184	Data is normally distributed
XI IPA 6	0.392	Data is normally distributed

Based on the test results in table 9, it can be concluded that each class in the population is normally distributed because each class has a P-value that is obtained greater than the level () set (= 0.05). The test results can be seen in Appendix 2 on page 95.

c. Variance Homogeneity Test

The variance homogeneity test was conducted in order to test the variance similarity of each data group. Homogeneity testing with the *Bartlett test* can be used if the data to be tested is more than 2 (two) groups of data / samples. The steps in the homogeneity test are as follows:

1) The hypotheses tested are:

   H0 : $\sigma_1^2 = \sigma_2^2 = \ldots = \sigma_6^2$

   H1 : there are at least two unequal variances.

   Information:

   σ_i^2: Variansi Populasi, dimana $i = 1,2,\ldots,6$

2) Determine the test statistics *Bartlett* by using *Minitab software*

The Barlett test can be performed if the data used has been tested for normality and the data is normally distributed. H_0 accepted or homogeneous data variance if P_{value}((significant value) is more than $\alpha = 0.05$ = 0.05 and rejected otherwise. The analysis carried out obtained $P_{value} = 0{,}333$ mean $P_{value} > \alpha(0.05)$. Therefore, it can be concluded that the population has a homogeneous variance. Homogeneity test results can be seen in Appendix 3 on page 98.

d. Performs the average similarity test

The mean similarity test is used to see whether the data mean of the population are identical or not. Because the data is normally distributed and the variance of the data is homogeneous, the test used is the one-way *Analysis of Variance* (ANOVA) technique. The hypothesis tested for this mean similarity is:

$H_0: \mu_1 = \mu_2 = \cdots = \mu_6$

H_1: There are at least two means that are not the same.

In this study, the average of similarity test was committed using *Minitab software*. Based on the results of the average of similarity test, it was obtained *P-value* = 0.296. So it can be concluded that the population has the same average, because the *P-value* is more than the real level $\alpha = 0{,}05$. The results of the average of similarity test can be seen in Appendix 4 on page 99.

e. Performing Sampling

After taking the test above, it was found that the population had the same average, so random sampling was taken. The Determination of sample class was finished by simple random sampling (*Random Sampling*), namely by lottery system. The method was to take a random roll of paper containing class names, namely from class XI IPA 1 - XI IPA 6. The roll of paper was taken 2 (two) pieces simultaneously and then assigned as a sample class. The experimental class was class XI IPA 4 while for the control class was class XI IPA 5.

C. Variables and Data

1. Variable

The variables used in this study are:

a. Independent Variable

The independent variables in this study are the Problem Based Learning (PBL) in the experimental class and the Direct Learning Model in the control class.

b. Dependent variable

The independent variable in this study is the mathematical reasoning ability of XI IPA students at SMAN 7 Padang.

2. Data

The type of data used in this research consists of primary data and secondary data.

a. Primary data in this study are data that show students' mathematical reasoning abilities obtained from giving the final test. The primary data sources were students of class XI IPA at SMAN 7 Padang who were the research samples.

b. Secondary data in this study were the midterm scores for class XI IPA and data on the number of students in class XI IPA at SMAN 7 Padang. Secondary data sources are administration and mathematics teachers at SMAN 7 Padang.

D. Procedure

1. Preparation

a. Establishing a research venue and schedule.

b. Managing research permits. This research was conducted from 30 September 2019 to 26 October 2019.

c. Determining the sample class after the normality test, homogeneity test and average similarity test are conducted. The sample class in this study was class XI IPA 4 as the experimental class and class XI IPA 5 as the control class.

d. Preparing learning tools, that is the Learning Implementation Plan (RPP) which can be seen in Appendix 6 on page 101 and Student Worksheets (LKPD) which can be seen in Appendix 7 on page 160.

e. Validating the device to find out whether the device is valid and fit for use. The research instrument was validated by two mathematics lecturers from the Faculty of Mathematics and Natural Sciences, UNP, namely Drs. Mukhni, M.Pd and Mr. Dr.H. Edwin Musdi, M.Pd and one math teacher who teaches in class XI SMA Negeri 7 Padang, namely Mrs. Yundriani. The validation results can be seen in Appendix 8 on page 204 and Appendix 9 on page 213.

f. Preparing test questions for mathematical reasoning abilities. The test consists of a grid of questions and guidelines for answering test questions in the experimental class and the control class. The test material includes all subject matter that is performed at each meeting, as for the ability test grid which can be seen in Appendix 11 on page 220.

g. Compile test questions for mathematical reasoning abilities, in the form of essay questions. Mathematical reasoning ability test questions can be seen in Appendix 21 on page 260.

h. Compiling answers and scoring rubrics for tests of mathematical reasoning abilities which can be seen in Appendix 13 on page 222.

i. Validating the mathematical reasoning ability test questions to determine whether the questions are valid and suitable for use. This question was validated by two mathematics lecturers of Faculty of Mathematics and

Natural Sciences, UNP, namely Drs. Mukhni, M.Pd and Mr. Dr.H. Edwin Musdi, M.Pd and one math teacher who teaches in class XI SMA Negeri 7 Padang, namely Mrs. Yundriani. The validation results can be seen in Appendix 14 page 239.

2. Implementation Stage

The learning process in both classes is committed using different learning models. For the experimental class, it uses Problem Based Learning (PBL), while the control class uses direct learning. The research implementation procedure can be seen in Table 10.

Table 10. Learning Implementation Stage

Activities	Experiment Class	Control Class
Introduction	**Orientation** 1. Preparing students as psychic and physical to follow the process learning. 2. Doing the opening with greetings and praying to start learning. 3. Checking student attendance. **Giving references** 4. Conveying goals learning to be achieved based on indicator. **Apperception** 5. Relink the previous lessons. **Motivation** 6. Motivate students to learn and give an overview of the benefits regarding that material studied. 7. Deliver the model learning to be used namely Problem Based Learning. 8. Students are grouped in small group consisting over 3-4 students	**Orientation** 1. Preparing students online psychic and physical to follow the learning process. 2. Doing the opening with greetings and praying to start learning. 3. Check student attendance. **Phase 1: Delivering goals and Preparing students** 4. The teacher conveys a goal learning to be achieved based on indicators. **Apperception** 5. Teacher repeats previous lessons. **Motivation** 6. The teacher motivates students to learn and give an overview of the benefits regarding that material studied.
Core	**Phase 1: Orientation of students to problem.** 9. Students observe events in daily activities related to the material being studied **(Observe)** 10. Students submit questions regarding things observed **(Asking).** 11. Students are given a problem with regard to the material the learning there on LKPD. **Phase 2: Organizing**	**Phase 2: Demonstrating knowledge and skills** 7. The teacher delivers the material lessons and demonstrations skills in a way demonstration. **(Observe)** **Phase 3: Guiding the training** 8. The teacher provides exercises and provide guidance if there is difficulty in do the exercises. **(Reasoning)**

	students to learn 12. The teacher encourages students to discuss that problem given with the group which has been formed. 13. The teacher encourages students to collect appropriate information by implementing experiment for getting that clarity requires for solve the problem **Phase 3: Guiding individual experience / group** 14. Teachers guide students in presenting work results group 15. Students do investigation about the questions that are submitted in LKPD so that students can conclude the good results of their job **(collect the information and reason)** 16. Students fill in the questions on the LKPD. **Phase 4: Develop and presents the work** 17. Students in each group present the results of their group discussions. The teacher designates which group will present the results of the discussion (Communicating). 18. Students return to their seats **Phase 5: Analyze and evaluate the process problem solution** 19. Students respond to results presentation from the group who appear. **(Communicating).**	**Phase 4: Check nderstanding and provide feedback.** 9. Teacher asks for one students to write down answers that have been completed **(Communicating)** 10. The teacher asks other students to respond to that result done by is friend. **(Asking)** **Phase 5: Deliver opportunity for training continued and applied** 11. The teacher gives assignments advanced about that material studied.

	20. The teacher gave reinforcement from the results of the discussion group. 21. Individual students collect LKPD.	
Closing	**Closing: analyze and evaluate the process solution to problem** 22. Teachers guide students summarize 23. Students reflect with the teacher and match evaluation test. 24. Teacher gives homework to students in order more understand that material has been studied and convey that material will be studied week ahead so that students are better to prepare their own self. 25. Teacher ended learning.	12. Teachers with students summed up that material has been studied. 13. Teacher gives homework to students in order more understand the material that has been studied and convey that material will be studied week ahead so that students are better prepared. 14. Teacher ends learning.

3. Completion

The things that are conducted at the research completion stage are as follows:

a. Conducting tests of mathematical reasoning abilities in both sample classes after the subject has been studied.

b. Processing the data from the two sample classes, both the experimental class and the control class. The assessment results for the experimental class can be seen in Appendix 23 on page 263 and the assessment results for the control class can be seen in Appendix 24 on page 265.

c. Drawing conclusions from the results obtained according to the technical analysis used.

E. Research Instruments

The instruments used in this study were quizzes and tests of students' reasoning abilities.

1. Quiz

Quizzes are given to see students' mathematical reasoning abilities per indicator as long as the PBL model is applied. Quizzes are given at each learning closing activity. The quizzes are given in accordance with the material taught on that day. Quizzes are arranged based on indicators of mathematical reasoning abilities.

2. Mathematical reasoning ability test

This test is conducted to measure and determine students' reasoning abilities. The test given is a written test in the form of appropriate description of mathematical reasoning indicators. The material tested in the test is in accordance with the material provided during the research. In order to obtain a valid test, the following steps are taken:

b. Analyzing the basic competency (KD).
c. Studying and understanding the material.
d. Creating a grid of test questions based on indicators of mathematical reasoning abilities.
e. Making test items based on the grid along with the answer key.
f. Validating test questions to two mathematics lecturers and a math teacher.

Conducting tests of mathematical reasoning abilities in schools which have the same characteristics as SMAN 7 Padang is SMAN 2 Padang. Several phases which are considered in the selection of schools for testing this test, are:

1. Having an average mathematical ability which is almost the same, it can be seen from the results of midterm tests.

2. Having KKM for the same mathematics subject, namely 80.

3. Having the same accreditation, namely A accreditation.

4. Using the same curriculum, namely the 2013 curriculum.

g. Analyzing test questions. This analysis is carried out to identify the questions that are used, revised or discarded. To find out the quality of the test, the following things need to be considered:

1) Distinguishing Power

The distinguishing power of the questions is determined by finding the index of difference between the questions. The item difference index is a number that shows the difference between the high and low groups. According to Prawironegoro (1985: 11) states to calculate the distinguishing power of the problem, the following steps are taken.

a) Sorting the data from highest value to lowest value.

b) Taking 27% of the group that got high scores and 27% of the group which got low scores.

$n_t = n_r = 27\% \text{ x N}$

c) Counting the *degrees of freedom* (df) with the formula:

$$df = (nt - 1) + (nr - 1)$$

d) Looking for the differentiating index of questions with the following formula

$$I_p = \frac{M_t - M_r}{\sqrt{\frac{\sum x_t^2 + \sum x_r^2}{n(n-1)}}}.$$

Information:
I_p : Question differentiation index
M_t : Average score of the high group
M_r : The average score of the group is low
$\sum x_t^2$: The sum of the squares of the high group score deviations
$\sum x_r^2$: The sum of the squares of the deviation for the low group score
n : 27% x N
N : The number of test takers

Question which has a significant differentiation index when calculated I_P is ≥ table I_P on degrees of freedom was found previously. Based on the results of trial analysis with I_P table = 2.18. The results of calculating the distinguishing power of each question are stated in Table 11 below:

Table 11. Distinguishing Power in Each Problem

Question number	***IP***	**Information**
1	5.2915	Significant
2	3.6742	Significant
3	4.3301	Significant
4	4.8038	Significant
5	2.6734	Significant

The calculation of the differentiation index for test questions can be seen in Appendix 18 page 250.

2) Question difficulty index

The item difficulty index is calculated to find out whether the questions are organized into categories of easy, medium, or difficult. To find out the essay form of question difficulty index used the formula stated by Prawironegoro (1985: 14), namely:

$$I_k = \frac{D_t + D_r}{2mn} \times 100\%$$

Information:

Ik	: difficulty index
Dt	: total score of the high group
Dr	: the total score of the low group
m	: question score if correct
n	: 27% x N
N	: The number of Test takers

The criteria used to determine which questions are classified as easy, medium, or difficult are as follows:

a) Difficult Question, if I.k <27%

b) Medium Question, if $27\% \leq I_k \leq 73\%$

c) Easy Question, if I.k > 73%

Based on the results of the test item analysis, the difficulty index is obtained as shown in Table 12.The calculation results can be seen in Appendix 19 on page 254.

Table 12. Problem Trial Difficulty Index

Question Number		Information
1	50%	Moderate
2	64.29%	Moderate
3	71.43%	Moderate
4	57.14%	Moderate
5	62.5%	Moderate

3) Classification of test questions

Every question which has been analyzed needs to be classified into questions that can be used, corrected, or replaced, as stated by Prawironegoro (1985: 16) with the following criteria:

a) Question is still used if *Ip* significant and 0% <I*k* <100%

b) Question is repaired if:

Ip significant and I*k* = 100% or *Ik* = 0%

Ip insignificant and 0% <*Ik* <100%

c) Problem is replaced if I.*p* insignificant and I*k* = 100% or I.*k* = 0%.

Table 13. Classification of Acceptance of Trial Results

Question Number	I_P	**Information**	I_k	**Information**	**classification**
1.	5.2915	Significant	50%	Medium	Put on
2.	3.6742	Significant	64.29%	Medium	Put on
3.	4.3301	Significant	71.43%	Medium	Put on
4.	4.8038	Significant	57.14%	Medium	Put on
5.	2.6734	Significant	62.5%	Medium	Put on

It can be seen that in Table 13, the interpretation of all question items can be obtained. The analysis results of acceptance criteria of the complete test item can be seen in Appendix 20, page 256.

4) Reliability test

Test reliability is the level of confidence or reliability of the test. It is meant that a test is said to be reliable if the test is used to measure repeatedly, the result is relatively the same or fixed. The reliability of the test in an essay can be calculated using the *alpha* formula as suggested by Hamzah (2014: 233), namely:

$$r_{11} = \left(\frac{n}{n-1}\right)\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

$$\sigma_t{}^2 = \frac{\sum x_i{}^2 - \frac{(\sum x_i)^2}{N}}{N}$$

Information:

r_{11} : Reliability test
$\sum \sigma_i{}^2$: The sum of the variance in the score of each item
$\sigma_t{}^2$: Variance total
k : The number of question items
n : The number of questions
N : The number of test takers
$\sum x_i$: Score total of each item
$\sum x_i{}^2$: The sum of the squares of the score for each item

Furthermore, providing interpretation of the test reliability coefficient (r_{11}) is used criteria as in Table 14.

Table 14. Criteria for Test Reliability

No.	Reliability Value (r)	Value Interpretation of r
1.	$0.80 < r_{11} \leq 1.00$	Very high
2.	$0.60 < r_{11} \leq 0.80$	High
3.	$0.40 < r_{11} \leq 0.60$	Moderate
4.	$0.20 < r_{11} \leq 0.40$	Low
5.	$0.00 < r_{11} \leq 0.20$	Very low

Based on the calculation of the reliability of the test questions for the mathematical reasoning ability test, the results were obtained 11 = 0.677, it means that the reliability of the test has a high interpretation, so that it can be used to test students' mathematical reasoning abilities. The calculation of the reliability of the test questions for the mathematical reasoning ability can be seen in appendix 20 on page 259.

5) Assessment rubric

Students' mathematical reasoning abilities are expressed by grades through a rubric for assessing reasoning indicators. The rubric used is a scale 4 analytic rubric which can be seen in Table 4 on page 19.

F. Data Analysis Techniques

Data analysis aims to test the correctness of the proposed hypothesis. In this study, the instruments used to obtain data are quizzes and tests of mathematical reasoning abilities.

a. Quiz Data Analysis

Per indicator, the students' mathematical reasoning ability was seen from the results of the quiz at each meeting, during research in the experimental class. Student quizzes were assessed using a rubric for assessing mathematical reasoning abilities can be found in Table 4 on page 19. The score analyzed is the percentage of scores obtained by students at each meeting. Through this analysis, it is expected that the students' reasoning abilities per indicator can be seen. The results of the calculation of the percentage of student scores qualify with an increase or not.

b. Data Analysis of Mathematical Reasoning Ability Tests

The instrument used in this study was a test. The test given is in the form of essay questions. The data obtained from the final test results will be processed using quantitative data analysis. Analysis of the data on the results of the mathematical reasoning ability test aims to test whether the tested hypothesis is accepted or rejected. To analyze the research data, the hypothesis was tested using the following steps.

a. Normality test

The test used is the *Anderson-Darling* test with the *Minitab software.*

1) The hypotheses tested are:

H0 : the test data for students' mathematical reasoning ability of the sample class is normally distributed

H1: the sample class students' mathematical reasoning ability test data was not normally distributed.

Interpretation of this normality test can show a *P-value*. If the P-value obtained is greater than the determined real level ($\alpha = 0{,}05$) then *H0* is accepted. If on the contrary, the final test data is not normally distributed or *H1* is accepted.

b. Homogeneity Test of Variance

The homogeneity test of variance aims to determine whether the final test data of the two sample classes has homogeneous variance or not. This test is performed using the F test. The hypothesis according to Walpole (1992: 314) in the homogeneity test is as follows.

$$H_0: \sigma_1^2 = \sigma_2^2$$

$$H_1: \sigma_1^2 \neq \sigma_2^2$$

Information:

σ_1^2: The Variance of Mathematical reasoning abilities for groups of students whose learning uses the Problem Based Learning (PBL).

σ_2^2: The Variance of reasoning ability mathematical for students group with using direct learning.

From the results obtained, the *P-value* interpretation was carried out with the second criterion that the final test data for the sample class had a homogeneous variance if P- *value* > real level (α) or accept H0. In contrast, the two final test data of the sample class do not have homogeneous variance or accept *H1*. The homogeneity test in this study was conducted with the *Minitab software.*

c. Hypothesis test

To test the research hypothesis can be divided into three alternatives:

a. Data on students' mathematical reasoning abilities are normally distributed and homogeneous variance.

If the data is normally distributed and has homogeneous variance, that is $\sigma_1^2 = \sigma_2^2 = \sigma^2$ but σ^2 unknown, then the test performed using statistical *t-test*.

b. Data of students' mathematical reasoning abilities were normally distributed and the variance was not homogeneous.

If the data is normally distributed but not homogeneous, then according to Walpole (1992: 305) the statistic used is the *t-test* '.

c. Data on students' mathematical reasoning abilities were not normally distributed.

If the data is not normally distributed, the hypothesis test is performed with non-parametric statistics using the *Mann-Whitney U-test.*

CHAPTER IV

RESULTS AND DISCUSSION

A. Research Results

This chapter is presented the research results that have been obtained from the application of the Problem Based Learning (PBL) on mathematical reasoning abilities which are then compared with the application of direct learning models to students' mathematical reasoning abilities. In addition, it also explains how students' reasoning abilities for each indicator during learning adopt the PBL model in XI IPA class of SMA Negeri 7 Padang.

1. Data Description

Based on research conducted from 30 September 2019 to 26 October 2019, the research data is described as follows.

a. Quiz

Mathematical reasoning abilities of XI IPA students of SMA Negeri 7 Padang were seen based on the percentage of students who obtained each score for each quiz during the application of the Problem Based Learning (PBL). Quiz I to quiz VI were attended by 35 students. Students' mathematical reasoning abilities are seen from the percentage of students who get a score of 0-4 per indicator on each quiz in Table 15.

Table 15. Percentage of Students with Scores of 0-4 Per Indicator on the Reasoning Ability Quiz

Indicator	S	Quiz 1 (%)	Quiz 2 (%)	Quiz 3 (%)	Quiz 4 (%)		Quiz 5 (%)	Quiz 6 (%)	
1	4			22.9				35.7	
	3			37.1				36.4	
	2			40				27.9	

	1			0				0	
	0			0				0	
2	4				14.3		22.9		
	3				45.7		47.4		
	2				31.4		25.7		
	1				8.6		4		
	0				0		0		
3	4	2.8	8.6						
	3	48.6	40						
	2	34.3	42.8						
	1	14.3	8.6						
	0	0	0						
4	4					20			32.9
	3					40			45
	2					34.3			18.1
	1					5.7			4
	0					0			0

Information:
Indicator 1: Making a guess
Indicator 2: Drawing conclusions from a statement
Indicator 3: Providing an alternative to an argument
Indicator 4: Finding patterns in a mathematical phenomenon

Based on Table 15, it can be seen that indicator 1 is found in the 3rd quiz and 6th quiz. When compared to the percentages of the two quizzes, students who obtained a scale of 4 increased in the 6th quiz while there is a decrease in students who obtain a scale of 3 and 2. Indicator 2 is found in the 4th and 5th quiz. Compared to fourth and fifth quizzes, students who obtain a scale of 4 and 3 experiences an increase in the fifth quiz while those who obtain a scale of 2 and 1 decrease. Indicator 3 is found on the 1st quiz and 2nd quiz. When compared to the percentages of the two quizzes, those who obtained a scale of 4 and 2 increased in the second quiz, but the percentage who obtained a scale of 3 and 1 decreased. Indicator 4 is found in the 4th and 6th quiz. If Compared to the percentage of the

4th and 6th quizzes, those who get on a scale of 4 and 3 increase while there is a decrease on a scale of 2 and 1 on the 6th quiz

The indicators contained in each quiz, the first quiz and the second quiz, have indicators that provide an alternative to an argument. The third quiz has an indicator of making a guess. The fourth quiz has indicators of drawing conclusions from statements and finding patterns in mathematical symptoms. The fifth quiz has indicators of drawing conclusions from statements. The sixth quiz contains indicators of proposing conjectures and finding patterns in a mathematical phenomenon. When compared based on the percentage of students who received a scale of 4 for each indicator, it can be concluded that PBL has an influence on students' reasoning abilities. Complete calculations can be seen in Appendix 22 on page 261.

b. Mathematical Reasoning Ability

The test data for students' mathematical reasoning abilities from the experimental class using the Problem Based Learning (PBL) and the control class with the application of the direct learning model were obtained through the final test with 5 essay questions, where each question represented an indicator of mathematical reasoning. The test was carried out at the end of the study, namely on October 26, 2019. The test in the experimental class was attended by 35 students and 33 students in the control class. Test result data can be seen in Table 16.

Table 16. Results of Mathematical Reasoning Ability Test of the Sample Class

Class	The number of students	Average	Deviation standard	Score the highest	Score Lowest
Experiment	35	76	11.68	100	55

Control	33	67.42	12.81	90	45

Based on Table 16. It can be seen that the average test score of the experimental class is higher than the control class. The average test score for the experimental class was 76 while the mean for the control class was 67.42. The highest score of the experimental class is higher than the control class. Where the highest score of the experimental class is 100 while the control class is 90.The lowest score of the experimental class is also higher than the control class, which is, the lowest scores of the sample class is 55 of the experimental class while the control class is 45. Then, the standard deviation of the experimental class is lower than the control class, namely the experimental class is 11.68 and the control class is 12.81. This shows that students' mathematical reasoning abilities of the control class are more diverse than the experimental class. The Complete calculations can be seen in Annex 23 on page 263 and Appendix 24 on page 265.

The results of students' mathematical reasoning abilities in the sample class can be seen through the average percentage score for each indicator. The following is the percentage average score of students' mathematical reasoning abilities on each indicator.

Table 17. Percentage of Sample Class Students Who Get a Score of 0-4 on the Mathematical Reasoning Ability Test

Class	Indicator	Question No.	Score 4		Score 3		Score 2		Score1		Score 0	
			F	%	F	%	F	%	F	%	F	%
E	1	4	9	25.71	18	51.43	8	22.86	0	0	0	0
K			4	12.12	17	51.52	8	24.24	3	9.09	1	3.03
E	2	5	12	34.28	17	48.57	5	14.29	1	2.86	0	0
K			6	18.18	14	42.42	11	33.33	2	6.07	0	0
E	3	2	6	17.14	17	48.57	12	34.29	0	0	0	0
K			5	15.15	16	48.48	12	36.37	0	0	0	0

Class	Indicator	Question No.	Score 4		Score 3		Score 2		Score1		Score 0	
			F	%	F	%	F	%	F	%	F	%
E		3	11	31.43	19	54.29	5	14.28	0	0	0	0
K			8	24.25	14	42.43	9	27.27	2	6.06	0	0
E	4	1	13	37.14	11	31.42	10	28.57	1	2.86	0	0
K			5	15.16	14	42.42	7	21.21	7	21.21	0	0

Information:
Indicator 1: Making a guess
Indicator 2: Drawing conclusions from a statement
Indicator 3: Providing an alternative to an argument
Indicator 4: Finding patterns in a mathematical phenomenon
E: Experiment class
K: Control class

Based on Table 17, it can be seen that each indicator of mathematical reasoning ability the number of students in the experimental class who obtained the maximum score was more than the control class. Indicator 1 is in question number 4, the number of students who get the maximum score for the experimental class is 9 people, while the control class has 4 people. Indicator 2 is in question number 5, the number of students who get the maximum score in the experimental class is 12 people, while the control class is 6 people. Indicator 3 is found in questions 2 and 3. In question number 2, the number of students who get the maximum score for the experimental class is 6 people, while the control class is 5 people. For question number 3, the number of students who obtained the maximum score in the experimental class was 11 people, while the control class had 8 people. Indicator 4 is in question number 1, the number of students who get the maximum score in the experimental class is 13 people, while the control class has 5 people. This shows that the experimental class students' mathematical reasoning ability is better than the control class.

2. Data analysis

a. Quiz Data Analysis

The ability of Students' mathematical reasoning based on the percentage of quiz scores, for the maximum score on each indicator has increased. Quiz I was attended by 35 people from 35 students of the experimental class. The subject being tested is the determinant of the order 2x2 matrix. The percentage of students who get a score of 4 is 2.6% this is because in working on quiz questions, students are still in a hurry so that students have not been able to solve the problem optimally, but no one gets a score of 0. Quiz II was attended by 35 people out of 35 students experimental class. The subject being tested is solving contextual problems involving a 2x2 matrix order. The percentage of students who got a score of 4 was 8.6%. There was an increase from quiz 1, where quiz 1 and quiz 2 have the same indicators, namely providing an alternative to an argument. Quiz III was attended by 35 people from 35 students in the experimental class. The subject being tested is determining the inverse matrix of the order 2x2. The percentage of students who get a score of 4 is 22.9%.

Quiz IV was attended by 35 people from 35 students of the experimental class. The subject being tested is to determine the determinant of the 3x3 order matrix using the Sarrus method. The percentage of students who get a score of 4 is 14.3% for indicators of drawing conclusions from a statement and 20% for indicators of finding patterns in a mathematical phenomenon.

Quiz V was attended by 35 people from 35 students in the experimental class. The subject being tested is to determine the determinant of the matrix of the order 3x3 with using the Minor method. The percentage of students who get a score of 4 is 22.9% with the indicator drawing conclusions from a statement. When compared with the fourth quiz for indicators of drawing conclusions, there was an increase of 8.6%.

Quiz VI was attended by 35 people from 35 students in the experimental class. The subject being tested is determining the inverse matrix of the order 3x3. The percentage of students who get a score of 4 for the indicator proposes an assumption that is 35.7%, when compared to the third quiz, there is an increase of 12.8%

So based on the results of the percentage score per indicator from the six quizzes implemented, it can be concluded that there is an effect of the PBL model on the reasoning ability of each indicator.

b. Data Analysis of Mathematical Reasoning Ability Tests

This analysis aims to test whether the proposed hypothesis is accepted or rejected. The hypothesis of this study is that students 'mathematical reasoning abilities with the application of the Problem Based Learnin (PBL) are better than students' mathematical reasoning abilities with the application of direct learning models. Before hypothesis testing is used, first the normality and homogeneity of variance tests are carried out with the help of Minitab software.

1) Normality Test

The normality test of the results of the mathematical reasoning ability test in the experimental class and control class was carried out using the Anderson-Darling test. Based on the normality test conducted, it was found that the *P-Value* of experimental class was 0.118, while the *P-value* of the control class was 0.180, because *P-Value* > $\alpha = 0.05$, then the final test results of the sample class mathematical reasoning ability are normally distributed. The results of the normality test can be seen in Appendix 25 on page 267.

2) Homogeneity Test of Variance

The homogeneity test of variance aims to determine whether the final test data of the two sample classes has homogeneous variance or not. Because the final test data on the mathematical reasoning ability of the sample class were normally distributed, the homogeneity test of variance was carried out using the F test. The results of the variance homogeneity which is conducted is $P - value$ = 0.595, because $P - value > \alpha$ $(\alpha = 0.05)$so it can be concluded that the test data of sample class has a homogeneous variance or H_0 accepted. The results of the variance homogeneity test can be seen in Appendix 26 on page 268.

3) Hypothesis Test

The Hypothesis testing aims to determine whether the research hypothesis is accepted or rejected, or whether the mathematical reasoning abilities of students whose learning uses the Problem Based Learning (PBL) are better than students with direct learning. After the homogeneity test of variance was carried out and the test data were obtained with a normal and homogeneous distribution, then the hypothesis was tested, namely the t-test. In this study, the hypothesis testing used *Minitab software* with comparative interpretations $P - value$ with α (the real level defined is 0.05). H_0 accepted if $P - value > \alpha$ Based on the results, the hypothesis test is obtained $P - value = 0.003$ which means $P - value < \alpha$ so it can be concluded that H0 rejected or H1 accepted. This means that students 'mathematical reasoning abilities with the application of the Problem Based Learning (PBL) are better than students' mathematical reasoning abilities by applying the direct learning model. Hypothesis test results can be seen in Appendix 27 on page 269.

Based on this explanation, it can be explained in detail the mathematical reasoning abilities of students in achieving each indicator of mathematical reasoning used.

a) Proposing Allegation

After analyzing the student's answer sheets in the two sample classes, the results of the students' mathematical reasoning abilities can be described in proposing conjectures. This indicator is represented by question number 4. The question number 4 is as follows.

> If known $A = \begin{pmatrix} 2 & 3 \\ 1 & 3 \end{pmatrix}$ and $B = \begin{pmatrix} 2 & 1 \\ 4 & 3 \end{pmatrix}$. Assuming the value of
>
> $\det(B^{-1}(A^{-1}B^{-1})^{-1}A^{-1})$

In this question, students are expected to be able to meet the indicators of proposing Allegation. From the problems presented, there is some information needed to solve the problem. Students are required to provide conjectures or estimates in determining the determinant value. In this case students must know the characteristics of a determinant in solving problems. The percentage of the number of students for each score on the indicator proposes an assumption can be seen in Table 18 below.

Table 18. Percentage of Students for Each Score on Indicators Making Conjectures

Class	Score				
	4	3	2	1	0
Experiment	25.71%	51.43%	22.86%	0%	0%
Control	12.12%	51.52%	24.24%	9.09%	3.03%

Based on Table 18, it can be seen that for a score of 4 in the percentage of the experimental class is higher than the control class. The score for 4 in experimental class was 13.59% higher than the control class. For the score of 3 in the control class is 0.09% higher than the experimental class. This is because there are still many students from the control class who err in determining the properties of a determinant of the given problem. When viewed from a score of 2, a score of 1, and a score of 0, then the percentage of the control class is higher than the experimental class. Overall, it can be seen that many students in the experimental class are at a score of 4.In the experimental class, no one is at a score of 1 and a score of 0. This shows that the experimental class is able to solve the problem of proposing conjectures well compared to the control class for question number 4.

The Problem Based Learning (PBL) model has student orientation stage on the problem. At this stage students observe the problems presented by the teacher. Students are asked to name things that are known according to the context of the problem presented. This is in accordance with Agus (2011: 75) that in the first phase students are encouraged to express their ideas freely and openly. So that the student orientation stage on the problem can help students in developing their ability to submit guesses. The following shows the answers of the experimental class and control class students in proposing conjectures.

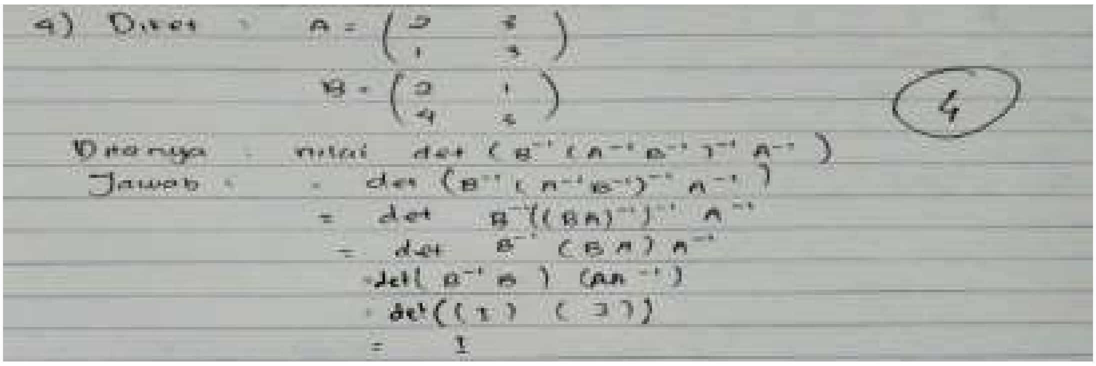


Figure 4.Examples of Answers from Experimental Class Students Who Get a Score of 4 for Question Number 4

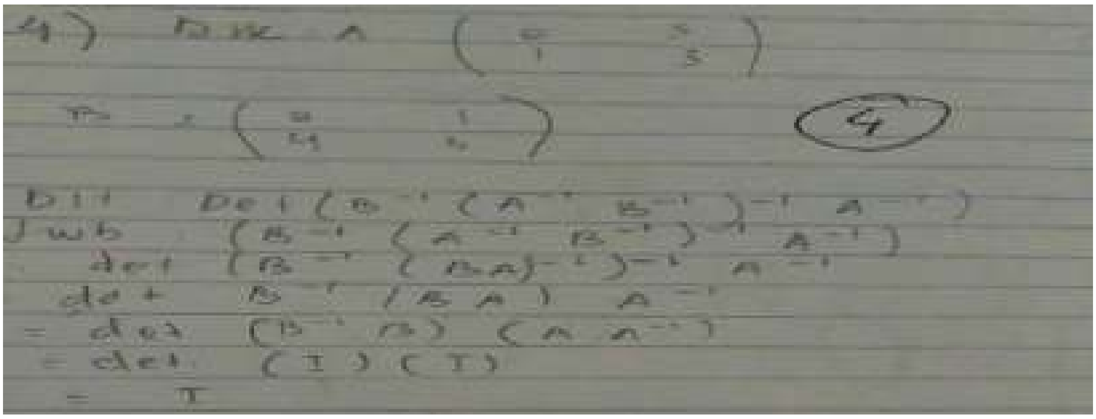


Figure 5.Examples of Answers from Control Class Students Who Received a Score of 4 for Question Number 4

Based on Figure 4 and Figure 5, it can be seen that the answers of the experimental class and control class students were able to propose the correct guess so that they were given a score of 4. In the experimental and control class students were able to propose guesses as expected, namely determining the determinant value using properties. In addition to getting a score of 4, the experimental class students also got a score of 3.The following is an example of the answers of the experimental class students who got a score of 3.

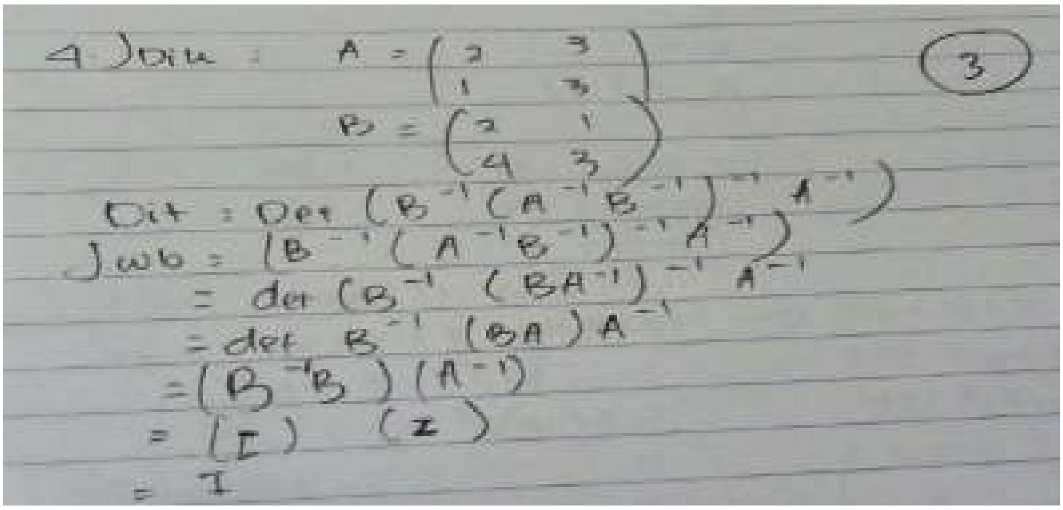


Figure 6. Examples of Answers from Experimental Class Students Who Get a Score of 3 for Question Number 4

Based on Figure 6, it can be seen that students have been able to determine the determinant value using properties but there are errors in completing the final answer. Students should make$(A.A^{-1})$because (A^{-1}) different from $(A.A^{-1})$.Therefore, student answers like this are given a score of 3. The students who got a score of 2 are as follows.

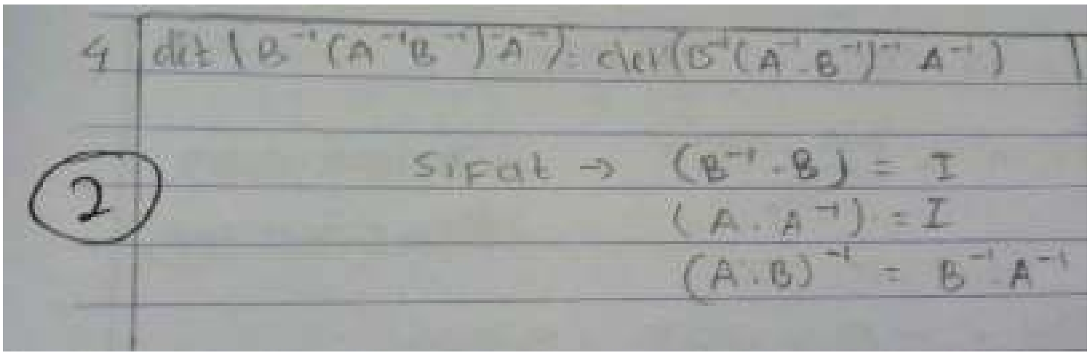


Figure 7. Examples of Answers from Experimental Class Students Who Get a Score of 2 for Question Number 4

Based on Figure 7, it can be seen that students have not been able to propose allegation correctly, students only make the properties of the inverse. Therefore, student answers like this are given a score of 2.

b) Drawing Conclusions from a Statement

After analyzing the student answer sheets in the two sample classes, the results of the students' mathematical reasoning abilities can be described in drawing conclusions from a statement. This indicator is represented by question number 5. The question number 5 is as follows.

> Check out the following statements
>
> If A is matrix containing a row of zeros and is a matrix containing a column of zeros, matrices A and B have an order $n \times n$ then it applies $|A| = |B| = 0$

In this question, students are expected to be able to meet the indicators of drawing conclusions from a statement. This problem requires students to be able to prove a statement of the problem given. The percentage of the number of students for each score on the indicators draw conclusions from a statement can be seen in Table 19 below.

Table 19. Percentage of Students Each Score on Indicators Draw Conclusions from a Statement

Class	Score				
	4	3	2	1	0
Experiment	34.28%	48.57%	14.29%	2.86%	0%
Control	18.18%	42.42%	33.33%	6.07%	0%

Based on Table 19, it can be seen that for a score of 4 and a score of 3 on the experimental class is greater than the control class. However, almost half of the students in the experimental class was score 3. This is because many students are incomplete in proving the statements given. And the control class has a lot of students who are at a score of 3 and a score of 2. At a score of 4 the experimental class is 16.1% higher than the control class. For the score of 3 the experimental class was 6.15% higher than the control class. While for scores 2 and 1 the control class was 19.04% and 3.21% higher than the experimental class. Because the percentage of the experimental class who got a score of 4 and a score of 3 was higher than the control class, it could be said that the students' ability to draw conclusions from the experimental class was better.

In *the Problem Based Learning* (PBL) model, there are stages to analyze and evaluate the problem-solving process. This stage hones the students' ability in the experimental class to be able to draw conclusions from a statement correctly. According to Agus (2011: 76) at the stage of analyzing and evaluating the problem solving process, educators guide students to analyze and evaluate their own thinking processes. So that students have systemic thinking skills. With students habitually doing this stage, participants are accustomed to drawing conclusions from a statement. The following shows the answers of the experimental class and control class students in drawing conclusions from a statement.

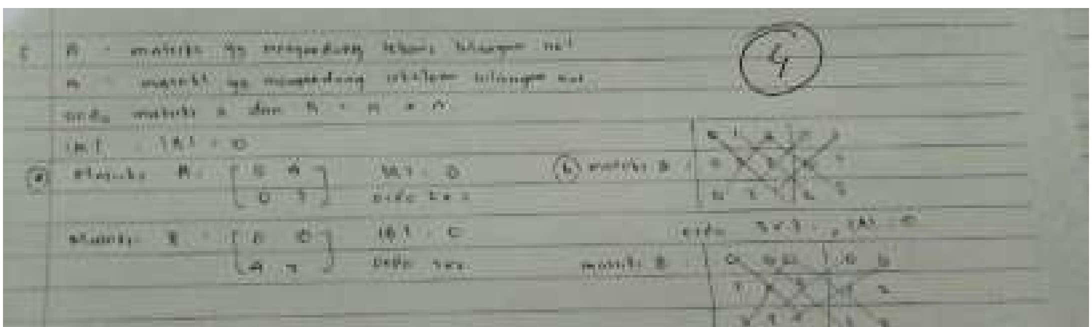


Figure 8.Examples of Answers from Experimental Class Students Who Received a Score of 4 for Question Number 5

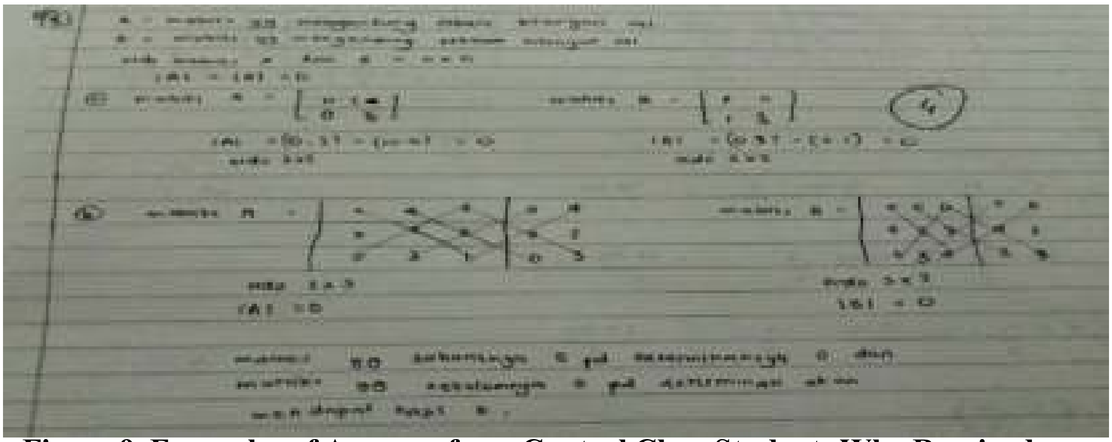


Figure 9. Examples of Answers from Control Class Students Who Received a Score of 4 for Question Number 5

Based on Figure 8 and Figure 9, it can be seen that the answers of the experimental class and control class students have been able to draw conclusions from a statement correctly so that they are given a score of 4. In the two pictures the students' answers show that students can prove the truth of a statement. Students have also been able to determine the determinant value for both the order 2x2 matrix and the 3x3 order matrix well. Therefore, the answer as above is given a score of 4.

In addition to getting a score of 4, the experimental class students also got a score of 3, a score of 2, a score of 1 and none of the students got the lowest score of 0. Here are examples of answers from students who got a score of 3.

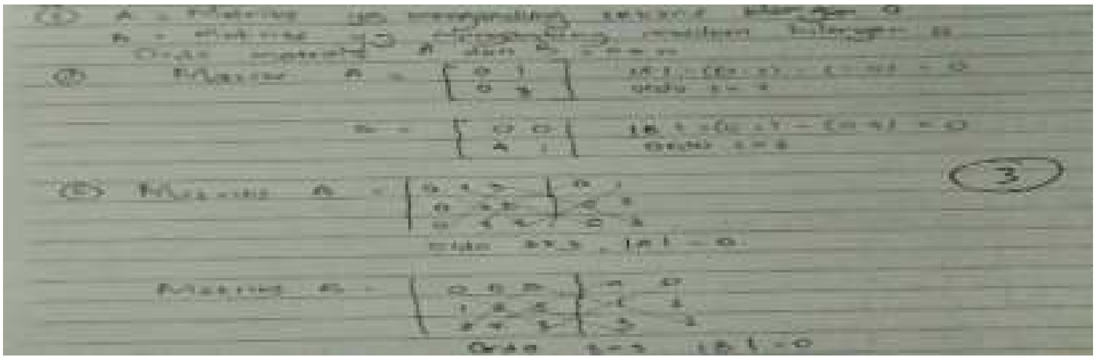


Figure 10. Examples of Answers from Experimental Class Students Who Get a Score of 3 for Question Number 5

In Figure 10, it can be seen that students have been able to make steps to draw conclusions from a statement, but students' answers are incomplete. Students do not make a statement from the statement that is proven. Therefore, student answers like this are given a score of 3. Here is an example of the answers of students who received a score of 2.

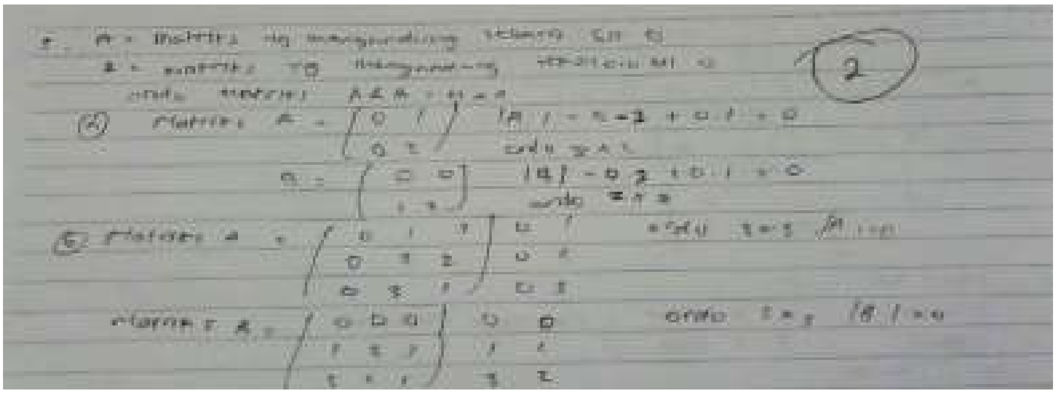


Figure 11. Examples of Answers from Experimental Class Students Who Get a Score of 2 for Question Number 5

Based on Figure 11, it can be seen that the students' answers were almost correct but there was a mistake in finding the determinant value of the 2x2 order.

Students write down $|A| = 0 \, . \, 2 + 0 \, . \, 1 = 0$, it should be $|A| = (0 \, . \, 2) - (0 \, . \, 1) = 0$. Therefore, student answers like this are given a score of 2. The following is an example of the answers of students who received a score of 1.

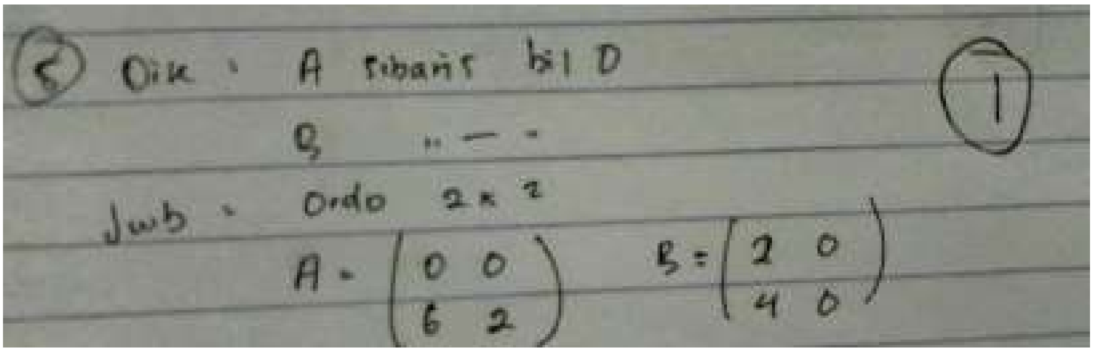


Figure 12. Examples of Answers from Experimental Class Students Who Get a Score of 1 for Question Number 5

Based on Figure 12, it can be seen that students only make a matrix and do not write down steps to make conclusions from a statement. Then the student's answer is given a score of 1.

c) Providing an Alternative to an Argument

After analyzing the student answer sheets in the two sample classes, the results of the students' mathematical reasoning abilities can be described in providing alternatives to an argument. This indicator is represented by questions number 2 and 3. The questions number 2 and 3 are as follows.

2. Tia went to a bookstore to buy 2 notebooks, 1 pen and 1 pencil for Rp. 6,500.00. The price of 2 pens and 1 pencil is twice the price of a notebook. The difference between the price of a notebook and the price of a pencil is equal to two thirds of the price of a pen. Determine the price of 1 notebook, 1 pen, and 1 pencil. Calculate using the matrix rule

3. The circumference of the table surface in a rectangular shape is 420 cm. It is known that the length is 30 cm longer than the width. Determine the length and width of the table surface. Calculate using the matrix ruleIn this question, students are expected to be able to meet the indicators providing an alternative to an argument.

This problem requires students to be able to determine the price of a notebook, a pen, and a pencil. Students can solve problems using the inverse or using the Cramer method. The percentage of the number of students for each score on the indicator provides an alternative to an argument can be seen in Table 20 below.

Table 20. The percentage of students per score on the indicator provides an alternative to an argument

Class	No Problem	Score				
		4	3	2	1	0
Experiment	2	17.14%	48.57%	34.29%	0%	0%
Control		15.15%	48.48%	36.37%	0%	0%
Experiment	3	31.43%	54.29%	14.28%	0%	0%
Control		24.24%	42.43%	27.27%	6.06%	0%

In Table 20 it can be seen that the percentage of the experimental class who got a score of 4 was 17.14% for question number 2 and 31.43% for question number 3, while the percentage of the control class who got a score of 4 was 15.15% for question number 2 and 24.24% for question number 3. This means that students in the experimental class answered more correctly and precisely according to the indicators providing an alternative to an argument.

In the *Problem Based Learning* (PBL) model, there is a stage of guiding individual and group investigations and a stage of developing and presenting the work. This stage hones the ability of the experimental class students to conduct investigations to find answers to the problems given. Then collect information by holding discussions. These are in accordance with Agus (2011: 74) that teachers encourage students to get the right information, carry out experiments, and discover explanations and solutions. With students accustomed to investigating and gathering information, students are accustomed to providing alternatives to an argument. The following shows the answers of the experimental class and the control class students in providing an alternative to an argument.

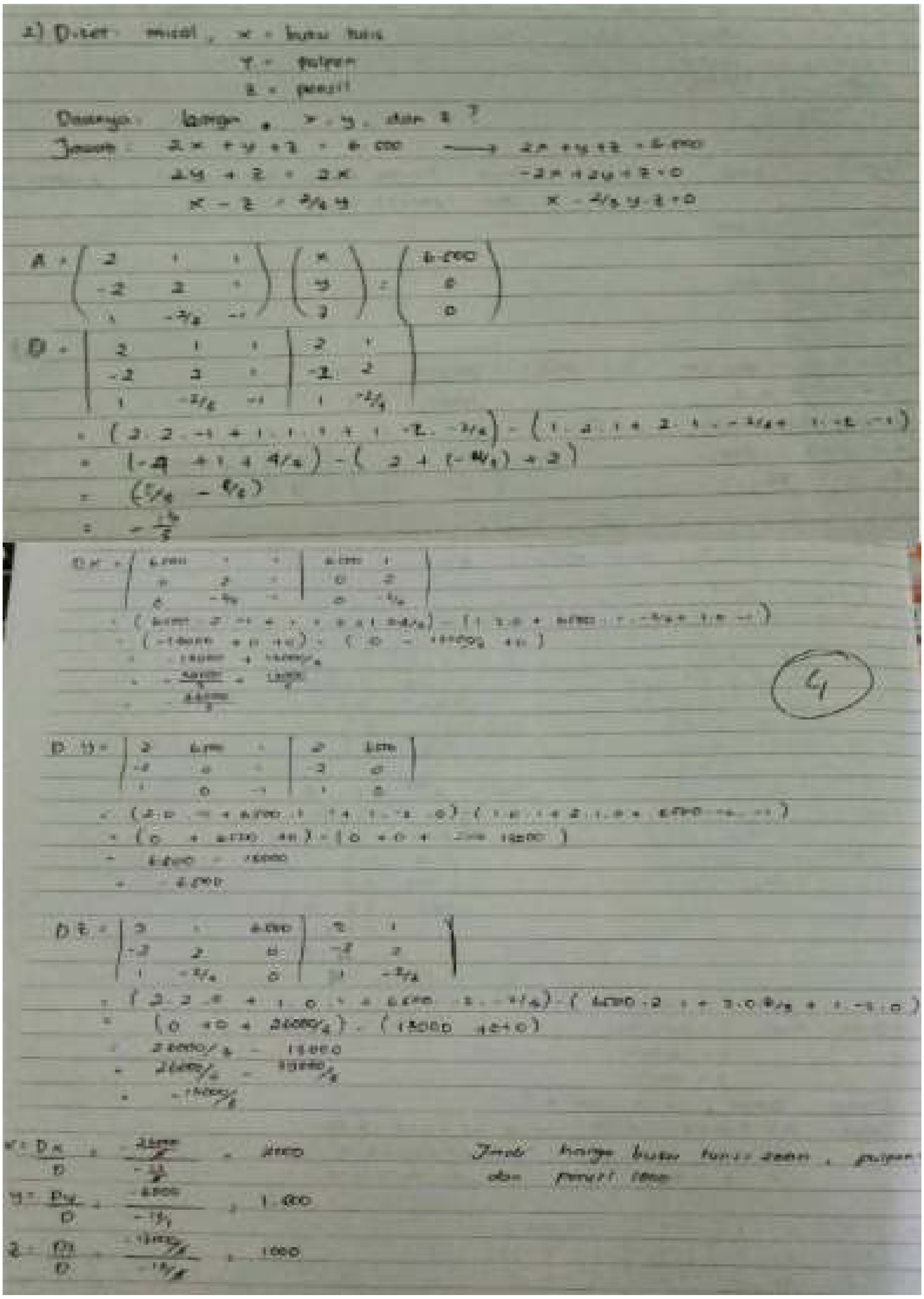


Figure 13.Examples of Answers from Experimental Class Students Who Get a Score of 4 for Problem Question 2

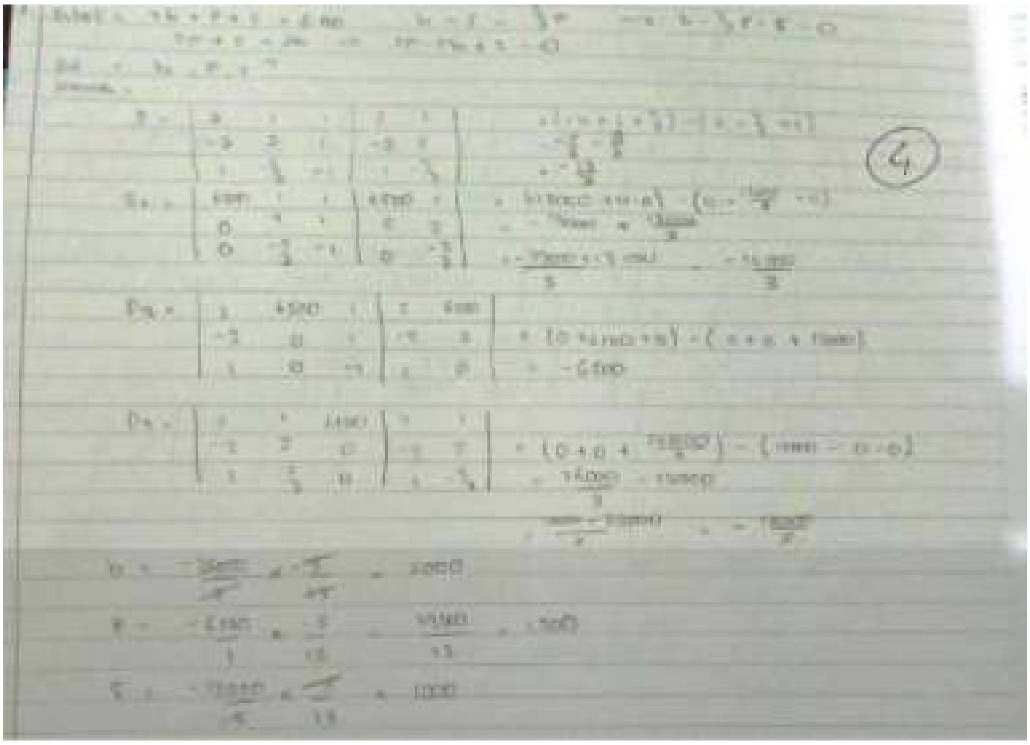


Figure 14. Examples of answers from control class students who received a score of 4 for Question Number 2

Based on Figure 13 and Figure 14, it can be seen that the answers of the experimental class and control class students were able to provide an alternative to an argument so that they were given a score of 4. Students were able to provide alternatives, namely solving problems using the cramer method. Students are also correct in making calculations so that the alternative solutions given are correct.

In question no 2, students in the experimental class not only got a score of 4, but there also got a score of 3 and a score of 2. Here is an example of the answers of students who got a score of 3.

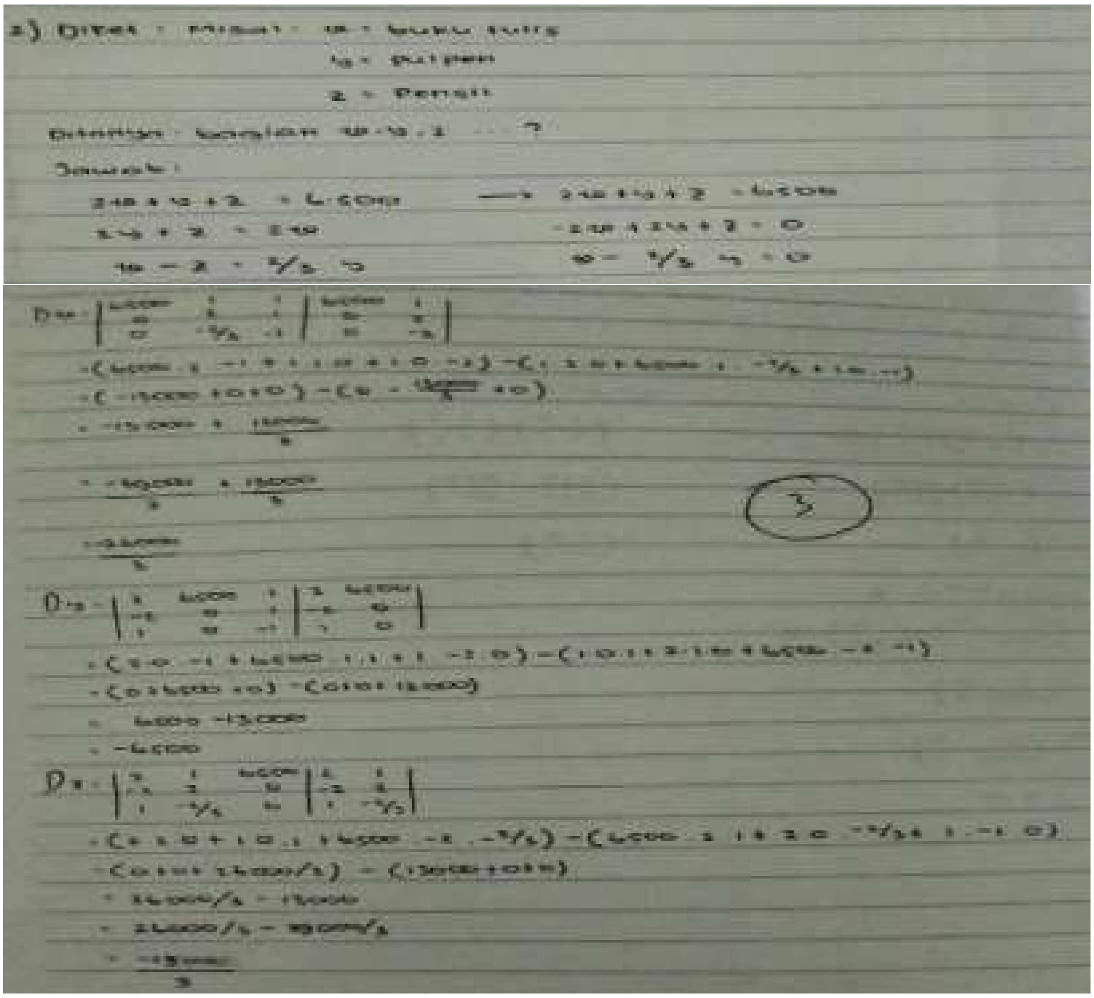


Figure 15. Examples of Answers from Experimental Class Students Who Get a Score of 3 for Question Number 2

In Figure 15 it can be seen that students have been able to provide alternatives to an argument, but these students do not provide answers regarding the values of the variables x, y and z. Therefore, student answers like this are given a score of 3. The following is an example of the answers of students who received a score of 2.

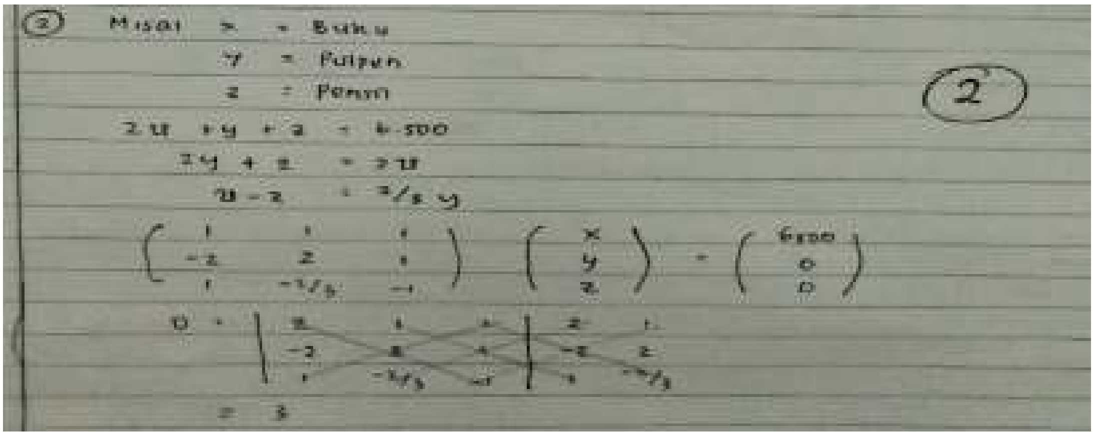


Figure 16. Examples of Answers from Experimental Class Students Who Get a Score of 2 for Problem Number 2

In Figure 16. It can be seen that students are incomplete in answering the questions given. Students only answer to determine the value of D. So that student answers are given a score of 2.

Here is an example of student answers in the experimental class and control class who got a score of 4.

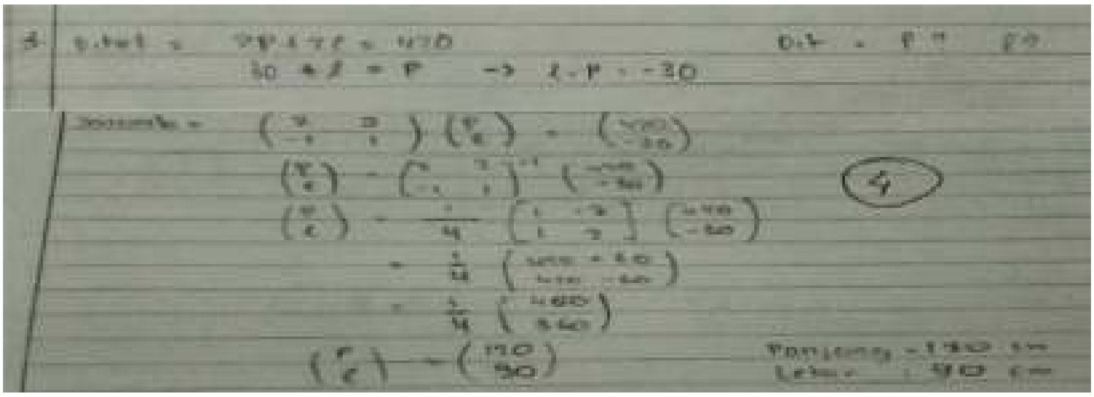


Figure 17. Examples of Answers from Experimental Class Students Who Get a Score of 4 for Question Number 3

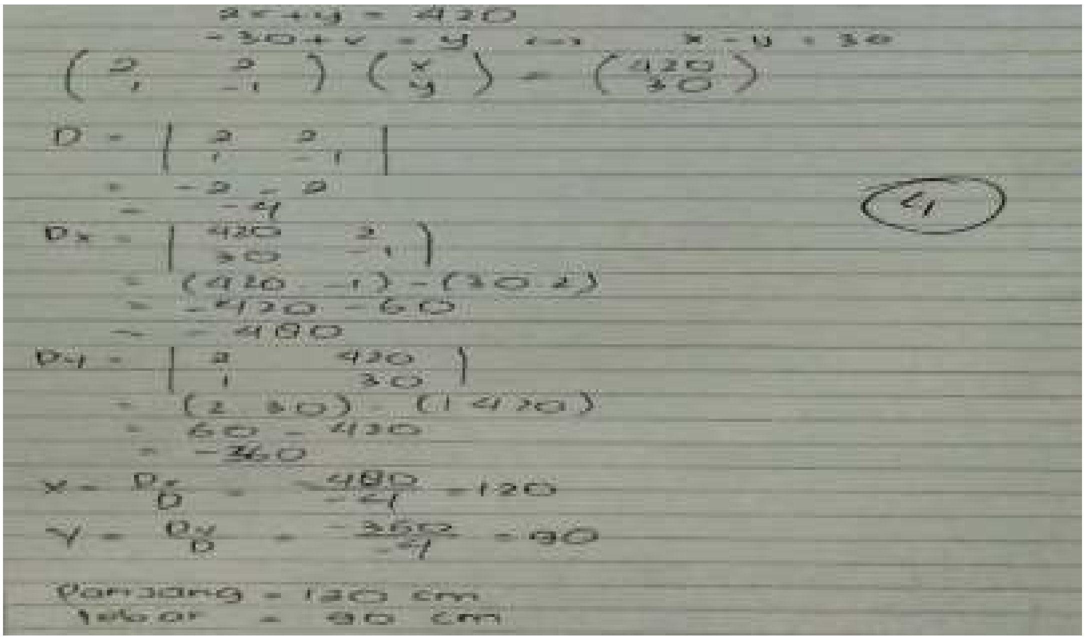


Figure 18.Examples of Answers from Control Class Students Who Received a Score of 4 for Qusetion Number 3

Based on Figure 17 and Figure 18, it can be seen that the answers of the experimental class and control class students were able to provide an alternative to an argument so that they were given a score of 4.

d) Finding the Pattern of a Mathematical Symptom

After analyzing the student answer sheets in the two sample classes, the results of students' mathematical reasoning abilities can be described in finding patterns of mathematical symptoms. This indicator is represented by question number 1. The question number 1 is as follows.

If known A matrix $= \begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix}$ = (11 01) then $A^{2019} + I =$ B. You decide $|B|$.

In this question, students are expected to be able to meet the indicators of finding patterns of mathematical symptoms. This problem requires students to be able to find the pattern of matrix multiplication, after finding a pattern in multiplying the matrix, the value can be determined A^{2019} on that question. The percentage of the number of students for each score on the indicator found a pattern of a mathematical symptom can be seen in Table 21 below.

Table 21. Percentage of Students Each Score on Indicators Finds Patterns of Mathematical Symptoms

Class	Score				
	4	3	2	1	0
Experiment	37.14%	31.43%	28.57%	2.86%	0%
Control	15.16%	42.42%	21.21%	21.21%	0%

Based on Table 21, it can be seen that for a score 4 the percentage of the experimental class is higher than the control class. For the score 4 of experimental class is 21.98% higher than the control class. For the score 3 of the control class was 10.99% higher than the experimental class. This is because there are still many students from the control class who erroneously determine the properties of a determinant of the given problem. Score 1 percentage of the control class is higher than the experimental class. Overall, it can be seen that many students in the experimental class are at a score 4. This shows that the experimental class is able to solve the problem of finding patterns of a mathematical phenomenon well compared to the control class for question number 1.

In *Problem Based Learning* (PBL), there is a stage for organizing students to learn and a stage for guiding individual and group investigations. At this stage the teacher helps students to define and organize learning tasks related to the problems given and helps students collect the information needed. The thing that can be done by the teacher so that the experimental class students can find a pattern of a mathematical phenomenon is to maximize doing LKPD. The following is an example of the answers of the experimental class and control class students who got a score of 4.

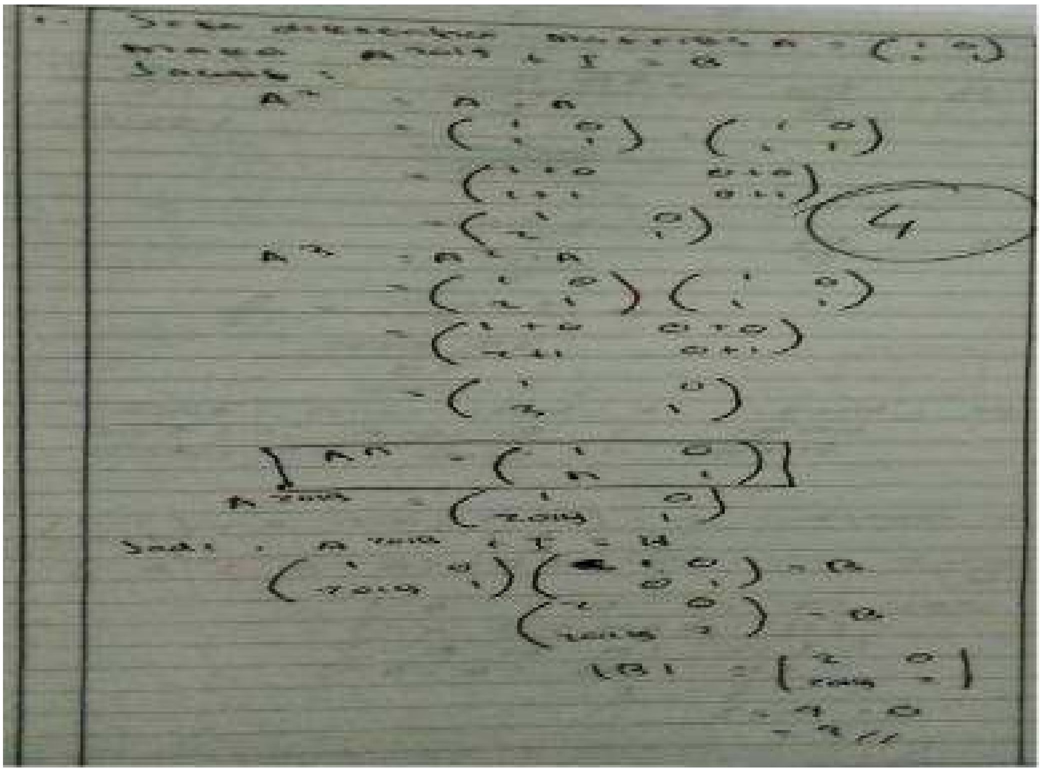


Figure 19. Examples of Answers from Experimental Class Students Who Received a Score of 4 for Question Number 1

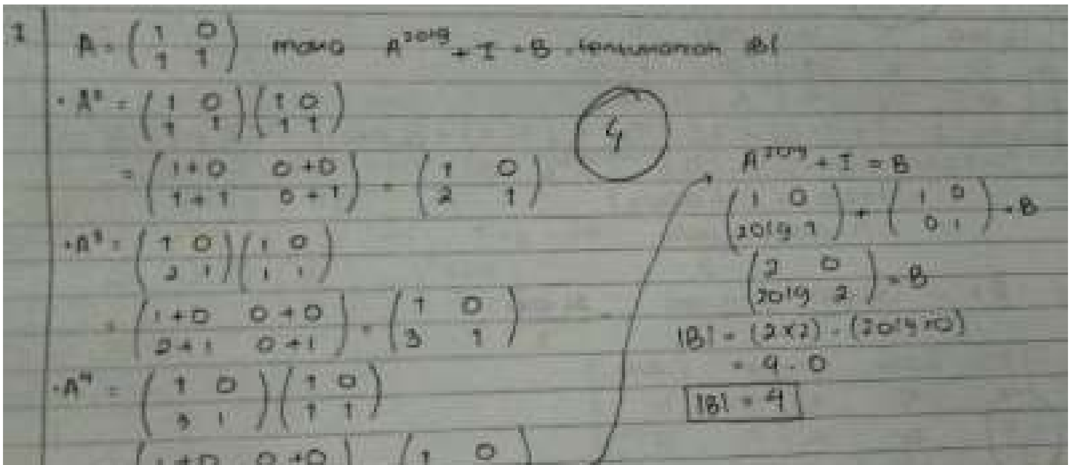


Figure 20. Examples of answers from control class students who received a score of 4 for Question Number 1

Based on Figure 19 and Figure 20, it can be seen that the answers of the experimental class and control class students were able to find the pattern of a mathematical phenomenon correctly so that they were given a score of 4. However, the answers of the experimental class students were more structured than the answers of the control class students. Besides a score of 4, there are also experimental class students who get a score of 3, a score of 2, and a score of 1 and there are no students who get the lowest score, namely 0. Here is an example of the answers of students who got a score of 3.

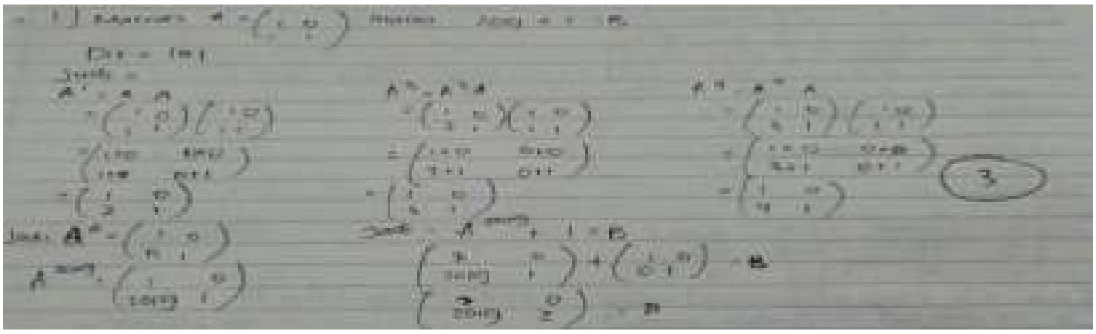


Figure 21. Examples of Answers from Experiment Class Students Yang Getting a Score of 3 for Question Number 1

Based on Figure 21 it can be seen that students have been able to find patterns of a mathematical symptom of the problems given, but students have not written down the answers to the questions given, namely the results of $|B.|$It should that the students found B matrix, the students should discover det (B) While students who have not found the value of the B matrix get a score of 2. Here is an example of the answers of the experimental class students who got a score of 2.

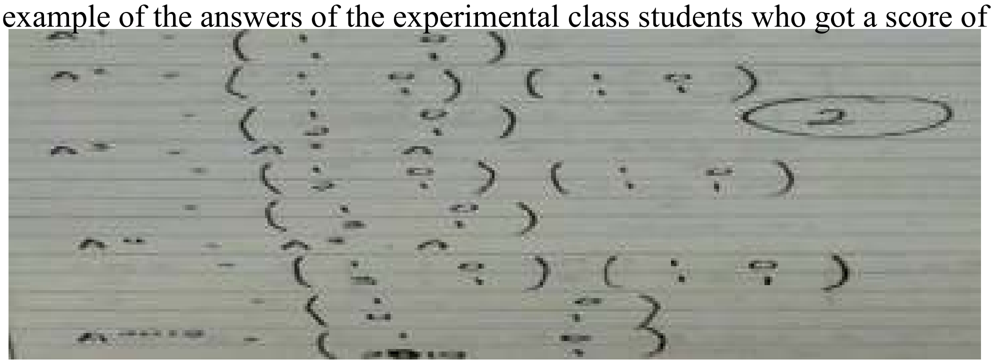


Figure 22. Examples of Answers from Experiment Class Students Yang Getting a Score of 2 for Qusetion Number 1

Based on Figure 22 it can be seen that the experimental class students have been able to find patterns, but students do not determine the value of det (B), so the answer is incomplete. In the experimental class there are students who get a score of 1. Here is an example of the answers of students who got a score of 1.

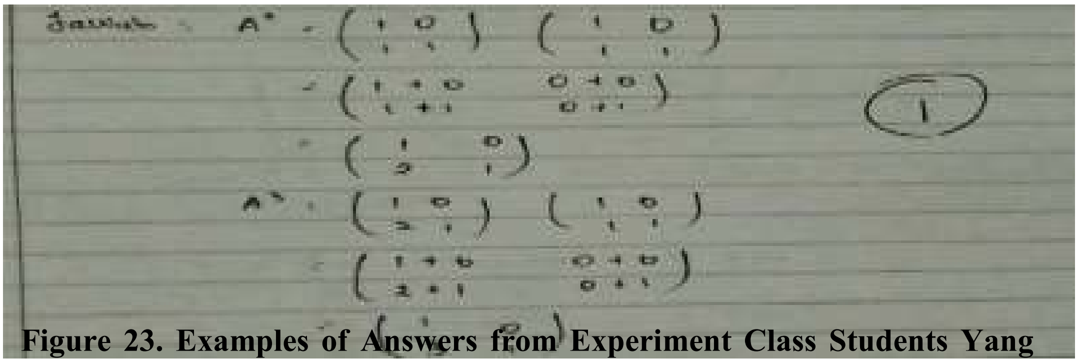


Figure 23. Examples of Answers from Experiment Class Students Yang Getting a Score of 1 for Question Number 1

Based on Figure 23, it can be seen that students have not been able to find a pattern from a mathematical course. So that students cannot determine the value of det (B). Therefore, student answers like this are given a score of 1.

B. Discussion

1. Students' Mathematical Reasoning Ability for Each Indicator

The mathematical reasoning abilities of the experimental class students who were given treatment in the form of the application of the *Problem Based*

Learning (PBL) model in the learning process had an influence on the students' mathematical reasoning abilities for each indicator. Quiz results associated with the results of the reasoning ability test for each indicator have increased when viewed from the score acquisition.

The first indicator is found in the 3rd quiz, 6th quiz, and the number 4 reasoning ability test. When compared to the 3rd quiz with the 6th quiz, there is an increase in the percentage of students who get the maximum score, namely 12.8%, however, when compared to the 6th quiz with the test results, there was a decrease of 9.99%. For score 3, there was an increase of 15.03% in the reasoning ability test when compared to the results of the 6th quiz.

The second indicator is found in the 4th quiz, 5th quiz, and reasoning ability tests for question number 5. When compared to the 4th quiz with the 5th quiz, there is an increase in the percentage of students who get a maximum score of 8.5%. When the 5th quiz was compared with the test results, there was an increase of 11.38%.

The third indicator is found in the 1st quiz, 2nd quiz, tests of reasoning abilities for questions 2 and 3. When compared to the 1st quiz with the 2nd quiz, there is an increase in the percentage of students who get the maximum score of 5.8%. When the second quiz was compared with the test results, there was an increase of 8.54%.

The fourth indicator is found in the 4th quiz, 6th quiz, and the reasoning ability test for question number 1. When compared to the 4th quiz with the 6th quiz, there is an increase in the percentage of students who get a maximum score of 12.9%. When the 6th quiz was compared with the test results there was an increase of 4.24%.

The increase in students' reasoning abilities is caused by the application of the *Problem Based Learning* (PBL) model in the learning process. Through the stages of implementing PBL, students will be trained to understand problems, analyze, and draw conclusions in the form of solutions to problems. Through this series of activities students will get used to providing arguments which is logical about a problem and students have the opportunity to develop skills in reasoning and independent learning (Rahmi Hijri 2015).

According to Armiati (2011) problem-based learning (PBL) is learning based on the constructivism approach, where students are faced with cognitive conflicts. This condition requires them to commit an analysis before giving answers, so that it can trigger the development of students' mathematical reasoning abilities.

Based on the discussion above, it can be concluded that the percentage of students' quiz scores and test results has increased. So, in general it can be concluded that with the application of the *Problem Based Learning* (PBL) model, the development of students' mathematical reasoning abilities has increased.

2. Student Response

The responses given by students to *the Problem Based Learning* (PBL) model show that each meeting is getting better. This can be seen from the implementation of the stages in *the Problem Based Learning* (PBL) model and the results of student works on the LKPD. At the stage of student orientation to the problem, students are introduced to a problem where they are asked to understand the problem that is given individually. The problems given are related to everyday life so that students can indirectly submit allegations because of problems close to their lives. Ade Mulya (2015) said that at the beginning of PBL learning, students were faced with past problems, and then teacher helps students formulate conjectures from the problems given. According to Desi Suryaningsih (2015) the *Problem Based Learning* (PBL) model uses questions (problems) related to everyday life, so as to motivate students to know how to solve them reasonably. This was also stated by Siti Mudhiah & Ali Shodikin (2019) that PBL is supported by Jean Piaget's theory because new knowledge is not given to students in a finished form, but students build and develop their own knowledge from the results of interactions with their environment. Then the teacher forms small groups consisting of 3-4 students and distributes LKPD to students individually and then the students are invited to understand the problems contained in the LKPD.

Furthermore, at the stage of organizing students to learn, at this stage students were asked to discuss the solution to the problems contained in the LKPD in groups. The predictions that the students have previously obtained are discussed with group members. This can improve the students' reasoning abilities. In accordance with what Tatang (2007) stated that group discussions armed with different ideas / ideas from each student have the potential to improve reasoning, because during group discussions students learn to construct their knowledge through new information obtained in the discussion. . It is also revealed by Rosmita (2019) that through the group work process students' thinking abilities can be optimized, because during group discussions students can hone, test, and develop their thinking skills on an ongoing basis.

Then the stage of guiding individual and group experiences, at this stage students in groups carry out investigations by discussing to determine the right strategy in solving the problems given, where students will carry out experiments to analyze and define the problem. This is in accordance with what Armiati (2011) stated, namely the third PBL characteristic is authentic investigation, where students collect information that can help students find real solutions to the problems given. Students analyze and define problems, and develop hypotheses and conduct experiments. At the first meeting the students did not seem to be active in conducting group discussions, where students prefer to work on LKPD individually so that there are students who do not work on LKPD and wait for answers from friends, but the teacher motivates students to discuss in groups by saying that group results greatly affect individual scores, so that each group member must understand the results from the work of LKPD. Then at the next meeting students have started to carry out group discussions to solve the problems contained in the LKPD.

Then, at the stage of analyzing and evaluating the problem solving process, these stage students reflect or evaluate investigations during group discussions. Where the teacher will call group members to present the results of the discussion in front of the class, this activity can train students' reasoning skills in drawing conclusions from a statement through the process that students have done during problem solving activities. Alias Masek & Sulaiman Yamin (2011) stated that the process in PBL is theoretically able to develop students' thinking, because the teacher as a facilitator monitors the progress of the group, one of which is through presentations. During the presentation the teacher made direct observations such as probing and asking questions, to trigger students' meta-cognition. This is in accordance with Lutfiah, el dk, stated The application of PBL can improve students' high-level thinking skills because in the learning process students will be asked to actively solve a problem, choose a logical solution based on ideas / ideas to get a conclusion as a form of reflection from previous knowledge.

3. The link of Students' Mathematical Reasoning Ability with Data Analysis Results

Based on each data analysis result obtained, it is proven that the model PBL learning improves students' mathematical reasoning abilities. The results of the quiz of students' mathematical reasoning abilities in the experimental class generally showed an increase in each indicator. The results of the mathematical reasoning ability test conducted at the end of the study also showed that the experiment class obtained higher results than the control class. In accordance with research conducted by Yanto Permana and Utari (2015) which states that the *Problem Based Learning* (PBL) learning model is effective against mathematical reasoning abilities. This can be a supporter of the truth of the results of the hypothesis test, which is true that the mathematical reasoning ability of students whose learning with the application of the *Problem Based Learning* (PBL) model is better than the mathematical reasoning abilities of students who learn using the direct learning model in XI IPA class at SMA Negeri 7 Padang Year Academic 2019/2020.

C. Research Constraints

Research conducted in XI IPA class at SMA Negeri 7 Padang regarding the effect of the *Problem Based Learning* (PBL) model on mathematical reasoning abilities has a positive influence on students. However, there are limitations and obstacles faced by the math class which is located at the last hour, so it is difficult to direct and refocus students to follow the lesson.

The second Constraint is in LKPD working, where students are less interested in reading the narratives contained in the questions, students are more interested in directly asking the teacher, but it will take a long time to answer questions from each student. This can be overcome by motivating and guiding students back to reading each existing narrative and explaining that the narrative really helps students in solving a given problem as a whole.

Third, in working on LKPD, there are some students who only rely on the results of their friends' completion, so that the teacher motivates students to work on the LKPD individually with the results of group discussions and then the teacher makes an agreement to choose several students randomly to explain the results of the LKPD in front of the class, then each student is expected to understand and master content of LKPD which they are performed.

CHAPTER V

CLOSING

A. Conclusion

Based on the results of research conducted in XI IPA class at SMA Negeri 7 Padang in the 2019/2020 academic year which has been described, it can be concluded that:

1. The mathematical reasoning ability of students whose learning with the application of the *Problem Based Learning* (PBL) model is better than the mathematical reasoning abilities of students whose learning is by applying the direct learning model,
2. Students' mathematical reasoning ability of each indicator is learning with the application of *the Problem Based Learning* (PBL) model has increased as seen from the results of quizzes and tests of reasoning abilities.

This is because the *Problem Based Learning* (PBL) model involves students directly in carrying out the stages of solving a problem. The *Problem Based Learning* (PBL) model also involves students actively in the learning process, so that learning is no longer centered on the teacher.

B. Suggestions

Based on the research that has been done, there are several things that can be suggested as follows:

1. Teachers should be able to keep students focus though learning is at the last hour. One alternative that can be applied is to provide ice breaking in the learning process.
2. Teachers should be able to increase students' interest in reading the narratives contained in the questions when working on LKPD. One alternative that can be applied is to emphasize to students that narrative can help them solve a given problem.
3. Teachers should supervise each group regarding student involvement in working on LKPD, because this will have an impact on their mathematical reasoning abilities.

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