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Using Problem-Based Learning to Promote Students' Critical Thinking and Mathematical Problem-Solving Skills

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Abstract: Using Problem-Based Learning to Promote Students' Critical Thinking and Mathmatical Problem Solving Skills. Objectives: This study aims to promote students' ability to think critically and solve mathematical problems in terms of the level of mathematical curiosity using Problem-Based Learning model. **Methods:** The method of research is quasi-experimental with the mixed method with a sequential explanatory strategy. **Findings:** There were differences in the students' critical thinking and mathematical problem solving skills taught by problem-based learning and conventional learning, but no difference based on the level of mathematical curiosity. **Conclusion:** Problem-based learning is recommended as an alternative solution for learning in the classroom in an effort to improve critical thinking skills and solve mathematical problems.

Keywords: problem-based learning, critical thinking skills, mathematical problem solving skills, mixed method research.

Abstrak: Menggunakan Problem-Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis dan Pemecahan Masalah Matematis Siswa. Tujuan: *Penelitian ini bertujuan mengetahui kemampuan berpikir kritis dan pemecahan masalah matematis ditinjau dari level mathematical curiosity mahasiswa dengan menerapkan model Problem-Based Learning.* ***Metode:*** *Metode penelitian adalah kuasi eksperimen dengan metode campuran dengan strategi eksplanatoris sekuensial.* ***Temuan:*** *Terdapat perbedaan kemampuan berpikir kritis dan pemecahan masalah matematis mahasiswa yang diajarkan dengan problem-based learning dan pembelajaran konvensional, namun tidak terdapat perbedaan berdasarkan level curiosity matematis.* ***Kesimpulan:*** *Problem-based learning direkomendasikan menjadi solusi alternatif pembelajaran didalam kelas dalam upaya meningkatkan keterampilan berpikir kritis dan penyelesaian masalah matematis.*

Kata kunci: *problem-based learning, keterampilan berpikir kritis, keterampilan pemecahan masalah matematis, penelitian mixed method.*

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INTRODUCTION

The ability to think critically (critical thinking skills) and solve problems (problem solving skills), are part of the 4Cs skills (critical thinking and problem solving. communication, collaboration and creativity skills) are skills that are needed so that humans are able to face changing circumstances or challenges. challenges in life in the 21st century (Purwaningsih & Wangid, 2021). Critical thinking is a person's effort to collect, interpret, analyze, and evaluate information for the purpose of reaching reliable and valid conclusions (Chukwuyenum, 2013; (Changwong, 2018), as well as problem-solving skills which are skills that are very necessary, especially in learning.

Regarding the importance of critical thinking skills and problem solving, in the NCTM document it is explained that critical thinking and problem solving are an essential part of mathematics and mathematics education, that is to say that students must learn to think critically and solve mathematical problems, in addition to reasoning, communication in basic education and medium (Jl & Parman, 2013). This suggests that the importance of critical thinking and problem solving in learning mathematics. Critical thinking skills, according to (Cáceres et al., 2020), are often neglected by teachers in the learning process in class. One of the reasons is the difficulty of a teacher to direct learning that integrates this ability.

Critical thinking is the essence of analyzing and re-evaluating existing thought processes. Johnson (2007) defines that critical thinking is a directed and clear process that is used in mental activities such as solving problems, making decisions, persuading, analyzing, and conducting scientific research (Zetriuslita et al., 2017). Critical thinking in mathematics is thinking that tests, questions, connects, evaluates all aspects in a situation or a problem (Firdaus et al., 2015).

For problem solving abilities, the OECD explains that student assessment is material for measuring mathematical literacy so that students not only master the material but are able to solve and interpret problems in various real-life situations (Pratiwi, 2019). In the PISA problem, there are contents, namely Shape and Space, Change and Relationship, Quantity, and Uncertainty. According to Stacey, the most difficult questions in PISA are change and relationship content. In change and relationship content, students' reasoning and creativity skills are needed in solving real context problems and manipulating them into algebraic forms(Simalango & Aisyah, 2018). Because this is related to problem solving, for this reason there is a need for an increase in problem solving abilities in students towards learning mathematics. With an increase in problem-solving skills in learning mathematics, it can improve other abilities, for example thinking logically, analytically, creatively and others. students must be able to interpret the problems given into mathematical sentences, solve them, evaluate problem solvers and test or retest the accuracy of the answers to the problems given (Zetriuslita et al., 2018).

However, in reality the ability to solve mathematical problems is still low, based on the results of research conducted by Kharisma and Asman, information was obtained that: 1) not all problem solving questions are in mathematics; 2) students' mathematical problem solving abilities are still weak; 3) the learning process is not sufficient to guide and train students to be able to solve problems (Kharisma & Asman, 2018). The problem that occurs is that students are reluctant to look for answers to the questions given, they don't try to ask the teacher about problems they don't understand, this will affect student activity in learning (Zetriuslita & Ariawan, 2021b).

The thing that must be paid attention to by the teacher is to arouse the curiosity of students, so that they are motivated to analyze things in learning (Kadek et al., 2020). In addition, curiosity has a meaning as a behavior to know and find out about a problem (Fauzi et.al., 2017). Furthermore, the importance of mathematical curiosity as a reason to look at critical thinking skills and solving mathematical problems is because the indicators between the three are interrelated.

Based on the opinion above, the ability to think critically, solving mathematical problems with attention to mathematical curiosity needs to be developed in life, especially in the world of education, especially education in tertiary institutions, this is in accordance with the scientific vision and mission of the study program. To develop this ability, learning is needed that can facilitate it, one of which is the Problem Based Learning model.

Critical thinking skills can be seen as a foundation for critical thinking, namely the ability to: 1) identify problems; 2) find ways that can be used to deal with problems; 3) identify assumptions and unstated values; 4) understand and use appropriate, clear, and distinctive language; 5) analyzing data; 6) assessing facts and evaluating statements; 7) recognize the existence of a logical relationship between problems; 8) draw the necessary conclusions and similarities; 9) examine the similarities and conclusions one draws; 10) rearrange one's belief patterns based on broader experience; 11) make appropriate judgments about certain things and qualities in everyday life (Zetriuslita et al., 2016)

Critical thinking can arise when in learning there is a problem that triggers it and is followed by questions: Solving the problem in another way, "Asking what if questions?", "What's wrong?", and "What will you do?" . Situations like this have not yet appeared in conventional mathematics learning, so that students' critical thinking skills are less trained. In terms of critical thinking skills are needed by students in overcoming various problems in everyday life.

Problem solving as a key component in the mathematics learning curriculum (Cahyono, 2015). The demand to make students able to solve problems well has become a central theme in learning mathematics. Mathematics learning should contain problem solving as the main part of all aspects of its activities. Teachers should provide students with "rich" problems, problems related to everyday life, and problems that challenge and motivate them. Problem solving is an effective way to explore new mathematical ideas.

Branca (1980) and Bulut (2010) in (Fasha et al., 2018) explain that problem-solving ability is a general goal of learning mathematics, even as the heart of mathematics. Problem solving in mathematics is essentially a high-level thinking process. Solving problems in teaching mathematics is solving non-routine questions using various concepts, principles and skill. Non-routine questions are questions whose completion requires further stages of thinking because they do not have clear procedures. These non-routine questions are presented in new situations that are rarely encountered by students before, so students are expected to be able to use previously learned concepts to solve everyday problems. Polya (1973) dan Motter (2010) put forward four indicators of problem-solving ability, namely understanding the problem, making or preparing a settlement plan, carrying out calculations, and re-checking the results of calculations that have been obtained previously (Kharisma & Asman, 2018). Mathematical Curiosity is defined as a strong encouragement that exists within students in understanding the material or mathematical problems given (Zetriuslita & Ariawan, 2021a). Curiosity about the mathematical problems given encourages students to get answers to the questions they have. One way to get answers is to ask educators. Asking activities help students to construct their understanding independently. Conceptual understanding obtained by constructing understanding is better than the understanding obtained. For this reason, it is necessary to develop students' curiosity in learning mathematics because curiosity will encourage students to acquire new knowledge. The mathematical curiosity meant here is students' curiosity about problems or conflicts presented in learning mathematics (Iqoh et al., 2021). Attitude and learning process were affected by learning, one of them problem-based learning model (Demirel & Daðyar, 2016 ; Yew & Goh, 2016).

Based on the above, the research questions to be answered are: 1) Are there differences in the ability to think critically and solve mathematical problems between students who receive learning using the Problem Based Learning model from students who receive conventional learning in terms of: (a) all students, (b) level of mathematical curiosity (high, medium and low)? 2) What is the process of critical thinking, solving mathematical problems between students who receive learning using the Problem Based Learning model and students who receive conventional learning?

METHODS

Participants

The population in this study were students in the 7th semester of the Mathematics Education Study Program FKIP Islamic University of Riau (UIR) for the 2022/2023 academic year and the sample was 32 class 7A students as the experimental class and 34 class 7B students as the control class Purposive.

Research Design

The research design is a quasi-experimental (Creswell, 2014) which aims to obtain quantitative data about critical thinking skills and mathematical problem solving of students who receive learning using the Problem Based Learning model with students who receive conventional learning, while the qualitative data obtained is used to determine critical thinking process and student problem solving. The research method uses a combination of quantitative and qualitative methods or known as the mixed method with a sequential explanatory strategy (Creswell, 2014). The research design used in this study was a quasi-experimental type with an untreated control group design with pretest and posttest (Setyosari, 2010).

Instruments

The instruments are test and non-test instruments. The test instrument is in the form of description questions to measure students' critical thinking skills, solving mathematical problems, while the non-test instrument is in the form of student mathematical curiosity questionnaires. For instrument test using two indicators of critical thinking skills and two indicators of problem solving and non-test instrument is in the form of student mathematical curiosity questionnaires using five indicator by forty statements.

The indicator of mathematical critical thinking ability namely; (1). The ability to identify and justify concepts, namely abilities provide reasons for mastery of the concept; (2). Ability to analyze, namely the ability to choose and determine important information from the questions given, and the indicator of mathematical problem-solving ability are; (1) understand the problem; (2) solving the problem according to the plan that has been made.

Meanwhile, for mathematical curiosity, indicators are used (1) Ask about information or problems provided; (2) Want to know things directly detailed; (3) Enthusiasm/ enthusiasm in learning; (4) Looking for information from various sources; (5) Trying alternative solutions to problems.

Procedures

Data was collected through tests of critical thinking skills, solving students' mathematical problems and filling out mathematical curiosity questionnaires on learning with the Problem Based Learning model in the experimental class and conventional learning in the control class. Test and non-test data were obtained from pre-test and post-test results. Firstly : Testing the normality, if the data is normally distributed, proceed with the homogeneity test, if not, use the non-parametric test. Secondly. Test the homogeneity of the experimental class and control class data. Finally, testing the similarity of the two means using a parametric statistical test, namely the Independent-Samples t-test, and non-parametric test, namely Rank, Mann Whitney-test.

As a basis for grouping students based on the level of mathematical curiosity (high, medium, low), the researcher takes the scores from the mathematical curiosity questionnaire before learning. To classify the level of mathematical curiosity adopted based on the level of Initial Mathematical Ability an be seen in Table 1 below:

Table 1. Mathematical curiosity level

Category	MCL Score Intervals
High	$x \geq \bar{x} + stdev$
Medium	$\bar{x} - stdev \leq x < \bar{x} + stdev$
Low	$x < \bar{x} - stdev$

Notes: x = scores of student mathematical curiosity questionnaires, $\bar{x}$ = average score stdev = Standard deviation. Arikunto's grouping is modified by taking the percentage of the high and low groups which is 30% of the remaining students for the medium group (40%).

Data Analysis

Data was collected through tests of critical thinking skills, solving students' mathematical problems and filling out mathematical curiosity questionnaires on learning with the Problem Based Learning model in the experimental class and conventional learning in the control class. Statistical tests were performed using SPSS version 25 for Windows. Test and non-test data were obtained from pre-test and post-test results. Testing the normality by One-Sample Kolmogorov-Smirnov-Test. Variances Homogeneity test by Lavene-test and testing the similarity of the two means using a parametric statistical test, namely the Independent-Samples t-test and non-parametric test, namely Rank, Mann Whitney-test. The validity and reliability of critical thinking ability tests as follows in Table 2:

Table 2. Validity and reliability of critical thinking ability test

Test number	**Validity**		**Reliability**	
	r_{xy}	**Notes**	R_{11}	**Category**
1	0.535	Valid	0.807	Very high
2	0.432	Valid		

Table 3. Validity and reliability of problem solving ability test

Test number	Validity		Reliability	
	r_{xy}	Notes	R_{11}	Category
3	0.705	Valid	0.807	Very high
4	0.518	Valid		

While the validity and reliability of problem solving ability tests can be seen in Table 3:

To obtain a score for critical thinking skills, a scoring guide is needed for student answers to each item. The scoring criteria used adapted from (Facione, 2016) in The Holistic Critical Thinking and Problem Solving Scoring Rubric – HCTSR namely: Strong 4: Consistently does all or almost all Acceptable 3: Does most or many Unacceptable 2: Does most or many Significantly Weak 1: Consistently does all or almost all.

■ RESULTS AND DISCUSSION

Description of experiment class and control class pretest

Description of pretest mean score of experiment class and control class were shown Table 4. below:

Table 4. Description of students' pretest data on the experimental and control classes

Descriptive Statistics					
Class	N	Minimum	Maximum	Mean	Std. Deviation
Experiment	32	5.0	45.0	31.750	9.7087
Control	34	5.0	40.0	23.882	9.8650
Valid N (listwise)	32				

From Table 4, descriptively it can be seen that the average of pretest the experimental class is higher than the control class. To see whether this difference is significant or not, an inferential statistical test is performed. Previously, the normality and homogeneity of the data were tested. Based on the results of statistical tests, the pretest data were normally distributed as indicated by the One-Sample Kolmogorov-Smirnov Tes (this determination is based on the amount of data where the pretest score experiment class is 0.200 (greater than α = 0.05) , and control class is 0.116 (greater than α = 0.05) While the significance value of the Test of Homogeneity of Variances is 0.098 (greater than α = 0.05), which indicates that the data have the same variance (homogeneous).

From the Independent Samples Test, obtained sig = 0.023 < α, Ho received, it means no difference for experiment class and control class. It can be said, if there is a difference between the mathematical critical thinking ability and mathematical problem solving that are influenced by the learning model used.

Description of mathematical critical thinking ability

Description of mathematical critical thinking ability was obtained from the post-test results after being given treatment which included the mean, standard deviation based on mathematical curiosity level and learning. Data recapitulation of achievement of mathematical critical thinking ability is presented in Table 5 below:

Table 5. Description of students' critical thinking data on the experimental and control classes

Class	Mean	Deviation Standard	Minimum	Maximum
Experiment	9.250	6.895	.00	20.00
Control	14.764	5.348	1.00	20.00

From Table 5 descriptively it can be seen that the average ability of the experimental class is lower than the control class. To see whether this difference is significant or not, an inferential statistical test is performed. Previously, the normality and homogeneity of the data were tested. Next, the hypothesis testing will be carried out in the next stage.

Hypothesis 1:

There is a difference in the achievement of mathematical critical thinking ability between students who receive learning using the Problem Based Learning model and students who receive conventional learning.

In testing this hypothesis, formally, the statistical hypothesis (H_0) and the research hypothesis (H_1) are as follows:

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

H_0: There is no difference between critical thinking ability of the experimental class student with the control class student.

H_1: There is difference between critical thinking ability of the experimental class student with the control class student.

Criteria for testing the difference from two classes are, Ho is accepted if the significant value is greater than $\alpha = 0.05$ and Ho is rejected if the significant value is smaller than $\alpha = 0.05$. To test hypothesis 1, the following steps are taken:

1. Test the normality of the mathematical critical thinking score data between students who receive learning using the Problem Based Learning model and students who receive conventional learning. Normality test results with the One-Sample Kolmogorov-Smirnov (K-S) test are obtained Sig = 0.021 < α = 0.05, meaning that H_0 is rejected, the data is not normally distributed.
2. Because the data is not normally distributed, from the non-parametric test by Mann-Whitney test is obtained that *Asymp sig* = 0.002 < α meaning that H_0 is rejected. It can be concluded that there are differences in the achievement of mathematical critical thinking skills between students who receive PBL learning and students who receive conventional learning. When viewed from the Mean Rank, the control class has a higher score than the experimental class. Thus, it can be concluded that the achievement of mathematical critical thinking skills between students who get conventional learning is better than students who get PBL learning.

Problem Based Learning (PBL) is constructivism learning designed to emphasize student activity (student center) and prioritize problems as a starting point in understanding learning material. (Ali, Hukamdad, Akhter, & Khan, 2010) states that in PBL, students from passive listeners of information become active learners, learn independently and become problem solvers. Also (Ikman et al., 2016) in his research concluded that PBL is effective in improving the critical thinking skills of class X students of SMA 1 Wawotobi-Unaaha South Sulawesi for the 2015/2016 academic year. Research that is in line with the above research regarding the application of PBL is Hmelo-Silver, (2004) in (Masek & Yamin, 2011) that if the PBL steps are implemented well, it will enable students to develop their critical thinking skills, especially in the second and third steps of PBM, students will focus on solving problems. given both individually and in groups, at that time the role of the educator was to provide direction so that students were not confused by the problems given.

In this study, it happened that the achievement of students' mathematical critical thinking skills was strongly influenced by learning tools such as the implementation of learning contained in the lecture implementation plans and student worksheets which contained more on the development of critical thinking skills. In practice, to maximize the involvement of students who are actively involved in learning, students sit in small groups of 4 to 5 people who have heterogeneous abilities. This is intended so that there is no domination of certain students, but it is hoped that students who have higher initial abilities than other students can contribute to their groups so that the learning process is more interactive and meaningful.

In contrast to the results obtained in this study, conventional learning has better critical thinking skills than learning with the PBL model, because at this first meeting, students did not seem enthusiastic about participating in the learning process, because this method was new to them, although some students still seemed confused, their enthusiasm remained. In practice, lecturers are more focused on developing students' thinking processes and ignoring mathematical communication skills and training students' curiosity in the learning process, this is also evident in the contents of the student worksheet. Researchers as lecturers feel that they have not been optimal in implementing PBL steps because they are still adjusting to student readiness conditions.

This research is in line with the literature review which states that minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching (Kirschner et al., 2010).

One of the reasons is that it is very difficult for students to interpret the problems in word problems into mathematical sentences, which is the key to being able to solve the problems given. According to Cars, Perry, and Conroy (in Sutawidjaja, 1998) strategies for promoting this indicator related to students include: (a) students must be encouraged to accept ignorance and feel happy finding out, (b) sometimes students are allowed to choose problems from a number of problems given to make questions or questions, and (c) students must be encouraged to take risks and look for alternative solutions to problems.

In the control class, because of conventional learning, students are explained the material, they are more enthusiastic about participating in lectures, thus giving better results than the PBL class. Direct instruction can help students understand the material even better (Zetriuslita et al., 2021; Nuraeni & Aisyah, 2022). For experiment class, the highest score is indicator 1 namely; students' thinking or mathematical abilities is in the indicator 2 namely; "The ability to identify and justify concepts, namely abilities provide reasons for mastery of the concept;" i.e. 5.24. While the lowest score is students' mathematical critical thinking skills in PBL was achieved at 4.10 on the indicator "Ability to analyze, namely the ability to choose and determine important information from the questions given. The same thing happened in conventional learning, the highest and lowest score in students' mathematical critical thinking skills were achieved on the same indicators as PBL learning as shown in figure 1.

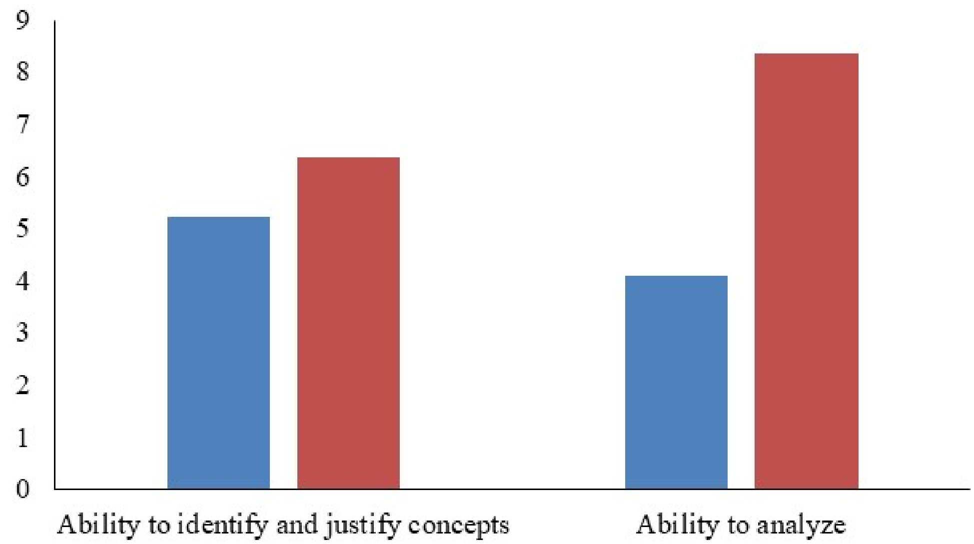

Figure 1. Score of critical thinking indicator

From figure 1, it can be concluded that for each indicator, the score of the experimental class (PBL) is lower than the control class (direct instruction). This happens because students prefer learning in the control class compared to PBL with little guidance.

Description of Mathematical Problem Ability

Description of mathematical problem solving ability was obtained from the post-test results after being given treatment which included the mean, standard deviation. (See Table 6) below.

Table 6. Description of students' problem solving data on the experimental and control classes

Class	Mean	Deviation Standard	Minimum	Maximum
Experiment	9.875	6.6563	1.0	20.0
Control	13.088	6.1465	1.0	20.0

From Table 6 descriptively it can be seen that the average mathematical problem solving ability of the experimental class students is lower than the control class. To see if this difference is significant or not, an inferential statistical test is carried out, previously tested for the normality and homogeneity of the mathematical problem solving data.

***Hypothesis 2*:**

There are differences in the achievement of mathematical problem solving abilities between students who receive learning with the Problem Based Learning model and students who receive conventional learning.

In testing this hypothesis, formally, the statistical hypothesis (H_0) and the research hypothesis (H_1) are as follows:

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

H_0: There is no difference between problem solving ability of the experimental class student with the control class student

H_1: There is difference between problem solving ability of the experimental class student with the control class student

Criteria for testing the difference from two classes are, H_0 is accepted if the significant value is greater than $\alpha = 0.05$ and

H_o is rejected if the significant value is smaller than $\alpha = 0.05$.

To test hypothesis 2, the following steps are taken:

1. Test the normality of the mathematical problem solving score data between students who receive learning using the Problem Based Learning model and students who receive conventional learning. Normality test results with the One-Sample Kolmogorov-Smirnov (K-S) test are obtained Sig = 0.006 < á = 0.05, meaning that H_0 is rejected, the data is not normally distributed.
2. Because the data is not normally distributed, from the non-parametric test by Mann-Whitney test is obtained that *Asymp sig* =0.049 < á meaning that H_0 is rejected. It can be concluded that there are differences in the achievement of mathematical problem solving skills between students who receive PBL learning and students who receive conventional learning. When viewed from the Mean Rank, the control class has a higher score than the experimental class. So it can be concluded that the achievement of mathematical problem solving skills between students who get conventional learning is better than students who get PBL learning.

For experiment class, the highest increase in indicator 1 namely; students' thinking or mathematical abilities is in the indicator 2 namely; " Understand the problem ;" i.e. 6.17. While the lowest increase in students' mathematical problem solving skills in PBL was achieved at 3.86 on the indicator " Solving the problem according to the plan that has been made. The same thing happened in conventional learning, the highest and lowest increases for students' mathematical critical thinking skills were achieved on the same indicators as PBL learning, namely the lowest achieved was 6.38 and the highest was 8.38. The same thing happened in conventional learning, the highest and lowest increases for students' mathematical problem solving skills were achieved on the same indicators as PBL learning, namely the lowest achieved was 5.29 and the highest was 7.79. It can be shown at figure 2.

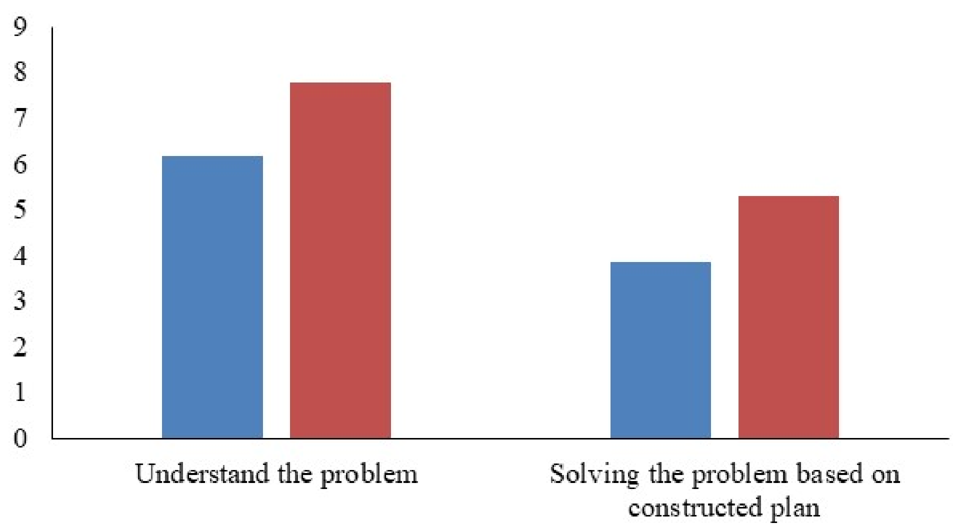

Figure 2. Score of problem solving indicator

From figure 2, it can be seen that for each indicator, the score of the experimental class (PBL) is lower than the control class (direct instruction). This happens because students prefer learning in the control class compared to PBL with little guidance. This result is reinforced by the results of interviews with students for learning choice, they prefer an explanation from the lecturer. The result of interviews can be seen Table 7 below:

Table 7. Interviews results

Lecturer :	What difficulties did you experience in solving the questions given?
Student 1 :	There were some difficulties that I experienced when solving problems, namely in understanding and also determining what formulas to use in the problem or material
Student 2 :	The difficulty is the example problem with different practice questions so confused me inside determine the formula used when complete the given questions
Student 3 :	The difficulty I experienced was confusion in solving the questions given. What are the steps to solve the problem due to lack of understanding of the properties that can help solve the problem, especially in the trigonometry section.
Lecturer :	Do you have suggestions for what to do with the learning model provided for the next implementation?
Student 1 :	In my opinion, the learning model that must be carried out is explaining the material being taught and conducting question and answer because the material in this complex analysis requires high precision and focus. And I personally also need quite a long time to understand each of the steps
Student 2 :	By using the lecture method or explaining in advance the steps for completing the material described.
Student 3 :	My suggestion is that learning should be done using the lecture method, because that will make it easier for students to understand the material, and assignments should not be given at home because solving these problems is a little confusing so you need direct directions in the process.

Achievement of Critical Thinking Ability and Mathematical Problem-Solving Ability Based on Mathematical Curiosity Level

Achievement of mathematical critical thinking based on mathematical curiosity level students that for high level, by Mann-Whitney Test, are obtained sig = 0.130 > α = 0.05, it means there is no difference, and for medium and low level, by t-test, are obtained sig = 0.074 > α =0.05, there is no difference. It can be concluded that there is no difference in the achievement of mathematical critical thinking skills between students who receive PBL learning and students who receive conventional learning in terms of the Mathematical Curiosity level.

Whereas achievement of mathematical problem solving based on mathematical curiosity level students that for high level, by Mann-Whitney Test, are obtained sig =

0.161 > α =0.05, it means there is no difference, and for medium and low level, by t-test, are obtained sig = 1.098 > α = 0.05, there is no difference. It can be concluded that there is no difference in the achievement of mathematical critical thinking skills between students who receive PBL learning and students who receive conventional learning in terms of the mathematical curiosity level.

Based on the above data, the level of curiosity does not affect students' critical thinking skills and problem solving, because from the difference test, data is obtained for the high level Sig = 0.698 > α, medium level Sig = 0.200 > α and low level Sig = 0.098 > α, which means that there is no difference in student curiosity for two class. Which has an impact that does not give effect to the ability to think critically and problem solving abilities.

From the description and results of tests on students' mathematical critical thinking abilities as a whole it was concluded that there were differences in the achievement of critical thinking skills and mathematical problem solving of students who received learning using PBL learning with those who received learning using conventional learning, but the control class was better. from the average achievement of critical thinking skills and mathematical problem solving students who received PBL learning were less than students who received conventional learning.

This research is in line with the literature review which states that there was an increase in the activities of teachers and students by implementation of the direct learning model. (Usman, 2022; Muawanah et al., 2022; Munfa & Mujiyanto, 2020;Amintoko & Timur, 2017)

Quantitatively, that learning, PBL has not had an effect on students' critical thinking skills and mathematical problem solving, whereas in conventional learning, there is a difference in the attainment of critical thinking skills between students who receive less PBL learning than students who receive conventional learning.

Furthermore, for the mathematical curiosity level, it was concluded that there were no differences in the achievement of critical thinking skills and mathematical problem solving of students who received learning using PBL learning and those who received learning using conventional learning, meaning that differences in the level of mathematical curiosity students did not influence the achievemen;t of critical thinking skills and problem solving. their math problem. The main cause when seen during the lecture process is the lack of readiness of students to take part in learning through PBL, because lecturers are used to delivering material, especially for Complex Analysis courses which require a high level of readiness in learning. Other causes besides the lack of readiness of students to study independently and in groups, are also influenced by their low curiosity. Even though this attitude is a capital for active and independent learning.

In practice, there are obstacles in terms of developing all three abilities at once in learning, this is closely related to the learning tools and the steps that must be taken by lecturers in order to involve all abilities explicitly. However, the three abilities developed are actually integrated with one another, which distinguishes which ability is the most dominant. Also the results of this study are strongly influenced by the readiness of students and the environment that supports them. If students have a desire to always want to learn without having to get detailed explanations, then PBL is suitable to be applied.

From interviews with students was founded that most of the students are unfamiliar also in learning no explanation is given in advance or if there is an explanation, it is very minimal, so that they do not know what to do about a given task. In this case, the student has not been able to independently build their knowledge, need more detailed assistance of educators in understanding the material provided.

CONCLUSIONS

From the results of data analysis, it can be concluded that there are differences in the achievement of critical thinking skills and mathematical problem solving of students who receive learning using PBL learning with those who receive learning using conventional learning, but the control class is better, which can be seen from the average achievement of thinking skills. critical thinking and mathematical problem solving of students who receive less PBL learning than students who receive conventional learning. As for the mathematical curiosity level, it was concluded that there were differences in the achievement of critical thinking skills and mathematical problem solving for students who received learning using PBL learning and those who received learning using conventional learning.

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