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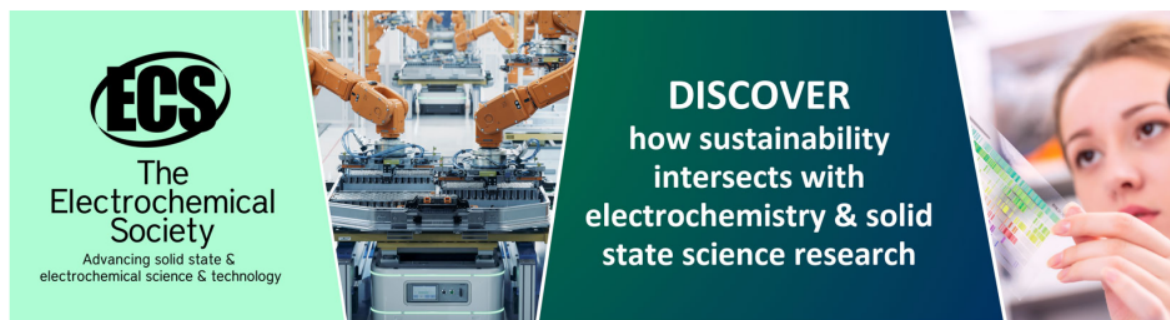
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Learning higher-order thinking skills using problem-based learning model

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Abstract. This research is a descriptive qualitative research to describe student activities during learning by applying Problem-based learning model and students' higher-order thinking skills after applying higher-order thinking skills based learning using problem based learning (PBL) model on the two-variable linear equation system topic. The study was conducted at a Junior High School in Palembang, with research subjects totaling six students in class VIII3. The learning process was adjusted to the phases of the Problem-based learning model. The researcher uses higher-order thinking skills questions on students' worksheets and test questions. Data collection techniques in this study used observation sheets, test results, and interview results. The results of this study indicate that the dominant student activity arises is discussing with the group in planning problem solving strategies, listening to examples of problems given and solving problems that exist on the student worksheets using problem solving strategies that have been discussed as well as dominant higher-order thinking skills emerge is analytical skills.

1. Introduction

In learning to analyze, evaluate, and create categorized as high-level thinking skills [1 - 3]. One of them is in mathematics learning higher-order thinking skills is one of the important things to be developed [4 - 7]. Learning can encourage students to be able to think at a higher level by applying learning based on higher-order thinking skills [8]. Higher-order thinking skills of students in Indonesia are still relatively low, this is seen from the results of Indonesia's achievements in PISA. The average Indonesian mathematics score is lower than the average OECD mathematics score which is only 386, while the OECD score is 490 [9]. In addition, the results of TIMSS Indonesia received 38 ratings from 42 participating countries [10].

To improve the low level of thinking skills of students needed a learning model that can help students think higher level [11]. The Problem-based learning model can be implemented in the classroom to improve students' higher-order thinking skills [12, 13, 14]. Problem-based learning model can also improve students' problem solving skills [15, 16]. In addition, in learning problem-based learning model are more effective than conventional learning [17, 18]. The problem-based learning model is a learning model that uses problems in real life to train and improve thinking skills, problem solving, and conceptual knowledge that must be learned by students [19].

The purpose of this study was to describe student activities during the application of higher-order thinking skills based learning using problem-based learning model and high level thinking skills of students after applying higher-order thinking skills based learning using Problem-based learning model.



2. Method

This research is a qualitative descriptive study. The instruments used in the study were observation sheets, test questions, interview guidelines, student worksheets using higher-order thinking skills questions, and lesson plans that applied phases in the Problem-based learning model. The study was conducted at a Junior High School in Palembang with learning implementation consisting of four meetings in class VIII 3. The subjects in this study were five students in the category of one high, two medium, and two low ability students. During the implementation of learning the researcher applies the phases in the Problem-based learning model, namely student orientation to the problem, organizing students to learn, guiding individual and group investigations, developing and presenting work, and analyzing and evaluating problem solving processes.

Data collection techniques used are observation, tests, and interviews. Observation aims to see student activities that arise during learning by applying a Problem-based learning model. Student activities during learning were observed by two observers using an observation sheet. Observations were made to see indicators of student activity that emerged during the learning process. The test is used to see students' higher-order thinking skills after applying learning using a Problem-based learning model. The test is given after three learning meetings. Essay test questions (descriptions) are carried out for 100 minutes because it consists of three questions higher order thinking skills. After conducting the test, researchers conducted interviews to find out more about how students solve problems. Researchers conducted interviews based on the results of research subjects' answers. Researchers can analyze the data obtained based on data obtained while in the field by describing the facts obtained from each research subject.

3. Result and Discussion

The learning activities were conducted in three learning meetings and one test meeting. In the implementation of the first, second, and third meeting learning the researchers implemented the phases to the Problem-based learning model, namely the orientation phase of the students to the problem by greeting, doing apperception by asking questions, submitting learning objectives, and giving examples of two variables linear equation system in everyday life. Next the researcher organizes students to learn by dividing students into several study groups consisting of four until five people, distributing student worksheets, and asking students to ask about information on students' worksheets that are unclear, as well as providing information about the rules of discussion and ask students to understand the problem. In the guiding phase of individual inquiry and the research group guides students to discuss and work together to solve problems, solve problems in the manner that has been discussed, and students are allowed to ask questions when experiencing difficulties. In the phase of developing and presenting the work students are asked to recheck the problem solving process, prepare for problem solving, and group representatives present the results of the discussion. In the phase of analyzing and evaluating the problem solving process students are asked to examine and improve the results of problem solving, guide students in concluding the topic being studied, and given the opportunity to ask questions about unclear topic. After that, the researcher closes the lesson by giving homework, asking students to learn the next topic, and saying hello. However, there are differences in each meeting, depend on the learning topic. At the first meeting the researcher taught about the concept of a two-variable linear equation system and how to solve it using graph and substitution methods. At the second meeting the researchers taught about how to solve the system of linear equations using the elimination method and at the third meeting the researchers taught about making equations that formed a system of linear equations of two variables from known points on the graph. Researchers also use student worksheets by using higher-order thinking skills questions at the second and third meetings.

Table 1 about the results of observations of student activities based on indicators that can be seen during the learning of the first, second, and third meeting by applying the problem-based learning model phase:

Table 1. Observation of Student Activities

Subject	Meeting	Indicator					
		K1	K2	K3	K4	K5	K6
TC	1	√	X	√	X	X	X
	2	√	√	√	√	X	X
	3	√	X	X	√	√	X
AB	1	√	√	√	√	√	X
	2	√	√	√	X	X	X
	3	√	√	X	X	X	X
WA	1	√	√	√	X	X	X
	2	√	√	√	√	X	X
	3	√	√	X	X	X	X
AR	1	√	√	X	√	√	√
	2	√	√	√	X	X	X
	3	X	√	X	X	X	X
IN	1	√	√	√	X	√	√
	2	X	√	√	X	X	X
	3	√	√	X	X	X	X

Information:

√ : Appear

X : Not Appear

K1: Listen to examples of problems given by the teacher.

K2: Discuss with the group in planning problem solving strategies

K3: Solve the problems that exist on the student worksheet using the problem solving strategy that has been discussed

K4: Present problem solving in the group discussion in front of the class

K5: Give a response or respond to the opinions of other students while discussing the results of the presentation

K6: Evaluating the resolution of group problems based on the results of the presentation

Based on the Table 1, it shows that students are more dominant in planning strategies for problem solving, listening to the problems that are given by the teacher, and solving the problem from student worksheet in teaching progress. These findings are also supported by student worksheet and videos of teaching progress. Appearing during learning are discussing with the group in planning problem solving strategies, listening to examples of problems given by the teacher, and solving existing problems in students' worksheet using problem solving strategies. This is also supported by student worksheets and video recordings of subjects during learning.

At the first, second, and third meeting, it can be seen that all dominant subjects bring up an indicator of listening to examples of problems given by the teacher except AR subjects and IN subjects. The subject is also dominant to bring up indicators discussing with the group in planning problem solving strategies except TC subject. All subjects also dominantly showed indicators of solving problems that exist in student worksheet using problem solving strategies. In addition, the subject also shows dominant indicators regarding solving existing problems in student worksheet using problem solving strategies except AR subjects. In line with [19] which shows that in problem based learning there are advantages that can help students in solving a mathematical problem and also gives an influence on the first step, namely student orientation to the problem. During the learning process, it can be seen that the subject IN was busy doing other things and does not pay attention to the problems described by the researcher when teaching and when working on the worksheets, the subject students tend to ask other students about information that is known from the problems on the worksheets of the students. TC subjects tend to work on their group worksheets individually and rarely discuss with the

group to solve problems. All subjects tended not to respond or respond to the opinions of other students while discussing the results of the presentation and evaluating the results of the presentation of other groups, except AR subjects and IN subjects who tended to comment to evaluate the results of the discussion even though the answers of the subjects were almost similar. The subject also tended not to present the problem solving results of the group discussion in front of the class, this is because the subject was embarrassed and afraid to present the answer alone. Only AB subjects who seemed enthusiastic and brave to appear alone when asked to present the results of their group discussions even though the subject AB appeared alone in front of the class. In line with [20] which shows that at the evaluation stage of learning the subject is reluctant to ask because the subject tends to follow the flow and tends to approve the material that was taught.



Figure 1. Subject AB Presents Results of Group Discussion.

Figure 1 shows that only AB subjects seemed enthusiastic when asked to present the results of their group discussions even though AB subjects appeared in front of the class. Indicators of student activity to be seen are adjusted to the phases of the Problem-based learning model being applied. In the problem-based learning model phase there is a high level of thinking skill that can be done, namely analyzing the problem, choosing the strategy to be used, and solving the problem. The problem-based learning model is one of the learning model that is oriented at higher order thinking skills. In line with [21] which states that the problem-based learning model is effective for increasing students' higher-order thinking skills.

At the fourth meeting, researchers conducted a test to see students' higher-order thinking skills. The test is carried out for 100 minutes with 3 questions higher order thinking skills. High-level thinking skill is seen in analyzing, evaluating, and creating. The following high-level thinking skills that arise from the results of the research subjects' answers:

Table 2. High-Level Thinking Skills Arising from the Results of Research Subject Answers

Subject	Analyzing		Evaluating	Creating	
	A	B	C	D	E
TC	√	√	√	√	√
AB	√	√	X	√	√
WA	√	√	√	√	√
AR	X	√	X	√	√
IN	X	√	X	X	X

Information:

A: Analyze the information needed to solve the problem

B: Analyze the strategies that will be used in solving problems

C: Check the correctness of problem solving

D: Make a mathematical model of the problem in the problem

E: Make an equation from the known points and the equation that makes up a two-variable linear equation system and not a two-variable linear equation system

3.1 Analyzing

Based on the results of the answers to the test questions, it can be seen that all research subjects can analyze the information needed and the strategies that will be used to solve the problem. However, from the results of answers to questions number 1, AR research subjects did not write down the information needed correctly. Here is the answer to the AR subject:

Handwritten solution for a system of linear equations:

$$\begin{aligned} 1 \quad & x = 2y \\ & x + y = 120 \\ & 2y + y = 120 \\ & 3y = 120 \\ & y = \frac{120}{3} \\ & y = 40 \\ & x = 2y \\ & x = 2 \times 40 \\ & x = 80 \\ & 80 : 2 = 40 \text{ ayam} \\ & 40 : 2,5 = 16 \text{ bebek} \\ & \text{jadi ayamnya 40 dan} \\ & \text{bebeknya 16} \end{aligned}$$

Figure 2. The answer of subject AR.

Figure 2 shows that the AR subject did not write down the information needed to solve the problem. AR subject immediately wrote down the problem solving. From the results of interviews with AR subjects it can be seen that AR subjects can mention the information contained in the questions, but AR subjects seem hesitant in explaining the information needed for the questions. The AR subject answered that all the information contained in the problem was needed all to solve the problem as the statement "yes ma'am, used by all ma'am". From the AR subject's statement during the interview with the answers written while working on the test questions, it can be seen that the AR subject cannot analyze question number 1. However, the AR subject can analyze the strategies that will be used in solving problems. From the three AR test subject questions, you can solve all the problems according to the strategy chosen. From the interview results it is known that AR subjects use an easier way, according to the statement "because it's easier, ma'am". Dominant analytical skills emerge rather than evaluating and creating skills. This is in line with research [22] which states that analyzing indicators have the highest percentage of occurrence.

3.2 Evaluating

Based on the results of answers to student test questions it can be seen that all research subjects did not check the correctness of problem solving of the three questions. All research subjects are dominant after finding the values of x and y immediately complete the answers as asked of the problem and make conclusions from problem solving. Like the following AB subject answers:

Handwritten solution for a system of linear equations:

$$\begin{aligned} & x = \frac{32.000}{3} = 11.000 \\ & 77.000 - 77.000 : 8 = 9.500 \\ & 3x + 8y = 100.000 \\ & 3(11.000) + 8(9.500) = 100.000 \\ & 33.000 + 76.000 = 100.000 \\ & 109.000 = 100.000 \\ & 9.000 \\ & 105.000 - 100.000 = 5.000 \\ & \text{jadi uang dari bank cukup cukup memberi 3 eskrim} \\ & \text{karena Syahid dan 8 PSNIMCORAT} \\ & \text{karena uang dari KIKAS 5.000} \end{aligned}$$

Figure 3. The answer of subject AB.

Figure 3 can be seen the answer of subject AB who did not re-check the truth of the x and y values he got. When the researcher conducted an interview with subject AB, subject AB answered that he could not check the truth of x and y values because he did not know how to check the truth of his

values. However, after the interview is known that TC subjects and WA subjects can check the correctness of the x and y values in problem solving problem number 2. The following answers TC subjects, MF subjects, and WA subjects when checking the x and y values in the interview:

$$\begin{array}{l} 5x + 9y = 91.000 \\ 5(11.000) + 9(9.000) = 91.000 \\ 55.000 + 36.000 = 91.000 \end{array} \quad \begin{array}{l} 11.000 \times 5 = 55.000 \\ 9.000 \times 9 = 36.000 \\ x + y = 91.000 \end{array}$$

Figure 4. Subject TC and Subject WA check the truths of x and y values.

Figure 4 shows that TC subjects and WA subjects when interviewed can check the correctness of the x and y values by substituting the x and y values to the equation that is already known to the problem. So, there are 2 subjects who can re-check the truth of the settlement and 3 other subjects cannot check the truth of the settlement because they do not know how. Student skills in evaluating are still difficult to do because students feel the answer is correct and do not know how to check it. In line with [23] which states that not all are able to provide an assessment of the solutions provided.

3.3 Creating

Based on the results of the test answers it can be seen that all research subjects can make mathematical model of the problem, and make equations that form a two-variable linear equation system and not a system of two-variable linear equations from known points on the graph.

5. dik: garis l , $A(1,3)$ dan $d(2,3)$
 garis k , $B(2,1)$ dan $c(3,5)$
 dit: persamaan yg memotong sendiri
 Persamaan yg bukan sendiri

Jwb: $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$ $\frac{y-y_1}{y_2-y_1} = \frac{x-x_1}{x_2-x_1}$
 $\frac{y-3}{3-3} = \frac{x-1}{3-1}$ $\frac{y-1}{5-1} = \frac{x-2}{3-2}$
 $\frac{y-3}{0} = \frac{x-1}{2}$ $\frac{y-1}{4} = \frac{x-2}{1}$
 $(y-3)(0) = (x-1)(2)$ $(y-1)(4) = (x-2)(1)$
 $y-3 = 2x-2$ $4y-4 = 1x-2$
 $y-3+3 = 2x-2+3$ $4y-4+4 = 1x-2+4$
 $y = 2x+1$ $4y = 1x-6$

Figure 5. One Subject's Answer Makes Equations from a Known Point.

Figure 5 shows that all subjects except the IN subject alone cannot create equations that form a two-variable linear equation system and not a system of two-variable linear equations from known points on the graph. The IN subject cannot create an equation that forms a two-variable linear equation system and not a two-variable linear equation system from known points on the graph because the IN subject does not know how, the subject IN cannot determine the intersecting line and does not intersect from the points which is already provided in the graph. In line with [22] which states that creating indicators are the lowest indicators in their research, one of the reasons is because students must be able to determine the right initial idea. However, the subject IN can make a mathematical model of the problem. From the results of the interview it was obtained that the subject IN could make a mathematical model of information known to the problem.

4. Conclusion

Based on the results of data obtained from class VIII.3, it can be concluded that student activities during higher order-thinking skills using problem-based learning model are discussing with the group in planning problem solving strategies, listening to examples of problem given by the teacher, and solving problems on the student worksheet using problem solving strategies. In addition, the dominant high-level thinking skills of students that emerge are indicators of analytical skills.

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