The Effectiveness of Problem-Based Learning Through E-learning on Students' Critical Thinking Skills During the COVID-19 Pandemic

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Abstract. The learning process during the pandemic is carried out by e-learning. Thus, an appropriate learning model is needed to improve students' critical thinking skills. This study examines the effect of problem-based learning through e-learning on students' critical thinking skills during the COVID-19 pandemic. This research was conducted at SMA Islam As-Shofa Pekanbaru. This study employed quasi-experimental research with the research subjects of 10th-grade students of SMA Islam As-Shofa Pekanbaru. In practice, students were given a pretest and posttest. The research parameters are students' critical thinking skills. Indicators of critical thinking skills are analyzing, synthesizing, recognizing, solving problems, concluding, and evaluating. Data collection on critical thinking skills is pretest and posttest questions. Data were presented and analyzed inferentially. The results of students' critical thinking skills obtained an N-gain index of 0.44 (effective category). Overall, the Problem Based Learning (PBL) learning model through e-learning effectively improves students' critical thinking skills, but in detail from the five indicators, it is less effective for improving evaluation.

Keywords: E-learning · Problem Based Learning · Critical Thinking

1 Introduction

During the COVID-19 pandemic, a process of teaching and learning activities was carried out employing e-learning. With the Work from Home (WFH) policy, teachers and students can learn to use digital learning technology as a necessity. Students need time to adapt to online learning and face new changes that can affect their learning capacity [1].

The online method has several advantages, one of which is that it can be done anywhere and anytime so that with online learning, students have plenty of time to study. Students and teachers can interact through several applications [11]. E-learning has an impact on students' higher-order and critical thinking skills [13]. Online learning can use internet-based learning and can also be based on websites known as web-based learning, both of which use an online network that can connect one user to another [12]. Learning methods that are shifted suddenly and in the long term certainly have an

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impact on several aspects, one of which is the readiness of educators and students in online learning. Similarly, the culture of the Indonesian people is so diverse that habits and readiness to learn in this network must also differ [7].

The problem-based learning (PBL) model allows students to find knowledge independently and to engage during the learning process. It stimulates students to analyze problems, formulate hypotheses, gather and analyze data, and conclude answers to the problems given [3].

Critical thinking is a skill that is very important and functions effectively for all aspects of life. To achieve the best results in the learning process, active thinking is required. The optimal learning process necessitates critical thinking on the part of students. Critical thinking requires a process of habituation through classroom learning activities. Students need critical thinking skills in real life, but these skills are often overlooked during the learning process [20]. Critical thinking is a conceptual mental approach in which an individual intentionally evaluates the quality of his thinking by employing reflective, independent, clear, and rational thinking [5]. The ability to examine and assess evidence received from observations, experience, reasoning, or communication in order to determine the truth of the information and provide reliable and rational conclusions is known as critical thinking [14]. Critical thinking is the ability of an individual to locate information and overcome a challenge by asking himself questions about the problem at hand [4].

Based on the observations at SMA Islam As-Shofa, this school already has facilities that meet the requirements for implementing online learning. The criteria for schools that are suitable for online learning, according to [19], are e-learning readiness generally consists of: (a) Assumptions; (b) Curriculum; (c) Facilities; (d) Human resources; (e) Access. Furthermore, the results of the observations revealed that students' critical thinking skills in analyzing and concluding were in the good category. However, students' abilities to synthesize, recognize and solve problems, and evaluate are on average lower than 50 and as low as 60%.

An appropriate learning alternative is necessary to improve students' critical thinking skills to anticipate this problem so that students have a critical, open, reflective, problem-solving, collaborative, and better interpersonal skills mindset. Problem-based learning (PBL) is a method of stimulating higher-order thinking in problem-solving situations, including critical thinking skills [20]. The PBL model is a having to learn model that emphasizes problem-solving in real life. This learning model encourages students to get to know how to learn and how to work together in groups to solve problems that occur [15]. The learning process uses a systematic approach to solving problems so that they are accustomed to facing everyday life [6]. Based on the background, learning through e-learning based on the Problem-based Learning model improves the Students' Critical Thinking Skills at SMA Islam As-Shofa Pekanbaru.

2 Method

2.1 Research Site

This quasi-experimental research was conducted from October 2020 to May 2021 at SMA Islam As-Shofa Pekanbaru. The population of Class XI students was 76 people

KE	O1	X1	O3
KK	O2	X2	O4

Fig. 1. Pretest posttest control group design

from 3 classes. The research subjects used a random sampling technique (through the lottery), then assigned the control class and the experimental class.

2.2 Research Design

The research design was the pretest-posttest control group design (Fig. 1).
Description:

EC: Experimental class
CC: Control class
O1: Initial critical thinking skill in the experimental class
O2: Initial critical thinking skill in the control class
X1: Using problem-based learning
X2: Without using problem-based learning
O3: Critical thinking skills at the end of the experimental class
O4: Critical thinking skills at the end of the control class.

2.3 Data Collection Technique

Prior to beginning the subject, students' critical thinking skills are tested. Pretest giving aims to examine students' initial skills. The posttest is administered after the material has been completed, and the entire test treatment procedure is provided online in the form of a Google form. The questions on the pretest and posttest are identical (multiple choice form). This is done to ensure that three is no disparity in knowledge and understanding. Grating about critical thinking (Table 1) as follows:

2.4 Data Analysis

If the data obtained is in the form of a score, the score data will be converted into a value (N), namely the score obtained (Sn) divided by the maximum score (Sm) multiplied by the maximum value of 100, then the average value, minimum value, maximum value, and standard deviation (Sd) are determined. To determine the increase in critical thinking, the data used is in the form of a gain score (g), which is the result of the reduction in the posttest average (Sf) with the pretest mean score divided by the maximum value (100) minus the pretest average value. Interpretation of the gain index (g), according to the classification by [9], is in Table 2.

Table 1. Question content outline about students' critical thinking skills

Indicators of Critical Thinking	Question content outline	Cognitive Domain	No question
Analyze	1. Distinguish kinds of bone based on their shape.	C4	1, 2
	2. Identify information from human skeleton images.	C1	3, 4
Synthesize	3. Relate the various joints and their direction of motion of a statement.	C6	5, 6
	4. Compile facts on the nature of muscle works.	C6	7, 8
Identify and Solve Problems	5. Give examples of types of bones.	C1	9, 10
	6. Understand bone function in humans.	C1	11, 12
Conclude	7. Summarize the bone formation process.	C5	13, 14
	8. Determine the division of the human body frame, namely axial and appendicular.	C3	15, 16
Evaluate	9. Categorize abnormalities in bones and muscles.	C6	17, 18
	10. Interpret technology related to motion systems.	C5	19, 20

Table 2. Normalized Gain Index Score and Classification

Normalized Gain Index	Classification
$(g) \geq 0.70$	Very effective
$0.30 \leq (g) \geq 0.70$	Effective
$(g) < 0.30$	Less effective

3 Results and Discussion

3.1 Process Learning Profile

The learning process in the experimental class is carried out following the steps of the PBL model. The control class and the experimental class took a pretest and posttest. The problem-based learning (PBL) learning model consists of 5 learning stages. The

Table 3. Description of Test Results in The Control Class and The Experimental Class

No	Test	Number of Students (N)	Lowest Score (Min)	Highest Score (Max)	Mean	Standard Deviation (Sd)
1	Pretest of the control class	26	40	85	61.73	13,634
2	Posttest of the control class	26	40	90	70.96	11,646
3	Pretest of the experimental class	25	40	85	60.40	14,994
4	Posttest of the experimental class	25	45	95	76.20	12,268

first stage is the student orientation stage on the problem, where at this stage, students are stimulated to analyze a problem and ask or express opinions about the problem. The second stage is organizing students to learn by giving e-LTPD to students. The third stage involves directing both individual and group investigations. The teacher divides the group using the breakout room, and then the students discuss the breakout room with their respective groups. The fourth stage is developing and presenting the work, students presenting the e-LTPD results of their discussion, then being responded to by other groups. The fifth stage is assessing the problem-solving process, which involves students analyzing and drawing conclusions from group discussions. A follow-up in homework is given at the end of the process, which concludes with closing greetings.

3.2 STudent's Critical Thinking Skills

The results of the pretest and posttest, as shown in Table 3, are used to assess students' critical thinking skills.

The number of students (Table 3) in the control class is 26 students, and the experimental class is 25 students. In the pretest of the control class, the lowest score is 40, the highest score is 85, and the average score is 61.73. In the posttest of the control class, the lowest score is 40, the highest score is 90, and the average score is 70.96. In the pretest of the experimental class (PBL), the lowest score is 40, the highest score is 85, and the average score is 60.40. In the posttest of the experimental class, the lowest score is 45, the highest score is 95, and the average score is 76.20. Overall, after being given different treatments between the control and experimental classes, the results show that the experimental class's average value is higher than the control class.

Table 4. Details of the Level of Effectiveness of Students' Critical Thinking in The Control and Experimental Classes

No	Indicator	Control class					Experimental class				
		Score		Category		N-Gain	Score		Category		N-Gain
		Pre	*Post*	*Pre*	*Pre*		*Pre*	*Post*	*Pre*	*Pre*	
1	Analyze	65.38	72.12	FC	FC	0.19 (less effective)	61.00	81.00	LC	C	0.51 (effective)
2	Synthesize	60.58	68.27	LC	FC	0.19 (less effective)	51.00	80.00	VU	C	0.59 (effective)
3	Identify and Solve Problems	74.04	77.88	CK	CK	0.14 (less effective)	71.00	82.00	CK	K	0.37 (effective)
4	Conclude	67.31	77.88	FC	FC	0.32 (effective)	65.00	83.00	FC	C	0.51 (effective)
5	Evaluate	40.38	52.88	VU	VU	0.20 (less effective)	54.00	65.00	VU	FC	0.23 (less effective)
Average score		61.54	69.81	LC	FC	0.21 (less effective)	60.40	78.20	LC	C	0.44 (effective)

Descripbtion: C: Critical, FC: Fairly Critical, LC: Less critical, VU: Very Uncritical

3.3 Details of the Level of Effectiveness of Students' Critical Thinking in the Control and Experimental Classes

Students' critical thinking skills based on the pretest and posttest indicators of the control and experimental classes (Table 4) are as follows.

The details of the comparison of the score of each indicator of critical thinking between the control class and the experimental class are as follows: (a) On the indicator of analyzing in the control class, the average pretest score is 65.38, the posttest increases to 72.12, and Normalized gain of 0.19 (less effective), but in the experimental class the average pretest score is 61.00, the posttest increases to 81.00, and Normalized gain of 0.51 (effective); (b) On the indicator of synthesizing in the control class, the pretest is 60.58 and the posttest increases to 68.27, and Normalized gain of 0.19 (less effective), but in the experimental class, the pretest is 51.00 and the posttest increases to 80.00, and Normalized gain of 0.59 (effective); (c) On the indicator of recognizing and solving problems in the control class, the pretest score is 74.04 and the posttest increases to 77.88, and Normalized gain of 0.14 (less effective), but in the experimental class, the pretest score is 71.00 and the posttest increases to 82.00, and Normalized gain of 0.37 (effective); (d) On the indicator of concluding in the control class, the pretest is 67.31 and the posttest is 77.88, and Normalized gain of 0.32 (less effective), but in the experimental class, the pretest is 65.00 and the posttest is 83.00, and Normalized gain 0.51 (effective); e) In the indicator of evaluating in the control class, the pretest is 40.38 and the posttest

is 52.88, and Normalized gain of 0.20 (less effective), while in the experimental class, the pretest is 54.00 and the posttest is 65.00, and Normalized gain 0.23 (less effective).

In the control class, the average pretest score is 61.54, and the posttest is 69.81 with an Normalized gain of 0.21 (less effective), while in the experimental class, the average pretest score of 60.40 and the posttest increases to 78.20, and Normalized gain of 0.44 category (effective).

From the details of critical thinking indicators, it was found in the control class from the five indicators showing that four indicators were less effective and only one indicator (conclude) was effective. In contrast, in the experimental class, all indicators showed an increase in effectiveness with PBL-based learning through e-learning, except for one indicator (evaluate). In the control class, the highest increase in indicator score is found in the fourth indicator, concluding, while the lowest increase is in evaluating. The highest increase in the experimental class is in the second indicator, synthesis, while the lowest increase is in evaluating.

3.4 Students' Critical Thinking Skills

Critical thinking skills include five indicators, namely the skills to analyze, synthesize, identify, and solve problems, conclude, and evaluate.

The indicator of analyzing in the control class is in the less effective category, while in the experimental class, it is in the effective category. Analyzing can be viewed from the students' skills to identify and differentiate. Students can distinguish bone shapes in human body parts well and can identify information from human skeleton images because, during the learning process, students have been trained to understand the meaning of the problems presented by the teacher. Analyzing is the beginning of solving problems in learning. This is in line with [17] study. In the control class, students only rely on the information provided by the teacher. Whereas in the experimental class, students can analyze problems well because students are trained to explore the information themselves or look for additional references.

Critical thinking is a mental tool to analyze information and carry out the necessary investigations by exploring situations, phenomena, questions, or problems to formulate hypotheses and conclusions, which combine all possible information and can be believed to be true [2]. Critical thinking is the skill to think at a high level which is carried out by a person consciously based on their knowledge to find their analysis results. As a result, problem-based learning is said to improve students' analytical skills. According to [8], students' abilities to analyze problems improve, which directly improves critical thinking skills.

Since students in the experimental class think more actively to connect the problem with the problem hypothesis, the indicator of synthesizing in the experimental class is categorized as effective in increasing students' critical thinking skills. Students can provide arguments for approximate answers to problems. For example, by being given the problem of hip bracelet fractures occurring more frequently in women than men, students can respond with arguments about why this happened. Synthesizing can be viewed from the students' skills to connect and compose, namely connecting the various joints with the direction of motion and compiling the facts of the nature of the muscle work. Students can connect problems with everyday life and can make hypotheses from

problems given by the teacher. This is because students can provide provisional estimates of the problems obtained by thinking about answers or hypotheses. Students can provide arguments based on the problems found. Therefore, problem-based learning is declared effective in improving the skills to analyze and synthesize problems. This is in line with [11] that students are encouraged to disclose problems, formulate solutions, determine action, and use arguments with the PBL Model to foster students' critical thinking skills.

The indicator of recognizing and solving problems in the control class is in the less effective category, while in the experimental class, it is in the effective category. In the control class, students find it difficult to solve problems because they are not trained to look for information and are more fixated on the teacher's material without delving into the problem. However, in the experimental class, students are used to solving problems because the problems faced come from everyday life, then students look for references independently, then dig up more information about the problem by holding discussions with their group friends to answer the problem. Students receive material from the teacher's explanation, but students take a direct role in the learning process. Besides that, they also try to find information to solve problems provided by the teacher in the worksheet [18].

Recognizing and solving problems can be viewed from the students' skills to classify, classifying the types of bones and their functions. Students can recognize the problems they get and solve them well. This is because the problems from questions come from problems in everyday life. This is because, in the PBL learning model, students are directed to think alone or in groups to find references/sources of answers to problems. Students carry out active group discussions so that problem-based learning is declared effective for students' skills to recognize and solve problems. The application of the e-learning-assisted Problem Based Learning (PBL) model shows a statistically significant increase in problem-solving and independent learning skills [17].

The indicator of concluding in control and experimental classes is in the effective category. This is because, in learning, students are used to practicing to conclude lessons to conclude reasonably. Thus, with or without using a problem-based learning model, concluding skills can be increased. The conclusion can be seen from students' skills to answer questions, namely concluding the process of bone formation, and determining the division of the human body frame properly. This is because the PBL Model trains students to conclude the problems discussed. Therefore, problem-based learning is declared effective in improving students' skills to conclude problems. This is in line with [11], through concluding activities at the end of learning, students' critical thinking skills in the concluding aspect can be increased. One of the characteristics of someone who can think critically is to be able to conclude reasonably.

The indicator of evaluating in control and experimental classes is in the less effective category. This is because students are only accustomed to concluding without responding to conclusions. Students lack self-confidence, are reluctant to respond to assess, criticize, and suggest the work of their friends from other groups. Students only justify answers from friends without giving responses even though the answers are not quite right. Evaluating problems can be viewed from the students' skills to categorize and interpret. Evaluating in the less effective category can be considered to have problems in mastering learning material, verbal, and written communication in conveying their

ideas/opinions. Students are less precise in categorizing the types of disorders and interpreting technology related to motion systems. Students only want to listen to their friends who conclude the presentation results, only justify the conclusions of their friends, but do not want to add conclusions and criticize if their friends conclude incorrectly/wrongly. Evaluating is a reflection process of solving problems in critical thinking skills. Therefore, problem-based learning is stated to be less effective in improving students' skills in evaluating. This happens because evaluating is the final form of decision-making in solving individual problems [8].

Overall, problem-based learning in the control class is within the less effective classification for systems that are increasing' ability to think critically whereas it is in the effective category for developing the students' critical thinking skills in the experimental class. This is due to the fact that problem-based learning prepares students to face problems in their daily lives by encouraging deeper thinking. According to the details, it's indeed beneficial to enhance indicators for analyzing, synthesizing, identifying and solving problems, and concluding, but it is less effective in increasing the ability to evaluate problems. As a result, problem-based learning is effective for developing critical thinking skills. This is consistent with the findings of the [16] study, which found that the Problem Based Learning (PBL) model has a significant effect on improving students' critical thinking skills. Critical thinking skills in the experimental class using PBL are superior to those in the control class using a traditional [10].

4 Conclusion

This research concluded that the Problem-Based Learning (PBL) model delivered via e-learning has a positive impact on students' critical thinking skills. However, of the five indicators, improving evaluating the material on the motion system at SMA Islam As-Shofa Pekanbaru is the least effective.

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