

# Critical and Creative Thinking: More Influential Problem Based Learning or Problem Posing Learning?

Rina Astuti<sup>1,\*</sup> Mardiyana<sup>2</sup> Triyanto<sup>3</sup>

<sup>1</sup> Postgraduate of Mathematics Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

<sup>2,3</sup> Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

\*Corresponding author. Email: [mrinaastuti@gmail.com](mailto:mrinaastuti@gmail.com)

## ABSTRACT

One of the competency requirements of the industrial revolution 4.0 that needs to be developed is the ability to think critically and creatively. Therefore, the purpose of this study is to describe the effectiveness of problem-based mathematics learning, problem posing and conventional approaches and a comparison of their effectiveness in terms of critical and creative thinking skills of class X SMK Surakarta. The method used in this study is an experimental method, with a pretest-posttest control group design. The population studied were SMK students in the city of Surakarta, while the sample was taken from three selected classes in three SMKs. Then from the three classes, it was randomly determined which class was assigned to be the first experimental class, the second experimental class and the control class. The data analysis technique was MANOVA and the significance level was 5%. The results showed that (1) problem-based learning was better than problem posing and conventional in terms of students' critical thinking skills. Problem posing learning is better than conventional learning in terms of critical thinking skills. (2) problem posing learning is better than problem-based and conventional learning in terms of creative thinking skills.

**Keywords:** Critical thinking, Creative thinking, Problem based learning, Problem posing.

## 1. INTRODUCTION

An important competency that must be possessed by every individual in the era of globalization is critical and creative thinking. The demands of critical and creative thinking in the world of education are contained in the 2013 curriculum objectives. Therefore, this study aims to determine the critical and creative thinking skills of class X students. The students' critical and creative thinking skills are one of the characters needed by students to be able to compete in this 21<sup>st</sup> century. This is in accordance with the four competencies that students must have in the 21st century called the 4Cs, namely critical thinking and problem solving (Critical Thinking and Problem Solving), creativity (Creativity), communication skills (Communication Skills), and the ability to work the same (Ability to Work Collaboratively). One of the subjects taught in schools in the education curriculum in Indonesia, which supports 4C is mathematics.

Mathematics is one of the subjects that has an important role in education [1] that given since elementary education. Mathematics has an important role in education that can help students form logical, systematic, critical and creative thinking patterns. This is reinforced by the statement that mathematics is a subject that must be given at every level of education as stipulated in Law no. 23 of 2003 concerning the National Education System. Mathematics as a subject that is very dominant in the development of science and technology, is not just learning to count quickly or memorizing formulas to solve problems. However, by learning mathematics, it leads students to be able to understand the process, analyze, communicate and evaluate something. This makes mathematics a compulsory subject at every level of formal education.

The fact that has happened until now, mathematics is considered a scourge subject with difficult material, which causes students' mastery of mathematics to be weak. Students often complain that they cannot

understand, do not understand, do not like and often even avoid. In interviews with teachers, the learning model that teachers often use is direct learning. Direct teacher-centered learning, with teachers who are more active and more communication during the learning process is one-way learning and no cooperative group [2]. Direct learning does not develop creativity and student activity, so students have difficulty conveying, expressing and communicating their opinions.

It is time for teachers to leave the learning process that tends to prioritize memorization or just looking for one correct answer to a problem. The learning model must begin to be implemented properly. The learning model is one of the important aspects in the maximum learning process. The one-way learning model, where the teacher explains and the students listen, causes students to get bored following the lesson. Students need to be encouraged to think, reason and evaluate. Students need to have learning motivation and learning goals. The hope is that students feel excited and challenged to learn.

One of the learning models that can activate students in the classroom is Problem Based Learning (PBL). The essence of PBL is the existence of problems as a reference for student learning. PBL is a learning situation that uses problems as guides and triggers for the student learning process. This learning begins with presenting problems to students that can encourage students to build their own knowledge [3]. Furthermore, it is said that this type of learning is active, integrated and interrelated. In addition, as in cooperative learning, in PBL students work in groups and share responsibility for learning together. PBL focuses on challenges that make students really think to find solutions to given problems [4]. The PBL learning model is "a teaching approach that uses real-world problems as a context for students to learn about critical thinking and problem-solving skills, and to acquire essential knowledge and concepts from the subject matter" [5]. PBL can help students develop skills in giving reasons and thinking when looking for data or information in order to get a solution to a problem [6]. PBL is a cooperative learning, student-centered learning approach that organizes curriculum and learning in unstructured situations and in the form of real-world problems [7]. Problem-based learning is used to stimulate higher-order thinking in problem-oriented situations, including learning how to learn. Through the application of problem-based learning, students are expected to be able to explore and find their own solutions to problems provided by educators so that they can provoke the student learning process [8]. PBL is a learning model that emphasizes the presentation of factual problems or those related to the

real world so that ongoing learning can have meaning for students [9]. PBL is a learning approach that begins with exposes students to the math problem, then students are required to solve the problem that is rich with mathematical concepts. One of the characteristics of PBL is positioned students as self-directed problem solver through collaborative activities to encourage students to be able to find the problem and plan completion, trains students and familiarize skilled serves to reflect the findings in the inquiry about the effectiveness of their way of thinking in solving the problems that faced. Problem-based learning is an approach to learning that challenges students to learn through problem solving which done by cooperatively in small groups [10]. Problem-based learning is a suitable learning model that is used to overcome mathematics problems. Problem-Based learning requires the teachers to apply meaningful learning by presenting the problems related to the learners' daily life. The teachers also have to fully give the students a chance to think freely to find the concept as well as solve the problem [11]. Problem-based learning that is believed to create the learning environment where the problems can encourage learning. In sum up, learning begins with a problem to be solved, and the posed problem can be the way for the students to acquire new knowledge before they can solve the existing problems [12].

The learning model that can activate students in the classroom, apart from PBL is Problem Posing. Problem posing is a term in English which comes from the word "problem" which means problem, problem, or problem and the word "pose" which means to propose. Problem posing can be interpreted as submitting questions or submitting problems. The problem posing approach can motivate students to think critically, as well as dialogically, creatively and interactively [13]. Problem posing is a process carried out so that students make mathematical experiences, make personal interpretations of real situations, and formulate them as meaningful mathematical problems [14]. Problem posing in learning essentially asks students to ask questions or problems. The background of the question or problem can be based on a broad topic, questions that have been done or certain information given by the teacher to students [15]. Problem posing is an approach that requires students to ask questions and make solutions that are expected to be able to develop thinking skills focused on posing students' problems [16]. Problem Posing is a learning model that generates new problems or math questions or reformulates math problems or questions of problems or math problems that have been given [17]. Submission of problems is essentially a task for

students to create or formulate their own problems which they then solve by themselves or other friends. The ability to submit problems is based on the knowledge possessed by students. Problem posing activities have positive influences on students ability to solve or resolve mathematical problems and provide a chance to gain insight into students understanding of mathematical processes and concepts. Mathematics problem posing is a task which asks students to pose or construct a mathematical problem based on given information, and then solve the problem [18].

The learning process in the classroom has an impact on student development. Teachers expect the learning process to provide maximum results in improving students' learning abilities. One of them is to improve students' critical and creative thinking skills.

Critical thinking is a search for understanding, more than just acquiring knowledge [7]. Critical thinking is thinking sensibly and reflectively in deciding what to believe or do [19]. Critical thinking is another name for evaluating ideas [20]. Critical thinking allows students to study problems systematically, face many obstacles in an organized way, formulate innovative questions, and design appropriate solutions to problems encountered [21]. Critical thinking has been a key factor in differentiating students who only do mathematics from those who truly understand what they are doing. Students apply critical thinking to find the best strategy from many possible alternatives to get a solution [22]. Critical thinking is a systematic discovery process using existing facts and can be accepted by common sense [23]. Critical thinking can change students mindsets, but in reality, students only receive knowledge and information directly and tend to skip the stages of processing that knowledge [24]. Critical thinking is the most valuable skill that can be passed on by the school to its graduates and becomes a learning goal at all levels of discipline [25]. Critical thinking is a systematic ability to incorporate prior knowledge, mathematical reasoning abilities and also be able to apply cognitive strategies in mathematical problem solving [10]. Critical thinking is one of the high-level skills that is the goal of world education today [26]. Therefore, students critical thinking processes are in the form of (1) understanding the problems in the questions given, (2) providing reasons based on relevant facts/evidence at each step, (3) choosing the right reasons to make conclusions, (4) using appropriate information. with the problem, (5) explain further, (6) research or re-check thoroughly. The use of interesting learning models such as PBL is one solution so that students

can develop their critical thinking skills. Learning that is only monotonous can result in low student achievement because students' critical thinking skills are less than optimal.

Creative thinking is a cognitive ability, original, and problem-solving process that allows individuals to use their intelligence in unique ways [27]. Therefore, mathematical creative thinking skills must be instilled and developed in students. Creative thinking can also be a way of generating new ideas by combining, changing or re-applying existing ideas [28]. Creative thinking is the ability to think that begins with sensitivity to the situation at hand, that in that situation it is seen or identified a problem that wants or must be resolved [29]. Creative thinking is thinking in more than one way in solving problems and can increase innovation and student learning activities [30]. Creative thinking is a thought that can express ideas to obtain high results for students by finding their own concepts in creating new creativity with mental and physical readiness in individual students who will get challenges for themselves through their abilities [31]. Creative thinking skills are the foundation of science, which are very important for students is a form of expressing oneself in a unique way [32]. The creative thinking process of students in the form of (1) fluency in giving the right answer, (2) providing a coherent and complete solution, (3) working in a different/new way. on the critical and creative thinking skills of vocational school students.

## **2. TYPE OR RESEARCH DESIGN**

This research is a quasi-experimental type of research. The dependent variable was measured twice, namely before the treatment through the pretest and after the treatment through the posttest. The research design used in this study was a multivariate analysis of two unequal cell paths. This design was conducted to determine the effect of one independent variable on the two dependent variables. The independent variable is the problem-based learning model and problem posing, while the dependent variable is the ability to think critically and creatively.

## **3. RESEARCH PLACE AND TIME**

The research was carried out at Vocational Schools: Kristen 1, Pancasila and Saint Mikael Surakarta in the 2018/2019 academic year. The learning activities in the research were carried out in eight meetings. One face-to-face/meeting is 2x45 minutes. The face-to-face implementation adjusts to the lesson schedule that applies in each school.

**4. POPULATION AND SAMPLE**

The population of this study was all students of X class vocational schools in Surakarta City for the 2018/2019 academic year. From the population, three schools were taken randomly as a sample using a stratified cluster random sampling technique. From each sample three classes were taken randomly to get each treatment, as first experimental class, second experimental class and control class.

**5. DATA AND INSTRUMENT**

The data in this study were obtained through the technique of giving pretest and posttest. The pretest questions are used to see the students initial abilities on the material of sequences and series. Posttest questions are used to obtain data on students critical and creative thinking skills, after students are given treatment with certain learning models.

Evidence of the validity of the test instrument is content validity. Determination of the validity of the instrument items is carried out by an expert or validator (expert judgment) with aspects or criteria for review in terms of material, language and construction. The test instrument that has been declared valid can be tested on students. The results of the test instrument trial were then analyzed to determine the reliability of the test instrument.

The reliability coefficient was calculated using the Alpha technique. This coefficient is calculated on the

test of critical and creative thinking skills. The test results state that the critical thinking ability question has a reliability of 0.787 and the creative thinking ability question has a reliability of 0.702 The critical and creative thinking ability test instrument has met the reliable requirements.

**6. DATA ANALYSIS TECHNIQUES**

Data analysis of a study is a very important step in research activities. Correct and precise data analysis will produce correct conclusions. The data analysis technique used in this study is a statistical technique with two-way multivariate analysis with unequal cells. In multivariate analysis of variance, the assumptions that must be tested are the multivariate normality of the population and the homogeneity of the variance and covariance matrices. The statistical tests used in this study were Box-M, Bartlett, Wilks' Lambda, Lilliefors, Scheffe.

**7. RESULT AND DISCUSSION**

The research applied to the three classes can be seen in the following tables. Each class studied includes two dependent variables, namely the ability to think critically and creatively. The results were obtained through tests of critical and creative thinking skills. Table 1 shows a description of the students' initial ability data before being given treatment.

**Table 1.** Initial ability descriptive statistics

Dependent Variable	Learning	Mean	N	Variance	Kovariance
Critical Thinking	PBL	47.57	92	149.87	77.21
	Problem Posing	44.94	89	154.05	72.00
	Direct Learning	44.03	73	128.86	67.32
Creative Thinking	PBL	45.65	92	170.69	77.21
	Problem Posing	46.76	89	186.02	72.00
	Direct Learning	44.27	73	128.18	67.32

Table 1 shows that the variance-covariance matrix is used in the multivariate population normality test and the homogeneity of variance and covariance. The results obtained with this test are the data comes from a population that is normally distributed and homogeneous.

Furthermore, each class that was treated with the specified learning model, the results obtained can be seen in Table 2. It shows that the variance-covariance matrix is used in the multivariate population normality

test and the variance-and-covariance homogeneity test. The results obtained with this test are that the data comes from a population that is normally distributed and homogeneous. The students' initial ability data were carried out by various tests including normality test, homogeneity test and balance test. Data from the population multivariate normality test results, three groups of learning models are 96% of PBL, 98% for Problem Posing and 97% for Direct Learning.  $H_0$  can be accepted if  $d_j^2 \leq \chi^2_{(0.05;2)}$  is more than 50%. It

**Table 2.** Descriptive statistics of critical and creative thinking ability based on learning model

Dependent Variable	Learning	Sum	Mean	Variance	Covariance
Critical Thinking	PBL	7088.00	77.04	91.73	70.61
	Problem Posing	6440.00	72.36	81.69	46.71
	Direct Learning	4984.00	68.27	97.92	110.75
Creative Thinking	PBL	6492.00	70.57	171.81	70.61
	Problem Posing	6680.00	75.06	144.37	46.71
	Direct Learning	4884.00	66.90	220.12	110.75

**Table 3.** Summary of initial data univariate normality test

Dependent Variable	Learning	$L_{obs}$	$L_{\alpha;n}$	Test Decision
Critical Thinking	PBL	0.088	0.092	$H_0$ accepted
	Problem Posing	0.092	0.094	$H_0$ accepted
	Direct Learning	0.101	0.104	$H_0$ accepted
Creative Thinking	PBL	0.086	0.092	$H_0$ accepted
	Problem Posing	0.086	0.094	$H_0$ accepted
	Direct Learning	0.099	0.104	$H_0$ accepted

can be concluded, that all samples come from a population with a multivariate normal distribution.

The data from the univariate normality test for each dependent variable of the three groups of learning models can be seen in Table 3. It can be concluded based on Table 3, that each sample comes from a population with a univariate normal distribution.

The initial ability data were tested for homogeneity of the variance matrix and population covariance using the Box M test. The results of the calculation of the homogeneity test of the variance-and-covariance matrix obtained  $\chi^2_{(0.05;6)} = 12.592$  and  $\chi^2_{obs} = 2.412$ , then  $\chi^2_{obs} \notin DK$  (critical region). It can be concluded that the variance-and-covariance matrix of the two populations is homogeneous (same).

Furthermore, the initial ability data was tested for the homogeneity of the population variance of each dependent variable using the Bartlett test. The homogeneity test of the three groups with each learning model are obtained  $\chi^2_{obs} = 1.493$  for critical thinking and  $\chi^2_{obs} = 2.965$  for creative thinking. It is known, that  $\chi^2_{obs} \leq \chi^2_{(0.05;2)}$  with  $\chi^2_{(0.05;2)} = 5.991$  then  $\chi^2_{obs} \notin DK$ . It can be concluded that all populations of each dependent variable have a homogenous (same) variance.

The balance test on the initial ability data was used to determine whether each sample class given the PBL,

Problem Posing, and direct learning models had balanced abilities or not. The initial data balance test used one-way multivariate analysis of variance with  $DK = \{F \mid F > F_{(0.05;4;500)}\}$  (1)

Test calculation results balance is obtained value  $F_{obs} = 1.950 < F_{(0.05;4;500)} = 2.389$ . If  $F_{obs} \notin DK$  then  $H_0$  is accepted. It can be concluded that all sample classes have a balanced ability.

Hypothesis testing was performed using Multivariate Analysis of Variance (MANOVA) or multivariate analysis of variance in two unequal cell paths. Previously, it was necessary to test the prerequisite analysis first, in the form of a population multivariate normality test and a variance-and-covariance matrix homogenous test. Data on critical and creative thinking skills for each research sample are summarized in Table 4.

Population multivariate normality test data from critical and creative thinking skills are 98% for PBL, 100% for Problem Posing and 96% for Direct Learning.  $H_0$  can be accepted if  $d_j^2 \leq \chi^2_{(0.05;2)}$  is more than 50%. Thus, it can be concluded that all samples come from populations with multivariate normal distribution.

Table 5. is a description of the univariate normality test of critical thinking skills and creative thinking skills based on the learning model given to students. It is known that  $H_0$  will be accepted if  $L_{obs} \leq L_{\alpha;n}$  with  $\alpha = 0.05$ . It is known that the two dependent variables

**Table 4.** Description of critical and creative thinking ability data

Dependent Variable	Learning Models	Lowest Score	Highest Score	Mean	St. Dev.
Critical Thinking	PBL	60	96	77.04	9.58
	Problem Posing	52	88	72.36	9.04
	Direct Learning	52	92	68.27	9.90
CreativeThinking	PBL	48	92	71.22	13.46
	Problem Posing	48	92	75.06	12.02
	Direct Learning	48	88	67.78	14.73

**Table 5.** Summary of population univariate normality test based on learning model

Dependent Variable	Learning Model	$L_{obs}$	$L_{\alpha;n}$	Test Decision
Critical Learning	PBL	0.088	0.092	$H_0$ accepted
	Problem Posing	0.078	0.094	$H_0$ accepted
	Direct Learning	0.086	0.104	$H_0$ accepted
CreativeThinking	PBL	0.088	0.092	$H_0$ accepted
	Problem Posing	0.091	0.094	$H_0$ accepted
	Direct Learning	0.094	0.104	$H_0$ accepted

have  $L_{obs}$  below  $L_{\alpha;n}$ , then  $H_0$  is accepted for each test. The conclusion obtained is that all samples come from a normally distributed population.

Homogeneity test on student score data after treatment (posttest), was carried out based on the learning model. Homogeneity test in the form of multivariate and univariate homogeneity test. Multivariate homogeneity test of the population using the Box M test with this formula

$$DK = \left\{ \chi^2 \mid \chi^2 > \chi^2_{\left(\alpha, \frac{p(p+1)(k-1)}{2}\right)} \right\} \quad (2)$$

$H_0$  will be rejected if  $\chi^2_{obs} \in DK$ . The results of the multivariate homogeneity test are summarized in this table.

It is known that the learning model factor has  $\chi^2_{obs} = 5.413$  less than  $\chi^2_{(0.05;6)} = 12.592$  as a result  $\chi^2_{obs} \notin DK$  and  $H_0$  is accepted. The conclusion obtained is that the variance-and-covariance matrix of the population is homogeneous (same).

The homogeneity test of the population variance of the student's posttest data used the Bartlett test with  $\chi^2_{(0.05;2)} = 5.991$  and  $\alpha = 0.05$ .  $H_0$  will be rejected if  $\chi^2_{obs} \in DK$ . The homogeneity test of the three groups with each learning model is obtained that  $\chi^2_{obs} = 0.677$  for critical thinking and  $\chi^2_{obs} = 3.044$  for creative thinking. It is known that  $\chi^2_{obs} \leq \chi^2_{(0.05;2)}$  then  $\chi^2_{obs} \notin DK$ . It can be concluded that all populations of each dependent variable based on the learning model have a homogeneous (same) variance.

After the requirements for the normality test and homogeneity test are met, then the hypothesis is tested using Multivariate Analysis of Variance (MANOVA) or multivariate analysis of variance in two unequal cell paths. The results of the multivariate test of two unequal cell paths can be seen in Table 6. There are decision results, namely the learning model factor (factor A) it is known that  $H_{0A}$  is rejected, it can be concluded that there is a difference in the effect of the learning model on students' critical and creative thinking skills. Based on the results of the hypothesis

**Table 6.** Summary of two way multivariate analysis of variance

Source	SSCP Matrix	$F_{obs}$	$F_{table}$	Test Decision
Factor A	$\begin{pmatrix} 3182.233 & 1006.132 \\ 1006.132 & 2154.087 \end{pmatrix}$	14.017	2.370	$H_{0A}$ accepted

test, it is known that there is a rejection in  $H_{0A}$ , it is necessary to carry out further tests with the aim of knowing whether there are differences in each dependent variable. Further tests using two-way Analysis of Variance (ANOVA) with unequal cells.

The summary of the results of the two-way ANOVA test with unequal cells for critical thinking skills can be seen in the following Table 7.

**Table 7.** Summary of the results of anova two ways of critical and creative thinking

Source		Sum of Square	Degree of freedom	Mean Square	$F_{obs}$	$F_{tab}$	Decision
Learning Models (A)	Critical Thinking	3228.25	2	1614.12	18.92	3.03	$H_0$ rejected
	Creative Thinking	1905.58	2	952.79	6.37	3.03	$H_0$ rejected

From the summary of the results of the two-way ANOVA test with unequal cells in Table 7. below, it can be concluded that there are different effects between learning models on critical thinking skills and there are different effects between learning models on creative thinking skills. There is a hypothesis that is rejected, then a double comparison test is carried out

using the Scheffe method. The average comparison between lines is the average pair of students' critical and creative thinking skills between learning models. The summary of the research data test can be seen in Table 8. below.

**Table 8.** Summary of the average comparison test between rows

Dependent Variable	$H_0$	$F_{obs}$	$F_{table}$	Decision
Critical Learning	$\mu_{11} = \mu_{12}$	11.63	6.07	$H_0$ rejected
	$\mu_{11} = \mu_{13}$	36.69	6.07	$H_0$ rejected
	$\mu_{12} = \mu_{13}$	7.85	6.07	$H_0$ rejected
CreativeThinking	$\mu_{21} = \mu_{22}$	7.97	6.07	$H_0$ rejected
	$\mu_{21} = \mu_{23}$	1.87	6.07	$H_0$ accepted
	$\mu_{22} = \mu_{23}$	16.10	6.07	$H_0$ rejected

Based on Table 8. regarding the mean between rows, it can be concluded that, (1) The critical thinking ability of students who were treated with the PBL learning model was better than students who were treated with the problem posing learning model and direct learning model, as well as the critical thinking ability of students who were given treatment. the treatment of the problem posing learning model is better than the direct learning model. (2) The creative thinking ability of students who were treated with the problem posing learning model was better than the PBL learning model and direct learning.

problem posing learning models and direct learning, and students who were treated with problem posing models had better thinking skills. critically better than students who were given the direct learning model treatment.

Based on the multivariate analysis of variance (MANOVA) test of two unequal cell paths, it was found that each learning model had a different effect on students' critical and creative thinking skills. Then, two-way analysis of variance (ANOVA) and further test (comparison) were conducted. The results of the comparison test between lines on the critical thinking ability variable showed that students who were treated with the PBL learning model had better critical thinking skills than students who were treated with

The results of the comparison test between lines on the variable of student's creative thinking abilities, it was found that students who were treated with the problem posing learning model had better creative thinking skills than students who were treated with the PBL learning model and direct learning. The PBL learning model is as effective as direct learning in terms of creative thinking skills.

**8. CONCLUSION**

The results showed that students who were treated with the PBL learning model had better critical thinking skills than students who were treated with the problem posing learning model and direct learning. Students who are treatedwith a positive effect than the problem posing learning model and

direct learning, in terms of students' critical thinking skills. The use of the problem posing learning model is superior/effective than the direct learning model in terms of students' critical thinking skills. If it is viewed from the creative thinking ability of students, the use of problem posing learning models is more effective than PBL learning models and direct learning. PBL and problem posing learning models are currently used in online learning. The use of PBL and Problem Posing learning models is useful to assist students in developing their critical and creative thinking skills. For further research, the learning models can be applied in online learning.

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