



The Effect of Problem-Based Learning on the Critical Thinking Skills of Elementary School Students

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Abstract: This study aims to determine: (1) the difference in critical thinking skills between students taught using problem-based learning and expository learning, and (2) the influence of implementing problem-based learning on students' critical thinking skills. This study was quasi-experimental research. The study population consisted only of fifth-grade students from Krikilan 2 Elementary School. In the experimental group, the learning process took place using the problem-based learning model, while in the control group, it took place in an expository manner. The instruments used were tests that measure students' critical thinking abilities in cognitive aspects and a behavioral scale that measures students' critical thinking abilities in behavioral aspects. The data were then analyzed using: (1) descriptive statistics to describe critical thinking skills and learning outcomes, and (2) inferential statistics using independent sample t-tests and MANOVA to test the research hypotheses at a significance level of 5% ($\alpha = 0.05$). The research findings indicates that: (1) there is a significant difference in students' critical thinking skills between the group taught using problem-based learning and the group taught using expository learning, with a p-value of 0.004, and (2) the implementation of problem-based learning positively and significantly influences students' critical thinking skills, with a significance value of 0.005.

Keywords: problem-based learning, critical thinking skills, expository

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Introduction

Education must be carried out consistently as a deliberate endeavour to foster individuals' intellectual, social, and moral maturation. The implementation of education is often confronted with various challenges. However, the primary objective is to establish an educational framework that encompasses cultivating skills among students, which are essential for their current and future endeavours (Chusni et al., 2020).

At its essence, learning involves the interaction between the teacher and the students, among the students themselves, and between the students and the learning environment and other learning resources. During the interactive process, the teacher acts as a facilitator. In line with the opinion of Rusmono (2012), learning is an effort to create a condition that enables students to acquire adequate learning experiences.

In learning activities, teachers should have strategies that enable students to learn effectively and efficiently according to the intended learning objectives. Teachers can motivate themselves, enrich their knowledge by developing learning strategies, and explore various learning models as one of the foundations of educational development. Moreover, teachers should encourage students to use problem-solving skills or address issues. This way, students can develop critical thinking abilities and express their opinions in resolving various problems.

In today's society, critical thinking has emerged as a significant objective of higher education and is now recognised as a crucial competency that students should acquire (Prayogi et al., 2019). In the 21st century, students are encountering substantial transformations in multiple domains of life, including but

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not limited to digital literacy, technological progress, multicultural communities, global communication, innovation, and related areas (Saleh, 2019). Several advanced countries, including Europe, the United States, Australia, New Zealand, and Canada, have established critical thinking as a standard competency in their education systems (Verawati et al., 2019). Similarly, in developing countries like Indonesia, critical thinking has been defined as a competency goal in education, as stated in the Indonesian National Qualifications Framework (Prayogi et al., 2018). Critical thinking is a reflective process determining what should be believed and done (Ennis, 2018). Critical thinking ability is divided into two dimensions: skills and disposition. Recent studies have focused on skill indicators of critical thinking, such as analysis, inference, evaluation, and decision-making (Wahyudi et al., 2019). Additionally, Faiz (2012) argues that the primary purpose of simple critical thinking is to ensure the validity and accuracy of our thoughts. Through critical thinking, students can solve the problems they encounter.

Acquiring critical thinking skills is not solely focused on self-reflection but aims to cultivate heightened individual attentiveness and curiosity. It entails posing inquiries and critically analysing and evaluating various sources (Wale & Bishaw, 2020). Critical thinking is a cognitive process that involves following the steps of the scientific method. These steps include comprehending and defining problems, collecting, and analysing pertinent and dependable data, formulating assumptions and hypotheses, logically testing hypotheses, drawing meticulous conclusions, conducting evaluations, determining what to believe, and predicting potential outcomes. The objective of critical thinking is for individuals to carefully evaluate and deliberate upon their choices and actions before deciding (Saputri et al., 2020). Based on these viewpoints, one can infer that critical thinking entails engaging in logical decision-making processes, wherein the potential ramifications of accepting or rejecting a given proposition are carefully contemplated. Children need skills and abilities to express their problems to others. Students can acquire these skills when teachers create lesson plan that include challenging activities for students to think critically while solving problems. Activities encouraging students to collaborate and communicate should be included in every lesson plan they create (Septikasari, 2018).

Different learning models are necessary for teachers, and their implementation should also be varied. Teachers must understand numerous effective, creative, and enjoyable learning models and possess adequate skills to develop them. When the models used in learning are not diverse, students may feel uncomfortable participating in the learning process. Problem-based learning (PBL) is a model that allows students to learn through real-life problems. PBL allows students to work and find solutions from real-life situations (Gregory & Chapman, 2013).

According to Hotimah (2020), a teaching method is a technique used in the learning process to achieve learning objectives. PBL is a problem-based learning method that encourages group learning and working towards finding solutions, critical and analytical thinking, and identifying and using appropriate learning resources. PBL is where students are presented with a problem to be solved or conceptualized.

During the teaching process in Grade V at Krikilan 2 Elementary School, it was observed that the teacher used an expository teaching model and emphasized rote memorization, which resulted in students having less interest and enthusiasm. Different learning materials require the implementation of different teaching models. In field observations, it was found that the teacher used teaching methods that were not suitable for the learning materials. When teaching science subjects, the teacher relied heavily on lectures and textbooks. It caused the students to appear passive. For this subject, real-life examples or using the surrounding environment as a learning resource could have been incorporated (Pohan, 2020). By doing so, learning would become more meaningful, where students learn to know and do, be, learn to learn, and live together by socializing with peers and the environment.

Based on the observation results, students lack skills in critical thinking. It is reflected in their weak ability to analyze problems, low curiosity, and lack of independence and confidence. Students are less active in the classroom. Their engagement in asking and answering the teacher's questions during the learning activities is still suboptimal. This needs to be changed by the teacher to make students actively participate in learning by implementing various appropriate teaching models according to their conditions and characteristics. Many students have low learning outcomes. Based on the analysis, many students still lack focus in following the learning process, rushing, and being less careful when working on given exercises.

These diverse problems encourage researchers to implement PBL models to enhance students' critical thinking skills. The PBL learning paradigm is problem-based, and the learning activities are

geared towards problem resolution. According to the opinion (Fitria et al., 2022), PBL can aid students in the learning process. PBL is a constructivist learning flow model that calls for pupils to observe the realities of daily life. This model requires students to engage in a series of learning activities; however, it does not expect students to simply listen, take notes, and then memorise subject matter; through this model, students can actively think, communicate, search, process data, and draw conclusions. This PBL learning model intends students to actively participate in science learning activities to develop their critical thinking skills and scientific attitudes. For students to improve their activity and learning outcomes through the PBL learning model. Caroni (2021) concluded that online PBL courses can help students integrate knowledge and promote profound learning by strengthening students' critical thinking, problem-solving, independent learning, and teamwork skills. In addition, Utaminingsih et al. (2022) concluded that PBL with Peer Tutoring substantially impacts student's critical thinking skills.

Based on the background of the problem, the research problem formulation in this study are: (1) is there a difference in the critical thinking skills of students in Grade V of Krikilan 2 Elementary School between classes taught using PBL and classes taught using expository teaching methods in the subject of Science?, and (2) does the implementation of PBL impact students' critical thinking skills in Grade V of Krikilan 2 Elementary School in the subject of Science?

The objectives of this study are to determine: (1) the difference in critical thinking skills of students in Grade V of Krikilan 2 Elementary School between classes taught using PBL and classes taught using expository teaching methods in the subject of Science, and (2) the impact of implementing PBL on the critical thinking skills of students in Grade V of Krikilan 2 Elementary School in the subject of Science.

Methods

This research used a quantitative approach. The type of research conducted was a quasi-experiment, specifically a quasi-experimental design known as a pretest-posttest control group design. Research activities were conducted at Krikilan 2 Elementary School, Bulurejo, Krikilan, Bayat, Klaten. The time for research activities began in Semester I of the 2022/2023 Academic Year, in August 2022. Furthermore, the population of this study consisted of all students in Grade V of Krikilan 2 Elementary School. This study was a population study. The total number of students were 23, with 19 male and 4 female students. The sampling technique used in this study was cluster random sampling. The sample was selected from groups that are considered similar and non-hierarchical.

This research was conducted in three stages: (1) the preparation stage, which includes a field study consisting of school observations, (2) the implementation stage, which involves conducting the research starting with a pre-test, and (3) the evaluation stage, which includes concluding the post-test to determine if there is an effect of PBL model. The experimental design used was a pre-test-post-test control group design. The planned experimental design was presented in the following table:

Table 1. Experimental Design

Class	Pre-test	Treatment	Post-test
Eks	O ₁	X _a	O ₂
Ktr	O ₃	X _b	O ₄

Notes:

Eks : Experimental class
 Ktr : Control class
 O₁ : Pre-test of the experimental class
 O₂ : Post-test of the experimental class
 O₃ : Pre-test of the control class
 O₄ : Post-test of the control group
 X_a : experimental class treatment
 X_b : experimental class control

Data in this research was collected using two methods: tests and questionnaires. The test used to measure the students' critical thinking skills. The test items were in the form of open-ended questions, totalling ten items. The questionnaire was developed to assess the student's critical thinking skills based on their behavioral aspects of critical thinking.

The data collection in this research was conducted in the pre-research phase and the research process phase. In the pre-research phase, data was collected through interviews and observations during

the ongoing learning process. The data collection techniques during the experimental research process included pre-test (before treatment) and post-test (after treatment).

To analyse the data, the researcher employed two categories of statistics namely descriptive statistics and inferential statistics. Microsoft Excel and SPSS for Windows were utilised to calculate descriptive statistics. As for inferential statistics, the t-test and MANOVA (Multivariate Analysis of Variance) were used to analyse the data for this study. The t-test for independent samples was used to determine whether there is a statistically significant difference between the means of the experimental and control groups. On the other hand, MANOVA was used to assess the impact of PBL on the participants' critical thinking abilities.

Results and Discussion

The critical thinking skills test data include pre-test and post-test data from the control and experimental groups. The pre-test data indicate that the initial situation is associated with the students' critical thinking skills in both the control and experimental groups before the implementation of PBL intervention. The post-test data reflect the situation of the critical thinking skills of the students after the intervention. The results of the critical thinking skills data are presented in the following table.

Table 2. Data on Critical Thinking Skills

Description	Control Group (n=23)		Experimental group (n=23)	
	Pre-test	Post-test	Pre-test	Post-test
Mean	73.2174	76.8696	72.8696	83.6087
Std. Deviation	8.25148	5.97954	8.34105	8.94295
Variance	68.087	35.755	69.573	79.976
Minimum	58.00	70.00	58.00	65.00
Maximum	92.00	92.00	92.00	100.00

Based on the provided data, the mean pre-test score for the control group was 73.2174, with scores between 58.00 and 92.00. The experimental group exhibited an average pre-test score of 72.8696, ranging from a minimum score of 58.00 to a maximum score of 92.00. Following the intervention, the control group exhibited an average post-test score of 76.8696. The minimum score observed was 70.00, while the maximum score reached 92.00. The experimental group exhibited an average post-test score of 83.6087, ranging from a minimum score of 65.00 to a maximum score of 100.00.

Based on the findings obtained from the pre-test and post-test assessments, it is evident that the mean score of critical thinking abilities exhibited an increase within the control group, rising from 73.2174 to 76.8696. The experimental group's mean score of critical thinking skills exhibited an increase from 72.8696 to 83.6087. Based on a comparison of the score improvements observed in the control and experimental groups, it can be deduced that the experimental group exhibited a more substantial enhancement in critical thinking abilities than the control group.

The normality test and homogeneity test are required as prerequisite tests in the t-test. The normality test aims to determine whether the research subjects come from a normal distribution. The Kolmogorov-Smirnov method uses the SPSS for the Window program for the normality test. The hypothesis proposed to measure normality is as follows:

H₀: Data is normally distributed.

H_a: Data is not normally distributed.

If the significance value obtained is greater than the specified alpha (> α), which is 0.05, then it is accepted. Vice versa, if the significance value obtained is smaller than the specified alpha (<α) then it is rejected. The results of the normality test for the variable critical thinking skills in the control class and the experimental class are presented in the following Table 3.

Table 3. Normality Test Data

Variable	Sig. Kolgomorov-Smirnov				Asymp Sig. (2-tailed)	Description
	Data Group					
	Control Group (n=23)		Eksperimental Group (n=23)			
	Pre-test	Post-test	Pre-test	Post-test		
Critical thinking skills	0.968	0.764	0.514	0.984	Sig. > 0.05	Normal

Based on the presented Table 3, it can be observed that the obtained significance values for the variable critical thinking skills in the pre-test and post-test of both the control and experimental groups are greater than the specified alpha level. Therefore, the null hypothesis (H_0) is accepted, indicating that all the data are normally distributed.

The purpose of the homogeneity test is to ascertain whether the individuals participating in the research study originate from a population that is either homogeneous or heterogeneous. The researcher conducted the homogeneity test using Levene's test within the SPSS for Windows software. The hypothesis posited for the measurement of homogeneity is as follows:

H_0 : The variances of the variable are equal or homogenous.

H_a : The variances of the variable are not equal or heterogeneous.

If the significance value obtained is $> \alpha$ (greater than the specified alpha) which is 0.05 then it is accepted. It is rejected if the significance value obtained is $< \alpha$ (smaller than alpha) specified. The results of the homogeneity test on the critical thinking skill variable in the control group and the experimental group are presented in the following table:

Table 4. Summary of Homogeneity Test

Variable	Levene Statistic	Df1	Df2	Sig	
Critical thinking skills	0.032	1	44	0.263	Homogen

Table 4 shows that the significance values for the variable of critical thinking skills in the control and experimental groups obtained from the pre-test are greater than the specified alpha level. Thus, H_0 is accepted, and it can be concluded that all variable variances are equal (homogeneous).

The required tests for MANOVA are the homogeneity of variances and the homogeneity of covariance tests. The researcher used Levene's test with the SPSS program for Windows.

H_0 : Variance of the variables is equal or homogeneous.

H_a : Variance of the variables is unequal or heterogeneous.

The hypotheses presented are as follows: It is accepted if the obtained significance value is greater than the predetermined alpha level of 5% or 0.05. Conversely, if the obtained significance value is smaller than the predetermined alpha level, it is rejected. The results of the homogeneity test for the variable of critical thinking skills in the control and experimental groups are presented in the following table:

Table 5. Variant Homogeneity Test

	F	Df1	Df2	Sig.
Critical thinking	1.286	1	44	0.263

Based on the homogeneity test of variance using the Levene test shown in Table 5, the significance value of the variable students' critical thinking skills is greater than 0.05. This means that both the control and experimental groups have the same variance.

In testing the homogeneity of the variance/covariance matrix, what the researcher used was the Box's test. The hypothesis proposed to measure the homogeneity of the variance/covariance matrix is as follows:

H_0 : The dependent variable variance-covariance matrix is the same (no difference)

H_a : The dependent variable variance-covariance matrix is not the same (different)

If the significance value obtained is $> \alpha$ (greater than alpha) determined to be 5% or 0.05, it is accepted. Meanwhile, if the significance value obtained is $< \alpha$ (smaller than alpha) which is determined then it is rejected. The results of the homogeneity test of the critical thinking skills variable of students in the control class and the experimental class are presented in the table below:

Table 6. Homogeneity Test of Variant-Covariance

	F	Df1	Df2	Significance	
Critical thinking	1.363	0.482	1	44	0.372

Based on the Box test shown in the table above, the M-test Box value is 1.363 and the F-test value is 0.482, with a significance value (sig.) of 0.372. Since the obtained significance value is greater than 0.05, H_0 is accepted. This means that the variance-covariance matrix of the dependent variables is the same (no difference).

In testing the first hypothesis, the H_0 hypothesis to be tested is:

$\mu A1 = \mu A2$ (There is no significant difference in critical thinking skills between classes taught using PBL and classes taught using expository learning) compared to $H_0: \mu A1 \neq \mu A2$ (There is a significant difference in critical thinking skills between classes taught using PBL and classes taught using expository learning). To test whether there is a difference in students' critical thinking skills in Grade V at Krikilan 2 Elementary School in the subject of science, the researcher used independent samples t-test with SPSS for Windows. It is accepted if the obtained significance value (sig.) is greater than 5% or > 0.05 . It is rejected if the obtained significance value (sig.) is less than 0.05. The results of the t-test analysis for the post-test scores of critical thinking skills are presented in the table below:

Table 7. Post-Test Scores T-Test of Critical Thinking Skills

	t	Df	Sig.(2-tailed)
Critical Thinking Skills	3.004	44	0.004

The obtained significance value of 0.004 can be observed from table 7. The obtained significance value is lower than the predetermined alpha (α) value of 0.05 or 5%, thus leading to its rejection. Hence, it can be inferred that notable disparities exist in students' critical thinking abilities when comparing classes instructed via PBL approaches and classes conducted through expository learning methods.

The multivariate test, namely Hotelling's trace, is used to test whether implementing learning using a PBL model significantly affects the critical thinking skills of fifth grade students at Krikilan 2 Elementary School in science subjects. Multivariate test results are presented in the following table:

Table 8. Hotelling's Trace Multivariate Test

Value	F	Hypothesis df	Error df	Sig.
0.122	3.095	2	44	0.005

Based on the data presented in the table above, it can be observed that the F-value for the Hotelling's Trace test is 3.095, with a significance value of 0.005. The obtained significance value is smaller than the predetermined alpha level (α) of 0.05 or 5%. Therefore, it can be concluded that implementing PBL positively and significantly affects the critical thinking skills of the fifth-grade students at Krikilan 2 Elementary School in science.

Based on the above data analysis, it is concluded that students can develop critical thinking through problem-solving activities. The problems presented by the teacher, such as stories about natural phenomena, floods, and earthquakes that negatively impact living creatures on Earth, especially humans, will stimulate the students' curiosity to find solutions to these problems.

Through collaboration among students within their groups, participants can express their opinions based on their knowledge about the discussed issues. Discussions among the students arise due to the diverse knowledge each student possesses. Each student will share what they know based on what they have acquired through reading, listening, observing, or personal experiences. As a result of these varied experiences, students are encouraged to obtain information and knowledge from various learning

sources, such as books, the internet, or by seeking verification from their parents or teachers to validate their thinking processes.

Through this information searching process, students acquire new knowledge and information, aligning with Piaget's concept of assimilation and accommodation. Assimilation occurs when students incorporate new information into their existing knowledge, while accommodation arises when differences are identified between their pre-existing knowledge and the new knowledge acquired. Thus, the process of adaptation to new information is underway. This creates a state of equilibrium within the students. Within this process, students undergo development in their critical thinking skills (Utaminingsih et al., 2022). Implementing PBL in educational settings frequently faces challenges, particularly when instructing students in advanced cognitive abilities, such as critical thinking skills. One potential strategy to surmount these challenges involves utilising peer mentors. According to the viewpoint Fitria et al. (2022) put forth, Problem Based Learning (PBL) encompasses fundamental principles that necessitate the teacher's active involvement in fostering a vibrant learning environment. In this context, the teacher assumes a role beyond being the primary source of knowledge, as they are expected to engage students to facilitate their critical thinking abilities.

The main task of a teacher is to be responsible for helping students in terms of learning. In the process of teaching and learning, it is the teacher who conveys the lesson, solves problems that occur in class, and evaluates student learning, both before, during and after the lesson (Hotimah, 2020). Without the support of teachers, students' critical thinking skills cannot develop independently. This is because the problem-solving process for students is not easy. Based on student feedback, the researcher found that problem-solving activities were challenging for them. In this case, the problems they faced and had to solve were perceived as difficult tasks for the students, which aligns with Vygotsky's concept of the zone of proximal development (ZPD). However, students added that they could solve problems by asking their teachers. In other words, through scaffolding, teachers assist students in solving the problems they encounter.

In agreement with Christensen and Martin (Killen, 2009) that problem-solving activities foster critical thinking abilities and increase students' knowledge of the subjects being taught. When students are engaged in solving a problem, they feel actively involved in seeking a solution to the problem they are facing. This understanding enhances students' awareness of taking concrete actions to solve a problem presented by their teacher. The students' awareness appears to be consistent with their developing understanding of why certain actions need to be taken and the impact of those actions.

Conclusion

Based on the data analysis and discussion results, the researcher draws the following conclusions: (1) the significance value obtained is 0.004. The significance value obtained is below the predetermined alpha (α) value of 0.05 or 5%. Therefore, it can be concluded that there is a significant difference in the critical thinking skills of fifth grade students at Krikilan 2 Elementary School between classes taught using a PBL model and classes taught through expository learning in science subjects, and (2) the Hotelling's Trace F test value is 3.095 and with a significance value of 0.005. The significance value obtained is $<\alpha$ (smaller than alpha) which is determined to be 5% or 0.05. So, it can be concluded that applying the PBL model positively and significantly affects the critical thinking skills of the fifth-grade students at Krikilan 2 Elementary School in science subjects.

Based on the study's conclusions, implications, and limitations, the researcher provides the following recommendations: (1) for elementary school teachers, they can provide opportunities to implement PBL can enhance the development of students' critical thinking skills by presenting engaging problems to the students, (2) for schools, they can provide opportunities to develop teachers' expertise by implementing PBL, starting from the planning stage to the assessment process of students, (3) for future researchers conducting similar studies, they can develop more interesting problems for students and optimising each phase of PBL is recommended, and (4) for further research, it would benefit the researcher to develop an observation guide to measure students' attitudes towards critical thinking.

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