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The effect of problem-based learning model based on earthquake disaster mitigation on critical thinking ability

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ABSTRACT

This study aims to evaluate the impact of Problem-Based Learning (PBL) on the critical thinking skills of eighth-grade students at MTs Alkhairaat Pusat Palu, with a particular focus on earthquake disaster mitigation. This research is important because Indonesia, as a disaster-prone country, requires an effective educational approach to prepare students to face emergency situations, especially earthquakes. PBL can provide relevant and contextual learning experiences. This study used a quasi-experimental approach with unequal control groups. Participants included two classes; class VIII C which was the experimental class and received PBL intervention, while class VIII D served as the control class and received conventional instruction. Data were collected through essay tests administered before and after the intervention. Normality and homogeneity tests were conducted on the data before conducting a paired-sample t-test. The findings showed that students' critical thinking skills in the experimental class improved significantly, reaching a post-test average while the control class was lower. The t-test results indicated that PBL had a significant positive impact on critical thinking skills. Therefore, the PBL model aimed at disaster mitigation has proven effective in improving the development of critical thinking skills in students.

INTRODUCTION

Natural disasters are events that can disrupt community life and cause damage, loss, and psychological impact. These disasters may arise from natural phenomena, human activities, or a combination of both (Sukumaran, 2022). One of the most devastating natural disasters is the earthquake, which often occurs without warning and causes extensive damage to infrastructure and human life (Spiridonov et al., 2025).

Earthquakes are unpredictable natural occurrences. Although they frequently happen in regions located along tectonic plate boundaries such as the Ring of Fire, it remains uncertain exactly when and where they will occur (Subagia, 2015) . This sudden nature is due to abrupt tectonic movements beneath the Earth's surface, causing shifts in the crustal layers (Amestiasih et al., 2022)

There are two types of earthquakes that exist in the world, namely tectonic earthquakes and volcanic earthquakes. Volcanic earthquakes are a type of earthquake caused by magma activity in the bowels of the earth. Usually before a volcano erupts there are earthquake tremors that are felt around the volcano area. These vibrations are referred to as volcanic earthquakes. Meanwhile, tectonic earthquakes are shifts in plate layers either on the surface or in the bowels of the earth. Based on the location of the earth's plate shifts there are those on land causing earthquakes and those at sea causing tsunamis.

As part of its mission to achieve general welfare, the Unitary State of the Republic of Indonesia is entrusted with the responsibility of providing disaster protection, among other things, according to the 1945 Constitution of the Republic of Indonesia. Disaster risk management and reduction is a government plan based on the fact that Indonesia is exposed to various natural phenomena that have the potential to cause

disaster risk. This makes Indonesia known as a "disaster supermarket" even though it is considered quite good (Sukino et al., 2019)

The Island of Sulawesi holds important geological significance, especially in Central Sulawesi, where the Palu-Koro Fault arises. It is an Indonesian Fault System, stretching and extending for 500 kilometres. This makes the Palu-Koro Fault the second longest fault in Indonesia. The Palu-Koro Fault is active and is shifting on Sulawesi Island at a speed of 30 to 40 millimetres per year (Khoir et al., 2023) . The Central Sulawesi region is one of the areas at risk of disaster due to its proximity to both terrestrial and submarine sources of earthquakes. These sources of earthquakes are formed due to earlier tectonic activity. Undersea earthquakes are generated by the North Sulawesi subduction to the north of Sulawesi Island, and land-based earthquakes are generated by the active faults within Central Sulawesi, one of which is the Palu Koro Fault. The Palu-Koro fault extends from the north of Palu to the south of Bone Bay and forms the branching of the Walanae fault which is located in the southern part of Sulawesi Island and at the western end of the Makassar Strait forms the Peternoster fault (Saputra et al., 2019)

The 7.4 Mw earthquake that struck Palu on September 28, 2018, severely damaged infrastructure, particularly in the Lere coastal area, and disrupted vital sectors such as education (Fauzi & Mussadun, 2021). Many educational institutions were heavily affected, hindering learning and challenging educators in supporting traumatized students. Disaster mitigation, aimed at reducing impacts through preparedness and response, must be introduced early and integrated into learning. Knowledge of disaster mitigation strengthens resilience and is part of the national disaster management plan, with materials adapted to students' levels (Fitria et al., 2024). Modern approaches like Problem-Based Learning (PBL) are effective, as they foster active participation, problem-solving, and real-world engagement (Prasetyo & Kristin, 2020).

Law No. 24 of 2007 on disaster management provides the framework for disaster mitigation, requiring local governments to communicate disaster conditions and threats (Ayub et al., 2021). Schools, being vulnerable during earthquakes, need proper disaster management. Learning models, which structure classroom experiences, play a crucial role in achieving educational goals (Rokhimawan et al., 2022). In this context, PBL is applied to improve students' critical thinking within earthquake disaster mitigation.

Problem-Based Learning (PBL) engages students in authentic problem-solving activities integrated with scientific inquiry, fostering not only knowledge acquisition but also logical reasoning and evidence-based thinking (Maulidina et al., 2024). The PBL structure includes five main stages: orienting learners to a problem, guiding self-directed problem solving, fostering independent and group investigations, developing and presenting work, and finally, analyzing, reflecting, and evaluating outcomes (Rachmadtullah, 2015).

Critical thinking plays a vital role in this process, as it enables students to generate ideas, innovate, and make rational analyses. It involves processing, manipulating, and transforming information to make logical, evidence-based decisions (Hitchcock, 2017). In today's rapidly advancing technological and economic landscape, critical thinking is essential for sorting and evaluating information (Firdaus et al., 2019). Learners with strong critical thinking skills can identify logical connections, construct and evaluate arguments, critique evidence, formulate hypotheses, and analyze problems systematically while discerning fallacies and assessing the relevance of concepts (Azizah et al., 2018).

Previous research has shown that the Problem-Based Learning (PBL) model has the potential to improve students' critical thinking skills in various educational contexts. For example, Ernanda et al., (2022) found that implementing PBL can improve students' critical thinking skills in science learning. Furthermore, Abdullah & Ningrum (2024) demonstrated that this model is effective in improving students' understanding of disaster mitigation, although they did not specifically measure its impact on critical thinking skills. Muryani & Ni'matussyahara (2024) also examined the impact of disaster mitigation learning on students' awareness, but their study did not explore its influence on critical thinking skills in depth.

The gap in this research lies in the lack of studies specifically linking the PBL model to earthquake disaster mitigation and its impact on students' critical thinking skills, particularly in the educational context of disaster-prone areas like Palu. The novelty of this research lies in its specific focus on earthquake disaster mitigation through the application of the Problem-Based Learning (PBL) model, which has not been widely explored in the educational literature. This research was conducted at MTs Alkhairaat Pusat Palu, a disaster-prone area, ensuring its results are relevant and applicable to the local community. Furthermore, this study explicitly measured the improvement in students' critical thinking skills as a result of the implementation of PBL, demonstrating a direct relationship between the learning method and the development of these skills. Using a quasi-experimental approach, this study provides robust empirical data on the effectiveness of the PBL model, which can serve as a reference for further research and educational practice in disaster-prone areas.

Therefore, this study aims to evaluate the effect of a Problem-Based Learning model focused on earthquake disaster mitigation on the critical thinking skills of eighth-grade students at MTs Alkhairaat Pusat Palu. This research is expected to provide new contributions to the development of effective learning methods to improve students' critical thinking skills in the face of natural disasters, as well as provide deeper insights into the integration of disaster mitigation into the educational curriculum.

METHODS

The research followed a quantitative framework and used a nonequivalent control group design, a quasi-experimental method. Research methods that do not randomly pick participants are known as quasi-experimental approaches with non-equivalent control group designs. These studies assess the impact of interventions or treatments (Krishnan, 2024). Participants for the study were non-randomly selected from two homogeneous classes. The study aimed to assess the impacts of applying the PBL model, integrated with mitigation of earthquake disaster issues, on the critical thinking skills of eighth-grade students at MTs Alkhairaat Pusat Palu.

The study sample comprised two groups: class VIII C PBL (experimental group) and class VIII D PBL (control group), with the latter receiving instruction through conventional teaching methods. The experimental group is the cohort that undergoes the treatment or intervention under investigation by the researcher. The control group is the cohort that does not undergo the treatment or intervention under examination. Every group comprised 30 pupils. The research was carried out from May 3 to May 8, 2025, in MTs Alkhairaat Pusat Palu, situated at Jl. Sis Aljufri No. 36, Siranindi Village, West Palu District, Palu City, Central Sulawesi.

The methods of data collection included testing, observation, and documentation. The tests aimed to assess the critical thinking of students in both pre and post intervention phases. All test instruments underwent expert pre-validation on content and construct validity using relevant statistical methods with IBM SPSS 26.0. Observational data were applied to assess the PBL implementation with the lesson, whereas documentation supplied relevant materials in the form of photographs and student worksheets as well as the teaching materials.

The data analysis incorporated preliminary test evaluations as a baseline, in conjunction with hypothesis testing. The initial investigation was evaluating normal distribution using the Shapiro-Wilk test and assessing homogeneity through Levene's test. The paired sample t-test was utilised for within-group examination of the experimental group's pre- and post-test scores in hypothesis testing. A significance level of 5% was established as the threshold for the test ($\alpha = 0.05$). The null hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted with a p-value of less than 0.05, thereby confirming the treatment's statistical significance.

RESULTS AND DISCUSSION

Along with the data description, analysis, and discussion, I would like to present the impacts of Problem Based Learning on the critical thinking skills of VIII grade students at MTs. Alkhairaat Pusat Palu, focusing on the mitigation of earthquake disasters.

The aim of the inquiry was to evaluate the effectiveness of the problem-based learning approach focusing on earthquake disaster mitigation on the critical thinking skills of VIII grade students at MTs Alkhairaat Pusat Palu. Based on the information obtained with the pretest and posttest administered in the form of ten essay questions, we can summarize the findings as follows:

Table 1. *Pretest* and *posttest* scores of control and experimental classes

Data	Control Class		Experimental Class	
	Pretest	***Posttest***	***Pretest***	***Posttest***
Number of students	30	30	30	30
Highest Score	54	78	57	100
Lowest Score	30	60	43	80
Average	44,7	71,43	50,53	90,7

Based on the data above, the control class is a group that does not get special treatment. Descriptive results show that the average *pretest* score was 44.07, increasing to 71.43 on the *posttest.* The highest score increased from 54 to 78, while the lowest score increased from 30 to 60. This shows an increase in learning outcomes even without special treatment, this increase comes from the conventional learning process that continues to run. The experimental class received the intervention of the PBL model. Results showed an average *pretest* score of 50.53, increasing sharply to 90.70 on the *posttest*. The highest score reached 100, indicating that some learners got perfect scores. The lowest score also improved from 43 to 80, showing evenly distributed improvement even among low-performing learners.

As a whole, both the control and experimental classes showed an increase in scores from the pretest to the posttest. That said, the improvement in the experimental class was far more pronounced both descriptively in the increase in average score and the range and distribution of scores in the experimental class. The increase in learning outcomes in the experimental class was greater than the control class, both in average, minimum and maximum values. This shows that the treatment given to the experimental class was beneficial in terms of the students' critical thinking skills.

1. Normality Test

A normality test was conducted to check if the data collected from the research is normally distributed. For the normality test, the researcher applied the pretest and posttest scores from both the control and experimental groups. The researcher performed a normality test using IBM SPSS 26.0 Statistics for Windows Shapiro-Wilk Test; if the significant value is > 0.05 then the data distribution is normal. The results of the normality test performed in this study are shown in the table below.

Table 2. Normality Test

	Class	Shapiro-Wilk		
		Statistic	Df	Sig.
Results	Control Class Pretest	.932	30	.054
	Control Class Posttest	.937	30	.075
	Experiment Class Pretest	.957	30	.256
	Experiment Class Posttest	.962	30	.348

Based on the table above, the normality test conducted on the control class with pretest scores had a significance value of 0.054 > 0.05, and for posttest results, a significance value of 0.075 > 0.05. Thus, both pretest and posttest for the control class are normally distributed. The results for the experimental class also demonstrated normality with pretest and posttest values. The pretest had a significance value of 0.256 > 0.05 and the posttest had a significance value of 0.348 > 0.05. Both the pretest and posttest results for the experimental class are therefore normally distributed. Thus, it can be stated that the pretest and posttest results of both control and experimental classes are normally distributed with significance level α = 0.05.

2. Homogeneity Test

With the prior knowledge that the research samples were normally distributed from the normality test, the researchers then proceeded to conduct a homogeneity test. In this study, the homogeneity test was performed using Laven's Test which is a test of homogeneity of variance. In performing the homogeneity test using IBM SPSS 26.0, a significance level of α = 0.05 was applied. The null hypothesis of each sample being normal (homogeneous) is accepted if the significance value is greater than 0.05. The results of the homogeneity test are shown in the table below.

Table 3. Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Critical Thinking	Based on Mean	2.441	3	116	.068
	Based on Median	2.318	3	116	.079
	Based on Median and with adjusted df	2.318	3	99.963	.080
	Based on trimmed mean	2.547	3	116	.059

Based on the homogeneity test results in the table above shows the sig value. Based on Mean 0.068> 0.05, so it can be concluded that the data variance in the experimental class and control class is the same or homogeneous (normal).

3. Hypothesis Test

Hypothesis testing procedures are carried out to validate or invalidate a formulated hypothesis based on the data collected by the researcher. Both normality tests should be conducted first and passed before proceeding to hypothesis testing. In this case, a paired sample t-test was conducted. This method is used to evaluate the means of two dependent sample sets, often to determine the difference between two treatments or two measurements taken on the same individual. At a significance level of (2-tailed) <0.05, the null hypothesis is rejected and the alternative hypothesis is accepted. The outcomes from the hypothesis tests done in this study are illustrated in the accompanying table.

Table 4. Paired Sample t-Test

		Std. Deviation	t	Df	Sig. (2-tailed)
Pair I	Experiment Class Pretest - Experiment Class Posttest	20.325	26.341	59	<.001

The Pretest and Posttest score differences of the experimental class were analyzed using the Paired Samples t-Test. Based on the analysis performed, the t value was 26.341, df was 59 and significance value (Sig. 2-tailed) < 0.001. In this case, significance value is less than 0.05 (0.001 < 0.05), therefore the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted.

Thus, it is reasonable to conclude that the experimental class had a substantial change in the pretest and posttest score difference. This indicates that the educational intervention utilized in this study was applicable and that there was a substantial improvement in the students' learning outcomes.

The results indicate that the application of the Problem Based Learning (PBL) model on earthquake disaster mitigation improved the critical thinking skills of the students. This is shown by the increase in the average score of the experimental class from 50.53 (pretest) to 90.70 (posttest) with a maximum score of 100 and a minimum score of 43 posttest results of 80. In the control class, the score in conventional learning improved from 44.7 to 71.43 which is lower than the progress observed in the experimental class.

The meaningful enhancement achieved in the experimental class was verified with the paired sample t-test which recorded a significance value of < 0.001. This means that the null hypothesis (Ho) was rejected and the alternative hypothesis (Ha) was accepted. Thus, the application of disaster mitigation based PBL was proven to significantly impact the critical thinking skills of students.

The application of the PBL model is designed to facilitate the development of critical thinking skills for all learners as it is based on real problem solving and real life situations. The PBL model centered on disaster mitigation increases students‘ awareness on the importance of preparedness for earthquakes especially in the Palu region which is susceptible to such disasters. As a general rule, problem-based learning has a structure which begins by orienting the learner to a particular problem: the teacher informs the learning goals, gives relevant logistical information, and motivates the learners to engage in problem-solving activities that are meaningful to them. The second step, guiding learners in self-directed problem solving, is to help students define and structure learning goals aligned to the problem. The third step, fostering independent and group investigations, involves guiding learners to collect relevant information, conduct actual inquiry or think of possible explanations and solutions. The fourth step in the learning sequence is to develop, present and exhibit work which includes assisting learners in the formulation and preparation of learner reports. The last step is to analyse and reflect as well as evaluate the problem-solving processes and principles, guiding learners to self-assess the outcomes and processes they have undergone.

The development of critical thinking is of profound importance for students, especially during the problem-solving process. The capability of thinking critically enables students to generate ideas and devise innovations that address diverse issues or problems. Critical thinking is defined as the ability to analyse in an objective and rational manner. Critical thinking forms an integral part of every learner’s skill set and captures the ability to analyse, evaluate and reflect upon the information received. This skill can be trained by problem-based learning models that promote orderly and systematic thinking.

The tests for normality and homogeneity conducted on the data also confirmed normal and homogeneous distributions, reinforcing the validity of the findings from inferential analysis. Alongside improving cognitive skills, the PBL model equips students with an understanding and preparedness for disasters, making it contextually relevant. These findings, combined with the context of disaster education, contribute to the perspective that PBL models enhance learners’ critical thinking skills and overall educational performance. Addressing local and environmental concerns through disaster education integrates learning with the strategic demands of responsive education.

This research aligns with the research of Suhirman & Khotimah (2020) which states that the application of the Problem-Based Learning (PBL) model can improve students' critical thinking skills in the context of science learning. Furthermore, this research also supports the findings of Pu et al., (2019) who showed that PBL is effective in improving students' understanding, although it did not specifically measure critical thinking skills. However, unlike the research of Mulianingsih et al., (2025) which focused more on increasing students' awareness of disaster mitigation without directly linking it to critical thinking skills, this study emphasizes the importance of disaster preparedness as a result of the implementation of PBL. Furthermore, this study used a paired sample t-test to verify significant improvements, with a significance value <0.001, which provides strong empirical data, in contrast to some previous studies that may not report inferential analysis in the same detail. Thus, this study provides a new contribution by focusing on earthquake disaster mitigation and demonstrating a significant improvement in critical thinking skills through the implementation of the PBL model.

CONCLUSION

The findings of this study allow us to formally conclude that the implementation of the Problem-Based Learning (PBL) model focused on earthquake disaster mitigation substantially improved the critical thinking skills of eighth-grade students at MTs Alkhairaat Pusat Palu. This significant improvement was evident in the higher average posttest scores compared to the pretest in the experimental class, while the control class showed a smaller increase. The results of the paired-sample t-test yielded a significance value <0.001, indicating a highly significant change in student learning outcomes before and after the implementation of the PBL model. Thus, the implementation of the PBL model not only helps students achieve learning competencies but also motivates them to solve contextual, situational problems. This fosters critical thinking and problem-solving skills related to disaster preparedness, particularly earthquakes. This research makes an important contribution to the development of relevant and effective learning methods in the context of disaster education.

For future research, it is recommended that researchers explore the application of the PBL model in other disaster mitigation contexts, such as floods or forest fires, to see if similar results can be achieved. Furthermore, further research could include other variables, such as student motivation and engagement, to gain a more comprehensive understanding of the factors influencing the improvement of critical thinking skills. Longitudinal research could also be conducted to assess the long-term impact of implementing the PBL model on students' critical thinking skills.

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