

GUIDED INQUIRY-BASED EARTHQUAKE MEDIA: ENHANCING SCIENCE LITERACY AND CRITICAL THINKING IN POST-LIQUEFACTION SCHOOLS

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ABSTRACT

This study aims to analyze the effect of guided inquiry-based earthquake media on the scientific literacy and critical thinking skills of elementary school students in the Petobo liquefaction-affected area, Palu City. The low scientific literacy and disaster preparedness of students after the 2018 earthquake became the basis of this study. The method used was a quasi-experimental with a Non-Equivalent Control Group design, involving 53 sixth grade students. The experimental group implemented guided inquiry learning through the creation of a simple seismograph, while the control group used conventional learning. The results showed an increase in scientific literacy and critical thinking in the experimental group was higher than the control group, with a significant difference based on statistical tests and learning effectiveness that was classified as moderate to high. It was concluded that guided inquiry-based earthquake media was more effective in improving scientific literacy and critical thinking skills of students in disaster-affected areas.

Keywords: *Earthquake Media, Guided Inquiry, Science Literacy, Critical Thinking, Liquefaction*

A. Introduction

Indonesia is a country located at the confluence of three active tectonic plates, making it one of the countries with the highest levels of seismic activity in the world (Irsyam et al., 2017). This geological condition makes earthquakes a real and recurring threat, including the 2018 Palu earthquake that triggered a devastating liquefaction phenomenon in Petobo Village and destroyed hundreds of buildings and school infrastructure in the area (Oktari et al.,

2020). This event not only left physical damage but also psychological trauma that impacted the learning process and quality of students at five elementary schools in the Petobo area.

A fundamental problem faced by schools in disaster-affected areas is students' low scientific literacy and disaster preparedness. Based on data from the Ministry of Education, Culture, Research, and Technology's Education Report (2024), elementary school students' literacy skills in the

Petobo area are still in the poor to moderate category. This condition is exacerbated by the findings of Handayani et al. (2020), which show that students in disaster-affected areas have lower levels of scientific literacy than students in non-disaster areas, particularly in understanding geological concepts and disaster mitigation. Yet, scientific literacy is an essential skill that enables individuals to understand natural phenomena, evaluate scientific evidence, and make appropriate decisions in emergency situations (Holbrook & Rannikmae, 2019). Similarly, critical thinking skills, defined by Ennis (2011) as the ability to analyze information logically and make reasoned decisions, are essential for students living in disaster-prone areas.

Various theoretical studies have shown that guided inquiry-based learning has been proven effective in improving students' scientific literacy and critical thinking skills. The guided inquiry model is rooted in Piaget's and Vygotsky's constructivist theories, as well as Bruner's discovery learning theory, which emphasizes that the most meaningful knowledge is built through direct experience, independent inquiry, and active

reflection (Bruner, 2009). In this approach, students are positioned as active subjects who formulate questions, design investigations, collect and analyze data, and draw conclusions independently with the guidance of the teacher as a facilitator (Sanjaya, 2020). Several previous studies confirm the effectiveness of this approach; among them, Rokhayati (2022) found that scientific inquiry effectively improves elementary school students' scientific literacy, while Dhamayanti (2022) proved that inquiry strategies have a significant impact on critical thinking skills.

The main problem in this research is the lack of contextual, inquiry-based science learning media that are appropriate to the local experiences of students in the Petobo liquefaction-affected areas. Conventional learning, currently implemented, is deemed incapable of building a deep understanding of disaster phenomena and developing students' scientific thinking skills. This situation demands learning innovations that are not only scientifically relevant but also contextual to the students'

environment and disaster experiences.

To address these issues, this study developed and piloted a guided inquiry-based earthquake learning medium, which involved constructing a simple seismograph from recycled materials. This approach was designed to provide an authentic, contextual, and meaningful learning experience for students in disaster-affected areas. Through the seismograph creation process, students were directly involved in the scientific stages, from problem orientation and hypothesis formulation to instrument design and testing, data analysis, and conclusion drawing, all of which ultimately improved scientific literacy and critical thinking skills.

To the author's knowledge, there has been no research that specifically integrates three elements at once: (1) a guided inquiry approach, (2) the creation of simple seismograph media by students, and (3) the local context of liquefaction-affected areas as a basis for science learning in elementary schools. The novelty of this research lies in the use of real disaster experiences experienced by students as pedagogical capital to build scientific literacy and critical

thinking in a contextual and meaningful manner.

Based on the description, this study aims to analyze the influence of guided inquiry-based earthquake media on scientific literacy and critical thinking skills of sixth grade elementary school students in the Petobo liquefaction-affected area, Palu City, while also comparing its effectiveness with conventional learning.

B. Method

This study uses a quantitative approach with a quasi-experimental design of the *Non-Equivalent Control Group type*, involving two groups of students without random assignment. The study was conducted in five elementary schools in the Petobo Subdistrict area, Palu City-namely Petobo 1 Elementary School, Petobo 2 Elementary School, Petobo Inpres Elementary School, Al-Akbar Petobo Islamic Elementary School, and Iqra Petobo Islamic Elementary School-which are areas affected by liquefaction after the 2018 earthquake. The data source came from 53 sixth-grade students divided into an experimental group (32 students) and a control group (21 students). The

experimental group implemented guided inquiry learning through the creation of a simple seismograph from recycled materials, while the control group used conventional learning.

Data were collected through a multiple-choice and descriptive science literacy test that measured three main dimensions of the PISA framework: explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting scientific data and evidence. Furthermore, critical thinking skills data were collected through a descriptive test that referred to the six Facione indicators, including interpretation, analysis, inference, evaluation, explanation, and self-regulation. Data collection was conducted twice, before and after the treatment in both groups. The research instrument was validated by two expert validators and assessed by three practicing teachers, with the results being categorized as very valid.

Data analysis was conducted in stages. First, prerequisite tests were conducted in the form of the Kolmogorov-Smirnov normality test and Levene's homogeneity test to ensure the feasibility of using

parametric statistics. Second, improvements in learning outcomes were analyzed using normalized gain scores to measure the magnitude of improvement in each group. Third, differences in improvement between the experimental and control groups were tested using an *Independent Samples t-test* with a significance level of 0.05. Fourth, learning effectiveness was calculated using effect sizes to determine the extent of influence the treatment provided had on students' scientific literacy and critical thinking skills.

C. Result and Discussion

Result

This study involved 53 sixth-grade students from five elementary schools in the Petobo liquefaction-affected area of Palu City, divided into an experimental group (32 students) and a control group (21 students). Prior to treatment, all research instruments underwent expert validation, with the categories highly valid (89%–95%), and limited trials yielded practical and fairly practical categories. A summary of the instrument validation data is presented in Table 1.

Table 1. Summary of Research Instrument Validation Results

Instrument	Validator 1 (%)	Validator 2 (%)	Average (%)	Category
Scientific Literacy & Critical Thinking	89	92	90.5	Very Valid
Teaching Module	92	92	92	Very Valid
Questionnaire	95	90	92.5	Very Valid
Observation Sheet	87.5	90	88.75	Very Valid

Improvement in scientific literacy was measured using the Normalized Gain (N-Gain) value. Before treatment, the average pretest score for the experimental group was 40.84 and the control group was 40.38, indicating that both groups were at equal initial levels. After treatment, the experimental group achieved an N-Gain score of 0.71 (high category), while the control group achieved 0.55 (moderate category). On average, the experimental group achieved a posttest score of 83.00 compared to 72.28 for the control group. These differences are presented in Table 2.

Table 2. N-Gain Value of Science Literacy

Group	N-Gain Value	Category
Experiment	0.71	Tall
Control	0.55	Currently

Prerequisite testing showed that the data of both groups were normally distributed based on the Kolmogorov-Smirnov test (experimental significance = 0.319 and control = 0.196) and homogeneous based on the Levene test (significance 0.140), thus fulfilling the requirements of the

parametric test. The results of the hypothesis testing using the Independent Samples t-test produced a significance value of 0.001, which is smaller than the significance level of 0.05. Thus, there is a significant difference between the scientific literacy of the experimental group and the control group (Table 3).

Table 3. Results of the Scientific Literacy Statistical Test

Description	Exp.	Control	Homogeneity	Hypothesis Testing
Number of Samples	32	21	-	-
Pretest Average	40.84	40.38	-	-
Posttest Average	83.00	72.28	-	-
Normality Test (Sig.)	0.319	0.196	-	-
Homogeneity Test (Sig.)	-	-	0.140	-
Hypothesis Test (Sig.)	-	-	-	0.001

The results of the N-Gain analysis of critical thinking skills

showed that the experimental group obtained a score of 0.56 (medium

category), while the control group obtained a score of 0.31 (low category). Before treatment, the average pretest score of the experimental group was 56.81 and the control group was 56.38, indicating initial equality between the two groups. After treatment, the average posttest score of the experimental group reached 81.00, higher than the control group's score of 70.29. Table 4 presents a comparison of the improvement in critical thinking skills between the two groups.

Table 4. N-Gain Values of Critical Thinking Skills

Group	N-Gain Value	Category
Experiment	0.56	Currently
Control	0.31	Low

Table 5. Results of Statistical Test of Critical Thinking Skills

Description	Experiment	Control	Homogeneity	Hypothesis Testing
Number of Samples	32	21	-	-
Pretest Average	56.81	56.38	-	-
Posttest Average	81.00	70.29	-	-
Normality Test (Sig.)	0.454	0.109	-	-
Homogeneity Test (Sig.)	-	-	0.140	-
Hypothesis Test (Sig.)	-	-	-	0.001

The prerequisite test showed normal data distribution in both groups based on the Kolmogorov-Smirnov test (experimental significance = 0.454 and control = 0.109) and homogeneous data based on the Levene test (significance 0.140). Hypothesis testing using the Independent Samples t-test produced a significance value of 0.001 which is smaller than 0.05, so there is a significant difference between the critical thinking skills of students in the experimental group and the control group (Table 5).

To measure the practical impact of the intervention, the effect size was calculated using Cohen's d formula. The results are presented in Table 6.

Table 6. Summary of Effect Size Values of Learning Influence

Variables	Cohen's d	Category	Information
Science Literacy	0.615	Currently	Effective (above hinge point 0.40)
Critical thinking	0.477	Currently	Effective (above hinge point 0.40)

Discussion

The results of the study answered the main problem formulation that guided inquiry-based earthquake media had a significant

effect on the scientific literacy of elementary school students in the Petobo liquefaction-affected area. The experimental group's N-Gain value of 0.71 (high category) exceeded the

control group which only reached 0.55 (moderate category), with the difference being statistically confirmed through a significance value of 0.001.

This advantage can be interpreted through an inquiry-based learning mechanism that positions students as active subjects in the learning process. In the context of building a simple seismograph, students not only receive information about earthquakes but also directly engage in the process of explaining scientific phenomena, designing investigations, and interpreting their own generated vibration data—three key dimensions of scientific literacy within the PISA framework (OECD, 2022). This active engagement creates a deeper conceptual understanding than conventional, one-way learning.

These findings extend and strengthen the results of previous research. Jundu et al. (2020) demonstrated the effectiveness of inquiry in science learning in elementary schools, while Rokhayati (2022) demonstrated that the scientific inquiry approach improves the ability to identify scientific problems and design simple investigations. Haerani et al. (2020) added that the discussion

stages in inquiry learning directly strengthen students' scientific literacy. This research provides a novel contribution by integrating the local context of the Petobo liquefaction disaster as a learning setting, so that scientific literacy does not develop in an abstract space but rather grows from the students' own lived experiences.

The effect size of 0.615 supports this interpretation. According to Hattie (2009), this value exceeds the hinge point of 0.40, the minimum threshold for an intervention to be considered more effective than conventional learning. Thus, this finding is not only statistically significant but also practically pedagogically meaningful in the context of disaster education.

The research results also address the issue of the influence of inquiry on critical thinking skills. The experimental group's N-Gain value of 0.56 (medium category) significantly exceeded the control group's 0.31 (low category), with a significance value of 0.001, well below the 0.05 level.

The development of critical thinking in the experimental group can be interpreted through the inquiry mechanism that systematically

activates six core cognitive skills according to Facione (2020) : interpretation, analysis, inference, evaluation, explanation, and self-regulation. When students design a seismograph and select appropriate materials, they implicitly practice analysis and evaluation. When they interpret the resulting seismogram streak patterns, they practice inference and interpretation. This process cannot be facilitated by conventional learning that only transfers information.

These results align with Dhamayanti's (2022) findings , which concluded that inquiry-based learning significantly impacts critical thinking because it places students in problematic situations that require analytical and reflective thinking. Furthermore, in this study, the context of the Petobo liquefaction disaster created authentic motivation for students to think critically: they learned not only about earthquakes but also learned to face and understand the reality of the disaster they had experienced. This experience reconstructed static thinking patterns into systematic divergent thinking skills, as explained

in Vygotsky's (1978/1980) Zone of Proximal Development theory .

The effect size value of 0.477 is included in the moderate category based on Cohen's (1988) criteria ($d = 0.2$ small; $d = 0.5$ medium; $d = 0.8$ large) and exceeds the hinge point of 0.40 according to Hattie (2009) . This indicates that the intervention remains instructionally effective. The smaller value compared to scientific literacy is understandable because critical thinking skills are competencies that require more time and habituation to develop, so a single intervention in the short term tends to produce more moderate effects.

Overall, the findings of this study integrate into the mainstream knowledge on the effectiveness of inquiry learning. Furtak et al.'s (2012) meta-analysis of 37 experimental studies reported an average effect size of 0.50 for inquiry interventions on science understanding a figure very close to the findings of this study. Similarly, Minner et al.'s (2010) review of 138 studies confirmed that active investigation-based inquiry produced significantly greater gains in understanding than discursive inquiry.

The uniqueness of this research lies in the integration of three

elements that have not been widely combined in a single research design before: (1) a guided inquiry approach, (2) student-made learning media in the form of a simple seismograph, and (3) the local context of disaster education in post-disaster areas. Mutch and Gawith (2014) emphasized the importance of integrating disaster experiences into meaningful science learning narratives an approach that was fully implemented in this research.

These findings also shift perspectives on science learning in post-disaster areas. While previously, disaster-affected schools received more attention from the perspective of trauma recovery and physical rehabilitation, this research demonstrates that the disaster context can actually be a powerful pedagogical resource for building scientific literacy and contextual critical thinking. Simple seismographs made from recycled materials not only address the limitations of post-disaster laboratories (Susanto & Rahman, 2024) but also serve as a bridge between traumatic experiences and constructive scientific understanding, making science learning more meaningful, relevant, and having a

long-term impact on students in disaster-prone areas.

D. Conclusion

This study aims to analyze the influence of guided inquiry-based earthquake media on the scientific literacy and critical thinking skills of elementary school students in the Petobo liquefaction-affected area of Palu City. Based on the results of data analysis and hypothesis testing, the research questions were convincingly answered.

Guided inquiry-based earthquake media has been shown to significantly improve students' scientific literacy. The group implementing guided inquiry learning through the creation of a simple seismograph demonstrated a higher increase in scientific literacy compared to the group following conventional learning, with a statistically significant difference. This improvement included students' abilities to explain scientific phenomena, design and evaluate investigations, and interpret data related to earthquakes and liquefaction. The resulting effect size indicates that this intervention has a

significant influence in educational practice.

In line with these findings, guided inquiry-based earthquake media also significantly impacted students' critical thinking skills. The experimental group showed higher improvement than the control group, which only achieved low-level improvement. The process of designing, constructing, and testing a simple seismograph trained students to interpret information, analyze cause-and-effect relationships, draw inferences based on data, and reflect on their learning process independently. Therefore, it can be concluded that guided inquiry learning based on earthquake media is more effective than conventional learning in improving these two competencies in students in disaster-affected areas. These findings have important practical implications: teachers in disaster-prone schools are advised to systematically integrate the local disaster context into science learning, principals can encourage the adoption of an inquiry approach based on recycled materials as a solution to post-disaster laboratory limitations, and policymakers in disaster-affected areas need to consider developing a contextualized disaster preparedness-

based science curriculum as part of long-term educational recovery programs.

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