



Culturally-Based Renewable Energy Media to Enhance Critical Thinking in Elementary Science Learning

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ABSTRACT

This study investigates the effectiveness of renewable energy learning media, rooted in local culture, on enhancing the critical thinking skills of fifth-grade students at SD Muhammadiyah Demangan. Employing a quasi-experimental design, the research involved two groups: an experimental group that received the intervention using renewable energy-based media and a control group that followed conventional teaching methods. Data collection was conducted through pretest and posttest assessments. The findings revealed a significant improvement in the experimental group's critical thinking skills, with the average posttest score rising from 58 to 80.6 (surpassing the minimum passing criteria of 75) compared to the control group's average posttest score of 73. The results of the independent sample t-test indicated a significance value (2-tailed) of 0.018, confirming a statistically significant difference between the two groups. The study concludes that renewable energy learning media integrated with local cultural elements effectively improve students' critical thinking abilities and can be a valuable innovation in primary education.

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Introduction

An effective learning process results in quality education. The success of education can be achieved through engaging and enjoyable learning experiences [1]. Classroom learning is more likely to succeed when there is meaningful interaction between students and teachers, aimed at achieving educational objectives. A teacher is not only a transmitter of knowledge but also strategically creates an attractive, enjoyable, and engaging learning atmosphere, encouraging students to participate actively and comprehend the material with ease. Ultimately, such learning conditions contribute significantly to student achievement [2].

The 21st century is an era of rapid development in science and technology, requiring competitive talent to master diverse skills. As Indonesia faces the challenges of this century, it must maintain a balanced approach to development, with education playing a pivotal role. Learning processes can help students build the character and competencies to face 21st-century challenges. Effective learning integrates literacy, knowledge, skills, attitudes, and technological mastery [3]. In the digital era, students are expected to generate creative ideas. Conventional teaching methods often reduce students' learning interest and motivation [4]. Learning becomes more meaningful when teachers use instructional media to enhance understanding and support learning.

Instructional media refer to all tools or objects used in the teaching and learning process to convey learning information from sources (teachers or others) to learners (students) [5]. Media use is essential, as coordinating learning activities without media is increasingly complex. Media are flexible and can be used across all grade levels and learning activities. Instructional media foster greater student autonomy and accountability in learning and allow students to interpret content in ways that align with their understanding.

Technological advances in the 21st century are closely linked to energy use. Human dependence on natural energy sources for daily needs has led to environmental degradation, affecting air, climate, water, and soil [6], [7]. One of the best solutions is energy conservation and the transition to renewable energy sources. Awareness of renewable energy as an alternative to fossil fuels must be introduced early through formal education [8].

However, the advancement of technology has also facilitated the influx of foreign cultures into Indonesia. This is reflected in elementary school students' behavior, which often shows declining appreciation for local cultural values. Therefore, it is necessary to instill local cultural character in students to prevent the erosion of traditional values. Local culture refers to a community's indigenous customs and practices and serves as a defining identity of that group [9].

According to the 2022 Programme for International Student Assessment (PISA) results published by the OECD, there has been a global decline in student learning outcomes. The evaluation focused on science, reading, and mathematics competencies and revealed that the

quality of education in Indonesia remains a concern [10]. Based on the PISA findings, Indonesia must reform its education system to produce high-quality learning experiences that prepare students for the challenges of a rapidly evolving world. Critical thinking is a vital cognitive skill that helps individuals identify problems, generate solutions, and make informed decisions [11]. Hence, fostering critical thinking is essential for developing cognitive abilities and retaining information effectively [12].

In this 21st-century context, it is an opportune moment to enhance students' critical thinking skills. Many students unfamiliar with technology become disengaged when teachers continue using traditional methods. Therefore, educators must seek innovative solutions to stimulate learning and foster critical thinking. One practical approach is using instructional media during teaching and learning activities, which can boost students' learning motivation, concentration, and comprehension, ultimately improving their critical thinking skills.

Preliminary observations conducted on August 8, 2023, at SD Muhammadiyah Demangan revealed several issues. The teaching process remains teacher-centered, with students receiving large amounts of information without sufficient opportunities to engage in inquiry-based activities inside or outside the classroom. This limits students' development of critical thinking, as evident in their difficulties solving practice problems and their limited ability to conclude, offer further explanations, and build foundational skills as core indicators of critical thinking.

Learning in Grade 5 is still dominated by conventional methods centered on the teacher, with students primarily listening to lectures. Instructional media are underutilized, leading to boredom and ineffective delivery of subject matter. Moreover, science instruction in Grade 5 lacks sufficient teacher-student interaction, resulting in passive learners who struggle to analyze problems effectively.

This study is expected to contribute to school-based solutions addressing students' low levels of critical thinking. It also aims to enhance students' awareness of the importance of renewable energy and foster pride in Indonesia's rich cultural diversity. This study aims to examine the effect of renewable energy learning media based on local culture on the critical thinking skills of fifth-grade students at SD Muhammadiyah Demangan.

Methods

A. Research Design

This study employed a quasi-experimental research design with a quantitative approach, conducted at SD Muhammadiyah Demangan in July 2024. The specific design used was the Nonequivalent Control Group Design, involving two groups: experimental and control groups. Both groups were given a pretest to assess their baseline critical thinking skills. The experimental group received instruction using a culturally-based renewable energy instructional media, while

the control group underwent conventional instruction without such media. At the end of the intervention, both groups completed a posttest to determine the effect of the intervention on students' critical thinking skills.

B. Participants and Instruments

The study population comprised all fifth-grade students at SD Muhammadiyah Demangan, which comprised two intact classes. A total sampling technique was used, involving 40 students, with 20 students in the experimental group and 20 in the control group. The primary data collection instruments were:

- A critical thinking test, designed as essay questions, was administered during the pretest and posttest phases.
- Documentation techniques are used to record implementation activities and support data validation.

The independent variable in this study was the culturally-based renewable energy instructional media, while the dependent variable was students' critical thinking skills.

C. Data Analysis

The collected data were analyzed using inferential statistical methods. Before hypothesis testing, the data were subjected to normality and homogeneity tests to meet the parametric assumptions. An independent samples t-test was conducted to examine the differences between the experimental and control groups. The significance level was set at $\alpha = 0.05$.

- If $p < 0.05$, the null hypothesis (H_0), stating that instructional media has no significant effect on students' critical thinking skills, was rejected.
- Conversely, if $p \geq 0.05$, the null hypothesis was accepted, indicating no significant difference between the groups.

Results and Discussion

A. Learning Outcomes and Critical Thinking Development

Implementing the renewable energy learning media at SD Muhammadiyah Demangan yielded positive results, particularly in enhancing students' critical thinking skills. Critical thinking enables students to generate ideas and concepts, analyze deeply, and solve problems effectively. It involves distinguishing, selecting, organizing, and evaluating information and arguments.

Students' inability to think critically is often rooted in a lack of understanding of the subject matter, a tendency to memorize formulas rather than internalize concepts, and poor identification of core issues. Additionally, limited teacher capacity contributes to low active learning and student engagement levels. Evaluation results showed that students' critical thinking skills were generally weak, primarily due to limited responsiveness to challenges and

problems, low participation in classroom activities, and a lack of teacher creativity in employing varied educational tools.

Compelling and engaging learning media are crucial in transforming classroom dynamics. The renewable energy learning media significantly increased students' enthusiasm and learning outcomes. Students in the experimental group demonstrated heightened curiosity and active participation, mainly since they had never previously used such media in school.

The study involved classes: Class VA (control group) and Class VB (experimental group). While the control group received instruction without the media intervention, the experimental group experienced the use of renewable energy-based learning media.

B. Statistical Analysis Results

1. Normality Test

A normality test was conducted using the Shapiro-Wilk method via IBM SPSS Version 26 to determine whether the data followed a normal distribution. Table 1 presents the results.

Table 1. Normality Test Results

Variable	Group	Shapiro-Wilk Statistic	df	Sig.	Conclusion
Critical Thinking Skills	Pretest Experiment	0.937	20	0.214	Normal
	Posttest Experiment	0.977	20	0.889	Normal
	Pretest Control	0.954	20	0.433	Normal
	Posttest Control	0.936	20	0.202	Normal

As all significance values are greater than 0.05, it can be concluded that the data is usually distributed.

2. Homogeneity Test

The homogeneity of variance was assessed using Levene's Test in SPSS Version 26. Table 2 shows the results of the homogeneity test.

Table 2. Homogeneity Test Results

Method	Levene Statistic	df1	df2	Sig.	Conclusion
Based on Mean	0.092	1	38	0.763	Homogeneous
Based on Median	0.039	1	38	0.844	Homogeneous
Based on Median (adjusted df)	0.039	1	36.878	0.844	Homogeneous
Based on the Trimmed Mean	0.090	1	38	0.766	Homogeneous

Since the significance values exceed 0.05, the dataset is considered homogeneous.

3. Hypothesis Testing

After verifying the normality and homogeneity, an independent sample t-test was conducted to analyze the posttest results between the control and experimental groups. See Table 3 for the independent sample t-test results.

Table 3. Independent Sample t-test Results

Group Comparison	Sig. (2-tailed)	Mean Difference	Std. Error	95% CI (Lower)	95% CI (Upper)	Conclusion
Experiment vs Control	0.018	-7.600	3.073	-13.823	-1.377	Significant Difference

With a p-value of 0.018 (< 0.05), the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, confirming that the use of renewable energy learning media significantly affects students' critical thinking abilities.

C. Interpretation and Pedagogical Insights

The research began by administering pretests in both groups to measure students' baseline understanding of renewable energy. The instructional content covered topics such as types of renewable energy, its local cultural applications, and its positive and negative impacts.

In the experimental group, learning took place over two sessions. The first session involved a pretest and a lesson using the renewable energy media. Students engaged in group discussions on current energy issues and presented their findings. See Fig. 1 for the learning process in the experimental group.

**Fig. 1.** Implementation of Learning in the Experimental Group

Students were actively involved in Q&A sessions, analyzing energy problems, and connecting them to local cultural contexts. Each student then practiced using the renewable energy learning media, a tangible tool to reinforce conceptual understanding [13]. Fig. 2 shows the students practicing with renewable energy learning media.



Fig. 2. Students Practicing with Renewable Energy Learning Media

In the second session, posttests were administered. During discussions, students' critical thinking was nurtured as they had to analyze and respond to their peers' arguments, encouraging cognitive engagement. This supports Wulandari et al.'s (14) findings that integrating media in instruction boosts student interest and participation.

In contrast, the control group followed conventional methods: pretest, lecture, discussion on energy crisis threats, and posttest. See Fig. 3.



Fig. 3. Control Group Learning Process

Students in the control group appeared more passive, lacking the curiosity and inquiry-based behavior observed in the experimental group. Experimental group students demonstrated deeper exploration of content and higher motivation to engage with the media.

Before intervention, the experimental group had an average score of 58.0, with only 25% in the "good" category. After two sessions using the media, scores rose to an average of 80.6, with 40% rated "excellent" and no student scoring below 64. This illustrates a substantial improvement in critical thinking through engaging educational media [14].

Meanwhile, the control group showed less remarkable gains. Their average pretest score was 51.6, and their posttest score rose to 73. Despite some improvement, many students remained in the average performance range, suggesting that conventional teaching had a limited effect on enhancing critical thinking.

The findings align with Lesmana et al. [16], who observed that learning media challenge students to use multiple senses simultaneously, improving comprehension and focus.

Further validation was conducted using item validity and reliability analysis. The instruments used passed both validity (based on expert judgment and Pearson Product-Moment correlation) and reliability testing (Cronbach's Alpha), ensuring robust data collection. Subsequent analysis using SPSS confirmed the data met assumptions for normality and homogeneity. Final t-test analysis between posttest scores of both groups showed a significant difference ($p = 0.018$), confirming that the renewable energy learning media positively impacted critical thinking skills. This study supports the conclusion drawn by [17], which found significant improvement in students' critical thinking skills after the introduction of learning media.

Conclusion

Based on the findings and discussion, it can be concluded that the *renewable energy* learning media, which incorporates local cultural elements, significantly impacts the critical thinking skills of Grade 5 students at SD Muhammadiyah Demangan. This is evident from the posttest results in the experimental group. Prior to the intervention, the average score of students was 58 (categorized as low), with 25% of students in the "good" category and 75% in the "fair" category. After the implementation of the media, the average score increased to 80.6 (categorized as high), with 40% of students classified as "very good" and 60% as "good." The average posttest score in the experimental group (80.6) exceeded the minimum passing criteria (MPC) of 75, whereas the control group only achieved an average of 73, below the MPC. The improvement is further evident in the score distribution: in the experimental group posttest, the highest score was 100 and the lowest was 64, while in the control group (which did not receive the renewable energy media intervention), the highest score was 92 and the lowest was 56. Additionally, the hypothesis test using an independent sample t-test yielded a significance value (2-tailed) of 0.018. Since this value is less than the alpha level of 0.05, H_0 is rejected and H_1 is accepted.

Conflict of Interest

The authors declare that there is no conflict of interest.

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