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IMPLEMENTATION OF AN EXPERIMENT-BASED CONTEXTUAL TEACHING AND LEARNING (CTL) APPROACH USING SIMPLE ELECTRIC MOTOR MEDIA TO ENHANCE STUDENTS' PHYSICS LITERACY

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ABSTRACT
This study aims to analyze the improvement in students' physics literacy following the implementation of an experiment-based Contextual Teaching and Learning (CTL) approach using simple electric motor media in the topic of dynamic electricity. A quasi-experimental method with a One-Group Pretest-Posttest Design was employed, involving 26 tenth-grade students from SMA Negeri 1 Labuhanhaji. The research instrument consisted of a physics literacy test that met established validity and reliability criteria. Data analysis involved normality testing, the Wilcoxon Signed-Rank Test to assess differences between pretest and posttest scores, and Normalized Gain (N-Gain) analysis to determine the magnitude of improvement in students' physics literacy. The mean physics literacy score increased from 13.96 on the pretest to 20.77 on the posttest. The Wilcoxon test indicated a significant improvement following the intervention, while the mean N-Gain score of 0.55 was in the moderate category. Improvements were observed across all measured dimensions of physics literacy. These findings indicate that an experiment-based CTL approach using simple electric motor media has potential as an effective instructional alternative for enhancing students' physics literacy.

Keywords: Contextual teaching and learning; Experiment; Physics literacy; Dynamic electricity; Simple electric motor

1. INTRODUCTION

Physics literacy is an important competency in 21st-century learning because it encompasses the ability to understand scientific concepts, explain phenomena, interpret evidence, and apply physics principles in everyday life. Scientific literacy has long been framed as a broad and functional understanding of science that supports informed reasoning and the use of scientific knowledge in personal and social contexts (DeBoer, 2000; Fives et al., 2014; Gormally et al., 2012). The National Research Council (2012) and OECD (2019) similarly emphasize that science education should develop conceptual knowledge together with scientific practices, evidence evaluation, and the application of knowledge across contexts. Therefore, physics instruction needs to be designed to foster physics literacy through learning experiences that are contextual, meaningful, and connected to scientific practice.

The physics literacy skills of students in Indonesia remain a continuing concern. Studies in Indonesian physics education have reported that learners may show uneven achievement across scientific literacy competencies and knowledge dimensions (Pahrudin et al., 2019; Parno et al., 2020). Observations conducted at SMA Negeri 1 Labuhanhaji indicate that physics instruction is still dominated by content delivery and problem-solving exercises, leading students to rely more heavily

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on memorizing formulas than on developing deep conceptual understanding. This condition is particularly evident in *listrik dinamis* (dynamic electricity), which involves closely interconnected concepts such as voltage, electric current, and resistance. Instruction that emphasizes the derivation of mathematical equations without sufficient experimental activity can make it difficult for students to connect these concepts with electrical phenomena encountered in everyday life. As a result, students' scientific thinking skills and physics literacy may not develop optimally.

One alternative for addressing this problem is to implement the Contextual Teaching and Learning (CTL) approach through experimental activities. The CTL approach positions students as active learners who construct knowledge through experiences connected to real-life contexts (Trianto, 2011). Research on context-based science education indicates that contextual approaches can support meaningful understanding and more positive engagement with science (Bennett et al., 2007). Experimental and inquiry-oriented learning also gives students opportunities to formulate questions, make observations, conduct measurements, analyze data, and draw conclusions from evidence (Furtak et al., 2012; Minner et al., 2010; Pedaste et al., 2015). In physics education, guided physical laboratory experiences can support conceptual understanding and important inquiry practices when students receive appropriate guidance (Husnaini & Chen, 2019; Lazonder & Harmsen, 2016). In this study, experimental activities are supported by the use of *motor listrik sederhana* (a simple electric motor), which provides a concrete representation of electrical and electromagnetic relationships and allows students to engage directly with physical phenomena (Fitrian et al., 2023; Wulandari et al., 2024). The integration of CTL, experimental activity, and simple instructional media is therefore expected to create learning that is active, contextual, and meaningful.

Previous studies have reported that CTL-based physics learning can improve learning outcomes, conceptual understanding, learning engagement, and higher-order thinking skills (Desnita et al., 2022; Hanifah et al., 2023; Iskandar, 2022; Kusnadi et al., 2021; Wati et al., 2021). Other studies have shown that simple electric motor media and related experimental teaching aids can make abstract physics concepts more concrete and accessible through direct learning experiences (Fitrian et al., 2023; Guswantoro et al., 2024; Wulandari et al., 2024). More broadly, technology-enhanced and inquiry-oriented science instruction has been associated with stronger knowledge integration and conceptual learning when instructional support is provided (Lee et al., 2010). However, most of the studies directly related to CTL or simple electric motor media have focused on learning outcomes, conceptual mastery, critical thinking, or media development, while research integrating an experiment-based CTL approach using simple electric motor media to improve physics literacy in dynamic electricity remains relatively limited.

Based on this research gap, the present study offers three aspects of novelty. First, it integrates the Contextual Teaching and Learning approach with an experimental method using simple electric motor media within a single instructional design. Second, it evaluates learning effectiveness using physics literacy indicators that include identification of scientific issues or questions, conceptual understanding, contextual application, scientific reasoning, physics investigation, and evidence-based evaluation. These indicators are consistent with broader perspectives that conceptualize scientific literacy as involving knowledge, reasoning, interpretation of evidence, and the application of science in context (DeBoer, 2000; Fives et al., 2014; Gormally et al., 2012; OECD, 2019). Third, the study implements the learning approach in dynamic electricity using simple instructional media that are relatively easy to construct, offering potential for schools with limited laboratory facilities. Therefore, this study aims to analyze the improvement in students' physics literacy through the implementation of an experiment-based Contextual Teaching and Learning (CTL) approach using simple electric motor media in the topic of dynamic electricity at SMA Negeri 1 Labuhanhaji.

2. METHODS

This study used a quasi-experimental method with a One-Group Pretest-Posttest Design to analyze the improvement in students' physics literacy after the implementation of the Contextual Teaching and Learning (CTL) approach through experimental activities using simple electric motor media. The study was conducted at SMA Negeri 1 Labuhanhaji, South Aceh Regency, during the second semester of the 2025/2026 academic year. The participants were 26 tenth-grade students in Class X Madinah, selected using purposive sampling.

The research instrument was a physics literacy test consisting of 30 multiple-choice questions developed based on the indicators of physics literacy. Before being used in the main study, the instrument was administered to 27 students who were not included in the research sample to assess its validity and reliability. The results showed that 26 items met the validity criteria and had a high reliability coefficient. Therefore, the 26 valid items were used as the research instrument.

Data collection was conducted in three stages: pretest, treatment, and posttest. The pretest was administered to measure students' initial physics literacy skills before the intervention. The students then participated in learning activities using the CTL approach through experimental activities supported by simple electric motor media on the topic of dynamic electricity. After the treatment was completed, the students were given a posttest using the same instrument to measure their physics literacy after the intervention.

The data were analyzed using Microsoft Excel. A normality test was conducted using the Liliefors test, a modification of the Kolmogorov-Smirnov test, to determine the distribution of the research data. Hypothesis testing was conducted using the one-tailed Wilcoxon Signed-Rank Test, while the magnitude of improvement in students' physics literacy was analyzed using the Normalized Gain (N-Gain). The N-Gain results were interpreted using low, moderate, and high categories.

3. RESULTS

Descriptive Statistics of Students' Physics Literacy Pretest and Posttest Scores

The results were first presented using descriptive statistics to provide an overview of students' physics literacy skills before and after the implementation of the Contextual Teaching and Learning (CTL) approach through experimental activities using simple electric motor media. The descriptive statistics included the minimum score, maximum score, mean, median, and standard deviation, as presented in Table 1.

Table 1. Descriptive Statistics of Students' Physics Literacy Pretest and Posttest Scores

Descriptive Statistic	Pretest	Posttest
Minimum score	9	15
Maximum score	17	26
Mean	13.96	20.77
Median	14	21
Standard deviation	2.29	2.72

Table 1 shows a clear difference between students' physics literacy scores before and after the intervention. The mean score increased from 13.96 on the pretest to 20.77 on the posttest. The minimum score increased from 9 to 15, while the maximum score increased from 17 to 26. The median also increased from 14 to 21, with standard deviations of 2.29 for the pretest and 2.72 for the posttest. A normality test was subsequently conducted to determine the appropriate hypothesis test.

Normality Test of Pretest and Posttest Data

After the descriptive statistics were obtained, a normality test was conducted as a prerequisite for determining the appropriate hypothesis test. The Liliefors test was applied to both the pretest and posttest data. The results are presented in Table 2.

Table 2. Normality Test of Pretest and Posttest Data

Data	L calculated	L table	Interpretation
Pretest	0.122	0.174	Normal
Posttest	0.226	0.174	Not normal

As shown in Table 2, the pretest data had a calculated L value of 0.122, which was lower than the table value of 0.174. Therefore, the pretest data were normally distributed. In contrast, the posttest data had a calculated L value of 0.226, which was higher than the table value of 0.174, indicating that the posttest data were not normally distributed. Therefore, hypothesis testing was continued using the nonparametric Wilcoxon Signed-Rank Test.

Wilcoxon Signed-Rank Test

Because the posttest data were not normally distributed, hypothesis testing was conducted using the nonparametric Wilcoxon Signed-Rank Test (one-tailed). This test was used to determine whether a significant difference existed between students' pretest and posttest physics literacy scores following the implementation of the CTL approach through experimental activities using simple electric motor media. The results are presented in Table 3.

Table 3. Wilcoxon Signed-Rank Test

Test Statistic	Value
Sample size	26
Positive rank (T+)	349.5
Negative rank (T-)	1.5
T calculated	1.5
T table	98
Decision	H0 rejected; Ha accepted

The Wilcoxon Signed-Rank Test results show that the positive rank (T+) was 349.5, whereas the negative rank (T-) was 1.5. The calculated T value was 1.5, while the table value was 98. Because the calculated T value was lower than the table value, H0 was rejected and Ha was accepted. These results indicate a significant difference between the pretest and posttest physics literacy scores. The magnitude of improvement was then analyzed using the Normalized Gain (N-Gain).

Normalized Gain (N-Gain) Analysis

After a significant difference between the pretest and posttest scores was identified through the Wilcoxon test, a Normalized Gain (N-Gain) analysis was conducted to determine the magnitude of improvement in students' physics literacy following the intervention. The N-Gain analysis results are presented in Table 4.

Table 4. Normalized Gain (N-Gain) Analysis

Parameter	Value	Category
Mean N-Gain	0.55	Moderate
Effectiveness percentage	55%	Fairly effective

The N-Gain analysis showed that the mean N-Gain score for students' physics literacy was 0.55, which falls within the moderate category. The learning effectiveness percentage was 55%, placing it in the fairly effective category.

Physics Literacy Analysis by Indicator

In addition to the overall analysis, physics literacy improvement was analyzed for each indicator to provide a more detailed description of students' performance following the implementation of the CTL approach through experimental activities using simple electric motor media.

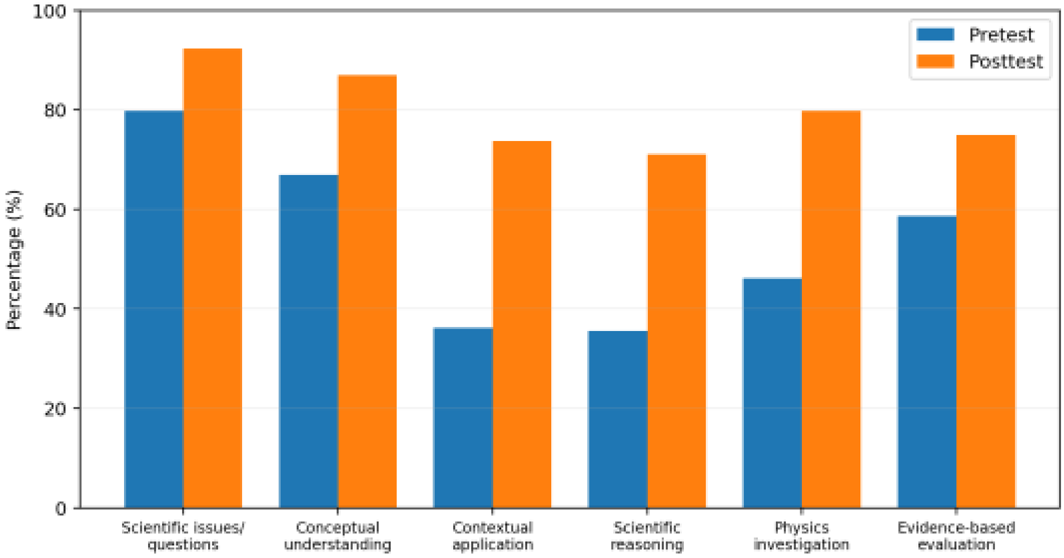

Figure 1. Comparison of Pretest and Posttest Percentages Across Physics Literacy Dimensions

Figure 1 shows that all physics literacy dimensions improved following the intervention. The identification of scientific issues or questions increased from 79.81% on the pretest to 92.31% on the posttest. Conceptual understanding increased from 66.92% to 86.92%, contextual application from 36.15% to 73.85%, scientific reasoning from 35.58% to 71.15%, physics investigation from 46.15% to 79.81%, and evidence-based evaluation from 58.65% to 75.00%.

4. DISCUSSION

The results show that implementing the Contextual Teaching and Learning (CTL) approach through experimental activities using simple electric motor media improved students' physics literacy in the dynamic electricity topic. The mean physics literacy score increased from 13.96 on the pretest to 20.77 on the posttest, the Wilcoxon Signed-Rank Test indicated a significant difference, and the N-Gain value of 0.55 was in the moderate category. These findings indicate a positive change following instruction that combined contextual learning, experimental activity, and concrete instructional media. The pattern is consistent with research showing that context-based science learning can support meaningful engagement with scientific ideas (Bennett et al., 2007), while inquiry-based instruction can promote conceptual learning when students actively reason from evidence and receive appropriate guidance (Furtak et al., 2012; Lazonder & Harmsen, 2016; Minner et al., 2010).

The improvement in physics literacy can be interpreted in relation to the instructional characteristics of CTL and experimentation. In the dynamic electricity topic, students did not receive concepts solely through teacher explanations. They directly observed the operating principles of a simple electric motor through activities involving design, assembly, and testing. During the learning process, students identified problems, formulated hypotheses, conducted experiments, collected and analyzed data, and drew conclusions from their observations. These activities correspond closely to the orientation, conceptualization, investigation, conclusion, and discussion phases commonly identified in inquiry-based learning (Pedaste et al., 2015). They also reflect evidence from laboratory research showing that guided physical experimentation can support both conceptual learning and inquiry performance (Husnaini & Chen, 2019). This interpretation is consistent with CTL principles emphasizing active engagement, meaningful learning, reflection, and the application of concepts in everyday contexts (Iskandar, 2022; Khutbah, 2011; Muliani et al., 2024; Trianto, 2011; Wati et al., 2021).

Analysis by physics literacy dimension showed improvement across all six dimensions. The largest increases occurred in contextual application, scientific reasoning, and physics investigation, which had relatively low pretest scores. This pattern suggests that the intervention was especially useful for helping students apply concepts, reason from observations, and participate in investigation. Such outcomes are compatible with broader conceptions of scientific literacy that emphasize the ability to interpret evidence, evaluate scientific information, and use scientific knowledge in context (DeBoer, 2000; Fives et al., 2014; Gormally et al., 2012; National Research Council, 2012; OECD, 2019). Indonesian studies have also reported that scientific literacy in physics varies across competency domains and can improve when learning provides structured opportunities to solve problems, apply concepts, and work with evidence (Pahrudin et al., 2019; Parno et al., 2020).

The findings also strengthen previous research concerning CTL and experimentally supported physics learning. Desnita et al. (2022), Hanifah et al. (2023), Iskandar (2022), Kusnadi et al. (2021), and Wati et al. (2021) reported positive outcomes from contextual or CTL-oriented learning for learning outcomes, conceptual understanding, critical thinking, or student engagement. Fitrian et al. (2023), Wulandari et al. (2024), and Guswantoro et al. (2024) further illustrate the educational feasibility of simple electric motor or related electromagnetic teaching aids. At a broader level, technology-enhanced inquiry science units have been shown to support knowledge integration (Lee et al., 2010), while studies of inquiry practices caution that the quality of guidance and the way inquiry is structured are important for learning outcomes (Furtak et al., 2012; Gee & Wong, 2012; Lazonder & Harmsen, 2016). The present study therefore contributes evidence from a local school context in which contextualization, direct experimentation, and simple physical media were combined to target multiple dimensions of physics literacy.

Although the improvement in physics literacy was in the moderate category, the findings should be interpreted within the limits of the research design. The study used a One-Group Pretest-Posttest Design without a control group, so the observed improvement cannot be attributed exclusively to the intervention with the same level of confidence as a randomized or controlled comparison. In addition, the study involved only one class at a single school, which limits generalizability. Future research should employ a control or comparison group, involve larger and more diverse samples, and report effect sizes and inferential statistics that allow stronger comparisons across instructional approaches. Such designs would help determine more precisely which elements of CTL, experimentation, and simple electric motor media contribute most strongly to physics literacy.

5. CONCLUSION

The implementation of the Contextual Teaching and Learning (CTL) approach through experimental activities using simple electric motor media improved students' physics literacy in the dynamic electricity topic. The mean score increased from 13.96 on the pretest to 20.77 on the posttest, with an N-Gain value of 0.55 in the moderate category. All measured physics literacy dimensions, including identification of scientific issues or questions, conceptual understanding, contextual application, scientific reasoning, physics investigation, and evidence-based evaluation, showed improvement after the intervention.

These findings indicate that integrating CTL with experimental activities using simple electric motor media is a potentially effective instructional alternative for developing students' physics literacy through contextual, active, and inquiry-oriented learning experiences. Because the study used a single-group design and a limited sample, further controlled studies are needed to confirm the magnitude and generalizability of the effect.

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