



The Effect of Electrical Circuit Teaching Aids on Elementary Students' Scientific Literacy

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Abstract: Scientific literacy is important for helping elementary students understand and explain scientific phenomena. This study aimed to examine the improvement in fifth-grade students' ability to explain scientific phenomena after learning electricity through electrical circuit teaching aids. A quantitative approach with a pre-experimental one-group pretest-posttest design was employed. The participants were 20 fifth-grade students at SDN 01 Trans Bangsa Negara during the 2024/2025 academic year. Data were collected using a science literacy test focused on the ability to explain scientific phenomena and analyzed using descriptive statistics and a paired-samples t-test. The mean score increased from 36.80 on the pretest to 79.50 on the posttest. The paired-samples t-test indicated a significant difference, $t(19) = 17.778$, $p < .001$, with a large effect size (Cohen's $d_z = 3.98$). These findings indicate an improvement following the intervention, although the one-group design does not establish a causal effect. Electrical circuit teaching aids may support active learning of electricity concepts.

Abstrak: Literasi sains penting untuk membantu siswa sekolah dasar memahami dan menjelaskan fenomena sains dalam konteks kehidupan sehari-hari. Penelitian ini bertujuan untuk mengetahui peningkatan kemampuan siswa kelas V dalam menjelaskan fenomena ilmiah setelah pembelajaran materi listrik menggunakan alat peraga rangkaian listrik. Penelitian menggunakan pendekatan kuantitatif dengan desain pre-eksperimen one-group pretest-posttest. Peserta penelitian berjumlah 20 siswa kelas V SDN 01 Trans Bangsa Negara pada tahun ajaran 2024/2025. Data dikumpulkan melalui tes literasi sains yang berfokus pada kemampuan menjelaskan fenomena ilmiah dan dianalisis menggunakan statistik deskriptif serta paired-samples t-test. Rata-rata skor meningkat dari 36,80 pada pretest menjadi 79,50 pada posttest. Hasil paired-samples t-test menunjukkan perbedaan yang signifikan secara statistik, $t(19) = 17,778$, $p < 0,001$, dengan effect size besar (Cohen's $d_z = 3,98$). Temuan ini menunjukkan adanya peningkatan setelah intervensi, meskipun desain satu kelompok belum dapat memastikan hubungan kausal. Alat peraga rangkaian listrik dapat mendukung pembelajaran konsep listrik secara konkret dan aktif.

A. Introduction

Scientific literacy is an essential component of science education because it enables students to use scientific knowledge to understand phenomena, interpret evidence, and provide scientifically grounded explanations of events in everyday life. At the elementary level, developing scientific literacy is particularly important because students begin to establish conceptual foundations and ways of thinking that influence their subsequent learning of science. Within the Programme for International Student Assessment (PISA) framework, one important competency is the ability to explain phenomena scientifically, which involves applying appropriate scientific knowledge to describe and interpret phenomena. The development of this competency therefore requires learning experiences that enable students to connect scientific concepts with observable phenomena rather than merely memorize factual information (OECD, 2023). Recent reviews of elementary science education have also emphasized the importance of contextual and meaningful learning experiences in supporting the development of scientific literacy (Habsari et al., 2026; Putri et al., 2026). In addition, research on problem-based and student-centered approaches suggests that active engagement with scientific problems can provide opportunities for students to apply scientific knowledge in meaningful contexts (Utami et al., 2026).

In elementary science classrooms, however, students may experience difficulties when learning concepts that are not directly observable. Electricity is one example because concepts such as electric current, circuit continuity, and the relationships among circuit components cannot always be understood through verbal explanations or textbook representations alone. The problem becomes more pronounced when science instruction relies predominantly on teacher explanations and textbook-based activities, providing students with limited opportunities to observe and manipulate scientific phenomena directly. In such circumstances, students may be able to recall definitions but experience difficulty using scientific knowledge to explain why a particular phenomenon occurs. This distinction is important because explaining scientific phenomena requires students to connect conceptual knowledge with observable evidence and relationships among variables. Research on physics education has also shown that learners may experience difficulties in developing conceptual understanding when scientific ideas are represented primarily through abstract forms, highlighting the importance of appropriate representations and learning experiences (Banda & Nzabahimana, 2021; Munfaridah et al., 2021).

The use of concrete learning experiences is consistent with constructivist perspectives on learning. Piaget's theory of cognitive development suggests that elementary-aged children develop understanding through interactions with concrete objects and observable situations. For science learning, this implies that abstract concepts can be more accessible when students are provided with opportunities to directly observe, manipulate, and investigate relevant phenomena (Hayat et al., 2024). Hands-on and experiential learning can facilitate this process by positioning students as active participants in constructing knowledge rather than passive recipients of information. Previous research

has reported that hands-on activities can support the development of science process skills among elementary students, while experiential learning has also been associated with improved academic outcomes in science-related contexts (Purnomo et al., 2021; Ranken et al., 2025). Similarly, the use of models, interactive media, and concrete representations has been reported to facilitate students' understanding of scientific concepts (Teplá et al., 2022). Recent studies on instructional media and STEM-oriented learning also indicate the potential of active and media-supported learning experiences to engage students in science learning and develop science-related skills, although these studies have examined different topics and educational levels (Azzahra et al., 2026; Juwariyah & Aprima, 2025).

Electrical circuit teaching aids provide a particularly relevant context for implementing such an approach. A simple circuit consisting of batteries, wires, switches, and lamps allows students to manipulate physical components and observe changes resulting from different circuit configurations. Rather than receiving an explanation of electricity solely through verbal instruction, students can directly observe whether a lamp illuminates, identify relationships among circuit components, and connect these observations with scientific concepts. Research on students engaged in electronic circuit wiring has demonstrated the learning value of direct engagement with circuit components, although the context of that study involved undergraduate students (Alessandrini, 2023). Similarly, previous research on electric-circuit learning has demonstrated the value of tangible and interactive approaches for supporting students' understanding of circuit concepts (Tselegkaridis et al., 2024). Other studies have also indicated that concrete and hands-on learning environments can support students' engagement and the development of science-related skills (Purnomo et al., 2021). These findings suggest that physical teaching aids may provide an appropriate instructional bridge between abstract electrical concepts and students' observable experiences.

Recent literature further demonstrates that science education research increasingly emphasizes active, contextual, and student-centered learning. Astari et al (2025), for example, reviewed the implications of socio-scientific issues approaches for students' creative thinking in science learning, highlighting the broader movement toward learning environments that require students to actively engage with scientific issues. Similarly, Utami et al (2026) examined problem-based learning integrated with local wisdom in relation to scientific literacy, while Putri et al (2026) reviewed the implementation of Education for Sustainable Development in elementary school science learning. Although these studies address different pedagogical approaches and learning contexts, together they indicate growing attention to instructional designs that move beyond passive knowledge transmission and provide opportunities for students to engage actively with scientific concepts. However, such approaches do not necessarily address the specific competency of explaining scientific phenomena through direct interaction with concrete electrical phenomena.

Despite these developments, an important research gap remains. Existing studies have predominantly examined general learning outcomes, conceptual understanding,

motivation, creative thinking, or broader science process skills. For example, research on electric-circuit learning has frequently emphasized conceptual knowledge and understanding (Alessandrini, 2023; Banda & Nzabahimana, 2021; Tselegkaridis et al., 2024), while other studies have focused on general science process skills, motivation, or broader scientific literacy outcomes (Azzahra et al., 2026; Purnomo et al., 2021; Utami et al., 2026). Less attention has been given to the specific competency of explaining scientific phenomena within elementary science learning, particularly in the context of electricity. Moreover, studies that investigate concrete electrical circuit teaching aids often focus on whether students can understand circuit concepts rather than examining their ability to use scientific knowledge to explain observed phenomena. This distinction is important because improved conceptual understanding does not necessarily indicate that students can formulate scientifically appropriate explanations. Therefore, further empirical investigation is needed to examine whether hands-on interaction with electrical circuit teaching aids is associated with improvement in this specific scientific literacy competency.

The present study addresses this gap by focusing specifically on elementary students' ability to explain scientific phenomena during electricity learning. Unlike studies that evaluate teaching aids primarily through general achievement scores, conceptual understanding, or broader science process skills, this study uses an assessment designed to target the explaining scientific phenomena competency. The intervention places students in direct contact with electrical circuit components, allowing them to observe and manipulate concrete representations of electrical phenomena during learning. In this way, the study examines whether a concrete, hands-on learning experience is accompanied by improvement in students' performance on tasks requiring them to explain scientific phenomena. The focus on this specific competency provides a more targeted perspective on the relationship between concrete science learning experiences and scientific literacy at the elementary level.

Accordingly, this study aims to examine the improvement in fifth-grade students' ability to explain scientific phenomena after learning electricity using electrical circuit teaching aids. The research question is: Does students' ability to explain scientific phenomena improve after learning electricity through the use of electrical circuit teaching aids? Based on the theoretical rationale and previous empirical findings, the study hypothesizes that students' scores on tasks assessing their ability to explain scientific phenomena will be higher after the intervention than before it. The findings are expected to contribute empirical evidence concerning the use of concrete teaching aids for supporting specific scientific literacy competencies in elementary science education.

B. Method

This study employed a quantitative approach with a pre-experimental one-group pretest-posttest design. A quantitative approach was selected to examine measurable changes in students' performance before and after the intervention, while the one-group pretest-posttest design was used to compare students' scores obtained at two measurement

points (Bierer et al., 2025). The study was conducted at SDN 01 Trans Bangsa Negara, Ogan Komering Ulu Timur, Indonesia, during the even semester of the 2024/2025 academic year. The participants were 20 fifth-grade students. Total sampling was employed because all students in the selected class participated in the study, representing the entire accessible population of the class.

The dependent variable was students' ability to explain scientific phenomena as a specific competency within scientific literacy, whereas the independent variable was the use of electrical circuit teaching aids during science learning. The primary instrument was a science literacy test consisting of multiple-choice and essay items designed to assess students' ability to explain scientific phenomena related to electricity. The development of the instrument involved content review and empirical testing to ensure that the items were relevant to the competency being assessed (Coppi et al., 2023). Before implementation, the instrument was reviewed by science education experts and empirically tested using Pearson's product-moment correlation to examine item validity. Its internal consistency was assessed using Cronbach's alpha.

The research procedure consisted of a pretest, intervention, and posttest. First, students completed the pretest to measure their initial ability to explain scientific phenomena related to electricity. Second, students participated in two learning sessions, with each session lasting 2×35 minutes. During the intervention, the teacher introduced basic electricity concepts, after which students worked in groups to assemble and manipulate simple electrical circuits using batteries, wires, switches, and lamps. The electrical circuit teaching aids functioned as concrete instructional media that enabled students to interact directly with the learning content and observe the consequences of different circuit configurations (Teplá et al., 2022). Students subsequently connected their observations with relevant scientific concepts. After the intervention, students completed the posttest to measure changes in their performance.

The pretest and posttest scores were analyzed using descriptive and inferential statistics. Descriptive analysis included the mean, standard deviation, minimum, and maximum scores. Because the same students completed both assessments, a paired-samples *t*-test was used to examine whether the difference between the pretest and posttest scores was statistically significant, with the significance level set at $\alpha = .05$. Before conducting the paired-samples *t*-test, the normality of the difference scores between the posttest and pretest was assessed using the Shapiro-Wilk test. The magnitude of the observed change was examined using Cohen's *d* for paired samples, calculated by dividing the mean difference by the standard deviation of the difference scores. All statistical analyses were conducted using IBM SPSS Statistics version 26. Ethical procedures included obtaining permission from the school and maintaining the confidentiality of students' identities and research data. The complete sequence of the research activities, from the preliminary study and instrument preparation to the pretest, intervention, posttest, data analysis, and conclusion, is presented in Figure 1.

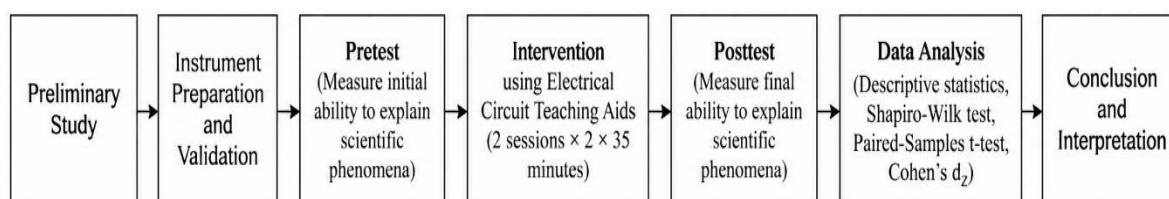


Figure 1. Research Procedure

C. Result

The results of the study are presented based on four statistical analyses: descriptive statistics, the Shapiro-Wilk normality test, the paired-samples *t*-test, and Cohen's *d_z* effect size. These analyses were conducted to examine changes in fifth-grade students' ability to explain scientific phenomena before and after learning electricity using electrical circuit teaching aids.

Descriptive Statistics

The descriptive statistics showed a clear increase in students' scores from the pretest to the posttest. As presented in Table 1, the mean pretest score was 36.80 (SD = 6.93), with scores ranging from 25 to 45. The posttest mean increased to 79.50 (SD = 8.28), with scores ranging from 70 to 90. Thus, the mean score increased by 42.70 points following the intervention. Regarding the minimum mastery criterion (Kriteria Ketuntasan Minimal, KKM) of 75, none of the students achieved the criterion in the pretest, whereas 12 of the 20 students (60%) achieved a score of at least 75 in the posttest.

Table 1. Descriptive Statistics of Pretest and Posttest Scores

Statistic	Pretest	Posttest
N	20	20
Mean	36.80	79.50
Standard Deviation	6.93	8.28
Minimum	25	70
Maximum	45	90
Students achieving the minimum mastery criterion (≥ 75)	0 (0%)	12 (60%)

The descriptive results indicate that students' performance in explaining scientific phenomena was higher after the learning intervention. Figure 2 provides a visual comparison of the mean pretest and posttest scores.

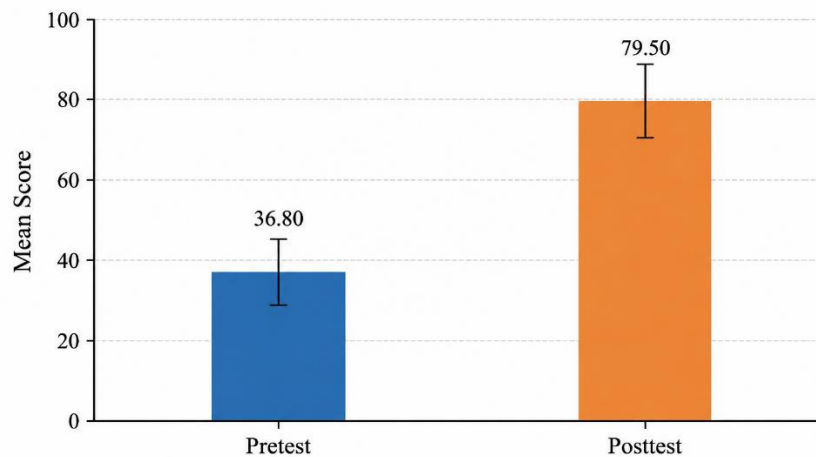


Figure 2. Comparison of Mean Pretest and Posttest Scores

Shapiro-Wilk Normality Test

Before conducting the paired-samples *t*-test, the normality of the difference scores was examined using the Shapiro-Wilk test. The analysis produced a Shapiro-Wilk statistic of $W = .950$ with $p = .366$. Because the p -value was greater than .05, the difference scores were considered normally distributed. Therefore, the normality assumption required for the paired-samples *t*-test was satisfied.

Table 2. Shapiro-Wilk Normality Test of Difference Scores

Variable	<i>W</i>	<i>df</i>	<i>p</i>
Difference scores (Posttest – Pretest)	.950	20	.366

Paired-Samples *t*-Test

A paired-samples *t*-test was subsequently conducted because the pretest and posttest scores were obtained from the same group of students. The analysis showed a statistically significant difference between the pretest and posttest scores. The mean difference was 42.70 points ($SD = 10.74$), with a 95% confidence interval ranging from 37.67 to 47.73. The test yielded $t(19) = 17.778$, $p < .001$.

These results indicate that students' posttest scores were significantly higher than their pretest scores. In relation to the research question, the findings show that students' performance on tasks assessing their ability to explain scientific phenomena increased following learning with electrical circuit teaching aids.

Table 3. Paired-Samples *t*-Test Results

Comparison	Mean Difference	SD Difference	95% CI	<i>t</i>	<i>df</i>	<i>p</i>
Posttest – Pretest	42.70	10.74	[37.67, 47.73]	17.778	19	< .001

Cohen's *dz* Effect Size

To determine the magnitude of the observed change, Cohen's *dz* was calculated using the mean difference divided by the standard deviation of the difference scores. The resulting effect size was $dz = 3.98$. This value indicates a large effect size, showing that the difference between students' pretest and posttest performance was substantial in magnitude.

Overall, the statistical findings consistently indicate an improvement in students' performance after the intervention. The mean score increased from 36.80 to 79.50, the difference scores satisfied the normality assumption, the paired-samples *t*-test showed a statistically significant difference, $t(19) = 17.778$, $p < .001$, and the effect size was large ($dz = 3.98$). These findings provide evidence of an improvement in students' ability to explain scientific phenomena following the use of electrical circuit teaching aids. Nevertheless, because the study employed a one-group pretest-posttest design without a control group, the observed improvement should be interpreted as an improvement following the intervention rather than definitive evidence of a causal effect.

D. Discussion

The findings of this study indicate a substantial improvement in fifth-grade students' ability to explain scientific phenomena after learning electricity using electrical circuit teaching aids. The mean score increased from 36.80 in the pretest to 79.50 in the posttest, representing a mean increase of 42.70 points. The paired-samples *t*-test showed a statistically significant difference between the two measurements, $t(19) = 17.778$, $p < .001$, with a large effect size (Cohen's $dz = 3.98$). These results indicate that students performed considerably better on tasks assessing their ability to explain scientific phenomena after participating in the intervention. The finding is particularly relevant because the measured competency is not simply the recall of electricity concepts, but the ability to use scientific knowledge to explain observable phenomena.

One possible explanation for this improvement is the concrete and interactive nature of the learning activities. Electricity is an abstract topic for elementary students because processes such as electric current, circuit continuity, and relationships among circuit components cannot always be directly observed. When these concepts are presented primarily through verbal explanations or textbook representations, students may memorize definitions without fully understanding the relationships between scientific concepts and observable events. In contrast, the electrical circuit teaching aids used in this study allowed students to assemble and manipulate batteries, wires, switches, and lamps. Through these activities, students could observe whether a lamp illuminated, identify changes resulting from different circuit configurations, and relate those observations to the underlying concepts of electricity. Such experiences provide opportunities for students to construct explanations based on direct observations rather than relying solely on memorized information.

This interpretation is consistent with Piaget's theory of cognitive development, particularly the importance of concrete experiences in elementary learning. Children at the elementary level benefit from interactions with concrete objects and observable situations because such experiences provide a foundation for developing more systematic conceptual understanding (Hayat et al., 2024). In the context of this study, the electrical circuit teaching aids functioned as concrete representations of otherwise abstract electrical processes. Students were able to manipulate the components and observe the consequences of their actions. This process may have helped students connect their existing knowledge with new experiences and gradually organize their understanding of electrical phenomena. Therefore, the improvement in students' scores can be understood not merely as the result of exposure to additional information, but also as a consequence of providing learning experiences that made abstract scientific concepts more observable and meaningful.

The findings can also be explained through a constructivist perspective. Constructivism views learning as an active process in which learners construct knowledge through interaction with their environment rather than simply receiving information from the teacher. During the intervention, students were actively involved in assembling circuits, manipulating components, observing outcomes, and relating their observations to scientific concepts. This learning process positioned students as active participants in constructing their understanding of electricity. Previous studies cited in the manuscript also support the relevance of concrete and interactive learning for science education. Habsari et al (2026) and Juwariyah & Aprima (2025) emphasize the importance of contextual and concrete learning experiences in supporting students' learning processes, while Teplá et al (2022) reported that models and interactive representations can facilitate students' understanding of scientific concepts. These perspectives suggest that physical teaching aids can provide an instructional bridge between abstract scientific knowledge and students' direct experiences.

The findings are further related to experiential learning theory. Experiential learning emphasizes the role of direct experience, reflection, and the connection between experience and conceptual understanding (Rahmi, 2024). The intervention in this study provided students with direct experiences of constructing and testing simple electrical circuits. Students could observe the consequences of connecting or changing circuit components and subsequently relate those observations to scientific explanations. This is important for the development of the explaining scientific phenomena competency because students need to connect scientific knowledge with evidence obtained from observable situations. Ranken et al (2025) similarly reported that experiential learning can contribute to academic achievement among children aged 4–14 years. Thus, the present findings are theoretically consistent with the view that meaningful experiences can support the development of scientific understanding.

The findings are also broadly consistent with previous research on hands-on science learning. Purnomo et al (2021) examined hands-on activity learning in elementary school science and focused on students' science process skills. Their work demonstrates the relevance of practical learning experiences for elementary science education, although their

findings should not be interpreted as evidence that hands-on learning automatically improves every learning outcome. This distinction is important because the present study focuses specifically on the ability to explain scientific phenomena rather than general science process skills. Research specifically related to electric-circuit learning also supports the relevance of tangible learning environments. Tselegkaridis et al (2024), through a meta-analysis of research on electric-circuit learning, highlighted the value of tangible and graphical user interfaces for supporting learning about electric circuits. Their review also showed that previous research has predominantly emphasized knowledge and conceptual outcomes, with comparatively less attention given to other dimensions of learning.

Other studies cited in the manuscript provide additional support for the importance of interactive learning environments. Annail et al (2025) reported the contribution of interactive learning media to students' learning motivation, while Laid & Adlaon (2025) reviewed innovative science teaching strategies, including hands-on learning, technology integration, and student-centered approaches. Munfaridah et al (2021) also discussed the importance of representations in helping learners address difficulties associated with abstract scientific concepts. Taken together, these studies provide a broader theoretical and empirical basis for interpreting the present findings: when students are given opportunities to interact with representations, tools, and scientific phenomena, they may have greater opportunities to connect conceptual knowledge with observable experiences.

Nevertheless, the contribution of the present study extends beyond demonstrating an increase in general learning scores. A key contribution is its focus on the specific scientific literacy competency of explaining scientific phenomena. The introduction of the study identifies a research gap because previous studies have often emphasized conceptual understanding, general academic achievement, motivation, or science process skills, whereas fewer studies have specifically examined students' ability to use scientific knowledge to explain observed phenomena in elementary electricity learning. This distinction is important because conceptual knowledge alone does not necessarily mean that students can formulate an appropriate scientific explanation. By targeting this specific competency, the present study provides a more focused perspective on how concrete electrical circuit learning can be related to scientific literacy development.

The findings therefore provide preliminary empirical evidence that learning electricity through electrical circuit teaching aids is accompanied by improved performance in explaining scientific phenomena. The improvement is theoretically understandable through Piaget's emphasis on concrete experience, constructivist learning through active knowledge construction, and experiential learning through direct engagement with phenomena. At the same time, the findings should be interpreted within the methodological limitations of the study. Because the research used a one-group pretest-posttest design without a control group, factors such as maturation, repeated testing, or other learning experiences cannot be completely excluded. Therefore, the results demonstrate an improvement following the intervention rather than definitive causal evidence that the teaching aids alone produced the improvement.

Overall, the findings answer the research question by showing that students' ability to explain scientific phenomena improved after learning electricity through the use of electrical circuit teaching aids. The statistically significant difference and large effect size indicate that the observed improvement was substantial. The study consequently extends existing research by connecting hands-on electrical circuit learning with a specific scientific literacy competency, rather than limiting the evaluation to general achievement or conceptual understanding. This provides a useful basis for further research using controlled or quasi-experimental designs to examine the extent to which electrical circuit teaching aids contribute to the development of scientific literacy among elementary students.

E. Implication

The findings of this study have practical and theoretical implications for elementary science education. Theoretically, the results support the application of constructivist and experiential learning perspectives by demonstrating the relevance of concrete, hands-on experiences in helping students connect abstract electricity concepts with observable scientific phenomena. Practically, electrical circuit teaching aids can provide teachers with a simple learning resource for facilitating active student engagement through assembling, manipulating, and observing electrical circuits. Such activities may help teachers provide learning experiences that encourage students not only to understand scientific concepts but also to use those concepts to explain phenomena. Therefore, the use of electrical circuit teaching aids can be considered a potentially useful instructional approach for supporting the development of the specific scientific literacy competency examined in this study, particularly in elementary electricity learning. However, the findings should be applied with consideration of the study context and design, and further research involving larger samples and control or comparison groups is needed to establish the effectiveness of this approach more robustly.

F. Limitation and Suggestion for Future Research

This study has several limitations that should be considered when interpreting the findings. First, the study involved only 20 fifth-grade students from a single elementary school, which limits the generalizability of the findings to students in other schools or educational contexts. Second, the use of a pre-experimental one-group pretest-posttest design without a control group limits the ability to attribute the observed improvement exclusively to the electrical circuit teaching aids because other factors, such as maturation, repeated testing, or learning experiences outside the intervention, may have contributed to the change (Bierer et al., 2025). Third, the assessment focused specifically on students' ability to explain scientific phenomena through a science literacy test, consisting of multiple-choice and essay items. Therefore, the findings may not fully represent other dimensions of scientific literacy or students' ability to apply their knowledge in more complex and authentic situations.

Future research should address these limitations by involving larger and more diverse samples from multiple schools and by applying quasi-experimental or true experimental designs with control or comparison groups to provide stronger evidence regarding the effectiveness of electrical circuit teaching aids. Future studies should also provide more comprehensive assessment instruments, including a clearly specified proportion of multiple-choice and essay items, scoring criteria, and tasks that require students to formulate and justify scientific explanations. In addition, researchers could incorporate open-ended questions, performance-based assessments, interviews, or practical tasks to obtain a deeper understanding of students' explaining scientific phenomena competency. Further research may also examine the retention of students' scientific understanding over a longer period and investigate whether similar concrete teaching-aid approaches can support scientific literacy in other abstract science topics.

G. Conclusion

This study concludes that fifth-grade students' ability to explain scientific phenomena improved following learning about electricity using electrical circuit teaching aids. The mean score increased from 36.80 on the pretest to 79.50 on the posttest, with a mean difference of 42.70 points. The paired-samples *t*-test showed a statistically significant difference between the pretest and posttest scores, $t(19) = 17.778$, $p < .001$, while the Cohen's *d* value of 3.98 indicated a large effect size. These findings suggest that concrete and hands-on interaction with electrical circuit components can provide meaningful learning experiences that support students in connecting scientific concepts with observable phenomena. Thus, the study provides preliminary evidence that electrical circuit teaching aids may support the development of the specific scientific literacy competency of explaining scientific phenomena in elementary science learning. However, because the study used a one-group pretest-posttest design without a control group, the findings indicate improvement following the intervention rather than definitive causal evidence that the teaching aids alone produced the observed improvement.

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