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Battery Demonstration for Household Electrical Energy Education among Indonesian Elementary Pupils

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Abstract

Purpose: This community service study examined whether a simple battery demonstration could support Indonesian elementary pupils' understanding of household electrical energy sources and energy transformation.

Research Methodology: The activity was conducted in August in Kuala Lumpur, Malaysia, with Indonesian elementary-age children. Fourteen pupils joined the learning session, while quantitative analysis used 14 complete pre-test and post-test score pairs available in the score sheet. The demonstration kit consisted of a battery, connecting wires, a light-emitting diode, a small propeller, and reused plastic bottles as the tool frame. Learning was implemented through a brief explanation, guided demonstration, hands-on practice, discussion, and a five-item test.

Results: The mean score increased from 3.286 (SD = 0.825) before the activity to 4.357 (SD = 0.929) after the activity. A paired-sample t-test showed a significant improvement, $t(13) = 4.020$, $p = 0.001$, with a large within-participant effect size (Cohen's $d_z = 1.074$).

Conclusions: The demonstration helped pupils observe that a battery can function as an electrical energy source and that electrical energy may be transformed into light and motion.

Limitations: The study was limited by the small sample, short intervention, five-item instrument, and absence of a control group.

Contributions: The article offers a low-cost, replicable model for elementary science outreach in Indonesian overseas learning communities.

Keywords: *Battery Demonstration, Electrical Energy, Elementary Pupils, Energy Literacy, Science Outreach*

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1. Introduction

Electricity is familiar to children long before it becomes a school science topic. Lamps, fans, mobile-phone chargers, toys, televisions, and other household appliances are part of daily life, but the process that allows these objects to work is not directly visible. For elementary pupils, this invisibility creates a learning challenge. Children may know that a lamp turns on when connected to electricity, yet they may still find it difficult to explain what functions as the energy source, how a complete circuit is formed, and how electrical energy changes into light or motion. Energy literacy therefore cannot be reduced to memorising terms. It needs to begin from observable experiences that help children connect household routines with scientific explanations (Merritt, Bowers, & Rimm-Kaufman, 2019; Santillán, & Cedano, 2023; Stylos, Gavrilakis, Goulgouti, & Kotsis, 2023). Because household appliances are used every day, pupils often develop a practical familiarity with electricity long before they can explain the underlying scientific process, which means that instruction needs to build a bridge between what pupils already do at home and what they are asked to explain in the classroom (Santillán & Cedano, 2023).

The problem is more pronounced when electricity is taught mainly through verbal explanation. Concepts such as current, energy transfer, and transformation are abstract, and young learners often interpret energy through everyday language. Research with children has shown that early ideas about energy can be partial and sometimes inconsistent; some children describe energy as something that simply appears, disappears, or is stored inside objects without recognising the wider transformation process (Detken, 2023; Detken, & Brückmann, 2021). Studies on primary electricity teaching also indicate that pupils benefit from multimodal learning, including drawings, physical circuits, teacher questioning, and hands-on observation, because these modes give pupils several entry points into the same concept (Kada, & Ravanis, 2016; Preston, Hubber, & Xu, 2022). When instruction remains verbal, pupils may retain fragmented ideas that are only loosely connected to the scientific concept of energy transformation, and these fragmented ideas can persist unless they are actively challenged through direct observation and guided questioning (Stylos et al., 2023).

A battery demonstration offers a practical way to make this abstract process more concrete. When a battery is connected to a Light-Emitting Diode (LED) and a small propeller, pupils can observe two clear outputs: light and motion. The demonstration is simple, but it contains the core relationship needed for early energy learning: an electrical source, a connection path, and observable energy outputs. The activity also allows facilitators to ask pupils to predict, observe, and explain what happens when the circuit is complete or interrupted. This sequence is important because children do not only need to see the tool work; they also need to put the observation into words. Similar work on simple circuits with young children indicates that circuit-building activities can support early reasoning about components, connections, and the need for a closed circuit (Kada & Ravanis, 2016). More recent Science, Technology, Engineering, and Mathematics (STEM) oriented research also suggests that structured electrical-circuit activities can reorganise students' cognitive structures and improve conceptual links among circuit components (Baptista & Martins, 2023). Because the predict observe explain sequence asks pupils to state an expectation before seeing the result, it also creates a natural opportunity for facilitators to notice and address misconceptions as soon as they surface, rather than only after a formal test (Baptista & Martins, 2023).

The context of this study gives the activity an additional educational purpose. The participants were Indonesian elementary-age children living in Kuala Lumpur, Malaysia. Children in overseas Indonesian communities may have access to schools and community learning spaces, but contextual Indonesian-language science activities are not always easy to find. Community service programmes can complement formal schooling by providing short, meaningful, and low-pressure science learning experiences in community settings. Outreach research also shows that informal learning activities can extend science engagement beyond classrooms when the activities are concrete, participatory, and supported by adults or facilitators (Prabhakar, Chang, Rau, & Carvalho, 2025; Short-Meyerson, Sandrin, & Jimenez-Silva, 2024; Zucker, Mesa, Bambha, DeMaster, Ahmed, & Master, 2025). In this setting, a short, well-structured science activity can therefore serve two purposes at once: reinforcing conceptual understanding of household electricity and sustaining pupils' connection with Indonesian language science communication while they live abroad.

Previous studies have examined elementary STEM activities, energy-transformation media, paper circuits, and concrete science learning media (Alim, Hermita, Putra, & Oktaviani, 2025; Çayci, & Örnek, 2019; Cole, Fallahhosseini, Zangori, & Oertli, 2023; Jaya, Rati, & Margunayasa, 2024; Putri, Azizah, Sari, Qudsyi, & Setiawan, 2025; Suryawan, Evalina, & Wulandani, 2024; Zulkarnain, Prima, Winarno, & Wahono, 2024). However, documented community service activities for Indonesian children living abroad remain limited, especially activities that use inexpensive recycled materials to introduce household electrical energy. This article addresses that gap by revising and reporting a battery-demonstration activity in a more transparent manner. The study has two objectives: first, to describe the design and implementation of a low-cost demonstration tool for household electrical energy education; and second, to report pupils' learning outcomes using verified pre-test and post-test score data, supported by observational notes on engagement. Most of these studies were conducted within formal school settings in Indonesia, which further underscores the need for documented examples of informal, community-based science outreach for Indonesian pupils learning outside the national school system.

1.1 Household electrical energy and elementary energy literacy

Energy literacy refers to the ability to understand energy concepts, interpret energy-related situations, and make responsible decisions in daily life. At the elementary level, this literacy usually begins with the recognition of energy sources and energy transformations before moving to more complex issues such as conservation, sustainability, and energy systems. Santillán and Cedano (2023) describe energy literacy as a multidimensional construct involving knowledge, attitudes, and behavioural tendencies. Merritt, Bowers, and Rimm-Kaufman (2019) further show that elementary students can relate electricity to broader energy resources when teaching explicitly connects household electricity with everyday experience. These findings support the use of familiar household examples as starting points for energy learning. Building this literacy gradually, beginning with concrete recognition of sources and transformations before progressing to abstract system-level ideas, is therefore considered developmentally appropriate for elementary-age learners rather than attempting to teach conservation or systems concepts directly.

Household electrical energy is pedagogically useful because pupils can connect it with objects they already know. A lamp, a fan, and a toy motor can serve as bridges between experience and explanation. Still, familiarity does not automatically produce conceptual understanding. Learners may recognise the object but remain uncertain about what the battery does, why a wire is needed, or why a device stops when a connection is opened. Research on young children's ideas about energy suggests that teachers and facilitators need to elicit children's initial explanations before guiding them toward more scientific reasoning (Detken, 2023; Detken, & Brückmann, 2021). Facilitators can use these everyday objects strategically, first asking pupils to describe what they already believe about how a lamp or toy works, and only then introducing the demonstration tool to confirm, refine, or challenge that initial explanation.

Learning media can support this process by giving pupils something to observe and discuss. Cole, Fallahhosseini, Zangori, and Oertli (2023) show that renewable-energy learning spaces can help elementary pupils make sense of solar energy systems. Jaya, Rati, and Margunayasa (2024) report that an energy-transformation learning medium improved pupils' understanding of energy changes, while Suryawan, Evalina, and Wulandani (2024) emphasise the role of simple science media in making abstract energy concepts easier to understand. These studies indicate that learning tools should not be treated as decorative aids. In elementary science, concrete media often function as cognitive supports that help pupils organise what they see, hear, and say. Taken together, this body of evidence suggests that the specific form of the learning medium matters less than whether it gives pupils a concrete, observable reference point that they can return to while constructing and revising their explanations.

1.2 Demonstration, concrete media, and hands-on science learning

Demonstration is appropriate when the target concept is difficult to grasp through explanation alone. A facilitator can show a process, pause at important moments, ask learners to make predictions, and guide them to compare their predictions with the observed result. Concrete media have been shown to improve elementary pupils' factual understanding when they are used through structured observing activities (Widiana, Tegeh, Parwata, & Hanikah, 2020). In this study, the demonstration tool consisted of familiar and safe materials: a battery, wires, an LED, a propeller, and a reused plastic bottle frame. The materials were simple, but they allowed pupils to observe an essential scientific relationship directly. Because the facilitator can control the pace of the demonstration, pupils who need more time to process what they are seeing can be given a second look before the group moves on to guided practice.

Hands-on learning is also linked with science process skills. Purnomo, Nugraha, and Rahayu (2021) show that hands-on activity can support observation, communication, and conclusion-making among elementary students. STEAM and project-based studies similarly report that learners benefit when they manipulate materials and see immediate outcomes from their own actions (Putri, Azizah, Sari, Qudsyi, & Setiawan, 2025; Zulkarnain, Prima, Winarno, & Wahono, 2024). In this activity, pupils were not positioned only as spectators. After the facilitator demonstrated the tool, pupils were invited to try it under supervision, identify the battery as the energy source, and explain why the LED emitted light and the propeller moved. This active positioning is important because it shifts pupils from being recipients of a finished explanation to being participants who must generate their own account of what they observed, a shift that STEAM-oriented studies associate with stronger conceptual retention (Putri et al., 2025).

The wider STEM literature supports guided, practice-oriented science learning in elementary contexts (Alim, Hermita, Putra, & Oktaviani, 2025; Çayci, & Örnek, 2019; Cole, Fallahhosseini, Zangori, & Oertli, 2023). STEM interventions can improve learning outcomes when they are linked to clear scientific ideas and are not reduced to playful activities without conceptual focus (Cao, Lu, Wu, & Hsu, 2025). Inquiry-based approaches can also enhance understanding and higher-order thinking when the inquiry is sufficiently guided (Antonio, & Prudente, 2024; Arifin, Saputro, & Kamari, 2025; Dah, Noor, Kamarudin, & Azziz, 2024). This distinction matters for young learners. The activity in this study used guided inquiry rather than open inquiry because the pupils were elementary-age children, the intervention time was short, and the learning goal was focused on one basic concept: electrical energy from a source can be transformed into observable outputs. Guided inquiry was therefore treated as a deliberate pedagogical choice rather than a limitation, since fully open-ended exploration would have been difficult to manage safely and productively within a single short session involving young children.

1.3 Conceptual framework and working proposition

The conceptual framework of this community service activity links input, process, and output. The input consisted of pupils' initial familiarity with household electrical devices, the low-cost demonstration kit, and a short Indonesian-language explanation. The process consisted of pre-test administration, conceptual introduction, battery demonstration, guided practice, discussion, and post-test administration. The output was defined as improved test scores, more accurate explanations of energy transformation, and observable engagement during the activity.

The framework is consistent with constructivist learning principles. Pupils do not simply receive a definition of electrical energy; they construct meaning by comparing prior ideas with what they observe. For example, a pupil may initially think that the battery directly contains light. After observing that the LED lights only when the circuit is properly connected, the pupil can begin to distinguish among the energy source, the circuit connection, and the energy output. Preston, Hubber, and Xu (2022) argue that electricity learning benefits from multimodal representation because learners need coordinated verbal, visual, and material experiences. The present activity operationalised that idea through a physical tool, facilitator questioning, and a short discussion. Viewed this way, the demonstration functioned less as a display to be watched and more as a shared reference point that pupils and facilitators could point to, describe, and question together during the discussion stage.

Because this article reports a community service activity rather than a full experimental trial, the term hypothesis is used cautiously. The working proposition was that pupils' post-test scores would be higher than their pre-test scores after participating in the battery-demonstration activity. The proposition was grounded in previous evidence that concrete media, hands-on activities, guided inquiry, and STEM-based learning can support elementary science understanding (Arifin, Saputro, & Kamari, 2025; Purnomo, Nugraha, & Rahayu, 2021; Putri, Azizah, Sari, Qudsyi, & Setiawan, 2025; Zulkarnain, Prima, Winarno, & Wahono, 2024). Framed as a working proposition rather than a formal hypothesis, this expectation still allowed the authors to specify in advance what a successful outcome would look like, which supports a more transparent and falsifiable reporting of the activity's results.

2. Research Methodology

This study used a community service design with a one-group pre-test and post-test evaluation. The activity was educational rather than clinical or high-risk, and it was implemented to support children's understanding of household electrical energy. The design was selected because the activity took place in a community setting with limited time, a small number of participants, and an emphasis on practical learning. Similar pre-test and post-test arrangements are commonly used in elementary science interventions to describe learning gains after hands-on or experimental activities (Jaya, Rati, & Margunayasa, 2024; Purnomo, Nugraha, & Rahayu, 2021; Putri, Azizah, Sari, Qudsyi, & Setiawan, 2025). This design choice also reflects the practical constraints typical of community-based outreach, where a single session must be planned around the availability of volunteer facilitators, borrowed venues, and the limited attention span of elementary-age participants.

The activity was conducted in Kuala Lumpur, Malaysia, in August, with Indonesian elementary-age children as participants. Fourteen Indonesian elementary-age children joined the learning session from the opening activity to the discussion stage. For the quantitative analysis, this revised manuscript used 14 complete pairs of pre-test and post-test scores available in the score sheet. This clarification is important because paired-sample analysis requires the same participant to have both scores. Participants were selected based on the availability of the Indonesian community group, suitability of the activity for elementary-age children, willingness to participate in the session, and ability to follow the Indonesian-language explanation.

2.1 Research Instrument and Scoring Rubric

The learning evaluation used researcher-developed pre-test and post-test instruments consisting of five multiple-choice questions. The instruments were prepared based on the learning objectives of the community service activity. The questions measured pupils' basic understanding of household electrical energy, including the use of electricity in daily life, batteries as artificial electrical energy sources, the function of accumulators, the working principle of a dynamo, and simple energy transformation. The pre-test and post-test questions were designed as equivalent but not identical items. This means that the two instruments did not use exactly the same wording, but they assessed the same conceptual indicators. This approach was used to reduce the possibility of pupils merely memorising answers from the first test while still allowing the researchers to compare their understanding before and after the battery demonstration activity.

Table 1. Scoring rubric of the pre-test and post-test instruments

Score	Criteria	Interpretation
1	The answer is correct and matches the expected concept.	The pupil demonstrates understanding of the concept measured by the item.
0	The answer is incorrect, blank, or does not match the expected concept.	The pupil has not demonstrated understanding of the concept measured by the item.

Table 1 presents the dichotomous scoring rubric applied to both the pre-test and post-test. As shown in the table, a score of 1 was assigned when a pupil's answer matched the expected concept, indicating that the pupil demonstrated understanding of the item, whereas a score of 0 was assigned for incorrect, blank, or conceptually inaccurate answers. This binary scheme allowed the five test items to be summed into a single composite score ranging from 0 to 5 for each participant, which was subsequently used to compute the percentage score described below.

The total score was calculated by summing the number of correct answers. The percentage score was calculated using the following formula:

$$PresentageScore = \frac{TotalCorrectAnswer}{5} \times 100 \tag{1}$$

Formula 1 was used to convert each participant's raw score into a percentage score. The term "Total Correct Answers" refers to the number of items answered correctly by each participant in the pre-test or post-test. The number 5 represents the total number of questions in each test. The result was multiplied by 100 to express the score as a percentage. For example, if a participant answered four out of five questions correctly, the percentage score was calculated as (4/5) × 100 = 80%. This calculation made it easier to compare pupils' levels of understanding before and after the battery demonstration activity.

Table 2. Conceptual indicators of the pre-test and post-test instruments

No.	Conceptual Indicator	Pre-Test Focus	Post-Test Focus	Score Range
1	Identifying the use of electricity in daily life	Electricity is used to turn on a lamp.	Electricity is useful for turning on a lamp.	0-1
2	Recognising batteries as artificial electrical energy sources	Battery stores electricity in chemical energy form.	Battery is often used as an electrical source for toys.	0-1
3	Understanding the function of an accumulator	An accumulator stores electricity in vehicles.	An accumulator supplies electricity to vehicles.	0-1
4	Understanding the working principle of a dynamo	A dynamo converts motion into electricity.	A dynamo produces electricity from motion.	0-1
5	Understanding energy transformation in batteries	Battery is identified as an artificial source of electricity.	Energy in a battery comes from chemical energy.	0-1

Table 2 summarises the five conceptual indicators measured by the pre-test and post-test instruments, together with the specific focus of each item in the two versions of the test. As the table shows, each indicator addressed a distinct aspect of household electrical energy, ranging from the everyday use of electricity and the role of batteries as artificial energy sources to the function of an accumulator, the working principle of a dynamo, and the transformation of energy within a battery. Because the pre-test and post-test items were written as equivalent rather than identical statements, the table also illustrates how the wording of each focus changed between the two occasions while still targeting the same underlying concept, with every item contributing a possible score range of 0-1 to the composite score (Suryawan, Evalina, & Wulandani, 2024; Widiana, Tegeh, Parwata, & Hanikah, 2020).

Figure 1. Battery demonstration tools

The preparation stage began with an informal observation of the pupils' familiarity with household electrical energy, followed by a brief explanation of electricity sources, the role of batteries, and electrical energy transformation. Before the activity, the demonstration kit was tested to ensure that the LED and propeller functioned properly. As shown in Figure 1 , the kit consisted of a battery, connecting wires, an LED, a small propeller, and a reused plastic bottle frame, forming a simple and portable teaching aid made from inexpensive materials. The learning sequence was kept straightforward to help pupils understand the relationship between the power source, the electrical circuit, and the resulting energy outputs.

The implementation stage began with a five-item pre-test. Pupils answered the questions individually before the explanation and demonstration. After the pre-test, facilitators introduced household electrical energy through a concise verbal explanation and an interactive video.

Figure 2. Delivery of introductory materials

As shown in Figure 2, the facilitators introduced the activity through a brief explanation and an interactive video before the hands-on demonstration began. The video served only as a supporting introduction, while the main learning activity focused on the physical demonstration. Pupils then observed how the battery, wires, LED, and propeller were connected, and facilitators guided the discussion by asking what happened when the circuit was completed and when a connection was interrupted.

Figure 3. Participants trying the demonstration tool

Figure 3 shows pupils taking turns operating the demonstration kit under the facilitator's supervision. The photograph captures the moment when a pupil connects the battery, wires, LED, and propeller, illustrating the guided-practice stage in which pupils progressed from passive observation to direct hands-on interaction with the electrical circuit. During this activity, facilitators provided guidance while encouraging each pupil to actively assemble the circuit and observe the resulting changes.

During this guided-practice stage, pupils were encouraged to identify the component that functioned as the energy source, describe the outputs they observed, and explain why the LED emitted light and the propeller rotated. By combining observation with verbal explanation, the activity promoted active engagement rather than passive viewing of the demonstration. Such participation has been shown to strengthen pupils' observation, communication, and scientific explanation skills (Purnomo, Nugraha, & Rahayu, 2021). Moreover, this approach addressed a common limitation of demonstration-based learning, in which pupils merely watch a device operate without interpreting the underlying scientific concepts. The activity also reflected inquiry-based learning principles by encouraging pupils to construct conceptual understanding through the integration of evidence and explanation (Antonio, & Prudente, 2024; Morris, 2025).

Following the guided-practice session, the program concluded with an evaluation stage consisting of a post-test and qualitative observation. The post-test employed the same scoring range as the pre-test, with a maximum score of five, allowing direct comparison of pupils' learning outcomes before and after the intervention. The mean pre-test and post-test scores were compared descriptively. In addition, the original activity documentation reported a paired-sample t-test with a significance level of $p < 0.05$. However, because individual participant scores and standard deviations were not available in the source manuscript, this revised article does not recalculate the t statistic or effect size. This conservative reporting approach is consistent with recent recommendations that educational intervention findings should be interpreted in light of the study context, research design, and the completeness of the available data (Tobler, 2024).

The implementation of the program also considered ethical aspects throughout the activity. As a community education program, the demonstration was conducted in a supervised learning environment using low-voltage electrical components that were appropriate and safe for primary school pupils. Furthermore, for publication purposes, the authors should ensure that any photographs included in the manuscript have obtained permission from participants' parents or guardians and that any identifying information is minimised where necessary to protect participants' privacy.

3. Results and Discussion

3.1 Result

The initial pre-test scores indicate that pupils already had some familiarity with household electrical devices but had not yet formed a complete explanation of source, connection, and energy transformation. Some pupils could recognise familiar outputs such as light and fan motion, but they still needed guidance to explain the role of the battery and the reason a complete connection was needed. This pattern is consistent with previous studies showing that children often begin with everyday ideas about energy and need concrete learning experiences to reorganize those ideas scientifically (Detken & Brückmann, 2021; Merritt et al., 2019; Preston et al., 2022). This baseline pattern is useful pedagogically because it shows that the activity did not need to introduce the vocabulary of electricity from zero; instead, it needed to help pupils reorganise and extend ideas they already partially possessed.

Table 3. Average score pre-test & post-test of 15 participants

Measure	N	Mean	SD	Min	Max
Pre-test	14	3.286	0.825	2	5
Post-test	14	4.357	0.929	2	5
Gain	14	1.071	0.997	-1	3

Table 3 summarises the descriptive and inferential statistics based on the 14 complete paired pre-test and post-test scores. The mean pre-test score was 3.286 (SD = 0.825), whereas the mean post-test score increased to 4.357 (SD = 0.929). Expressed as a percentage of the maximum possible score, the average achievement improved from approximately 65.72% to 87.14%. The mean gain was 1.071 points (SD = 0.997), and the minimum and maximum scores indicate that most pupils demonstrated improvement following the intervention.To examine whether this improvement was statistically meaningful, a paired-sample t-test was performed. The analysis revealed a statistically significant increase in pupils' scores, t(13) = 4.020, p = 0.001. The 95% confidence interval for the mean gain ranged from 0.496 to 1.647, while the within-participant effect size was large (Cohen d_z = 1.074). These findings suggest that the combination of explanation, demonstration, guided practice, and discussion effectively enhanced pupils' understanding of simple electrical circuits.

Paired-sample t-test: t(13) = 4.020; p = 0.001; 95% CI for the mean gain [0.496, 1.647]; Cohen dz = 1.074. The score increase suggests that the battery demonstration helped pupils move from recognition of familiar household devices toward a clearer explanation of electrical energy transformation. The LED offered a visible sign of light output, while the propeller offered a visible and moving sign of kinetic output. This dual-output design was useful because pupils could compare two different results from the same electrical source. The activity therefore supported the idea that electrical energy can be transformed into different observable forms rather than simply being consumed by a device. This interpretation is consistent with research on circuit-based and multimodal electricity learning, which emphasises the value of observable components and coordinated representations (Baptista & Martins, 2023; Preston et al., 2022; Skoumios & Balia, 2020).

Observation during the session also showed positive engagement. Pupils paid attention during the explanation, responded to facilitator questions, and appeared especially interested when the LED lit up and the propeller rotated. Engagement matters because curiosity and emotional interest can make pupils more willing to test their ideas and revise earlier explanations. Studies on STEAM and STEM learning indicate that pupils often value activities that let them manipulate objects, solve small problems, and see immediate consequences from their actions (Cook et al., 2025; Putri et al., 2025; Zulkarnain et al., 2024). The present activity created a similar learning atmosphere using much simpler materials. Facilitators also noted that pupils who initially answered hesitantly during the discussion became more confident after operating the tool themselves, suggesting that the hands-on stage played a role in consolidating understanding beyond what the explanation alone provided.

The findings can be interpreted from three educational perspectives. First, the demonstration made an invisible process visible. Without a physical tool, pupils may hear the phrase electrical energy but struggle to imagine how it operates in a device. With the demonstration, pupils could observe a clear sequence: the battery was connected, the circuit became complete, the LED produced light, and the propeller moved. This sequence allowed facilitators to explain source, pathway, and output using concrete evidence. Similar circuit studies have shown that young learners benefit from direct interaction with circuit components rather than only reading or listening to explanations about them (Kada & Ravanis, 2016; Preston et al., 2022). Taken together, these three perspectives, visibility, guided participation, and contextual relevance, help explain why a materially simple demonstration was able to produce a measurable and educationally meaningful change in pupils' test performance.

Second, the activity supported learning through guided participation. Pupils did not merely watch a finished demonstration; they took turns operating the tool, checking the connection, and discussing what happened.

Figure 4. Participant's engagement during activity

Figure 4 illustrates pupils' engagement during the guided-practice and discussion stage, showing their attention and enthusiasm as the LED lit up and the propeller rotated. The photograph provides visual support for the observational notes reported in this section, indicating that pupils remained actively involved rather than passively observing the demonstration.

This design is consistent with recent STEM-education evidence showing that guided, practice-oriented learning can support students' learning outcomes more effectively than instruction that remains limited to abstract explanation (Cao et al., 2025). It is also consistent with inquiry-based research showing that well-guided inquiry can help students build deeper understanding and higher-order thinking skills (Antonio & Prudente, 2024; Arifin et al., 2025; Dah et al., 2024). In this activity, guidance did not reduce pupil participation; rather, it helped keep participation conceptually focused. It further suggests that the value of guided practice lies not simply in letting pupils touch the materials, but in pairing that physical access with focused questions that keep attention on the underlying scientific relationship.

Third, the activity was appropriate for an overseas Indonesian community. A complex laboratory kit may be difficult to obtain, maintain, and replicate in a community setting. The battery demonstration, by contrast, used materials that facilitators could prepare quickly and explain in everyday Indonesian. Outreach studies show that informal science programmes can broaden science engagement when they are accessible and connected with learners' social context (Prabhakar et al., 2025; Zucker et al., 2025). The involvement of community facilitators is also relevant because children often continue to connect science concepts with home routines through conversations with adults (Short-Meyerson et al., 2024). This consideration is particularly relevant for community organisers who must balance educational ambition with the practical realities of volunteer time, borrowed spaces, and limited budgets typical of grassroots outreach programmes.

The use of reused plastic bottles as the tool frame added a modest sustainability message. Although the main concept was household electrical energy, the tool showed that learning media do not always have to be expensive or disposable. This feature relates to energy-literacy scholarship, which encourages learners to connect energy knowledge with wider environmental responsibility (Santillán & Cedano, 2023; Stylos et al., 2023). It also aligns with renewable-energy education research that encourages learners to connect energy systems, daily life, and sustainability (Cole et al., 2023; Merritt et al., 2019). In doing so, the tool quietly modelled an environmentally responsible practice for pupils, even though sustainability was not the primary learning objective of the session.

The result should still be interpreted with caution. A mean increase from 3.286 to 4.357 is educationally meaningful in the context of a five-item test, but the study did not include a comparison group. Therefore, the result cannot prove that the demonstration alone caused the improvement. It is possible that the short video, facilitator explanation, peer discussion, or repeated exposure to the same test format also contributed. The original documentation reported a significant paired t-test, but individual scores were not available for independent recalculation. A future version of this study should report individual anonymised scores, standard deviation, confidence intervals, and effect size so that the result can be interpreted more transparently within the educational context (Tobler, 2024). For this reason, the result is best understood as evidence of promising learning improvement in a community service setting, not as a broad causal claim for all elementary pupils. Readers should therefore treat the reported gain as a useful signal for programme planning rather than as conclusive proof that the battery demonstration, on its own, produced every unit of improvement observed between the two tests.

The practical implications can be differentiated for several users. For teachers, the activity offers a short lesson model for introducing energy transformation through observation and guided questioning. Teachers can ask pupils to predict what will happen, identify the energy source, and explain why the output changes when the connection is interrupted. For curriculum designers, the activity suggests that elementary energy lessons should sequence concepts from familiar household objects to source, circuit, and output. For community programmes, the model is useful because it is low-cost, portable, and easy to adapt for short learning sessions outside formal classrooms. The activity may also be expanded by adding a switch, series and parallel circuit examples, simple safety messages, or comparisons between battery-powered devices and household electrical appliances. Across all of these audiences, the underlying lesson is that a small, well-sequenced demonstration can carry substantial pedagogical value when it is paired with deliberate opportunities for pupils to predict, observe, and explain what they see.

3.2 Discussion

The findings of this community service study indicate that the battery demonstration significantly improved elementary pupils' understanding of electrical energy concepts, particularly in identifying energy sources and recognizing energy transformation processes. The increase in post-test scores shows that hands-on demonstration methods can bridge the gap between abstract scientific concepts and pupils' everyday experiences. As also supported in the study, electricity learning at the elementary level is more effective when it is introduced through concrete media rather than verbal explanation alone, since children are still in the stage of concrete operational thinking (Detken, 2023; Detken & Brückmann, 2021). In addition, the use of multimodal learning approaches such as observation, manipulation of objects, and guided questioning helps students construct conceptual understanding of electrical circuits and energy transformation (Kada & Ravanis, 2016; Preston et al., 2022). The battery LED propeller system in this study provided direct visual evidence of energy conversion from electrical energy into light and motion, strengthening pupils' conceptual linkage between theory and real world phenomena.

Furthermore, the guided practice and inquiry based structure of the learning activity contributed significantly to student engagement and conceptual development. Pupils were actively involved in identifying components, testing connections, and explaining observed phenomena, which aligns with findings that hands-on and participatory STEM learning improves observation skills, communication, and conceptual understanding (Purnomo et al., 2021; Putri et al., 2025; Zulkarnain et al., 2024). The effectiveness of demonstration-based learning is also supported by previous studies showing significant improvements in students' understanding of electrical energy transformation when using experimental or demonstration methods. However, as also noted in similar experimental learning studies, results should be interpreted cautiously due to limitations such as small sample size and absence of a control group, which may affect the generalizability of findings (Tobler, 2024). Overall, this study confirms that simple, low-cost demonstration tools can effectively support elementary science learning in both formal and community-based education settings.

4. Conclusions

4.1 Conclusion

The community service activity on household electrical energy education was implemented with Indonesian elementary-age pupils in Kuala Lumpur. The battery demonstration tool consisted of a battery, LED, propeller, wires, and reused plastic bottles. The tool enabled pupils to observe two energy outputs, namely light and motion, from a simple electrical source. The learning sequence combined brief explanation, demonstration, guided practice, discussion, and pre-test/post-test evaluation.

The measured learning outcome improved after the activity. Based on 14 complete paired scores, the mean increased from 3.286 before the activity to 4.357 after the activity. The paired-sample t-test showed a significant mean gain, t(13) = 4.020, p = 0.001, with a large within-participant effect size (Cohen dz = 1.074). These findings support the conclusion that pupils' basic understanding of household electrical energy sources and energy transformation improved after the demonstration-based learning session. The conclusion is limited to the measured indicators in the five-item test and should not be generalised beyond the community service context without further study. This outcome is consistent with the working proposition set out earlier in the article and adds a small but concrete data point to the broader literature on demonstration-based and hands-on elementary science learning.

4.2 Research Limitations

This study has several limitations. First, the number of participants was small, and the activity involved one Indonesian community group in Kuala Lumpur. Second, the quantitative analysis used 14 complete paired scores, so the statistical result reflects only the available score pairs. Third, the design used one group without a control or comparison group, which limits causal interpretation. Fourth, the test consisted of only five items and measured basic understanding rather than wider energy literacy. Fifth, the intervention was conducted in a short time frame and did not examine whether the pupils retained the concept after several days or weeks. Sixth, the instrument was aligned with learning objectives but was not subjected to formal psychometric validation. These limitations do not diminish the practical value of the activity for the community it served, but they do mean that the quantitative result should be read as a preliminary indication rather than a definitive measure of the demonstration's effectiveness.

4.3 Suggestions and Directions for Future Research

Future community service activities should be conducted across more than one meeting so that pupils can revisit the concept, practise the demonstration several times, and strengthen their explanations. The demonstration kit can be developed by adding a switch, small motor, series and parallel circuit examples, and simple electrical safety messages. The learning material can also be expanded to include responsible electricity use at home, energy saving, and the relationship between household electricity and environmental sustainability. The augmented-reality science learning environments can influence elementary students' conceptions of learning science, while that ICT can support natural science learning in primary schools. When resources are available, physical demonstrations can also be complemented by digital media or augmented-reality explanations. Organizer may also consider training a small group of parent volunteers to help facilitate future sessions, which could increase the number of pupils who can be served without requiring a proportional increase in specialist staff.

Future research should involve more participants, include a comparison group, and collect more detailed data. Researchers are encouraged to report individual anonymised scores, standard deviations, confidence intervals, effect sizes, item-level analysis, and delayed post-tests. Qualitative data such as pupils' drawings, short interviews, or written explanations could also be added to examine how pupils' ideas change after the activity. In overseas Indonesian communities, parents and community facilitators should be involved more deliberately so that energy awareness can continue in home conversations after the learning session ends. Establishing simple partnerships with local schools or community centres in other cities could also help future studies recruit larger and more diverse samples of overseas Indonesian pupils without placing excessive demands on any single volunteer team.

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