

Effectiveness of electric circuit trainers in improving students' learning of electricity concepts

Cris Noriel Sumaoang Jr.^{1&2*}

¹Department of Education, Lambayong National High School, Philippines

²Graduate School, Sultan Kudarat State University, Philippines. crisnorielsumaoang@gmail.com

*Corresponding author: crisnorielsumaoang@gmail.com

<https://doi.org/10.5281/zenodo.17459013>

Received: September 30, 2025 | Accepted: October 24, 2025 | Published: October 27, 2025

ABSTRACT

Technologies contribute to sustainable learning as the educational milieu finds ways to upgrade the ecosystem that can maximize the use of AI for improved student learning. This study aimed to determine the effectiveness of electric circuit trainers or simulators on students' learning performance. Through a quasi-experimental design, the study randomly selected from Grade 7 classes of 10 sections through a paper lottery. Two sections were selected from a total of ten sections, with forty students in the experimental group and forty in the control group. The pretest and posttest results for both groups were compared using the t-test. The mean gain scores of the experimental group and the control group differ significantly, according to the results. A notable difference suggests the effectiveness of the electric circuit trainer to improve students' understanding of fundamental electrical concepts. It is recommended to develop an upgraded version of the electric circuit trainer for more complex and advanced circuitry intended for students in higher grades.

Keywords: Electric circuit trainers, Electric simulators, Electricity concepts, Student learning

1. INTRODUCTION

Technology evolves rapidly, opening more doors for development, invention, and innovation. It transforms society and makes human lives a lot easier. In the recent era, even artificial intelligence chatbots have taken the education milieu by storm, which accentuates the rapid innovations taking place in the world. Technologies are a way of sustainable learning as education adapts to the changes in modern society.

In the Philippine setting, there is, however, a gap between the utilization of technologies for learning and the practical application of these technologies due to prevailing traditional practices in the classroom. It is essential that the learning environments foster conceptual understanding, especially in science (Aguiar-Castillo et al., 2021). Teaching and learning about electricity are integrated into science subjects and other scientific curricula, such as Technology and Livelihood Education, or TLE, in the K-12 curricula

Learning about electricity through technological application is vital for students' critical thinking (Assem et al., 2023; Yakkou et al., 2024) and enhances technological literacy, which is fundamental for people to keep inventing and innovating technologies and products that make life easier and more convenient. Aside from its abstract nature, teaching and learning the basic concept of electricity is difficult because there are a lot of misconceptions about learning electricity, such as clashing currents and short circuits (Aligo et al., 2021). Voltage, current, and resistance are examples of abstract, intangible concepts that are challenging to solve (Arabasi, 2018).

One of the primary challenges hindering learning and teaching the concept of electricity is the need for more real-world resources. Studies (Chernikova et al., 2020; Yakkou et al., 2024) argued the benefits of innovative ways of learning that motivate students in incorporating technologies to support their learning in an efficient manner. The use of simulations in an innovative pedagogical practice can enhance student learning through a more practical application of knowledge in a safe environment (Chernikova et al., 2020).

Nevertheless, Chernikova et al. (2020) emphasized that there is a lack of knowledge on which scenarios work best, who can benefit most from simulations, and what extra instructional support can aid students with varying learning needs. The influence of various simulation characteristics, such as duration and technology use, and instructional support or scaffolding, is not well-documented, particularly when it comes to providing effective help for students with varying degrees of prior knowledge (Cook et al., 2013; Chernikova et al., 2019).

Different teaching strategies were recommended to address misconceptions about learning electricity and improve students' understanding of the basic concept of electricity. One of these strategies is using effective instructional material.

Igiri and Effiong (2015) stated that instructional materials are vital to a student's academic performance. Likewise, the emergence of simulators and their integration into the curriculum can provide opportunities that stimulate students' learning (Yakkou et al., 2024). These indicate that learning materials make learning real and permanent, which is appropriate for improving conceptual understanding of electricity.

In this study, the trainer refers to the electric circuit learning material that the students evaluated to achieve their learning performance. Hence, this investigation proposed a learning material to enhance students' conceptual understanding of electricity. This study aimed to determine the effectiveness of electric circuit trainers on students' learning performance at Lambayong National High School, Philippines.

- 1) Determine the acceptability of the trainer in terms of:
 - a) Functionality;
 - b) Instructional applicability;
 - c) Aesthetic value;
 - d) Durability; and,
 - e) Safety.
- 2) Determine the significant difference between the pretest and posttest scores of the control group.
- 3) Determine the significant difference between the pretest and posttest scores of the experimental group.
- 4) Determine the significant difference between the mean gain scores in the control and experimental groups.

2. CONCEPTUAL FRAMEWORK

The study's conceptual framework consists of three components: the input, the process, and the output. The first input frame involves educational needs, curriculum requirements, and resources. In the teaching and learning process, identifying students' academic needs is essential to developing possible interventions to address the learning gap among the students and ensure that learning occurs. Aside from educational needs, the lesson must align with the curriculum requirements of the Curriculum Guide set by the Department of Education.

The second frame covers the design and development of the trainer, the validation and revision of instructional instruments, implementation, and the educational study. The design and development phase involves gathering the necessary materials, tools, and equipment for constructing the electric circuit trainer. It also includes testing and troubleshooting the device to ensure proper functionality and to determine whether revisions are needed. After construction and efficiency testing, a validation was conducted to assess the trainer's acceptability in terms of functionality, instructional applicability, aesthetic value, durability, and safety. The final stage is implementation, where the electric circuit trainer was used in instruction to determine its effect on students' learning performance, which is the primary focus of the educational study.

The last frame is the output, which is the electric circuit trainer. This stage includes its educational impact, results validation, recommendations, and research publication. The educational impact refers to the trainer's effect on students' learning performance, particularly in understanding the basic concepts of electricity, as presented in the study's results and findings. Results must be validated to check for errors and ensure accuracy. In addition to validation, recommendations are necessary to gather suggestions for enhancing and improving the device for future use, based on the study's results and findings. Finally, the research publication disseminates the study's results and conclusions to the scientific community, with the aim of inspiring others to adapt or conduct similar analyses to further improve the teaching-learning process.

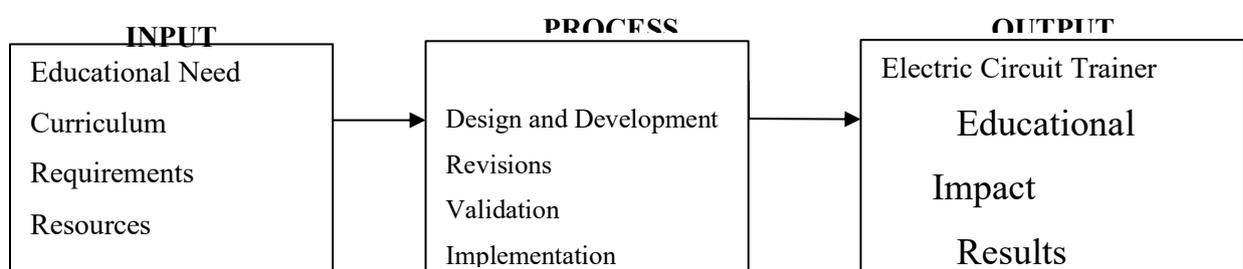


Figure 1. Conceptual Framework of Electric Circuit Trainer

3. RESEARCH METHOD

3.1. Research design

The study adopted a quasi-experimental method of research. The study used two groups, an experimental group and a control group of equal standing, which underwent a pre-test and a post-test. A non-randomized allocation of research respondents was appropriate, considering that the Lambayong National High School adopts a heterogeneous classroom setting wherein each section consists of students with different levels or ranges of abilities and with varying proficiency levels.

A quasi-experimental research method was appropriate for comparing groups under different circumstances, either to determine significant differences or to identify cause-and-effect relationships between groups without random assignment. In the control group, a conventional way of teaching basic concepts of electricity was applied, while in the experimental group, an electric circuit trainer was introduced during the instructions. After a parallel test is administered, the researcher determines the significant difference between the groups.

To avoid including insignificant and unnecessary details that may affect the study's outcome, the researcher focused on the following: the concept of electricity, such as series circuits, parallel circuits, and series-parallel circuits; the computation of resistance, voltage, and current and the principle of Ohm's Law; and the measurement of voltages, current, and resistance using a multi-tester. This study used a single-pole switch. It does not include a three-way or four-way switch. For the students' safety, using an alternate Current power supply was strictly prohibited.

3.2. Subjects and setting

The study was conducted at Lambayong National High School in the Municipality of Lambayong, Province of Sultan Kudarat, from February to April 2024. The school consists of junior high school and senior high school, which are from Grade 7 to Grade 10 and Grade 11 to Grade 12, respectively. The school caters to students from the province of Sultan Kudarat and its neighboring provinces.

Since the study focused on the basic concept of electricity, the subjects of the study were Grade 7 students, considering that most of the learners have no knowledge or background in basic electricity. The Grade 7 curriculum consists of 10 sections, which were included in the draw lots. Out of ten sections, two sections were drawn, one of which was the controlled group comprised of 42 students, and the other was the experimental group (40 students).

3.3. Data gathering instrument

In data gathering, the researcher used a questionnaire to evaluate the acceptability of the electric circuit trainer and to measure its applicability in the teaching-learning process. The research instrument used, the questionnaire, consists of two parts. The first part is an evaluation form, and the second part is a test questionnaire, which was used during the conduct of the pretest and posttest.

Since the researcher needs to validate the effectiveness of the electric circuit trainer, an evaluation form excerpt from the study of Lumanta (2019) was adopted. The evaluation form was designed as a survey questionnaire to determine the acceptability of the electric circuit trainer in terms of functionality, instructional applicability, aesthetic value, durability, and safety. A five-point Likert scale was used to measure the quality of the trainers based on the set criteria. The rating scale adapted in the evaluation form, with its verbal description and interpretation, is shown in Table 1 below.

Table 1. Rating scale to measure the acceptability of the electric circuit trainer in terms of functionality, instructional applicability, aesthetic value, durability, and safety.

| Scale | Range of Mean | Verbal Description | Interpretation |
|-------|---------------|--------------------|-----------------------|
| 5 | 4.20-5.00 | Excellent | Highly Acceptable |
| 4 | 3.50-4.19 | Very Good | Acceptable |
| 3 | 2.60-3.49 | Good | Moderately Acceptable |
| 2 | 1.80-2.59 | Fair | Less Acceptable |
| 1 | 1.00-1.79 | Poor | Not Acceptable |

The questionnaire contained fifty (50) questions adapted from the 2020 Self-Learning Modules produced and distributed by the Department of Education.

3.4. Validity and Reliability Test

Before the evaluation form and test questionnaire were produced and distributed to the respondents, the instruments were first assessed for validity and reliability to ensure that each item was relevant to the study and that the method used during the conduct of the study was consistent with what it intended to measure.

To validate the research instruments, the questionnaires were reviewed by 10 experts in the field from the province of Sultan Kudarat, representing various educational institutions in the area (Table 2). The validators examined the relevance of each item to ensure that it was properly structured to measure the specified domains. Out of 10 evaluators, four are specialized in electrical technology, two are specialized in electronic technology, and four are in the field of automotive technology.

Table 2: Summary of the profile of the evaluators

| Respondent | Specialization | Educational Attainment | Teaching Experience |
|------------|-----------------------|------------------------|---------------------|
| 1 | Electrical Technology | College Graduate | 5 years |
| 2 | Electronic Technology | Master's Degree | 15 years |
| 3 | Automotive Technology | Master's Degree | 7 years |
| 4 | Electronic Technology | Master's Degree | 11 years |
| 5 | Electrical Technology | Master's Degree | 10 years |
| 6 | Electrical Technology | College Graduate | 2 years |
| 7 | Automotive Technology | College Graduate | 8 years |
| 8 | Electrical Technology | College Graduate | 5 years |
| 9 | Automotive Technology | College Graduate | 7 years |
| 10 | Automotive Technology | Master's Degree | 7 years |

3.5. Data Gathering Procedure

Following the outline defense's approval, the researcher completed the required paperwork and conducted the study in accordance with the university's usual operating procedures. The researcher carried out the study after obtaining approval. To ensure that the research tools utilized in the study are pertinent and substantiate theoretical claims, the researcher verified them with subject-matter experts.

The researcher wrote to the Sultan Kudarat Division's Schools Division Superintendent to request permission to perform the study in the event that the research instruments were already verified. Following approval of the request, the researcher wrote a follow-up letter to the head of Lambayong National High School requesting authorization to carry out the study.

Following acceptance, the researcher began asking the assessors to rate the electric circuit trainer's acceptability in terms of its durability, safety, visual appeal, instructional relevance, and functionality. Additionally, the researcher determined the pretest and posttest dates. The first test was given to the experimental and control groups of the chosen Grade 7 sections of Lambayong National High School.

A posttest was administered following multiple sessions until all learning abilities were attained. After that, the examination findings are gathered and contrasted to see if there are any notable discrepancies between the pretest and posttest results for the experimental group and the control group.

3.6. Statistical treatment

Using the proper statistical tools for the study, the researcher collected, arranged, tabulated, and evaluated the data following the administration of the pretest and posttest. Descriptive statistical tools like percentages, computed means, and standard deviation were used to interpret the evaluation's results.

The percentage, mean, and standard deviation of the students' scores from the pretest and posttest were used to examine the results. Since the study's focus was on students' learning performance, raw scores were converted using the Department of Education's recommended grading scheme, as outlined in DepEd Order No. 08 s. Policy Guidelines on Classroom Assessment for the K–12 Basic Education Program, published in 2015.

The mean, standard deviation, and t-test for dependent samples were used to determine whether there was a significant difference between the control group's and the experimental group's pretest and posttest scores. The degree of freedom should be identified since it was crucial to ascertain the critical t-value, which was compared to the computed t-value in order to decide whether to accept or reject the null hypothesis. To calculate the p-value, which is crucial for determining whether the test was significant or not, the degree of freedom was also essential.

With regards to the mean gain scores of the control group and experimental group, mean, standard deviation, and t-test for two sample tests of significance concerning means are needed to analyze data. To compute the mean gain, the pretest was subtracted from the posttest first. If the result is positive, the posttest score is greater than the pretest. If the gain score was negative, it implies that the posttest score is less than the pretest score. After computing the gain score,

the researcher calculated the t-value.

3.7. Description of the Electric Circuit Trainer

The electric circuit trainer consists of a switch, a receptacle, a wire with an alligator clip, a resistor, and a bulb. Electrical and electronic components such as the switch, the receptacle, and the resistors were installed on a mounting board to make it secure. The mounting board used is made of plywood that is one-half inch thick. The size of the mounting board is 12 inches wide and 8.5 inches long. To make sure that the mounting board looks neat and clean, it was furnished with Formica. An aluminum frame was also attached on the side of the mounting board not just for decorative purposes but also to make it more durable.

For the switch, a single-pole switch was used, and it will be attached to a switch box installed on the mounting board. Just like the switch, a flush-type receptacle will be fixed on the mounting board so that only the faceplate of the device is shown to make it more presentable. With regard to the wire, automotive electrical wire will be used, particularly with a size of 16 AWG or American Wire Gauge. Both ends of the wire are attached with alligator clips that will be connected to a bolt that serves as the terminal of the mounting board so that it is more convenient to connect the components of the electric circuit trainer while doing circuitry.

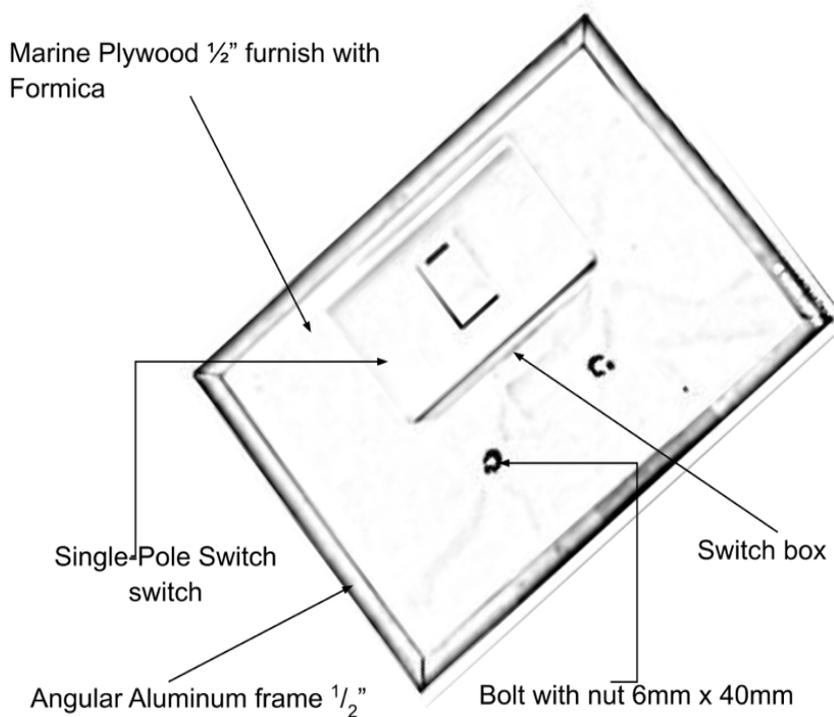


Figure 2: Sample of a Mounting Board Installed with a Single-Pole Switch

With regard to the resistors, each mounting board comprised five carbon-composition resistors with different resistance. Considering it is recommended to use a direct current for safety purposes, a direct current power supply was used. To have more variations, especially in doing hands-on exercises, the power supply used had multiple voltage outputs, such as 6 volts, 9 volts, 12 volts, and 24 volts.

Since a direct current power supply was utilized, the bulb should be compatible with direct current with a voltage range from eight to twenty-four volts. The sample of the design of the mounting board installed with a single-pole switch is shown in Figure 2 above, and the completed electric circuit trainer is in Figure 3.

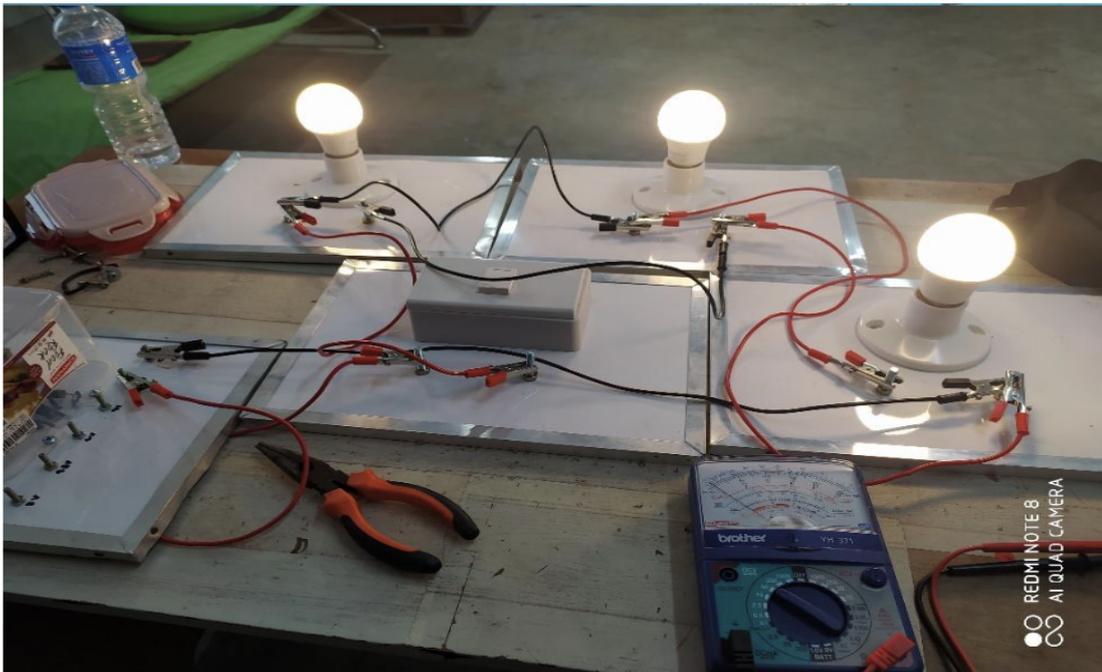


Figure 3: Assembled Electric Circuit Trainer

4. FINDINGS

Table 3 presents the result of the acceptability of the electric circuit trainer. It received an excellent rating across all specified domains, with a grand mean of 4.50 and a standard deviation of 0.58. This result indicates that the electric circuit trainer is a highly suitable learning material for helping students understand the basic concepts of electricity, as emphasized by one of the evaluators. Similarly, Lumanta (2019) highlighted that the electric circuit trainer is not only effective but also highly useful for enhancing learners' knowledge and skills in the fundamentals of electricity.

Table 3: Result of the evaluation on the acceptability of the electric circuit

| Functionality Indicators | Mean Ratings | SD | Verbal Description |
|--|--------------|-------------|--------------------|
| 1. Consistency in operation | 4.40 | 0.52 | Excellent |
| 2. Effectiveness of the design | 4.60 | 0.52 | Excellent |
| 3. Operational performance of the trainer | 4.50 | 0.53 | Excellent |
| 4. Easy to handle/manageable to use | 4.70 | 0.48 | Excellent |
| Mean | 4.55 | 0.51 | Excellent |
| Instructional Applicability Indicators | | | |
| 1. Provide hands-on exercises for skills development | 4.70 | 0.67 | Excellent |
| 2. Enhance and upgrade student's knowledge | 4.50 | 0.71 | Excellent |
| 3. Provide exercise that instills desirable habits and values for work | 4.40 | 0.52 | Excellent |
| Mean | 4.53 | 0.63 | Excellent |
| Aesthetic Value Indicators | | | |
| 1. The attractiveness and overall appearance of the design | 4.30 | 0.67 | Excellent |

| | | | |
|---|-------------|-------------|------------------|
| 2. Appropriateness of the size of electrical and electronic components, and the trainer | 4.40 | 0.84 | Excellent |
| 3. The harmonious arrangement of components | 4.40 | 0.52 | Excellent |
| The neatness of the product | 4.70 | 0.48 | Excellent |
| Mean | 4.45 | 0.63 | Excellent |
| Durability Indicators | | | |
| 1. Quality of materials used | 4.40 | 0.52 | Excellent |
| 2. Quality of workmanship | 4.50 | 0.71 | Excellent |
| 3. Can stand for rugged use | 4.20 | 0.63 | Excellent |
| Mean | 4.37 | 0.62 | Excellent |
| Safety Indicators | | | |
| 1. Safe to use for hands-on exercises/ activities | 4.60 | 0.70 | Excellent |
| 2. No damages/defects observed | 4.50 | 0.53 | Excellent |
| 3. Components are properly installed | 4.40 | 0.52 | Excellent |
| Mounting of electrical and electronic accessories is secured | 4.90 | 0.32 | Excellent |
| Mean | 4.60 | 0.51 | Excellent |

The trainer's acceptability in terms of functionality, instructional applicability, aesthetic value, durability, and safety also received excellent ratings. It functions effectively even after repeated use and can be operated with either direct or alternating current. Since it is adaptable to different types of circuits—series, parallel, or series-parallel—the electric circuit trainer proves to be highly effective for hands-on exercises.

In addition, the trainer's durability makes it well-suited for classroom demonstrations and group activities that encourage collaborative learning. In terms of appearance, it is generally considered attractive and neat. Beyond design and functionality, the electric circuit trainer is also safe to use, particularly during hands-on activities and practical exercises.

Table 4: Pretest and posttest scores of the control and experimental group

| Control Group | | | Experimental Group | | | | | |
|-----------------|-------|------|---------------------------|--|--|-------|------|---------------------------|
| Scores | Means | SD | Verbal Description | | | Means | SD | Verbal Description |
| Pretest | 66.60 | 2.02 | Did not meet expectations | | | 66.68 | 2.35 | Did not meet expectations |
| Posttest | 69.36 | 4.78 | Did not meet expectations | | | 75.50 | 7.01 | Fairly satisfactory |

Table 4 illustrates the pretest and posttest scores of the control and experimental group. The mean value in the pretest implies that the accumulated scores in the pretest did not meet expectations for both groups, while the mean value in the posttest scores of the experimental group is fairly satisfactory. Although the result is not that overwhelming, the outcome is quite positive, and that is already an achievement considering that teaching and learning technical-related subjects, such as the basic concept of electricity, are very challenging.

Table 5: Results of the t-test analysis between the pretest and posttest scores of the control group

| Scores | Mean | SD | df | t-stat | p-value |
|-----------------|-------|------|----|--------|---------|
| Pretest | 66.60 | 2.02 | 41 | 4.3455 | 0.0001 |
| Posttest | 69.36 | 4.78 | | | |

Moreover, Table 5 shows the results of the t-test analysis between the pretest and posttest scores of the control group. The finding reveals that since the computed t-value of 4.3455 is greater than the critical t-value of 2.0195 at the 0.05 level

of significance. With a two-tailed with 41 degrees of freedom, the null hypothesis is rejected. Since the p-value of 0.0001 is less than the 0.5 level of significance, it implies that statistically there is a significant difference in the result of the pretest and posttest in the control group.

The results indicated that even though the traditional method of teaching is applied in the control group, learning still occurs. Again, as pointed out in the study of Raja (2018), there's nothing wrong with the traditional didactic lecture, but relying on it is the problem. Indeed, it is a fact, but it is also undeniable that in a learning environment where learning resources are limited and a lack of learning materials is prominent, conventional methods of teaching still become the best option.

On the other hand, the result of the analysis between the pretest and posttest scores of the experimental group using a t-test for the dependent sample is presented in Table 6 below.

Table 6: Results of the t-test analysis between the pretest and posttest scores of the experimental group

| Scores | Mean | SD | df | t-stat | p-value |
|----------|-------|------|----|--------|---------|
| Pretest | 66.68 | 2.35 | 39 | 9.1354 | 0.0000 |
| Posttest | 75.50 | 7.01 | | | |

According to the findings, the experimental group's mean gains on the pretest and posttest are 66.68 and 75.50, respectively. The null hypothesis is implied to be rejected since the calculated t-value, 9.1354, is higher than the crucial t-value, 2.0227 at the 0.05 level of significance, two-tailed, with 39 degrees of freedom. Additionally, the results show that the experimental group's pretest and posttest scores are very significant because the p-value of 0.0000 is below the 0.05 threshold value.

The analysis of the mean gain scores of the experimental and control groups using the t-test for two sample tests of significance is displayed in Table 7. The experimental group's mean gain score is 8.83, while the control group's is 2.76, as the table illustrates. The experimental group had a standard deviation of 6.11, whereas the control group's was 4.12. The degree of freedom between the control group and the experimental group is 80. The computed t-value between the mean gain scores of the control group and experimental group is 5.2921, which resulted in the calculation of the p-value of 0.0000.

Table 7: Results of the t-test analysis between the mean gain scores of the control group and experimental group

| Group | Mean | SD | df | t-stat | p-value |
|--------------|------|------|----|--------|---------|
| Control | 2.76 | 4.12 | 80 | 5.2921 | 0.0000 |
| Experimental | 8.83 | 6.11 | | | |

Based on the results, the null hypothesis is rejected since the calculated t-value of 5.2921 is higher than the crucial t-value of 1.9901 at the 0.05 level of significance, two-tailed with 80 degrees of freedom. Additionally, the result indicates that there is a significant difference between the mean gain scores of the experimental group and the control group, given that the computed p-value is less than the significance level of 0.05.

5. DISCUSSION

This purpose of this study was to test the effectiveness of an electric circuit trainer to enhance students' understanding of electricity. Based on the result of the posttest of both experimental and control groups, it is observable that the scores of most of the students increased. The accumulated standard deviation for the posttest increases, which implies that the scores of the students in the posttest are more scattered compared to their scores in the pretest.

Since the teacher relied on the traditional method of teaching the concept of electricity for the control group, even if it was tackled multiple times considering its abstract nature and profound concept, it limits the students from understanding the concept of electricity. Raja (2018) clarified that there's nothing wrong with the traditional method of teaching; relying on it is the problem considering that not all the lessons can be done through classroom discussion. There are instances that actual demonstration and hands-on activities are needed for the students to understand the idea behind the concept of electricity.

Also, students with high ratings on the pretest tend to have a high score on the posttest, similar to the study of Dong et al. al. (2020). It was emphasized that if students have more prior knowledge, they tend to have a better level of learning engagement compared to those with less prior knowledge. This is important considering that prior knowledge and skills

are used and applied to learn new contexts or to solve new problems. It is not surprising that the students who rarely attend their class accumulated a low score in the posttest because their prior knowledge is not supplemented and updated with new information, which is so relevant for them to understand and solve a new problem. In a similar result, Chernikova et al. (2020) revealed that learning was improved using technology and scaffolding. Reflection phases were more beneficial to students with higher prior knowledge, while examples helped those with lower prior knowledge learn more effectively (Chernikova et al., 2020). This claim was also pointed out by Hailikari et al. al. (2008), which takes into account the importance of prior knowledge and its impact on students' learning performance. For the students to understand the new information given, they must be able to connect their new information with their past experiences and acquired knowledge.

Aside from the student's level of intelligence, another factor that affects students' learning performance is their views toward learning. Although a student's commitment to learning is a product of so many factors like socioeconomic status, student temperament and motivation, peer and parental support, and the learning environment (Godson & Ngusa, 2020), it is noticeable that the students regularly attending their class perform better compared to those who are always absent, and it reflects on the result of their work. The result of their performance, like their scores in the posttest, affected the mean gain of the entire class in both the experimental group and control group. This signified that a student's engagement in learning is very crucial for academic progress.

A significant difference was also found by the T-test analysis between the experimental group's and control group's pretest and posttest scores. When compared to the students in the control group, the experimental group's performance was superior. It is also observed that the scores of the low-performing students can affect the mean gain scores of the entire class. Students' engagement with learning is very crucial for academic progress. That's the reason why learning resources and learning materials like the electric circuit trainer are needed for the teaching and learning process to be more engaging. The result implies the educational effectiveness of an electric circuit trainer in enhancing students' learning of basic electricity. As indicated in the study of Akomolafe and Adesua (2016), the effective utilization of school physical facilities and the availability of learning resources, such as an electric circuit trainer, play a significant role in enhancing students' academic performance.

Moreover, the mean gain results show a significant difference, which implies the effectiveness of the electric circuit trainer in instruction to enhance students' learning in basic electricity. Similarly, the findings of the study of Che Kob et al. al. (2019) revealed that the use of instructional material has a beneficial effect on learning about a particular topic, like the series circuit and parallel circuit. Also, Frimpong (2021) emphasized that having adequate and appropriate teaching and learning resources reduces teachers' tasks to provide detailed explanations of concepts that the learning materials can provide visually and eventually enhance students' learning performance. Similarly, a study noted the electrical circuit kit's efficacy test as the trainer's percentage increased by 91%. Therefore, job sheets and trainers are very well categorized to be utilized to learn practical subjects related to basic electrical and electronics concepts (Hamid et al., 2020).

Using an electric circuit trainer, the teacher could facilitate hands-on activities that encourage students' active participation, not just to help students understand the course better but also to develop their confidence (Mekonnen, 2020). In addition, the use of an electric circuit trainer allowed the students to apply what they had learned to enhance their knowledge and understanding of the basic concepts of electricity.

6. CONCLUSION

Learning materials and other educational resources, such as simulators or electric kits/trainers, are crucial because they serve as instructional aids, particularly in explaining complex concepts like electricity. This study was conducted to test the effectiveness of an electric circuit trainer in enhancing students' understanding of electricity. The results revealed that the electric circuit trainer is effective and appropriate for improving students' learning of basic electricity and for developing skills when used properly.

The electric circuit trainer is relevant for a hands-on learning approach for the students to learn the real-life application of basic electricity concepts. By using such a trainer, students will be able to expand their learning beyond the classroom by gaining essential insights about the realities of electrical phenomena that cannot be conveyed through theoretical knowledge alone. Teachers, therefore, should integrate the use of the trainer with strategies anchored in empirical research, such as the application of problem-based learning or project-based learning.

Since the study focused on the basic concepts of electricity, it is suggested that an upgraded version of the electric circuit trainer be developed to cover more complex and advanced circuitry for students in higher grade levels. It is further recommended that the electric circuit trainer be used not only in Technology and Livelihood Education, particularly in Electrical Installation and Maintenance, but also in other learning areas with electricity-related topics. When used in combination with learning modules, the electric circuit trainer can be even more effective. Therefore, similar trainers should also be developed not only for electrical technology but also for other technical learning areas, integrated with diverse teaching strategies and approaches.

Lastly, future researchers could explore the integration of artificial intelligence, such as Chatbots, for students to learn about simulations or trainers to enhance learning about circuits, offer real-time feedback and clarifications, and serve as

a virtual helper for inquiries in accordance with ethical and safety standards. Exploring the integration of AI may improve the effectiveness, accessibility, and engagement of students in studying electricity.

REFERENCES

1. Aguiar-Castillo, L., Clavijo-Rodriguez, A., Hernández-López, L., De Saa-Pérez, P., & Pérez-Jiménez, R. (2021). Gamification and deep learning approaches in higher education. *Journal of Hospitality, Leisure, Sport & Tourism Education*, 29, 100290. <https://doi.org/10.1016/j.jhlste.2020.100290>
2. Aligo, B. L., Branzuela, R. L., Faraon, C. A. G., Gardon, J. D., & Orleans, A. V. (2021). Teaching and learning electricity: A study on students' and science teachers' common misconceptions. *Manila Journal of Science*, 14, 22–34. <https://www.dlsu.edu.ph/wp-content/uploads/pdf/research/journals/mjs/vol14/14-3-2021-gardon-et-al.pdf>
3. Akomolafe, C. O., & Adesua, V. O. (2016). The impact of physical facilities on students' level of motivation and academic performance in senior secondary schools in Southwest Nigeria. *Journal of Education and Practice*, 7(4), 38–42. <http://files.eric.ed.gov>
4. Arabasi, S. (2018). Educational approach to the wye–delta transformations using simple circuit analysis techniques. *International Journal of Electrical Engineering Education*, 55(3), 234–243. <https://doi.org/10.1177/0020720918767048>
5. Assem, H. D., Nartey, L., Appiah, E., & Aidoo, J. K. (2023). A review of students' academic performance in physics: Attitude, instructional methods, misconceptions and teachers' qualification. *European Journal of Education and Pedagogy*, 4(1), 84–92. <https://www.ej-edu.org/index.php/ejedu/article/view/551>
6. Che Kob, C. G., Abdullah, A. S., Norizan, N. A. A., & Shamsuddin, H. (2019). Effects of learning aid (kit) on student performance for electric circuits topics. *International Journal of Academic Research in Business and Social Sciences*, 9(1), 320–330. <http://hrmars.com/index.php/pages/detail/IJARBS5>
7. Chernikova, O., Heitzmann, N., Fink, M. C., Timothy, V., Seidel, T., & Fischer, F. (2019). Facilitating diagnostic competences in higher education: A meta-analysis in medical and teacher education. *Educational Psychology Review*, 32(1), 157–196. <https://doi.org/10.1007/s10648-019-09492-2>
8. Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. (2020). Simulation-based learning in higher education: A meta-analysis. *Review of Educational Research*, 90(4), 499–541. <https://doi.org/10.3102/0034654320933544>
9. Cook, D. A., Brydges, R., Zendejas, B., Hamstra, S. J., & Hatala, R. (2013). Technology-enhanced simulation to assess health professionals: A systematic review of validity evidence, research methods, and reporting quality. *Academic Medicine*, 88(6), 872–883. <https://doi.org/10.1097/ACM.0b013e31828ffdcf>
10. Dong, A., Jong, M. S., & King, R. B. (2020). How does prior knowledge influence learning engagement? The mediating roles of cognitive load and help-seeking. *Frontiers in Psychology*, 11, 591203. <https://doi.org/10.3389/fpsyg.2020.591203>
11. Frimpong, S. O. (2021). The role of teaching and learning materials and interaction as a tool to quality early childhood education in Agona East District of the Central Region of Ghana. *African Educational Research Journal*, 9(1), 168–178. <https://doi.org/10.30918/AERJ.91.20.112>
12. Godson, F., & Ngusa, B. M. (2020). Effect of school environment on student commitment towards learning among secondary schools in Moduli District, Tanzania. *East Africa Journal of Education and Social Science*, 3, 60–67. <https://doi.org/10.46606/eajess2020v01i03.0043>
13. Hailikari, T., Katajavuori, N., & Lindblom-Ylänne, S. (2008). The relevance of prior knowledge in learning and instructional design. *American Journal of Pharmaceutical Education*, 72(5), 113. <https://doi.org/10.5688/aj7205113>
14. Hamid, M. A., Permata, E., Aribowo, D., Darmawan, I. A., Nurtanto, M., & Laraswati, S. (2020). Development of cooperative learning-based electric circuit kit trainer for basic electrical and electronics practice. *Journal of Physics: Conference Series*, 1456(1), 012047. <https://doi.org/10.1088/1742-6596/1456/1/012047>
15. Igiri, C. E., & Effiong, O. E. (2015). Impact of instructional materials in teaching and learning of biology in senior secondary schools in Yakurr LGA. *International Letters of Social and Humanistic Sciences*, 62, 27–33. <https://doi.org/10.18052/www.scipress.com/ILSHS.62.27>
16. Lumanta, A. R. C. (2019). *Development and evaluation of basic electrical and electronics circuit trainer* [Unpublished thesis].
17. Mekonnen, F. D. (2020). Evaluating the effectiveness of 'learning by doing' teaching strategy in a research methodology course, Hargeisa, Somaliland. *African Educational Research Journal*, 8(1), 13–19. <https://files.eric.ed.gov/fulltext/EJ1242694.pdf>
18. Raja, F. U. (2018). Comparing traditional teaching method and experiential teaching method using experimental research. *Journal of Education and Educational Development*, 5(2), 276–288. <https://files.eric.ed.gov/fulltext/EJ1200262.pdf>
19. Yakkou, H., Chillali, A., & El Kadri Elyamani, N. E. (2024). The effect of using simulator “evolution of electrical systems” in electricity lessons on students' motivation and academic performance. *Heliyon*, 10(15),

e34770. <https://doi.org/10.1016/j.heliyon.2024.e34770>

