PANTAO
International Journal of the Humanities and Social Sciences
ISSN 3028-0877
Volume 4, Issue 2 (2025)

Design and fabrication of automotive lighting mock-up: An interactive approach to electricity systems for TVL automotive learners

Merwin N. Galad
College of Education
Benguet State University Bokod Campus
Bokod, Benguet
Email: catgenerals@gmail.com

Abstract: This study aims to design, fabricate, and evaluate an interactive automotive lighting mock-up to visualize current flow, enhancing the understanding of electricity systems for Grade 11 and Grade 12 TVL automotive learners. The research addresses the challenge of teaching abstract electrical concepts in automotive education by providing a tangible and interactive tool. The mock-up incorporates light-emitting diodes (LEDs) and traditional automotive bulbs to demonstrate current flow through various lighting circuits, including headlights, park/tail lights, directional lights, hazard lights, brake lights, and reverse lights.The methodology involves the design and construction of the mock-up using common automotive electrical components, followed by its implementation in selected TVL automotive classes. The effectiveness of the mock-up is assessed through a comparative study between traditional teaching methods and the newly developed tool. Data collected from learners' performance and feedback are analyzed using statistical tools, specifically a paired sample t-test, to determine the impact on their understanding and practical skills.Results indicate that the interactive mock-up significantly enhances learners' comprehension of electrical systems and their ability to troubleshoot and connect automotive lighting circuits. This improvement is attributed to the visual and hands-on nature of the mock-up, which bridges the gap between theoretical knowledge and practical application. The study concludes that visualizing current flow through interactive tools.

Keywords: automotive lighting systems, interactive mock-up, tvl automotive education, electrical systems comprehension, hands-on learning tool

Date Submitted: May 20, 2025
Date Accepted: June 2, 2025
Date Published: June 18, 2025

INTRODUCTION

Electricity is a fundamental and pervasive form of energy that plays a crucial role in modern society. It is a phenomenon associated with the presence and flow of electric charge. Electricity can be dated back in the ancient time when the Greeks discovered that rubbing certain materials, like amber, against animal fur would result in an attraction between the materials and small particles. This was an early form of static electricity. In 19th century, scientist such as Hans Christian Oersted and Michael Faraday conducted experiments that demonstrated the interrelation between electric currents and magnetic fields. Faraday's work laid the foundation for understanding electromagnetic induction, which is the basis for generating electric currents using magnetic fields. As time goes on electricity continuously revolutionized the lives of every individual. Electricity is introduced to almost every things that we see and touch and it continuously revolutionized our everyday lives.

Early automobiles were powered by internal combustion engines, which generates mechanical power to move the vehicle. In the early 20th century, electrical system began to make their way into automobiles. Electricity is used to crank the engine to charge batteries, to operate accessories and to give lights for illumination during dark times.

Electricity is one of the most exciting elements to play but if you hardly understand how electricity works in a circuit, you cannot appreciate or you will develop laziness in learning it due to the fact that the flow of electricity is invisible to the human eye. Some people may find difficulties in learning electricity because it cannot be seen, only the result of electricity can be seen, it has to be detected and measured and the test result have to be interpreted (James D. Halderman, 2016). Visualization of electrical currents reveals the magic behind the science." - Nikola Tesla. This words of one of the famous scientists shows that with proper visualization of electric current, you can solve the problem behind it. Many students at the high school level may need more knowledge and understanding of the complex electrical systems in automobiles. Common instructional tools used in automotive electricity in our locality uses electrical mock-ups to address the learners need to understand how current works in different lighting circuits found in automobiles. With the most abstract concept of electricity, it is observed that learners in automotive technology hardly understand how current works in a automotive lighting system. This research can address this problem by providing a visual and interactive tool that helps students comprehend the current flow and its implications in automotive lighting systems. Students often need help to connect theoretical concepts learned in the classroom to practical applications. Visualization not only aid in conceptual understanding but also contribute to problem-solving skills and the development of higher-order cognitive processes. Visualization can provide a bridge between theoretical concepts and real-world applications, helping students see the practical relevance of electricity (Ahmed Y. Al-Ammari, Abdul R. Omar, and Azlina Mohd Kosnin, 2013).

Many learners in automotive know the functions, the uses of the different lights in an automotive but when it comes to trouble shooting and connections of this lights, the learners become skills less. By using mock-ups, diagrams, animations, charts and other tools to visualize current flow, this research can further enable students to see how current flows through different components of lights in automobile (George Nikolaidis 2018) . Students may need more hands-on experiences and experimentation opportunities due to limited access to existing automotive systems. Using visualization tools can provide a practical and engaging learning experience that allows students to manipulate and observe current flow in a controlled environment. This research also aims to develop not only the visual capacity of the learners but also the learner’s skill when it comes to trouble shooting troubles on automotive lights, with the knowledge of how currents flows in the different circuit, the learners can easily conduct a quick but reliable trouble shooting attitude to solve the problem. The learners may also use this as an assessment for career exploration in the future, especially those who pursue vocational skill.

David Hestenes (1980s) emphasize on the use of diagrams, models, and simulations has had a lasting impact on education. Also visualization of learning something that cannot be seen has a great impact in understanding the concepts of what we intended to learn (Nikolaidis, Nitsas, and lliou, 2018).

This research also aims to solve the problem such as limited access to practical learning experiences. Students often lack opportunities to directly engage with automotive electrical systems, hindering their ability to grasp the complexities of current flow. By creating mock-ups and visualizations, this research offers students a tangible and accessible way to explore current flow and its implications in a controlled environment. Another one is difficulty in relating theory to practice. Understanding the theoretical concepts of current flow is often challenging for learners when they cannot visualize or apply them in real-world scenarios. Through interactive mock-ups and visual representations, this research aims to connect abstract theories to practical applications, facilitating a deeper understanding of electrical systems. Another is lack of engagement in automotive electrical subjects. Students may perceive automotive electrical subjects, as challenging and disengaging. By introducing an interactive and visually stimulating approach, this research seeks to generate excitement, foster curiosity, and increase student engagement in learning about current flow and its significance in the automotive context.

Existing automotive electrical wiring mock up are commonly used in the schools that offers automotive technology uses common electrical conductors to educate learners. Though students still enhance their skill in automotive lighting system, they often face difficulties in understanding abstract electrical concepts due to their intangible nature. Cruz (2012) explained that instructional materials are specific items in a lesson and delivered through various media formats such as video, audio, print, improved devices and so on. It is a channel of communication that carry messages with an enhanced instructional purpose. Also Babalcon (2015) reiterated that concerns about instructional modifications inspire faculty researchers to get ready with instructional materials, teacher–made tools and gadgets as well as technology- laden learning approaches to enable K to 12 graduates who may pursue courses in college to acquire lifelong learning skills that will make them better prepared for job opportunities for self-employment (p.61) Thus this study aims to innovate instructional tools that can provide more tangible nature of understanding electricity. The developed instructional tool can be used in secondary schools found in the municipalities of Benguet that offers automotive technology track.

Problem Statement

The general objective of the study is to fabricate and assess the effectiveness of an interactive automotive lighting mock-up that enables the visualization of current flow, aiming to enhance the understanding of electricity systems among Grade 11 and Grade 12 TVL (Technical-Vocational-Livelihood) automotive learners. Specifically, the study aims to:

1. Design a mock-up sketch for visualizing current flow.
2. Fabricate the visualizing current flow mock-up using portable tools.
3. Implement the interactive mock-up in selected Grade 11 and Grade 12 TVL automotive classes as a supplementary teaching tool for electricity systems.
4. Assess the effectiveness of the designed mock-up by comparing learners' performance using the traditional mock-up with those using the modified mock-up.

Conceptual framework

The conceptualization of the study was based on the observation in the Grade 11 and Grade 12 TVL automotive learners. Current practice when it comes to automotive electrical system area is theory to application. In the application area, most of the learners often burn fuses, wires, switches because they just connect the wire connections because of limited view on how current flow in the different circuit. This also leads to more time, more money, and more effort just to comply with the ongoing learning activity. This leads to the conceptualization of the study.

Since technical vocational livelihood learners are involve in this study, they are included in the input process. Automotive learners participation in this study is crucial because their performance will be the key factor in assessing the effectiveness of the product. This also includes Technical Educational Skill Development Authority (TESDA) training regulations and Techno-Olympic guidelines because the evaluation process is based on the guidelines of the two institution. Mock-up are also included as this is the base of this study. During the process, designing, fabrication and testing is carefully observed to be able to come out with a good output. After the product was implemented on the expected participants, data were collected and recorded and statistical tool is used in analyzing and interpreting the results. The outcome of the study is a modified visualizing current flow mock-up. A tool used as a supplementary instructional tool in automotive technical vocational livelihood program offered in the secondary education especially in learning automotive electricity lighting system.

METHODOLOGY

Research design

The research design used in this study is the Experimental research design . Experimental research design (Fisher 1935) is valued for its ability to establish cause-and-effect relationships and contribute to scientific knowledge by providing empirical evidence to support theoretical propositions or practical interventions. Experimental research aims to establish a cause-and-effect relationship between variables. It seeks to determine whether changes in one variable cause changes in another variable. Experimental also involves quantitative data to determine the effect of the study to provide a specific idea if the desired objective is acceptable or not to establish a clear recommendation or philosophy.

This method can be based on Francis Bacon's (1620) philosophy of empiricism. Empiricism is a philosophical doctrine that emphasizes the role of sensory experience in the formation of knowledge. According to empiricists, knowledge primarily comes from sensory experiences rather than innate ideas or pure reason. Through this students will used their sensory skills to manipulate the designed mock up to provide a concrete feedback as basis to see if the learners performance can support the desired objective.

In this study, experimental design was used because we are dealing with a control group and experimental group. The traditional mock-up is the control group because this serves as the base line of the study. The experimental group would be the modified mock-up because of the new interventions being tested. In order to assess the effectiveness of the modified mock-up compared to the traditional one, controlled variables such as instruction, content, administrator, track of learners involved and the environment must be control to avoid bias during the session. Such in this case, the same instruction were given to all participants and the content of the assessment is purely about automotive electrical system. Even the diagram used on the evaluation are all identical. The administrator who conducted the assessment is also the same for both traditional and the modified. Also, the environment for both the traditional and the modified is set to a place where possible outside disturbance are controlled to avoid any interference during the session. Secondary automotive learners are the only qualified participants regardless of gender and motivation.

Respondents of the study

The participants include the school heads, teachers, learners and other stake holder involved.

Selection and Description of Respondents

Participants are selected through the principle of purposive sampling (Lohr, 2010; Creswell 4th, 2014). This indicates that participants must be a technical vocational and livelihood secondary student major in automotive technology. This also one reason why the designed mock-up is intended for the enhancement of learners ability to grasp electrical information on secondary TVL automotive learners. This is applicable on selecting participants for both traditional and the designed mock-up.

Data Gathering Procedure

The data was collected after the approval of the committee involved in this study. Upon approval of the study, letters and consent was given to the concerned individuals especially the automotive learners which are the source of the data collected. Letter was sent to the school as prospect of conducting the study. This includes the school heads, teachers, learners and other stake holder involved. Diagram activity (appendix F page 44) was made to assess the performance of the learners during the conduct of the study. The diagram is a incomplete diagram where participants will be the one to fill the needed information by connecting the electrical terminal to its proper connection. Their output will be scored as basis of evaluating the product. Data are recorded, analyzed, evaluated to assess the effectiveness of the proposed mock-up in the improvement and easier teaching of electrical concept on automotive electrical lighting system for grade 11 and grade 12 learners.

Participants are selected through the principle of purposive sampling (Lohr, 2010; Creswell 4th, 2014). This indicates that participants must be a technical vocational and livelihood secondary student major in automotive technology. This also one reason why the designed mock-up is intended for the enhancement of learners ability to grasp electrical information on secondary TVL automotive learners. This is applicable on selecting participants for both traditional and the designed mock-up.

Data Analysis Procedure

In this study, only objective 3 and objective 4 needs a data which are analyzed using statistical tools. In the case of objective number 3, scores of automotive learners were recorded and analyzed with the formula of getting the mean of the learners scores. This means that if learners score were added and divided into the number of participants and if the mean is equal or higher to the passing mark, this indicates that with the use of the designed mock-up learners skill on automotive electrical system are enhanced. Data for objective number 3 can be viewed in the appendix G on page 45. Mean = Sum of participants scores divided by the total number of participants. Diagram activity (appendix F) is scored based on the Technical Education and Skills Development Authority training regulation under the core competencies (ALT723305 Test and Repair Wiring/Lighting System).

Objective number 4 data was treated using the paired t-test. The data gathered was interpreted based on the idea that by comparing two sets of scores you can identify which is better and this is rooted in statistical hypothesis testing, particularly the use of paired sample t-tests. One notable figure in the development of modern statistical methods, including hypothesis testing, is Sir Ronald A. Fisher. Fisher's contributions laid the groundwork for many statistical techniques used today, including methods for comparing means.

In comparing the data between the performance of learners from the traditional mock up and the modified mock up, a paired sample t-test was used considering the reason that the study compares two group of participants (traditional mock up and modified mock up), both groups came from the same group but have two different situation.

DISCUSSION OF FINDINGS

Designed Visualizing Current Flow Mock-up Sketch Plan

The following figure shows the result of the designed visualizing current flow mock-up. The figure shows the top view of the designed visualizing current flow mock up, this also includes the legend in order for the drawing to be able to have more clarity in reading the lines of the sketch.

Fabrication of the visualizing current flow mock-up

The fabrication of the interactive automotive lighting mock-up involved a systematic and well-planned process using standard automotive and electrical tools. The process began with cutting materials such as tubular bars and trim components according to specific measurements. This was followed by the assembly of the frame, which involved welding the materials into their designated angles and positions. Boring holes was the next step to accommodate fasteners for securing various components. Once the structural foundation was prepared, the attachment of different components—such as lighting elements—was carried out using bolts and tie wires.

The circuit connections were then established using electrical wires and flexible boards embedded with LEDs, allowing current flow through the various lighting circuits. After wiring, insulation of open connections was completed using electrical tape to prevent short circuits and ensure safety.

Throughout the fabrication process, careful planning and precision were essential to prevent misalignment, errors, and damage to components or tools. This methodical approach reflects the principles of Henry Lawrence Gantt, whose emphasis on structured planning and project scheduling—embodied in the Gantt Chart—underscores the importance of time management and task coordination in engineering and production workflows.

Implementation of the interactive mock-up in TVL automotive classes

The implementation of the interactive current flow mock-up in senior high school automotive classes significantly enhanced students' comprehension of electrical systems. Designed as a visual and hands-on learning tool, the mock-up encouraged active student participation regardless of age or gender. Learners demonstrated increased engagement by manipulating circuit components—such as removing fuses, detaching relays, and disconnecting ground lines—to observe the real-time behavior of LED indicators. This experiential approach deepened their conceptual understanding of current flow in automotive lighting circuits.

Performance data reinforced the tool's instructional effectiveness. Students who interacted with the mock-up consistently outperformed their peers taught through conventional methods. With a computed mean score of 51.7 out of a possible 60, participants achieved 86.2% of the total score, indicating a high level of mastery in electrical diagramming and application tasks. These findings align with the conclusions of Hattie and Yates (2013), who assert that visual learning tools enhance student motivation and engagement by making abstract concepts tangible and observable. In conclusion, the current flow mock-up not only served as a powerful visual aid but also proved to be a practical, learner-centered tool that bridges theoretical knowledge and real-world application in automotive electricity education.

Learners' performance using the traditional mock-up and the modified mock-up

The results of the study demonstrate that the designed interactive mock-up, which features a flexible circuit board embedded with light-emitting diodes (LEDs) to visualize current flow, significantly improves learners' understanding and performance in automotive electrical concepts compared to the traditional mock-up. Learners' outputs were evaluated based on the Techno-

Olympics rubrics for automotive servicing and TESDA's Automotive Electrical Assembly NC II Training Regulation, ensuring standardized and competency-based assessment.

A paired sample t-test was conducted using three separate trials with five automotive learners to compare their performance under both mock-up conditions. In Trial 1, the mean performance using the traditional mock-up was 40.00 (SD = 7.906), while the mean for the designed mock-up was 52.00 (SD = 5.701), showing a statistically significant improvement ($t(4) = -3.539, p = 0.024$). Trial 2 showed an even more substantial improvement, with learners scoring a mean of 31.00 (SD = 8.944) using the traditional tool and 53.00 (SD = 8.367) with the designed mock-up ($t(4) = -5.880, p = 0.004$). Trial 3 further supported these results, with a traditional mock-up mean of 28.60 (SD = 8.649) and a modified mock-up mean of 50.00 (SD = 6.124), again showing statistically significant difference ($t(4) = -4.327, p = 0.012$).

Across all trials, the designed mock-up consistently yielded mean score differences between 12 and 22 points higher than the traditional approach. These results confirm that the LED-based visualization of current flow not only engages students more deeply but also leads to a significant enhancement in conceptual understanding and practical skills.

These findings are in line with Altman (1990) and Newcombe (1998), who emphasized the paired t-test's role in evaluating significant differences between conditions applied to the same subjects. Furthermore, the study supports research by Peppler and Kafai, which highlights the value of tangible, interactive tools in technical education. By offering students an observable, hands-on experience with electricity in automotive systems, the designed mock-up bridges the gap between abstract theory and applied knowledge, ultimately enhancing learning outcomes in technical-vocational education.

CONCLUSION

The visualizing current flow mock-up is an innovative educational tool designed to enhance automotive students' understanding of electrical concepts by allowing them to observe current behavior in real time. Its primary feature is the integration of a flexible circuit board populated with color-coded light-emitting diodes (LEDs) that illuminate along current pathways to represent the flow of electricity. Each LED color corresponds to a specific automotive lighting circuit: blue for headlights, multi-color for park/tail lights, green for hazard and flasher lights, red for brake lights, and white for reverse lights. These circuits were the specific focus of this study.

The mock-up measures 48 inches in height, 43 inches in length, and 23 inches in width, and is mounted on a welded tubular steel frame for durability. Beyond the visual LED indicators, authentic automotive electrical components are incorporated to simulate realistic hands-on applications, giving learners exposure to actual tools and devices used in the field. The blinking of LEDs represents active current flow, effectively transforming abstract electrical theory into observable phenomena.

Comparative analysis conducted over three experimental trials consistently showed that students using the visualizing current flow mock-up outperformed those using traditional mock-ups. Statistical results revealed significantly higher mean scores among learners engaged with the designed tool, underscoring its pedagogical effectiveness. These findings, supported by Tables 1, 2, and 3 in the study (pp. 26–28), demonstrate that the mock-up is a more impactful and engaging educational resource for teaching automotive lighting systems than conventional methods.

In conclusion, the study affirms that the visualizing current flow mock-up bridges the gap between theory and practice, making it a powerful tool for improving technical skills and conceptual understanding in senior high school automotive education.

REFERENCES

Alias, N. A., & Hashim, S. (2011). Design and Development research in instructional technology. In *IGI Global eBooks* (pp. 1–23). https://doi.org/10.4018/978-1-61350-198-6.ch001

Baddeley, A. (1992). Working Memory: The Interface between Memory and Cognition. *Journal of Cognitive Neuroscience*, *4*(3), 281–288. https://doi.org/10.1162/jocn.1992.4.3.281

Bonnick, A., & Newbold, D. (2011). A practical approach to motor vehicle engineering and maintenance. In *Routledge eBooks*. https://doi.org/10.4324/9780080969992

Brown, J. (2004). Visual learning in science and engineering. *Computer Graphics*, *38*(4), 22–23. https://doi.org/10.1145/1039140.1039153

Cataraja, G., & Cataraja, R. (2022). Evaluation of the performance of the Technical Education and Skills Development Authority (TESDA) training institutions in Region VIII. *East Asian Journal of Multidisciplinary Research*, *1*(6), 947–960. https://doi.org/10.55927/eajmr.v1i6.695

Chu, J., Rittle-Johnson, B., & Fyfe, E. R. (2017). Diagrams benefit symbolic problem-solving. *British Journal of Educational Psychology*, *87*(2), 273–287. https://doi.org/10.1111/bjep.12149
Comia, A. C., & Aquino, J. M. (2023). TECHNICAL AND VOCATIONAL INSTITUTIONS TRAINING REGULATION COURSE AREAS ASSESSMENT AND CAREER PERFORMANCE OF CAREGIVING GRADUATES IN LAGUNA ACCREDITED TRAINING CENTER. *Education, Sustainability and Society*, *6*(2), 76–81. https://doi.org/10.26480/ess.02.2023.76.81

Denton, T. (2006). Advanced Automotive Fault Diagnosis. In *Routledge eBooks*. https://doi.org/10.4324/9780080462585

Denton, T. (2007b). Automobile electrical and electronic systems. In *Routledge eBooks*. https://doi.org/10.4324/9780080492490

Denton, T. (2013). Automobile electrical and electronic systems. In *Routledge eBooks*. https://doi.org/10.4324/9780080969435

Deulin, B. (2023). Increasing dependence of modern society on electricity. *Abyss (Voprosy Filosofii, Politologii I Social'noj Antropologii)*, *1*, 116–123. https://doi.org/10.33979/2587-7534-2023-1-116-123

Duleme, M., Perrey, S., Dray, G., & Tena-Chollet, F. (2018). Combining
Effective teaching and learning. (2013). In *Routledge eBooks* (pp. 26–43). https://doi.org/10.4324/9780203062241-7

Ehsani, M., Gao, Y., Gay, S. E., & Emadi, A. (2004). Modern electric, hybrid electric, and fuel cell vehicles. In *CRC Press eBooks*. https://doi.org/10.1201/9781420037739
Electric circuits. (2005). *Van Nostrand's Scientific Encyclopedia*. https://doi.org/10.1002/0471743984.vse2833
electrophysiological metrics in assessing changes in working memory load. *Frontiers in Human Neuroscience*, *12*. https://doi.org/10.3389/conf.fnhum.2018.227.00066

Forrester, R. (2016). *History of electricity*. https://www.semanticscholar.org/paper/History-of-Electricity-Forrester/e18968c080eb2a7a72899dba00bd62002cf8646b

Greig, J. (1949). Electrical engineers' handbook. *Nature*, *164*(4175), 765. https://doi.org/10.1038/164765a0

Han, H. D., & Toh, T. L. (2019). Use of animation to facilitate students in acquiring problem-solving: From Theory to Practice. *the Montana Math Enthusiast*, *16*(1–3), 377–388. https://doi.org/10.54870/1551-3440.1464

Kazmierkowski, M. (2010). Electric power systems (review of "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition ; Ehsani, Y.G. and Emadi, A.; 2010) [Book News]. *IEEE Industrial Electronics Magazine*, *4*(1), 75. https://doi.org/10.1109/mie.2010.936103

Larminie, J., & Lowry, J. (2003). *Electric vehicle technology explained*. https://doi.org/10.1002/0470090707

Luo, Y., & Yang, S. C. (2016). The effect of the interactive functions of whiteboards on elementary students' learning. *Journal of Educational Computing Research*, *54*(5), 680–700. https://doi.org/10.1177/0735633115628032

Naftaliev, E., & Yerushalmy, M. (2022). Guiding students' learning with an interactive diagram: The case of equations. *the Journal of Mathematical Behavior/the Journal of Mathematical Behavior*, *68*, 101008. https://doi.org/10.1016/j.jmathb.2022.101008

O'Bannon, B., Puckett, K., & Rakes, G. (2006). Using technology to support visual learning strategies. *Computers in the Schools*, *23*(1–2), 125–137. https://doi.org/10.1300/j025v23n01_11

Onal, N., & Demir, C. G. (2017). The Use of the Interactive Whiteboard in Mathematics and Mathematics Lessons from the Perspective of Turkish Middle School Students. *International Journal of Higher Education*, *6*(3), 195. https://doi.org/10.5430/ijhe.v6n3p195

Orbeta, A. C. (2021). Vocational education and training in the Philippines. In *Springer international handbooks of education* (pp. 1–30). https://doi.org/10.1007/978-981-16-8136-3_9-1

Power system relaying. (1993). *Choice/Choice Reviews*, *30*(09), 30–5021. https://doi.org/10.5860/choice.30-5021

Pressley, M., Goodchild, F., Fleet, J., Zajchowski, R., & Evans, E. D. (1989). The challenges of Classroom Strategy Instruction. *the Elementary School Journal/the Elementary School Journal*, *89*(3), 301–342. https://doi.org/10.1086/461578

R, A. (1923). Standard Handbook for Electrical Engineers. *Nature*, *111*(2788), 458–459. https://doi.org/10.1038/111458a0

Rosner, B. (1982). A generalization of the paired T-Test. *Applied Statistics/Journal of the Royal Statistical Society. Series C, Applied Statistics*, *31*(1), 9. https://doi.org/10.2307/2347069

Sadiku, M. (1997). Introduction to Electric Circuits [Book Reviews]. *IEEE Transactions on Education*, *40*(2), 162–163. https://doi.org/10.1109/te.1997.572332

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, *12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Tadle, R. L., Valdez, L. P., Fernandez, R., Uy, C., & De Castro, B. (2021). Students' experience of service quality of Technical Vocational Education and Training (TVET) programs of Private Higher Educational Institutions (HEIs) in the Philippines. *Journal of Technical Education and Training/Journal of Technical Education and Training*, *13*(3). https://doi.org/10.30880/jtet.2021.13.03.004

The role of the electric vehicle in the energy transition. (2021). In *Green energy and technology*. https://doi.org/10.1007/978-3-030-50633-9

Walter, S. D., & Altman, D. G. (1992). Practical statistics for medical research. *Biometrics*, *48*(2), 656. https://doi.org/10.2307/2532320

Westbrook, M. H. (2001). The Electric Car: development and future of battery, hybrid and fuel-cell cars. In *Institution of Engineering and Technology eBooks*. https://doi.org/10.1049/pbpo038e

Zanolla, S., Canazza, S., Rodà, A., & Foresti, G. L. (2014). Learning by means of an interactive multimodal environment. In *Advances in human and social aspects of technology book series* (pp. 143–153). https://doi.org/10.4018/978-1-4666-4490-8.ch014