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Research Article

Computer Based Learning and Laboratory Based Learning in Electric Circuits: A Literature Review

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ABSTRACT

Computer based learning and laboratory-based learning are widely used nowadays mainly for teaching and learning of both teacher and students especially in teaching electrical circuits. This paper aims to review computer-based learning and laboratory-based learning, specifically other forms of CBL and LBL and how these methods are integrated in teaching and learning electrical circuits, and its advantages and disadvantages. In conducting this literature review, the researchers adapted the PRISMA method in which various journal articles are screened through different stages. Criterion was imposed to guide the researchers in the inclusion and exclusion process. It was found out that there are other forms of computer-based learning (CBL) such as the Java-based virtual laboratory and Grid computing laboratory. Also, integrating computer-based learning and laboratory-based learning would build a workable environment that helped in motivating students in exploring electrical circuits. There are various advantages of computer-based learning such as time saving and easy access to laboratory manuals. On the other hand, advantages of laboratory-based learning include the positive impact of interaction, group discussion, and collaboration that was delimited by the computer-based learning.

Keywords*: computer based learning, disadvantages electric circuits, forms integrated, laboratory based learning*

Background

According to Lajoie and Azevedo (2006), computer-based learning environments (CBLEs) present important opportunities for fostering learning. However, there has been very little attention on understanding how successful students take advantage of these circumstances, and study in this area is crucial to ensure that their potential is achieved (Mandinach and Cline 2000).

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Computer based learning environments (CBLEs), as the name implies, use many parts of computer technology to aid persons in learning for a specific educational objective (Azevedo 2005a; Chen 1995; Lajoie and Azevedo 2006). Computer technology allows for a variety of information formats, including text, diagrams, and graphs, among others. Computer based learning environments (CBLEs) that employ numerous information representations are a sort of multimedia learning environment (Mayer, 2001, 2005).

Moreover, the digital revolution has had a significant impact on daily life, as seen by the increasing use of mobile devices and the smooth implementation of technology into everyday chores like shopping, reading, and getting directions. The usage of computers, mobile devices, and the Web is at an all-time high, and it's only likely to rise as technology improves, especially for consumers in developing nations. Although computer-based technology has pervaded many sectors of life and industry, little is known about how it might be utilized to encourage student involvement, a concept that is gaining traction in higher education according to its links to a number of favorable academic results.

The outbreak of the deadly disease called COVID-19 brought by a Corona Virus (SARS-CoV2), as the World Health Organization (WHO) hereby declared it as a pandemic, immensely affected the educational system putting it in a much challenging situation and forced the educational institution to shut down. With the absence of traditional (face-toface) learning, it gives rise to computer-based learning (CBL) as a substitute for off-line teaching. And as Computer-Based Learning (CBL) made distance education possible and easy, it is no longer an "Option" but it is now a "Necessity." (Dhawan, S. 2020; Khan et al., 2020).

According to Schindler, Burkholder, Morad, et al. (2017) Integration of technology into teaching and learning is not a new difficulty for universities. Administrators and teachers have struggled with how to effectively integrate technological advances like audio and video recordings, email, and teleconferencing to supplement or replace traditional instructional delivery systems since the early 1900s.

However, due to the high amount of new technologies and devices during the last two decades, this challenge has become much more challenging. The short storage life of modern devices and software, combined with large internal organizational impediments, makes it difficult for institutions to integrate new technology efficiently and effectively. Also, according to (Alluwaimi et.al., 2020) online set-up seems to be challenging, and the only way to make it more effective is to have a virtual laboratory where it can be more interactive, showing medical procedures in real situations, providing concise information as well as providing 3d virtual tools to mimic the situation in a most realistic manner.

Additionally, Laboratories make excellent teaching and learning environments. It makes use of raw facts or physical objects to help people grasp the subject better. It's a hands-on approach to learning. Laboratory learning involves consideration that actually occurs in a location where students can individually or as a group examine, explore, and experiment using items, materials, experiences, and ideas. This learning does not have to take place in a physical laboratory; it can take place in a variety of spaces, including an e-learning management platform and computer-simulated online laboratory.

According to Ka Yuk Chan (2012), learning can take place in a laboratory in a variety of methods, including observation of a case or phenomenon, hands-on practical instruction, and experimentation. The major goal of laboratory learning for the students is to help them gain practical skills in their field of study. Students can apply and enhance the theoretical concepts given in class by participating in laboratory activities. It also aims to improve a variety of learning outcomes, such as experiential learning.

Finally, this article talks about the comprehensive review of Computer-based learning and Laboratory-based learning as of the forms, integration and advantages and disadvantages.

Statement of the Problem

This study aims to comprehensively review the Computer-based learning and Laboratory-based learning in Electric Circuit used in teaching.

Specifically, this research aims to answer the following:

- What are the other forms of Computer-Based Learning and Laboratory-Based Learning?
- How are Computer-Based Learning and Laboratory-Based Learning integrated in teaching and learning electric circuits?
- What are the advantages and disadvantages of Computer-Based Learning and Laboratory-Based Learning?

Methods

This chapter discusses the research design, Samples, Data gathering procedure, Data analysis, Discussion, Study Selection, Study Eligibility, Ethical reconsideration, and Results.

Research Design

This systematic review is a qualitative type of research. To well tailor the literature used for this research, the researchers utilized Preferred Reporting Items for Systematic Reviews and Meta-Analysis or PRISMA. It is an evidence-based minimum set of literature, developed by Moher (2013) that helps the researchers for this systematic review.

Study Selection

To identify relevant articles related to this study, a PRISMA method was adapted. For each stage, all researchers independently reviewed each reference and disagreements were resolved by discussion. Every effort made to avoid between reviewers by ensuring the review process was independent and blinded.

In the first stage of the review, titles and abstract were screened, including the dates specifically in the range of 2015 up to 2022. Sources were classified as "yes", "no" or "maybe". For the second stage, research that shows no significance difference between Computer-Based Learning and Laboratory Based Learning in abstract was screened. We searched specifically for terms including computer based laboratory, laboratory based learning, effectiveness. For the third stage, text eligibility which reported Computer-Based Learning and Laboratory-Based Learning outcomes in teaching and learning electric circuits. In the fourth stage, a list of full text papers were compiled and tabled.

Study Eligibility

The inclusion criteria were established following the PRISMA method and organized according to the PRISMA framework. The search includes the following: articles from credible sources (e.g., Google scholar, and springer), publication year; ranges from 2015-present, aligned abstract and results in the SOP.

Only English text or translated in English text that was peer-reviewed were included in this review. To ensure the consistency and reliability of the studies, we excluded studies that were not in the inclusion criteria. Those papers that showed no significant difference were also not considered and belonged to the exclusion criteria. Also, research titles were considered if it was aligned to their abstract, otherwise, it was excluded.

Samples

The researchers used samples of journals on the internet for a detailed and broad search of literature. The Journals are coming from credible sources such as Google scholar, publish and perish, and springer.

Sampling Technique

Researchers collected a set of data or samples from the certain mentioned sources (Google Scholar and Springer), and PRISMA will be utilized to conduct this literature review.

Data gathering Procedure

Researchers gathered first evidence through the construction SOP (statement of the problem), then, conducted a wider scope of literature review and evaluated the studies through the abstracts. After selecting a competent study that fits on the research objectives, the Researchers extracted the necessary data and summarized the studies to later on do the compare and contrast.

Data Analysis

For the data analysis, the Researchers followed the following procedures: (i) Identify studies that are included as data. (ii) Gather the

identify set of data. (iii) Cleaning of data as preparatory for the analysis. (iv) Analyse the data. (v) Interpret the results of the data analysis. And lastly, making a conclusion out of the result found.

Ethical Consideration

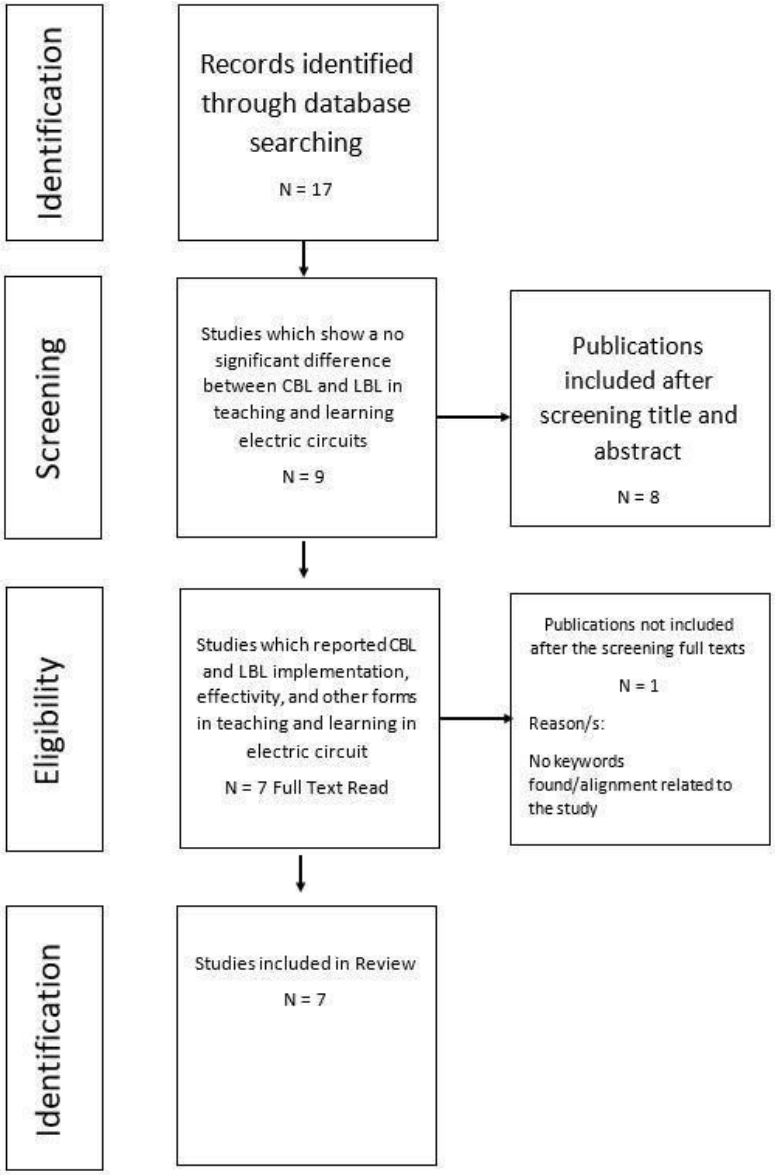
This paper is guided by ethical considerations and this includes: People who participate in this paper is free from coercion and free to withdraw. This paper do not harm either physical or psychological and therefore can be in a form of pain, stress, or anxiety. Citation of texts used from other articles are observed to avoid crimes such as plagiarism. This also assess relevant components only to avoid risks and other damaging acts.

Results and Discussion

Table 1. Final Database

Title	Author	Date published	Publication type
Effects of the Physical Laboratory versus the Virtual Laboratory in Teaching Simple Electric Circuits on Conceptual Achievement and Attitudes towards the Subject	Ercan, O. & Tekbıyık, A	October 2015	Journal article
A Case Study for Comparing the Effectiveness of a Computer Simulation and a Hands-on Activity on Learning Electric Circuits	Ekmekci, A & Gulacar, O	August 2015	Journal Article
An Online Virtual Laboratory of Electricity	Moltó, G & Gomez-Tejedor, J	April 2008	Journal article
Impact of a Remote Lab on Teaching Practices and Students Learning	Barreto et al.	2018	Accepted manuscript
Electriccircuit interactive laboratory	Khaddaj, S & Marmar, A.	October 2015	Research article
Digital Applications for Laboratory Sessions in Electronics Courses	Dahlgren, L & Nejsum, G	May 2021	Journal article
A Grid Computing Based Virtual Laboratory for Environmental Simulations. Lecture Notes in Computer Science book series	Montella, R. et.at.	2007	Journal article

Table 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart for article selection



After removing duplicates, the first database searches revealed a total of 17 titles (Figure 1). 8 articles satisfied the first stage of review requirements, and 7 sources were subjected to full text examination. There were 7 studies that satisfied the review requirements.

Analysis

Table 2 presents the results and the outcomes of the filtered journals and articles. One of the central aims of this study was to examine the related literature of computer-based learning and laboratory-based learning in electric circuits. The filtered data was gained upon following the criteria given such as limiting the articles and journals from the year 2015 up to the present, analyzing the contents about its relevance and to see if it is reliable and applicable to the review itself.

Through the set criteria, the journals and articles were involved in different phases of the process and in the end, the higher and better-quality studies were chosen and represented. There are 17 (n=17) main articles that are included in this research and are subject for screening. Upon proceeding to the first stage of

the inclusion and exclusion process, through "studies that show no significant difference between CBL and LBL in teaching and learning electric circuits" as the exclusion criteria, 8 (n=8) studies remained and 9 (n=9) studies were removed. Finally, out of 8 articles, through the last inclusion criteria which is " Studies which reported CBL and LBL implementation, effectivity and other forms in teaching and learning in electric circuits," 7 (n=7) articles remained while 1 article did not exceed the criteria given.

With regards to the eligibility of the studies to be included on the text that should be fully reviewed, 1 (n=1) study has been rejected as there are no keywords found/alignment which are related to our study. Also, in between the filtering process, there is one article that did not pass the set criteria for the date published (2015-2022), that was tagged as "Maybe". However during the process and stages of screening, the said article passed and achieved the criteria. As a result, there are 7 papers that are included in the data.

Discussion

Other Forms Of CBL

Java-based virtual laboratory is one of the other forms of CBL. This is a remote laboratory and is accessible via the internet by means of a Web browser and is entirely developed in Java. Java-based virtual laboratory is a form of CBL that allows the learners to build direct and alternating current circuits, therefore, useful in Electricity and Magnetism course subjects. This virtual laboratory program includes a graphical user interface that resembles the connection board, and the electrical tools that are being utilized inside a real laboratory to build electric circuits. Due to the graphics and program development, the virtual laboratory can be compared to the real laboratory set up, tagging it as if it is a "real life" laboratory environment and tools.

Grid Computing Based Laboratory implementation uses Globus Toolkit 4 (GT4). And this simulation uses a data grid approach, whereas software components, instruments as well as data are all wrapped by web services are being advertised on the VO Index Service homogeneously, commonly and consistently through the developed guidelines and the set standards of publishing tools. This kind of virtual simulation, has "Resource Broker Service Design and Development" wherein, it is the one that collects grid status data, processes queries wherein resources are represented in standard fashion.

Implementation

Integration of CBL and LBL

As an observation, there are only few 21st century learners who are motivated to pursue and explore Electrical Circuit related courses namely, Communications Engineering or in Electrical and Computer Engineering in the Electrical and Computer Engineering department and the like. That is why an innovative teaching is proposed and applied in a laboratory- based learning specifically in the Electric Circuits Laboratory. In line with this innovation is the integration of technologies inside the laboratory. The innovative teaching with technological integration includes the following:

Lab Setup

The regular laboratory classroom is finally equipped with 12 benches with 12 computer sets that are incorporated with power supply, digital multimeter, generator, digital oscilloscope, a breadboard and power and instrument cables. "Each set of equipment and cables are organized in a labeled cabinet for each bench used by a group of two students throughout the semester. For every experiment, a different set of components are prepared on a weekly basis in special kits holding the corresponding group numbers. Every team of students assigned to a bench is responsible for the proper utilization and organization of the equipment and the components kit. Regular testing of instruments, components, cables, and probes is performed before every experiment." (Khaddaj, S. & Marmar, A. 2016).

Lab Redesign

The traditional laboratory classroom is redesigned with the integration of the new technologies. (Refer to Figure 1 and Figure 2) If the traditional laboratories only have lab components, laboratory manuals and require the

teachers to discussed the objectives, theoretical backgrounds, procedures and additional questions as well as the diagram, new implementation of laboratory-based learning converted manuals into pdf forms as pre-lab, in-lab and post-lab documents for all the experiments the students ought to submit.

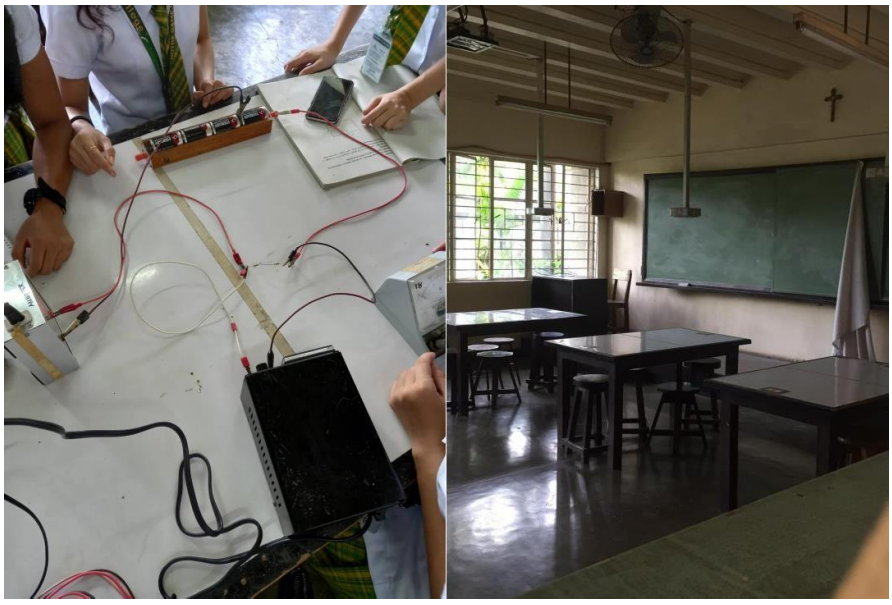


Figure 1. Traditional Laboratory Classroom

Figure 2. Integrated Traditional and Computer Based

Advantages and Disadvantages Of CBL And LBL

Utilizing virtual environment (VE) software in teaching Electric Circuits shown to be more effective than that of the physical environment (PE). VE most likely provides higher levels of conceptual development. Also, blending VE and PE provides real time opportunities to the learners and a real-like environment along with the rapid feedback options and repetition

opportunities. Also, results show that both approaches significantly improved pre-service mathematics and science teachers' learning of electric circuits. VE and PE instructional activities did not show significantly different results in terms of learning gains. Nevertheless, hands-on activity in Laboratory based learning can provide ample opportunities for group interaction as well as task-related discussions, considering the situation and placement.

Other researchers give emphasis to the advantage of CBL that is the weakness of LBL in regard to making laboratory manuals–the basic materials in laboratory class. Wherein, CBL saves more time and allows students to focus on their theoretical studies and completing the manual rather than manually making it after the experiment that would waste more time.

Moreover, some researchers discovered that laboratory-based learning (traditional) is more exciting for students. Learners' attentiveness is improved and higher in rate while doing theoretical analysis, relating it to the measurements on the spot, and then observing and analyzing the results directly during the laboratory session. "Increase in students' class participation and involvement was noticed during the laboratory session. At the end of the course, students are requested to fill in an anonymous survey that rates the achievement of the course learning outcomes and evaluates their comprehension of course topics" (Kaddaj, S. & Marmar, A. 2015).

Conclusion

Based on the result, it is concluded that there are existing different forms of Computer-based learning (CBL). The following forms are Java-based virtual laboratory and Grid Computing Based Laboratory which works for specific objectives in learning Electric Circuits. There are many other forms however, it is not included in this study. Also, during the wide array of database searching, the researchers were not able to acquire any information about other forms of Laboratory-based learning. Besides, integrating Computer-based laboratory (CBL) and Laboratory-based learning (LBL) would create a new and flexible environment, where it makes learners more motivated in exploring electric circuits. The integration requires new placement, new learning approach, and new competent teachers who are equipped with 21st century skills to achieve the aim. Although CBL can offer many things like easy, accessible pdf format manuals with provided layout and even saving time for laboratory activities rather than saving extra time for the teacher's discussion of the laboratory manual's content, CBL somehow delimits the possible positive impact that collaboration, interaction and peer group discussion the real time experiment can offer.

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