KEMENTERIAN PENDIDIKAN TINGGI

JOJAPS

eISSN 2504-8457

POLITEKNIK MALAYSIA
PORT DICKSON

Journal Online Jaringan Pengajian Seni Bina (JOJAPS)

Online Basic Electrical Circuit Practical Task Methodology Development for Electrical Technology Course

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Abstract

Electrical Technology is a compulsory subject taken by all engineering students in institutions of higher learning. The study found that students have difficulty adapting the basic theory of electrical circuits in problem solving, especially during practical laboratory training. This difficulty is compounded by the contagion pandemic of the Covid-19 epidemic that curbs face-to-face learning. Online learning is an alternative to the implementation of teaching and learning sessions. However, the constraint of the ability to own equipment such as computers or laptops is an issue in performing practical activities in a simulated manner. This innovation was developed to facilitate and improve students' understanding when performing practical exercises such as in the laboratory. Through this innovation, students can see more clearly the structure of the basic electrical circuit construction where the use of equipment is as real. This activity is implemented online without the need for students to download the practical application, namely TinkerCAD and Vidyard. Comparison between circuit calculation in theory and measurement using measurement tools can further strengthen understanding in problem solving related to basic electrical circuits. The practical session begins with understanding the given schematic circuit before building the connection on the virtual equipment properly. Next, students will perform calculations using several theoretical parameters based on the circuit that has been built. These parameters will be used in comparison with the value of laboratory online practical measurement. The measurement process based on the parameters used is to strengthen students' understanding. Students are also asked to record the practical implemented using the Vidyard application as evidence of individual practical implementation using cloud storage. Observation found that students were more likely to apply theory to laboratory practical training in a shorter period of time than previous methods. Students also did not have problems in performing simulations and recordings online.

Key-word: - *Electrical Technology, Online Practical, E-learning, innovative teaching*

1. Introduction

Under the Malaysian Education Development Plan (Higher Education) 2015-2025 PPPM (PT) Leap 4: Quality TVET graduates state that Polytechnics, Community Colleges and Vocational Colleges will provide vocational higher education to meet the needs of the industry. In line with the goal of establishing the Polytechnic as a post-secondary institution that produces a workforce in the fields of technical, commercial and hospitality, then the process of teaching and hands-on learning to be one of the important elements towards that goal (Kementerian Pendidikan Malaysia, 2015). Accordingly, the provision of equipment that meets practical needs becomes a requirement in obtaining products or graduates of polytechnics that have high marketability and effectiveness.

Electrical Technology course is a core course contained in the structure of diploma programs at the Department of Mechanical Engineering, Politeknik Ibrahim Sultan, Johor. This course is for all second semester diploma students which compulsory for qualifying a diploma award in the Department of Mechanical Engineering. In the content of the Electrical Technology course, there are four practical tasks that students need to do to fulfill the third Course Learning Outcome which is ‘organize appropriately experiments in groups according to the Standard Operating Procedure’. This Learning Outcome requires the student's psychomotor to be assessed up to the fourth domain where students' skills to assembles, calibrates, constructs, dismantles, measures, sketches and demonstrate various types of basic electrical circuits will be tested and assessed face to face.

Skills and practical teaching and learning (T&L) involve emphasis on the application of the psychomotor domain (Daniel, 2010). This domain was introduced by Simpson in 1972. The psychomotor domain consists of seven main classifications namely addressing, preparation, controlled movement, mechanism, specific movement, adaptation and originality (Simpson, 1972). However, COVID-19 first appeared in November 2019 in Hubei province, China. In January 2020, the World Health Organization (WHO) declared a pandemic situation that forced the world community to change its normal lifestyle. In line with the declaration of this pandemic, all countries have closed all sectors including the education sector. The move to close the education sector has caused all schools and higher learning institutions being closed to break the chain of transmission of this dangerous pandemic. As a result, the teaching and learning process face to face had to be stopped during the Movement Control Order (MCO).

In order to ensure that students do not lag behind in attending learning sessions, educators began to use the option to conduct learning online. However, for Electrical Technology courses that require students to apply the basic theory of electrical circuits in problem solving during face-to-face practical tasks sessions, there will be some constraints in the process to ensure Course Learning Outcome for this course can be achieved. Among the constraints faced are the level of understanding of students to apply the basic theory of electrical circuits in online problem solving, the ability of students to own equipment such as personal computers or laptops to perform simulations as well as lecturer evaluation methods to assess students' psychomotor domain.

2. Problem Statement

The T&L process is very effective if it involves a simulation process and practical tasks using real tools and certain equipment. However, the constraint of students' ability to own equipment such as computers or laptops that can meet the specifications of simulation software is an issue in performing practical activities. This innovation was developed to facilitate and improve students' understanding when performing practical exercises as in the laboratory. Through this innovation, students can see more clearly the structure of basic electrical circuit construction where the use of equipment is like real equipment. This activity is implemented online without the need for students to download and install the practical application software, namely TinkerCAD and Vidyard. For students who do not have a personal computer, they can go to a nearby cyber cafe because the practical work done can be recorded and stored in the cloud storage as proof of the implementation of practical work individually. This innovation also allows lecturers to assess the psychomotor domain of students while doing practical work. Comparison between circuit calculation in theory and measurement using measurement tools can further strengthen understanding in problem solving related to basic electrical circuits.

3. Objective

This innovation aims to develop an online practical work evaluation method for Electrical Technology courses for diploma students in the Department of Mechanical Engineering, Ibrahim Sultan Polytechnic.

4. Methodology

Curriculum Information Document Online System - Learning Management System (CIDOS-LMS) was developed by the Curriculum Development and Evaluation Division, Department of Polytechnic Studies. It is a learning platform designed to provide educators, administrators and learners with a single robust, secure and integrated system to create personalized learning environments. It is a tool that support T&L process via the internet between lecturers and students. Each polytechnic has its own e-learning platform in CIDOS-LMS. The e-learning platform for Polytechnic Ibrahim Sultan is PIS-LMS that allowed students to access T&L materials anytime and anywhere through internet connection. For Electrical Technology practical tasks, students can download the lab sheet from the PIS-LMS platform as shown in Figure 1.

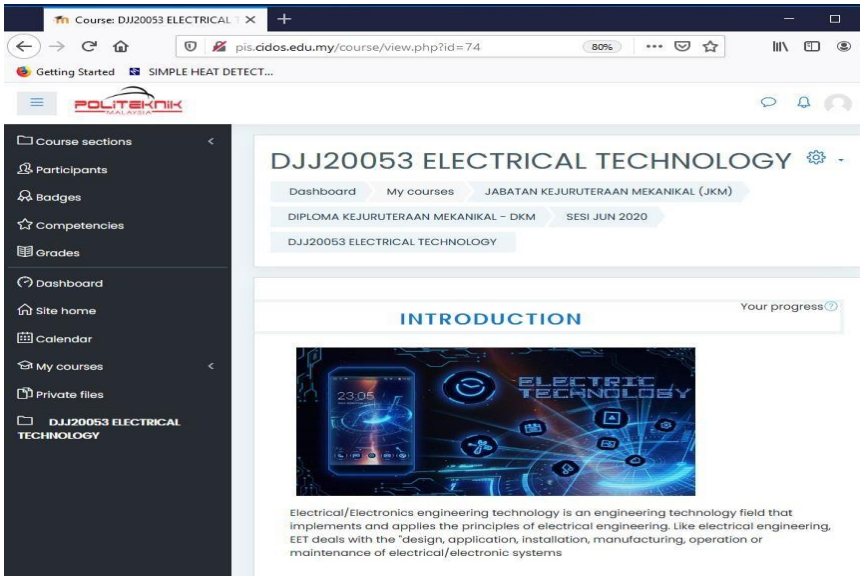


Figure 1: CIDOS PIS-LMS platform interface for Electrical Technology courses.

With educational institutions closed due to COVID-19, video can help lecturers and students stay connected as if in a lecture hall or electronic laboratory. Vidyard has a free Chrome extension that lets students record webcam or share videos in only a couple of clicks. Students can also upload other videos and easily manage and organize them all. For Electrical Technology practical tasks, screen recording is a suitable method to student's accomplishment validation. Students will record their process of construct a circuit and do a simulation in the TinkerCAD workspace using Vidyard. Students must add a little bubble that records their face via their webcam as prove to their own practical activity. It will appear on the video, letting lecturers see student face, making it easier to connect both parties and the practical tasks session, and at the same time can reduce cases of plagiarism of practical task among students. Lecturers can assess students' psychomotor skills to construct circuits and perform simulations on meter readings of the circuit through videos recorded by students as shown in Figure 2.

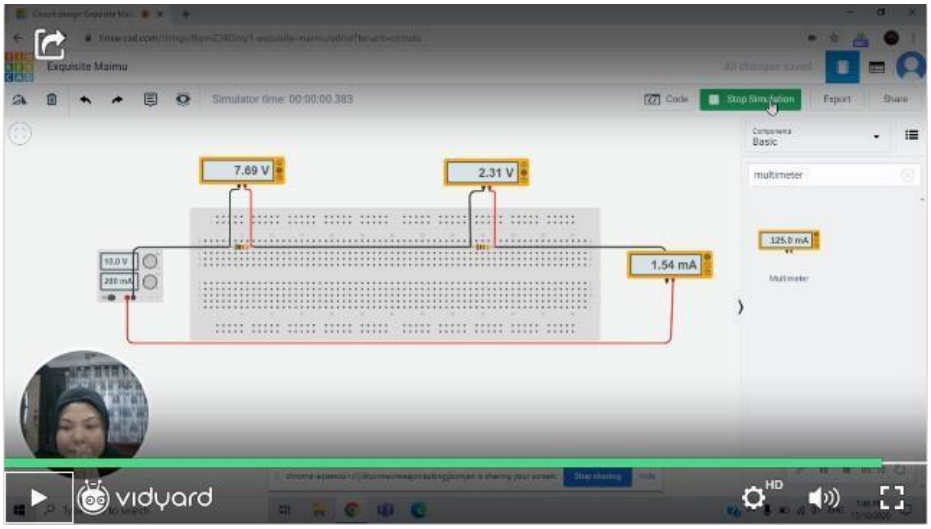
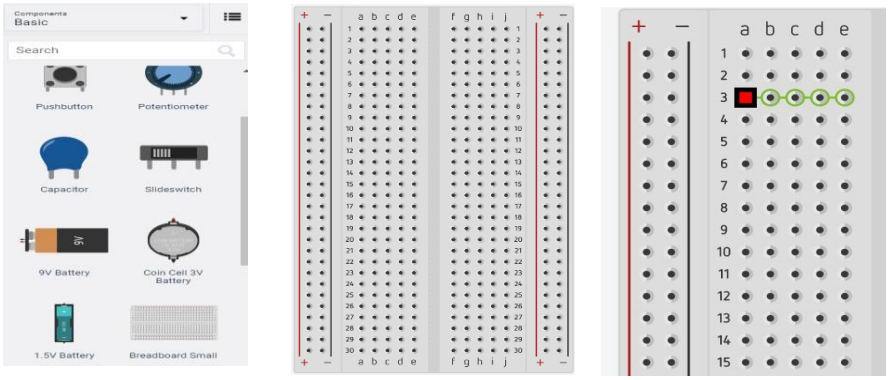


Figure 2: Lecturers can assess students' psychomotor skills to construct circuits and perform simulations on the circuit through videos recorded by students.

TinkerCAD is a free online service for creating of electronic circuits. This application includes basic circuits with LED lights, buzzers, switches and even light sensors. This application also can include a microprocessor as part of the design. Students can develop components in a flexible manner than can be quickly updated and modified to test a variety of options when developing a circuit. Student will use this process to learn how to create basic electronic circuits. TinkerCAD integrates with Microsoft, Google and also social media services like Facebook. Students can use their personal or institution email account to log into Autodesk TinkerCAD.

A circuit project includes a variety of electronics components include LEDs, buttons, resistors and a power source. The components student can use are displayed in a panel at the right of the page as shown in Figure 3(a). In Electrical Technology practical tasks, components are commonly assembled using a Breadboard. A Breadboard is a piece of plastic that has several holes. These holes are used to hold different components. The Breadboard will be selected and place the Breadboard onto the workspace using a mouse pointer.

The Breadboard has a grid of thirty by ten holes in the main area as shown in Figure 3(b). The rows are numbered 1 to 30 and the columns are labeled with the letters A through J. The columns A through E are separated from columns F through J by a piece of plastic. The edges of the board contain two columns with the same number of rows. These columns have negative and positive symbols. These columns and holes are used for the power supply. The components in the center part of the board will tap into these columns to draw electric current.



(a) (b) (c)

Figure 3: (a) The components in a panel at the right of the TinkerCAD page, (b) The grid of the breadboard, (c) The interactive way to explain the connection in the breadboard.

Figure 3(c) shows students can move their mouse pointer over one of the holes in the center part of the board. The hole beneath will be identified with a red square and black border. The other holes will be identified with green circles. These green circles indicate that each hole in the row is connected to each other hole in the row. There is a wire linking any connection within the same row. Students will use this linking to help develop connect components. Usually, during face-to face classes, the process of explaining the concept of using this Breadboard to students will take time because students are not very clear about the concept of connection on the Breadboard. With the help of TinkerCAD, students can quickly understand the concept because the connection on the Breadboard is shown visually and interactively.

After completing the practical tasks, solving the given problems and prepare the practical report, students can send a video recording of the practical process along with the completed practical report on the PIS-LMS platform. The flow chart in Figure 3 shows the process of Electrical Technology students performing practical tasks from beginning to end.

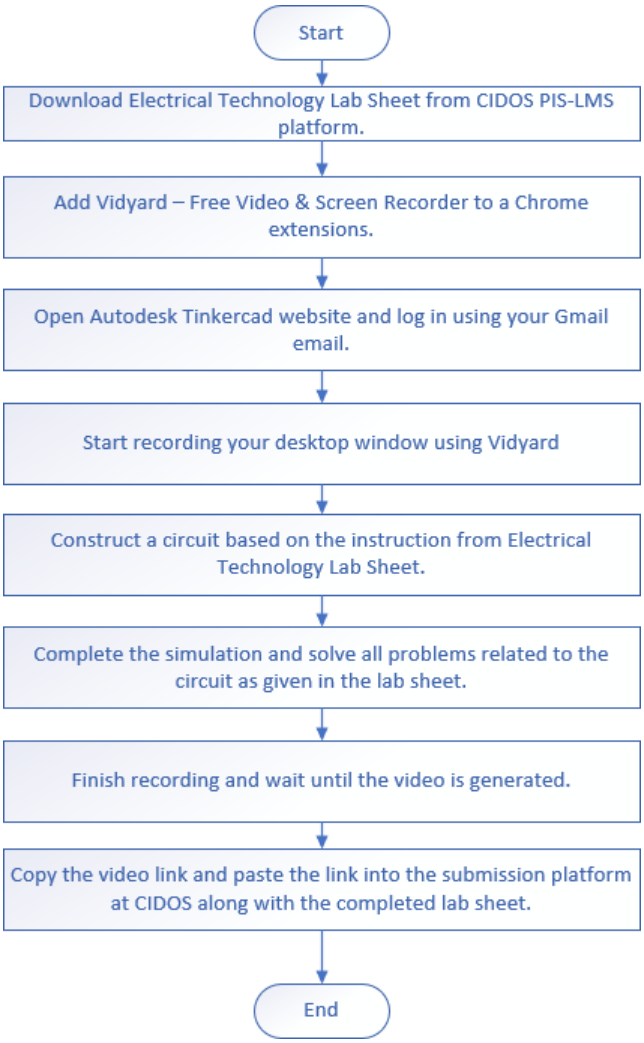


Figure 3: The process of students performing online practical tasks from beginning to end.

5. Findings

A brief survey was conducted using a questionnaire involving 46 respondents who are Electrical Technology students for the June 2020 learning session for the purpose of obtaining feedback on the effectiveness of implementation of Online Assessment Method for Electrical Technology Practical Tasks. The questionnaire consist of four parts as follows:

Section 1 : This section is to identify the readiness of students to face online learning sessions as well as the ability of students to provide the needs for online practical tasks sessions.

Section 2 : This section is to determine how well student can organize to accomplish practical task online.

Section 3 : This section is to determine how well student can construct and measure to complete the circuit requirement task. Section 4 : This section is to determine how well student can adapt and accept online practical task.

Table 1 shows the readiness of students to face online learning sessions as well as the ability of students to provide the needs for online practical tasks sessions. Students' readiness to face online learning session influences the use of TinkerCAD and Vidyard applications as an online practical tasks approach that replaces face to face practical tasks during this COVID-19 pandemic season. The results of the questionnaire showed that 83% of students have access to the internet, a personal computer or laptop as well as webcam to meet the needs of online learning. However, only 52% of students have a personal computer or laptop that capable of downloading and installing the simulation software that require a high memory capacity. Therefore, the use TinkerCAd and Vidyard applications is suitable for the needs of students because practical task sessions can be implemented online without students having to download and install the simulation software to their personal computers.

Table 1 : Readiness of students to face online learning sessions as well as the ability of students to provide the needs for online practical tasks sessions.

Bil	Item	Yes (%)	No (%)
1	The Covid 19 pandemic has affected the teaching and learning process around the world. Can you accept the change of learning system from face to face to online classes?	70.8	29.2
2	Online classes require students to have basic needs such as internet networks, computer or laptop and webcam. Can you meet this need?	83.3	16.7
3	Is your computer or laptop capable of operating simulator applications that require download and storage that require high memory capacity?	52.1	47.9

Table 2 shows students' theoretical knowledge related to the basics of electrical circuits as well as the skills to calculate the theoretical values of resistance, voltage and current in series circuits, parallel circuits and series-parallel circuits. Three-quarters of the students were found to have theoretical knowledge related to the basics of electrical circuits and have the skills to calculate the values related to the basics of the circuit after using the TinkerCAD application.

Table 2: Students' skills to organize and accomplish online practical tasks.

Bil	Item	Yes (%)	No (%)
1	From the lab sheet given, do you know how to determine the type of circuit to be construct?	75.0	25.0
2	Do you have the knowledge to get the theoretical value of the circuit given through calculation?	70.8	29.2
3	Do you know how to calculate values of resistances, voltage and current in series circuit?	87.5	12.5
4	Do you know how to calculate values of resistances, voltage and current in parallel circuit?	87.5	12.5
5	Do you know how to calculate values of resistances, voltage and current in series-parallel circuit?	83.3	16.7

Table 3 describes the skills and abilities of students to construct various type of circuits, perform measurements and take readings from the circuit as well as solve problems in the circuit after online practical task sessions. About 90% of students know how to use Breadboard, understand the basic concepts of circuit connection on Breadboard and know how to connect electronic components on Breadboard based on the circuit given in the lab sheet. More than 60% of students know how to use circuit measuring devices such as Voltmeter, Ammeter, Power Supply Generator and Function Generator. 83.3% of students know how to perform serial and parallel circuit tests and over 85% of students know how to measure and take voltages, currents and resistances readings in the circuit correctly. Most students can also troubleshoot the circuits if there are any problems in the circuit while making measurements and taking any readings from the circuit. This is because the TinkerCAD application has an interactive interface as well as the use of electronic equipment and components that resemble the original equipment and components as in the laboratory. The simulation process is also clearly shown interactively and this make it easier for students to understand the concept of electrical circuit more quickly and easily.

Table 3 : Students' skills to construct circuit, perform measurements and solve circuit problems.

Bil	Item	Yes (%)	No (%)
1	Do you know how to use breadboard?	93.8	6.3
2	Do you understand the breadboard connections?	91.7	8.3
3	Do you know how to use Voltmeter?	91.7	8.3
4	Do you know how to use Ammeter?	91.7	8.3
5	Do you know how to use oscilloscope?	62.5	37.5
6	Do you know how to use Power Supply?	89.6	10.4
7	Do you know how to use Function Generator?	72.9	27.1
8	Do you know how to connect component on the breadboard according circuit?	87.5	12.5
9	Do you know how to do parallel testing?	83.3	16.7
10	Do you know how to do serial testing?	83.3	16.7
11	Do you know how to measure voltage?	91.7	8.3
12	Do you know how to measure current?	93.8	6.3
13	Do you know how to measure resistance?	85.4	14.6
14	Do you know how to get signal on oscilloscope?	60.4	39.6
15	Do you know how to generate signal from function generator?	70.8	29.2
16	Do you know how to troubleshoot the circuit when there are problems while measuring the parameters?	62.5	37.5

Table 4 above shows students' acceptance to adapt and perform practical tasks online. 83.3% of students agreed that the TinkerCAD application used during online practical task sessions can help them to identify the equipment and components used even when they used virtually. 77.1% of students agreed that the Vidyard Chrome extension could help lecturers assess their psychomotor skills while doing practical work. 77.1% students also stated that they improved their understanding and knowledge practically after using TinkerCAD and Vidyard applications during online practical task sessions.

Table 4 : Students' acceptance to adapt and perform practical tasks online.

Bil	Item	Yes (%)	No (%)
1	Do you agree the TinkerCad app can help you identify laboratory tools even virtually?	83.3	16.7
2	Do you agree the Vidyard app can help lecturers assess psychomotor skills?	77.1	22.9
3	After performing practical tasks using TinkerCad and Vidyard, it can improve understanding and knowledge practically even online.	77.1	22.9

Overall, the readiness of students to face online learning sessions is encouraging. This shows that students who take the Electrical Technology Course also prepared to face online practical task sessions to meet the syllabus requirements that need to be assessed from the aspect of student psychomotor domain. The free online TinkerCAD application is found to have elements that help increase students' level of readiness in terms of easy to learn, easy to use and easy to understand. Therefore, lecturers need to pay attention to the importance of this element to constantly improve the Online Assessment Method for Electrical Technology Practical Tasks platform that has been developed to give an effective impact in the teaching and learning process.

6. Implications of the innovation

The development of the Online Assessment Method for Electrical Technology Practical Tasks has given implications to the assessment method of student psychomotor domain assessment. Previously, the psychomotor domain of students had to be assessed face to face while students were doing practical work in the laboratory. However, with the presence of the COVID-19 pandemic, face-to-face meetings between lecturers and students were not possible. Through this innovation, lecturers can assess the psychomotor domain of students through practical work recorded through the Vidyard Chrome extension. The use of simple, interactive and user-friendly TinkerCAD application makes it easy for students to understand the basic concept of electrical circuit assembly as well as circuit simulation. The use of equipment in TinkerCAD applications that resemble real equipment in the laboratory increases students' understanding of the use and function of the equipment. The process of teaching and learning for practical work as well as psychomotor assessment of students for Electrical Technology courses can be implemented through this innovation.

7. Recommendation

After conducting this innovation, the innovator has recommendations related to the implementation, advantages and disadvantages of Online Assessment Method for Electrical Technology Practical Tasks for the students, lecturers and future innovators.

For students.

All students of Politeknik Ibrahim Sultan have access to the CIDOS PIS-LMS platform. Therefore, all students are encouraged to use the platform, as much as possible in their teaching and learning process. For online practical task sessions, students can download lab sheets from the CIDOS PIS-LMS platform and send video recordings of practical sessions conducted along with completed practical reports on the same platform without using other communication applications such as Whatsapp and Telegram.

For lecturers.

Lecturers should be creative in using various free online applications that can help the implementation of the T&L process, especially those involving students' psychomotor assessment. They should identify appropriate online practical task activities that can be implemented in the virtual laboratory. Lecturer must be aware about their role in online teaching sessions and how online practical task activity should be implemented in the virtual laboratory.

For future innovators.

The future innovators are recommended to improve the Online Assessment Method for Practical Tasks so that their use has a more positive impact on the students and lecturers involved. Student psychomotor assessment rubrics can be improved to suit online assessment methods. They are also recommended to explore the study about effectiveness of the Online Assessment Method for Electrical Technology Practical Tasks in more depth so that all shortcomings can be improved for future use.

8. Conclusion

The readiness of students to face practical work sessions for Electrical Technology courses is quite encouraging. Therefore, the results of this innovation provide information and a true picture of the Online Assessment Method for Electrical Technology Practical Tasks. Lecturers can take the initiative to plan the best online practical task strategies and requirements by leveraging the various free online applications as well as the CIDOS e-learning platform provided as an effort to advance and equip themselves in 21st century T& L process.

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