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Correlation of Students' Perceptions and Performance Towards ODL Virtual Electrotechnology Laboratory Course

Wan Suhaifiza W Ibrahim, Nur Asfahani Ismail, Norlina Mohd Zain, Nur Iqtiyani Ilham, Zahari Abu Bakar

College of Engineering, School of Electrical Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, Jalan Purnama, Bandar Seri Alam, 81750 Masai, Johor, Malaysia

Email: wsuhaifiza@uitm.edu.my, asfahani9303@uitm.edu.my

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Abstract

Since the year 2020, Open Distance Learning (ODL) has made great impact on higher education institutions worldwide. ODL provides flexibility in education where students are able to attend online classes and watch recorded videos of lectures for revision or missed class. Though many institutions offer online-based course, it is still considered limited particularly in Electrical Engineering courses which requires hands-on in-lab practices. This is a challenge for higher institutions to adjust course content to be adaptable with ODL at the same time meet the course objectives. This paper studies students' acceptance towards ODL virtual Electrotechnology laboratory (EEE111) course in UiTM Pasir Gudang based on Exit-Entrance Survey conducted at the beginning and end of the course with the students' performance as the control group. The survey was conducted online with specific questions on students' perceptions of the course. A total of 165 respondents were recorded for EE111 and EE112 programs. The effectiveness of this virtual laboratory was evaluated at the end of the semester by referring to the students' performance in this course. Students have been assessed on practical skills, report writing, peer and lecturer review as well as on sustainability element in their mini project. The practical skills that contribute 90% from overall marks have been measured in practical test, laboratory work and mini project. Based on this study, it shows positive acceptance from the students towards ODL EEE111 course with 69.4% and 67.8% overall practical skills achieved for EE112 and EE111 programs respectively.

Keywords: Exit-Entrance Survey, Electrical Engineering, Learning Outcomes, Online Distance Learning, Virtual Laboratory.

Introduction

Our education institutions have been greatly affected by COVID-19 where teaching and learning activities are restricted to being on online or remote mode. Higher education institutions especially are forced to make adjustments to the syllabus content in order to accommodate for Open Distance Learning (ODL). Engineering education in higher institution is designed to develop problem-solving skills through problem-based learning for students to correlate theoretical and practical knowledge. As a consequence, practical knowledge which involves hands on training in laboratories are made as compulsory requirement by Engineering Technology Accreditation Council (ETAC) listed in Program Accreditation Standard 2020 governed by Board of Engineers Malaysia (ETAC, 2020). However, the challenges lie in developing online-based learning for laboratory courses as compared to conventional face-to-face learning method. More importantly, students' acceptance towards ODL reflects in their performances.

A case study on students' perspectives of laboratory course online learning shows positive feedback based on questionnaire survey (Al-Nsour et al., 2022). The challenges of electrical engineering online laboratory courses have been addressed in (Petkova & Terzieva, 2021) which draws more disadvantages than advantages. This is due to the lack of hands-on practice for students to experience and subsequently make comparison to theoretical knowledge. Hands-on practice is the main objective of laboratory courses and students can get discourage to be familiarized with equipment and components (Isa et al., 2022). Other than knowledge they can gain from hands-on experience, students' interest towards the course is equally important. A study performed by (Bishop et al., 2021) shows the relevance between different teaching method and acceptance of students towards the course. From the study, 100% of students enjoy doing practical laboratory activities in-lab compared to less than 60% of students enjoy watching recorded/live demonstrations of experiments. Another study on students' perceptions of online learning is done in (Ilham et al., 2021) for electrical engineering course. The findings conclude that majority of students exhibits positive attitude towards ODL. However, the said course does not involve laboratory activities. From the literature, course content contributes to the difference in students' acceptance of online learning. A survey-based study in (Zaghloul et al., 2021) conducted on Electronics Engineering students shows dissatisfaction of students towards remote electronics lab course with only 40% satisfaction. Students' satisfaction increases a little over 45% with home-kits to carry out hardware labs at home. Nevertheless, the findings are not being compared to students' performance to further fortify the surveys are legitimately responded. In (Umenne & Hlalele, 2020), it is shown that students' performance decreased for ODL-based laboratory compared to conventional practice. However, their study does not involve students' perceptions on the course.

This paper discusses students' acceptance on a virtual Electrotechnology laboratory course based on questionnaire survey conducted at the beginning and the end of semester. The findings are validated with students' performance as control group. The performance is based on course outcome (CO) and program outcome (PO) attainment outlined by ETAC requirement. COs are skills, competencies and attitude of students expected to gain by the end of a course (Bhuyan et al., 2020). Meanwhile POs are elements that reflects students' knowledge and ability to perform at the time of graduation (ETAC, 2020).

Course Outline of Electrotechnology Laboratory

Electrotechnology Laboratory (EEE111) is one of compulsory subjects in UiTM's Electrical Engineering Diploma program. It is an introductory course for students on basic electrical parts, instruments and measurements, consumer circuits, wiring systems, generation of electricity and distribution system as well as printed circuit board (PCB). Before COVID-19 pandemic hit worldwide, students were able to do in-lab experiments, however due to the pandemic, students are required to complete the course online with video demonstrations under guidance from lecturers. In this laboratory course there are eight experiments to be conducted individually and two experiments conducted in a group. The first three experiment lays out the general safety of laboratory based on UiTM's rules and regulations also introduction to some basic equipment, resistors and transistors that will be used regularly throughout the whole semester. Ohm's Law and Kirchosff's Law are introduced in two separate experiments as means to understand circuit connection as well as current and voltage divider rules that later will be learned in depth the following semester. There are two experiments dedicated for wiring including the installation system and installation method especially conduit. Two group-based experiments, turned into mini projects are simulation-based for direct current (DC) and alternate current (AC) circuit analysis designed on PCB.

Students are evaluated mainly during the allocated time of online session by answering some questions on the experiment of the week. Students' evaluation is based on ETAC Course Outcomes (COs) and POs mapping. Table 1 lists the mapping of CO-PO for this laboratory course. CO1 requires practical skills in laboratory activities and mapped to PO4 which is the ability to investigate well-defined problem. CO1-PO4 is evaluated in every experiment. For CO2-PO7, the sustainability element is embedded in students' mini project. CO3-PO9 and CO4-PO10 are also assessed in group project since students are required to work in a group and present their works.

Table 1
CO-PO mapping for EEE111 ODL

Course Outcomes (COs)		Program Outcomes (POs)	
CO1	Display good practical skills in conducting experiments and project using equipment/trainer board/suitable software and hardware tools during laboratory sessions. (P2)	**PO4**	Conduct investigations of well-defined problems; locate and search relevant codes and catalogues, conduct standard tests and measurements
CO2	Discuss the impact on society and the environment in finding the solution of well- defined engineering problems. (A2)	**PO7**	Understand and evaluate the sustainability and impact of engineering technician work in the solution of well-defined engineering problems in societal and environmental contexts
CO3	Work effectively as an individual and a team member while conducting the experiments in a group. (A3)	**P09**	Function effectively as an individual, and as a member in diverse technical teams
CO4	Present verbal and written communication skills in reporting the conducted experiments and project. (A2)	**PO10**	Communicate effectively on well-defined engineering activities with the engineering community and with society at large, by being able to comprehend the work of others, document their own work, and give and receive clear instructions

The practical element contributes 90% of the course, 5% assessment of project report, 3% lecturer and peer review and 2% on sustainability element as shown in Figure 1. Table 2 shows how the practical skills being measured in this course; 40% practical test, 30% laboratory work and 20% mini project. Students are tested on their practical skills at the end of semester. The test consists of overall perceptions throughout the course which is the main reason it carries 40% of total assessment.

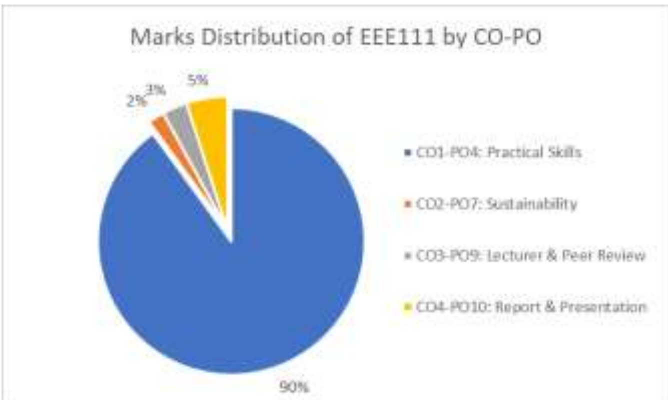

Figure 1: Assessment distribution of EEE111 ODL according to CO-PO

Table 2
Types of assessment for practical skills CO1-PO4

Assessment's Type	Percentage
Practical Test	40%
Laboratory Works	30%
Mini Project	20%
Total:	90%

Method Approach
This section will discuss the method approach of this study to investigate the effectiveness of ODL virtual laboratory based on survey by questionnaire among students and validated with the students' performance as control group. The approach is divided into two sections. The first section describes the Exit-Entrance survey in detail, such as the list of questions used, medium of survey and the timeline of survey was conducted. Meanwhile, the second section details out the implementation of this virtual lab and its evaluation process to measure the final performance of the students. There were overall 180 students from semester 1 from EE111 (85 students) and EE112 (95 students) program in this study and these virtual laboratories were their first experience.

a) Exit-Entrance Survey
The exit-entrance survey is an online questionnaire form that need to be filled out by students for each course that students registered every semester. The purpose of the exit-entrance survey is to measure the effectiveness of this course in improving students' existing knowledge and skills, hence determining whether students are learning something from this course. Students need to answer the entrance survey within the first two weeks of the beginning of the semester. This is used to assess students' level of knowledge relevant to this course. Students are also required to answer the exit survey within 2 weeks before the semester end. The aim is to re-evaluate students' level of understanding or knowledge after they have completed this course. The survey comes with five number scales of: 1 (strongly disagree), 2 (disagree), 3 (mixed feeling), 4 (agree) and 5 (strongly agree). Finally, the value of entrance survey will be deducted from exit survey, hence the result will show the effectiveness of the course from the students' perceptions and experiences throughout the semester. The list of Exit-Entrance survey's question is shown in Table 3. There are a total of 12 questions about practical skills that should be learned in this course.

Table 3
Exit-Entrance survey

No.	Questions
1	I understand the safety rules in laboratory.
2	I understand the function of basic test instrument such as oscilloscope, function generator, multimeter, and power supply
3	I understand an electrical symbols, schematic diagrams, and pictorial diagrams.
4	I understand the function and usage of basic hand tools such as screwdrivers, pliers, and soldering iron.
5	I understand and know resistor color coding scheme.
6	I understand breadboard and its connection.

7	I understand and know the function of electronic components and devices such as diode, transistor, and transformers
8	I understand and know the concept of Ohm's Law, Kirchoff's Law, and circuit connection in circuit analysis.
9	I understand and know the concept of one-way switch, two-way switch and socket outlet installation method and wiring test.
10	I understand the concept of Direct-On-Line starter and its application.
11	I understand the concept of circuit design and simulation software.
12	I understand the process of Printed Circuit Board (PCB) fabrication and component assembly.

b) Design of ODL Virtual EEE111 Laboratory

The conceptual of the ODL virtual laboratory is designed based on ETAC standard requirement tally with the physical laboratory conducted before COVID-19 pandemic scenario to complement the science, computing, and engineering theory. A blended learning course framework designed in (Budihal et al., 2021) is being referred to in this study. Our complete experimental design process of ODL virtual laboratory for EE111 is shown in Figure 2. The laboratory modules for all experiments have been revised accordingly into simulation-based or demonstration-based experiments to adapt the physical laboratory modules. The laboratory work for this course was delivered fully online either consisted of students performing simulations or watching recorded video demonstration of experiments and then analyzing provided data and completing the assessment in modules to check their understanding. The decision of the activities delivered in these methods was based on the original activity learning outcomes, as well as the availability of the required software (Bishop et al., 2021).

Generally, most of the laboratory modules are simulation-based experiment but in-case for non-simulation modules which require specific tools or equipment, a recorded video module is used to replace the simulation module (Isa et al., 2022). Since this is the first electrical laboratory for these students, it is very important to introduce them with the real equipment used in laboratory (e.g.: resistor, multimeter, dc generator, oscilloscope etc.) and demonstrate its functions in the recorded videos. The recordings were very detailed and demonstrated all the technical tools and steps in a logical manner. However, for a certain experiment that need analysis like measuring current or voltage, the best way is by performing simulations using either online circuit simulator like MultisimLive or TinkerCAD where students can create and share their circuits online with the instructors or by installing the simulator once and perform the experiments anytime and anywhere through their computer even during offline.

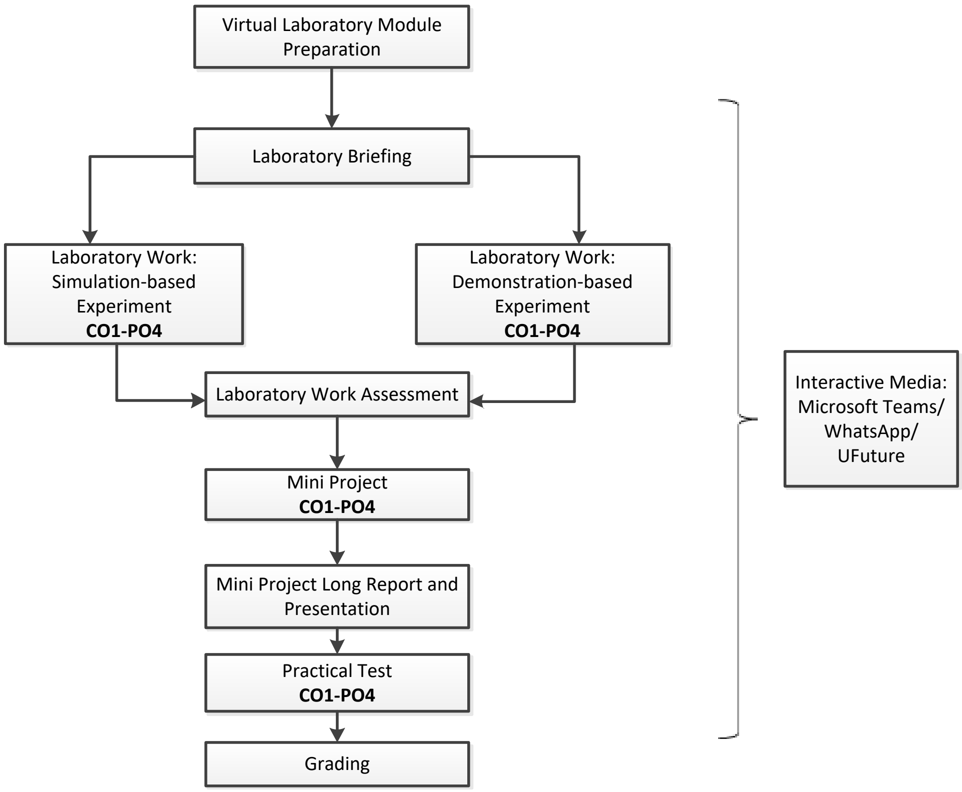

Figure 2: ODL EEE111 framework

Microsoft Team is the real-time communication medium used in this course for students to demonstrate their experimental work and Mini Project's progression to the lab instructor. This platform also used as interface for assessment/report submission as shown in Figure 3. Meanwhile, Figure 4 shows the example of asynchronous video recording for the demonstration-based experiment where the hardware implementation experiment is recorded by the course instructor and uploaded on the Microsoft Teams platform. Meanwhile, Figure 5 shows an example of virtual laboratory of simulation-based experiment using TinkerCAD online via Microsoft Teams during class. The grading of the laboratory evaluation was conducted based on the rubric which followed the ETAC standard. All the experimental assessments under CO1-PO4 are evaluated during the laboratory session based on scoring guide or rubric as shown in Table 4.

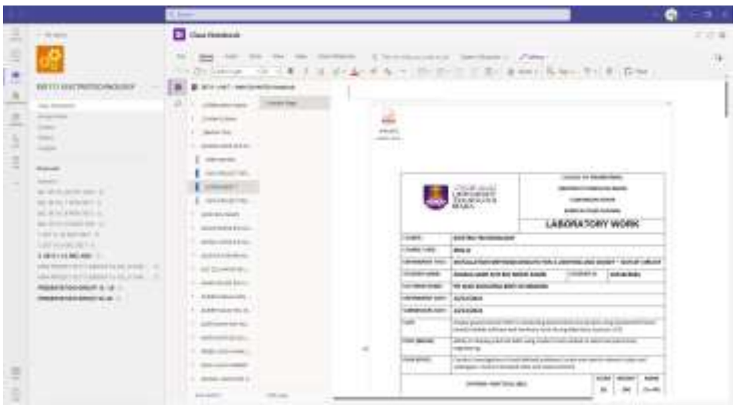

Figure 3: Laboratory work assessment submission platform

Figure 4: Demonstration video for installation of lighting and socket outlet circuit

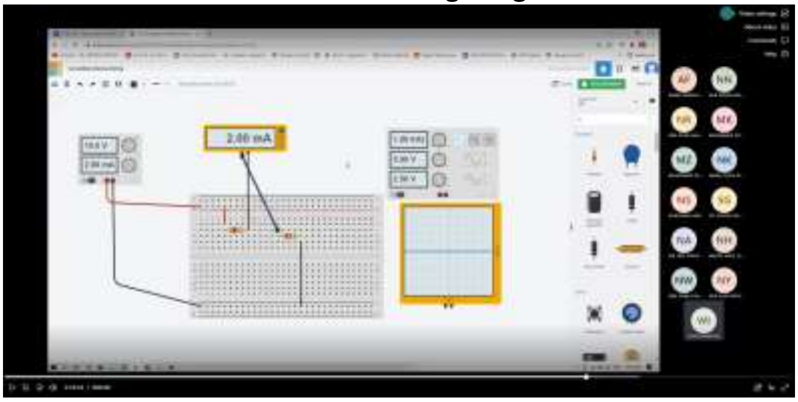
Figure 5: 3D Circuit Design using TinkerCAD Online

Table 4
EEE111 ODL rubric criteria

CRITERIA OF PRACTICAL SKILLS	
1	Ability to handle equipment tools / software efficiently
2	Ability to construct model/circuits/ system/coding using software tools
3	Compliant of safety rules and procedures while using the tools
4	Ability to produce output/result for all tasks using given/dedicated techniques and tools
5	Perform technical analysis using given/dedicated techniques and tools

In a semester, a total of 14 weeks allocated for the practical and learning process which in Week 1 and 2 are normally provided for preparation and briefing session. The remaining weeks were allocated for laboratory works and mini projects. Practical test was conducted on the final week as the test cover from Experiment 1 until 10. The overall implementation of the ODL virtual laboratory for EEE111 is conducted based on the lesson plan as shown in Table 5.

Table 5
EEE111 ODL lesson plan

Lesson Week	**Stage**	**Participants**	**Specifications**

Week 1 - 2	Preparation and Online Briefing	Coordinator	- Introduction to the course - Briefing on the timetables/modules/rubrics & virtual laboratory's implementation
		Lab Instructor	**- PREPARE VIRTUAL LABORATORY MODULE AND COMMUNICATION MEDIUM FOR STUDENTS WORKS**
		Students	- Downloads all the materials provided - Get familiar with the communication medium
Week 3 - 10	Laboratory Work (Experiment 1 – 8)	Lab Instructor	- Before lab: Release the experiment module and materials - During online lab: Virtual laboratory discussion and evaluation and question and answer session - After lab: Notify laboratory work's assessment submission and evaluate report
		Students	- Before lab: Read the manual and watch the recorded video or prepare the simulation of experimental work - During online lab: Virtual laboratory demonstration and presentation - After lab: Laboratory work's assessment submission
Week 11 - 12	Mini Project (Experiment 9-10)	Lab Instructor	- Before lab: Release the Mini Project module and materials - During online lab: Virtual Mini Project discussion and evaluation and question and answer session - After lab: Monitor the progress of Mini Project's work, notify Mini Project's report submission, and evaluate long report
		Students	- Before lab: Read the manual of Mini Project and prepare the simulation of Mini Project - During online lab: Virtual Mini Project's demonstration and presentation - After lab: Complete the Mini Project's work within time given and long report submission
Week 13	Mini Project's Presentation	Coordinator	- Prepare the Mini Project's timetable and notify students
		Lab Instructor	- Virtual presentation and evaluation and question and answer session - Comment and review on student's performance
		Students	- Prepare the Mini Project's presentation -Virtual Mini Project's demonstration and presentation

Week 14	Practical Test	Coordinator	- Conduct the virtual Practical Test -Summary and evaluation of students' overall performance
		Lab Instructor	- Evaluate the virtual Practical Test - Final review on other assessment
		Students	- Sit for the virtual Practical Test - Notification all complete modules.

Results and Discussions

In this section we present the findings from the Exit-Entrance survey as well as the overall performances evaluated by the instructors.

a) Students' Exit-Entrance Survey

A total of 165 students were surveyed about their experiences and outcomes with ODL virtual laboratory where 77 students are from EE111 program, and 88 students are from EE112 program. Figure 5 demonstrates the percentage of frequency for Exit-Entrance survey score for all questions in the survey for both programs. The Exit-Entrance survey score formula and example are shown in Eq. 1 and 2 respectively.

$$Exit - Entrance\ score = exit\ score - entrance\ score \qquad (1)$$

$$Exit - Entrance\ score = 5(Strongly\ Agree) - 1(Strongly\ Disagree) = 4 \qquad (2)$$

The result of the survey questions indicated that the virtual laboratories based on fully computer simulations and demonstration were well-received by students with almost 45.45% and 40.63% for EE111 and EE112 respectively at the highest score of Exit-Entrance Survey. The result also shows the high percentage at Score 3 where 43.07% for EE111 and 40.72% for EE112 as indicator of students that are generally satisfied with the effectiveness of this conducted virtual laboratory. Meanwhile, only a total of 11.47% and 18.65% for EE111 and EE112 respectively with score 2 and below reveals that this virtual laboratory was challenging for certain students where they might have difficulty in adapting this method approach. According to Table 6, Questions 1, 2 and 4 comprise with lowest score of Exit-Entrance Survey but in very minimal percentage in the range of 0.61-1.21% only. Questions 2 and 4 asked students if they can understand the function of basic test instrument (e.g.: oscilloscope, function generator, multimeter, and power supply) and basic hand tools (e.g.: screwdrivers, pliers, and soldering iron) that used in laboratory. This skill can be learnt more effectively when students can use this equipment face-to-face because there are various modes and settings that can be explored when running a hands-on laboratory.

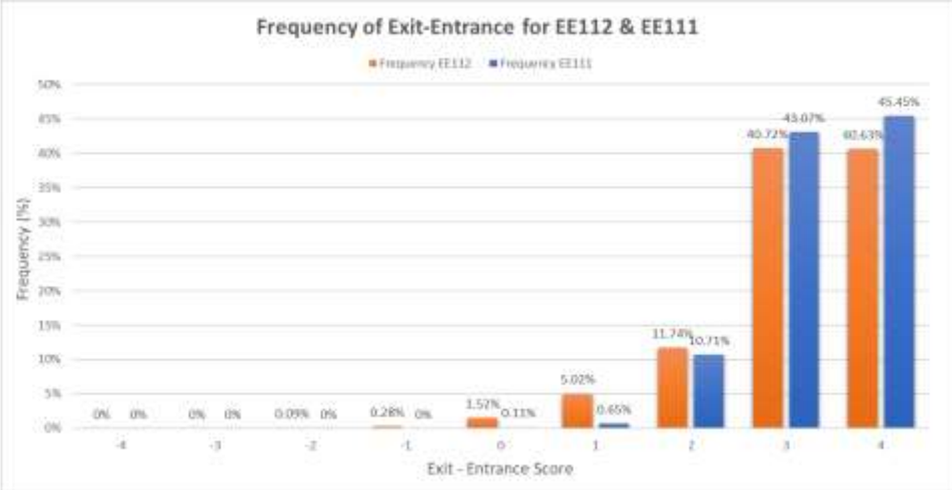

Figure 5: Overall frequency of exit-entrance score for both programs

Table 6
Frequency of exit-entrance score by questions for both programs

Exit-Entrance Score	-4	-3	-2	-1	0	1	2	3	4
Question No:	**Frequency (%)**								
Q1	0.00	0.00	0.00	0.61	0.61	4.85	7.88	40.61	45.45
Q2	0.00	0.00	0.00	1.21	0.00	3.03	14.55	40.00	41.21
Q3	0.00	0.00	0.00	0.00	0.61	4.24	7.88	41.82	45.45
Q4	0.00	0.00	0.61	0.00	1.82	3.03	10.30	36.36	47.88
Q5	0.00	0.00	0.00	0.00	0.00	1.82	13.33	41.21	43.64
Q6	0.00	0.00	0.00	0.00	0.00	1.21	10.91	43.03	44.85
Q7	0.00	0.00	0.00	0.00	2.42	3.03	11.52	44.24	38.79
Q8	0.00	0.00	0.00	0.00	1.21	3.64	12.12	47.88	35.15
Q9	0.00	0.00	0.00	0.00	0.61	2.42	12.12	37.58	47.27
Q10	0.00	0.00	0.00	0.00	1.21	3.03	12.12	44.85	38.79
Q11	0.00	0.00	0.00	0.00	0.61	1.82	10.91	43.03	43.64
Q13	0.00	0.00	0.00	0.00	1.21	3.64	11.52	41.21	42.42

b) Students' Performance

Figures 6 and 7 illustrate the students' performances in CO1-PO4 of end-semester scores for EEE111 for both programs. The results show that most students scored excellent grades of A- which is 25 students for each program, then followed by B+, B and B-. There are only small number of students that got lower grade such as C+ and below which highly proved the effectiveness of this virtual laboratory. In order to compare the Exit-Entrance Survey with these performance results, the percentage of grade was calculated in group of Excellent (A+, A, A-), Credit (B+, B, B-), Pass (C+, C) and Fail (C- and below). According to previous survey results, the percentages for combination of Score 3 and 4 are 81.35% and 88.52% for EE112 and EE111 respectively are almost tally with the combination results of excellent and credit score for both programs which are 88% and 86%.

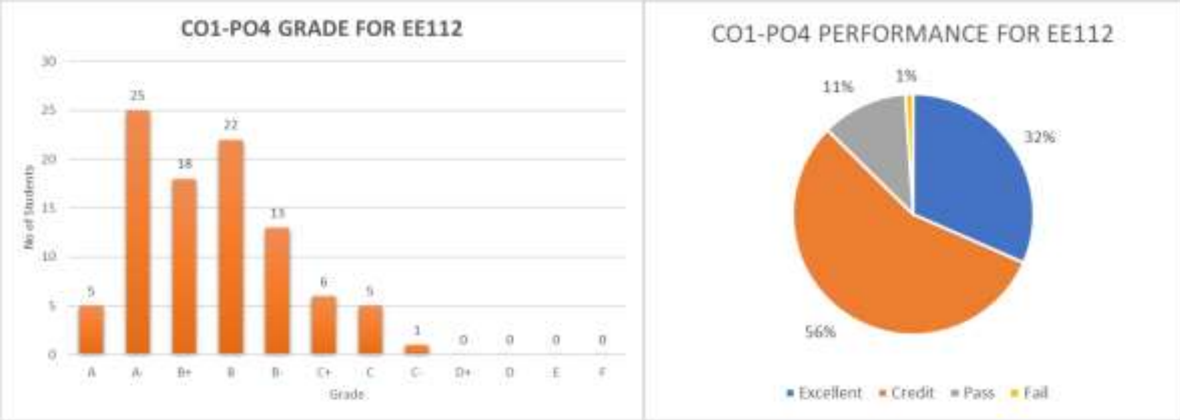

Figure 6: C01-PO4 attainment based on grade and overall performance for EE112 students

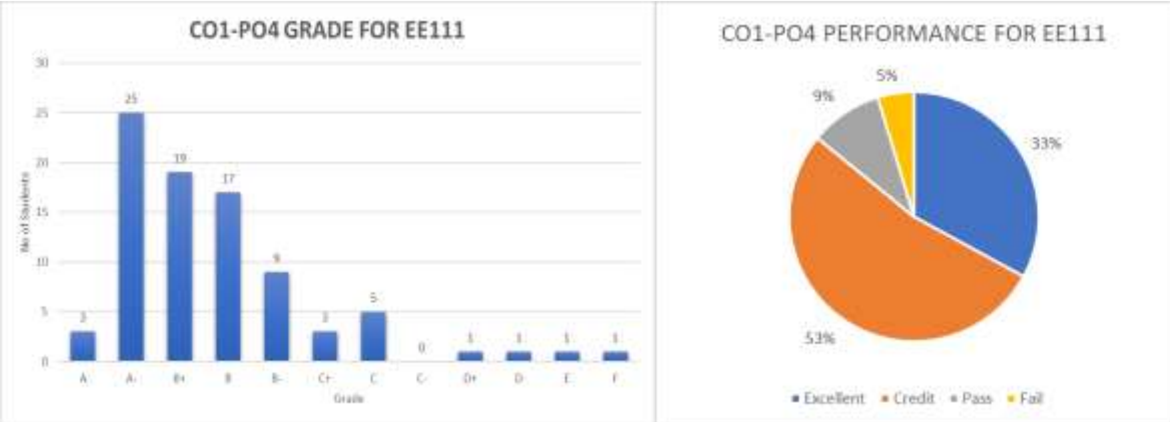

Figure 7: CO1-PO4 attainment based on grade and overall performance for EE111 students

Next, the overall CO-PO performance result for both programs is illustrated in Figure 8. As our highlight in this study is only on practical skills, thus we only refer on the first two graphs as marked in the square box. The overall performance of CO1-PO4 for both programs are 69.4% and 67.8% has reached the target of Performance Indicator (PI) that has been set at 65%. Even though the value is not as high as other CO-PO, it is still showing that this virtual laboratory is acceptable and adaptable among new students.

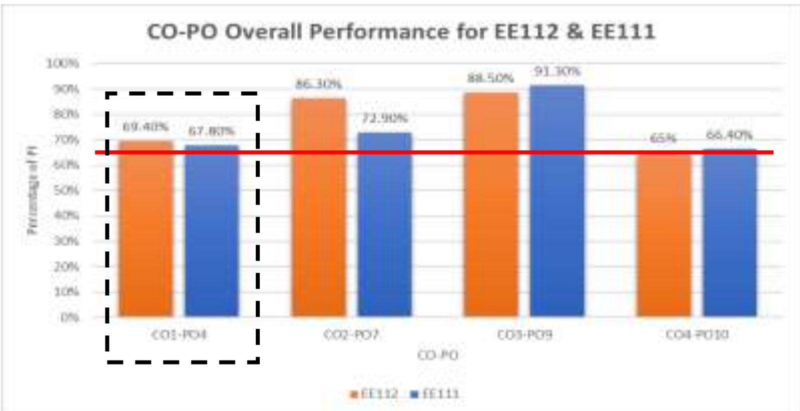

Figure 8: CO1-PO4 overall performance for ODL EEE111

Conclusion

This paper presents students' acceptance of ODL-based EEE111 course through findings obtained from survey which correlates with their performance by looking into overall PO attainment. PO4 that contributes to the majority of EEE111 assessment achieve above 65% of overall performance reflects positive acceptance from students. Based on the positive responds with more than 40% score 4 from the survey, it is proven that students are able to acquire knowledge on electrical and electronics components. Although ODL restricts the opportunity for students to experience hands-on practice, video demonstrations can assist students to better understand the experiments and with software simulation exercises, students are able to grasp the knowledge effectively as demonstrated from the overall performance. Lecturers are expected to develop flexible course content especially for laboratory courses so that they can easily be adapted to both ODL-based and conventional face-to-face teaching methods. For future works, teaching methods and assessment can be analyzed to further support students' acceptance towards ODL-based EEE111. An interactive website can be developed to further improve ODL EE111 making it more exciting for students to practice and test their skills.

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