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Abstract

Psychomotor skills are important for engineering students to have to become a professional engineer or technician. Psychomotor skills, often known as manual or physical abilities, are typically developed in a laboratory. This study's primary objective was to evaluate the performance comparison of the students' psychomotor skills during open-distance and face-to-face learning for the structural and material laboratory. Instead of simply following the pre-established rules from a laboratory manual as usual during face-to-face class, students are given the freedom to design the simulation experiments during open distance learning (ODL). The psychomotor skills are evaluated based on the practical test and project-based. According to the findings of this study, the student's performance on practical tests and projects achieved the comparable score for semester F2F and ODL. Even though there is a little difference in percentage of attainment for the project between those two teaching approaches, it is still satisfactory as both approaches are able to pass the requirement grade.

Keywords: Practical Test, Face to Face, Open Distance Learning, Project.

Introduction

Enhancing engineering education is one of the requirements for accreditation of engineering programmes (Engineering Accreditation Commission, 2012). To become proficient engineers, the students need to graduate with strong character traits. Thus, to give experience and practise before they graduate, laboratory experiments or practical work might be incorporated into the curriculum. Students can gain information, practical skills, and awareness of pertinent engineering challenges through laboratory activities (Salim et al., 2012).

The development of cognitive, affective, and psychomotor skills are the three learning domains listed in Bloom's Taxonomy (Hamid & Baharom, 2013). Psychomotor skills also known as technical skill often known as manual or physical abilities, are typically developed in a laboratory environment (Baharom et al., 2015). Technical skills are among the critical

abilities that engineering students must develop. These skills are necessary to guarantee engineering students a productive professional future following graduation. These skills can only be used in the lab, on assignments, and outside of the classroom. For engineering students, laboratory work is a crucial component of their education.

The abrupt COVID-19 epidemic in Malaysia required all higher education institutions (HEI) to switch from their initial face-to-face (F2F) teaching and learning to open and distance learning (ODL). Faculty of Civil Engineering, Universiti Teknologi MARA Pasir Gudang made online learning a requirement for all courses for semester March to July 2020. Most students benefit from the learning activities carried out by lecturers by using online platforms including Ufuture, Google Classroom, Google Meeting, Webex, and Facebook Live.

Students can study from any location, have the freedom to choose their learning session, save time, and still connect socially with the lecturer for assessment and lecture consultation when taking theory-based courses. The situation is very different for teaching learning practical courses, when students begin their learning activities from home and have no physical contact with the lecturer or their groupmate while doing laboratory exercises and practical assessments (Basantia, 2018). Studies done in the past have emphasised the difficulties in using online platforms to evaluate psychomotor skills in engineering education (Seth & Haron, 2016; Potkonjak et al., 2016). These are the difficulties that arise when using practical online learning courses during a pandemic epidemic to ensure that programme objectives are met. In terms of the process of implementing the evaluation, assessment of learning can be carried out with several assessment techniques according to the characteristics of the learning material, the students, and the learning environment in accordance with the situation and conditions (Try Andreas Putra et al.,2022). This study discusses on the evaluation and the performance comparison of the students based on their psychomotor skills achievement by using two teaching approach which are face to face learning(F2F) and open distance learning (ODL)

Psychomotor Domain in Structural and Material Laboratory

Couse Outcome described what students are expected to know and able to perform or attain by the end of the course. While programme outcome described what graduates are expected to know and able to perform or attain by the time of graduation which include the skills, knowledge, and behavior. So, in this Structural and Material Laboratory course consists of two CO's and PO's which is CO1-PO4, and CO2-PO4 that indicated the performance of psychomotor skill student. Two course outcome which are mapped to the psychomotor domain are shown in Table1. Psychomotor skills are evaluated in the course through the practical test and project.

Table 1
Mapping of course and programme outcome related to psychomotor domain

Course Outcome		Programme Outcome	Taxonomy Domain	Assessment
CO1	Assemble structural and material laboratory experiments using standard tests and measurements	**PO4** Conduct investigations of well-defined problems, locate and search relevant codes and catalogues, conduct standard tests and measurements.	P4	Practical Test
CO2	Laboratory activities related to structural and materials		P5	Project

Methodology

Laboratory work is a very important component for engineering students to develop psychomotor skills. Students will enhance their psychomotor skills while running the laboratory setting and projects that need practical skills. These skills are essential to ensure that diploma engineering students can conduct an instrument successfully as a technician after they graduate. This section explains the assessment that has been made in identifying the psychomotor performance of students during ODL and face-to-face classes for the two course outcomes that are mapped to the psychomotor domain.

Teaching Delivery and Lab Work Operations

For year two students pursuing the Diploma in Civil Engineering, the Structural and Material Laboratory is a compulsory course. The number of students in each small group in the lab sessions was limited to four. They were split up into smaller groups so they could interact during class, work in teams, and discuss while doing the project. The fourteen weeks of lab work were divided into two-hour long sessions. For the purposes of this study, data is based on the Face-to-Face class for Mac semester 2019, while the ODL is for the semester of March 2021.

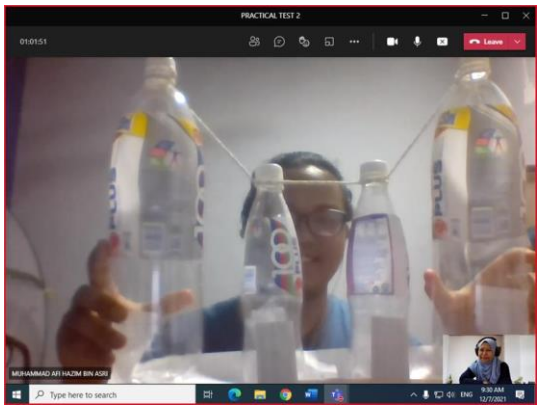
The Open-Ended Laboratory (OEL) approach is typically used to perform laboratory sessions. An OEL is a setting where students are free to design their own experiments as opposed to just following pre-established instructions from a laboratory manual or somewhere else. The pupils' ability to think critically and independently while strengthening their psychomotor abilities for conducting experiments would be enhanced. The students must come up with their own tactics and support them with justifications, ideas, and logical arguments. OEL practice sessions are often conducted face-to-face between the student and the lecturer. However, during MCO, it was impossible to implement the regular practice of OEL learning sessions, thus the laboratory lesson was completely switched to ODL. Table 2 describe the assessment and teaching delivery involve for both teaching approach. There are two type of assessment that are contribute to the psychomotor domain for this course which is practical test and project related to the laboratory technical skill. Figure 1 and Figure 2 show the comparison of psychomotor assessment for both learning approach (Face-to-Face and

Open Distance Learning).

Table 2
Type of psychomotor assessment and teaching delivery

Psychomotor Instrument	Face to Face Learning	Open and Distance Learning
Lecture	Practical laboratory experiment during class	The videos related to each of the laboratory session given to the students with an explanation from the lecturer.
Practical Test	In-person demonstration of conducting the experiments and explaining all the steps accordingly with the relevant data	Online interview with the Constructed model related with the experiment and explained all steps accordingly.
Project	Hands-on practice to complete tasks within the class session	Simulation of the experiment involve in the project.

a) In person demonstration



b) Online interview

Figure 1: Practical test evaluation for the face to face and open distance learning

a) Hands on experiment for project

b) Simulation of experiment for project

Figure 2: Project-based psychomotor assessment during face to face and open distance learning

Psychomotor Domain Evaluation Rubrics

As indicated in Table 3, Simpson's Psychomotor Domain taxonomy served as the foundation for the evaluation rubrics used in the Structural and Material Laboratory to evaluate the psychomotor domain. Students are required to achieve level P4 (mechanism) for CO1 (to be able to conduct the experimental work relevant to standard) level P5 (complex overt response) for CO2 (to be able to utilise appropriate techniques in the solving project activity).

Table 3
Level of simpson's psychomotor domain taxonomy adapted from (Chiew et al., 2021)

Level	Category	**Description**
P1	Perception	Ability to use sensory cues to guide motor activity.
P2	Set	Readiness of mental, physical, and emotional aspects that make one respond in a certain way to a situation.
P3	Guided response	First attempts to practice skills with guidance
P4	Mechanism	Perform simple acts with increasing efficiency and confidence
P5	Complex overt response	Perform practical skills with complex motor movements
P6	Adaptation	Modify movement patterns to meet special problem/ situation.
P7	Origination	Create new movement patterns to account for problematic / new situation.

The laboratory practical test is implemented in this course. The test was employed as one of the assessment components for the laboratory experiments to evaluate students' psychomotor skills and contribute 50% to the course grade. This assessment enabled the lecturers to identify the practical skills acquired by the students as well as their weaknesses in performing the experiments. Practical assessments are examined in-person with students during laboratory sessions for face-to-face learning. Students must demonstrate the experimentation process to collect meaningful data and use the proper equipment. The practical skills assessed during the practical test are shown in Table 4. This practical skill is adequate for online distance learning (ODL), but students will need to construct a simple model of the experiment to explain every step in an online interview with their lecturer. Each semester, they will have two practical tests in this course.

For project-based assignments in this course, students are given questions related to the current issue, which is sustainability. Sustainability is important for the well-being of our planet, the continued growth of a society, and human development. Based on this situation, students are required to find a suitable sustainable material that can be used as part of the replacement material in concrete. They work in groups and choose either to replace it with coarse aggregate, fine aggregate, or cement. All group members need to use different sustainable materials with the same amount of substance. Students are required to determine the workability of a sustainable concrete mix by conducting a slump test, to find the ways and means of the tests, and subsequently analyse the data and present it in a video presentation and it will evaluate based on the taxonomy level as shown in Table 5. This project will contribute 40% of the total percentage of assessment. This project is applicable for both

learning approaches, but there are differences in the way of conducting the experiment to solve this project-based problem. During face-to-face learning, the project is conducted during a laboratory session with all the standard equipment but different sustainability materials to fully meet the requirements. Students need to do a simulation on a slump test with the use of commonly available materials and equipment at home.

Table 4
Mapping of practical skills to psychomotor taxonomy level for CO1

Activity	Practical Skills	Taxonomy level
Practical Test	Identify the objective of the experiment or problem given.	P1: Perception
	Recognize the apparatus required to conduct the experiment	P1: Perception
	Decide number of specimen / sample type/ reading to be collected	P2: Set
	Prepare sample and setup the equipment	P3: Guided response
	Handling the equipment, specimen, or sample safely as in procedure	P4: Mechanism
	Demonstrate on how to conduct the experiments and explain all the steps accordingly.	P4: Mechanism
	Record relevant experimental data in orderly manner	P4: Mechanism

Table 5
Mapping of practical skills to psychomotor taxonomy level for CO2

Activity	Practical Skills	Taxonomy level
Project	Identify the purpose of the experiment or given scenario.	P1: Perception
	Recognizing the machine/tools or apparatus needed for the activities.	P2: Set
	Able to display the apparatus/ machine.	P3: Guided response
	Able to demonstrate or conduct the apparatus machine successfully as procedure.	P4: Mechanism
	Ability to adapt the obtained result to understanding of finding	P5: Complex overt response
	Ability to adapt the presentation Skills to understanding overall experiment	P5: Complex overt response

Results and Discussion

Psychomotor skills for this course are assessed by practical test and student's project. The practical test contributes 50% while student's project contributes 40% out of 100% assessment marks. Figure x1 shows the comparison of students' grade attainment of CO1:PO4 during F2F and ODL semester which comes from the marks of Practical Test. In comparison, 90% of the students obtained grade A+, A and A- for F2F semester while there are slightly decrement on the achievement of those grades during ODL semester which is 86%. There are 18% of the students obtained grade A+, 58% for grade A and 14% for grade A- during F2F semester. During ODL semester, the achievement for Grade A+ is slightly drop to 16% but rise to 60% for grade A and 14% for grade A-. In addition, students' attainment for the remaining grades in ODL semester increase by 4% compared to F2F semester which the least grade that student achieve is B. As for ODL semester, the least grade that obtained by the students is C.

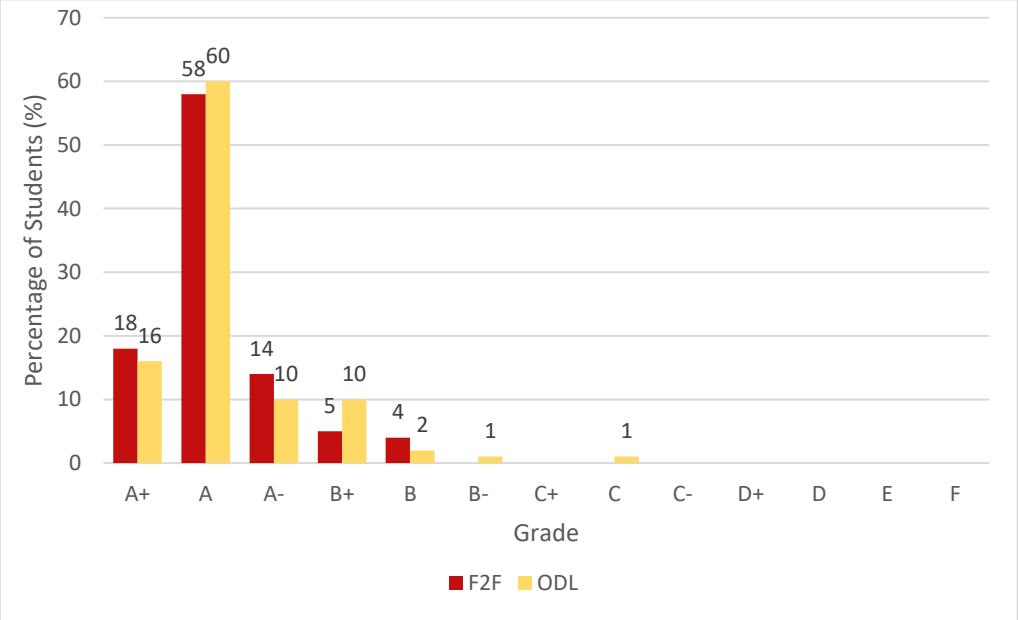


Figure 3: Comparison of student's attainment of CO1:PO4 during F2F and ODL

Overall, students performed very well on practical test evaluations for both F2F and ODL semesters. As can be seen in Figure 3, it is revealed that the student's attainment for grade A+, A and A- is only marginally decreased by the percentage of 4%, regardless of different method of teaching approach. This result might be attributed to the ability of student to perform experiments successfully without supervision, ability to handle and organise experiments safely with accurate apparatus, ability to show engagement in conducting experiments and demonstrate care and respect for the equipment set-up. In addition, based on the assessment evaluation, students able to score this practical test by recording any relevant and sufficient data to analyse to achieve the respective objective of the experiment. The finding confirmed that the practical test evaluations can be implemented via ODL by constructing a prototype model with appropriate tools in representing the actual apparatus in the experiment. However, it is noticeable that there is student who achieve grade C in this assessment. In conjunction with this case, students were possible not able to recognise, conduct and organise the experiments within the given time.

The comparison of students' grade attainment of CO2:PO4 during F2F and ODL semester is shown in Figure 4 which comes from the marks of Project. As for this assessment, the trend for the grade attainment is in an opposite direction. There are considerably

increment in percentage of students that obtained grade A+, A and A- during ODL semester in comparison with F2F semester. During F2F semester, only 1% of the students able to obtain A+, 44% for grade A and 26% for grade A-. In contrast, a higher achievement of percentage obtained by the students for grade A+ which is 5%, 65% for grade A and 24% for grade A- during ODL semester. Overall, students' grade attainment for CO2:PO4 shows that performance of students' during ODL semester is improved compared to F2F semester as achievement of grade A+, A and A- for ODL semester is increase to 94% compared to F2F semester which is 71%.

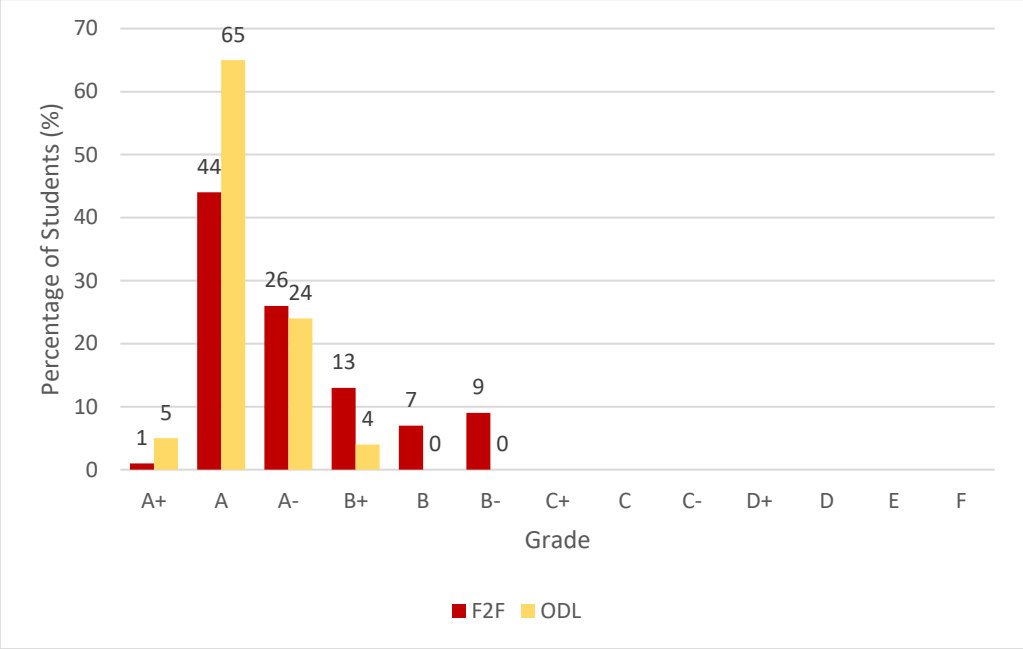


Figure 4: Comparison of student's attainment of CO2:PO4 during F2F and ODL

The finding obtained recorded the great achievement of students in terms of project assessment during ODL semester in comparing with F2F semester by the percentage of 23%. It is believed that majority of students were able to perform the project given successfully without supervision and independently. This indicates that students were gained positive attributes of psychomotor skills in order to conduct the experiment. During ODL semester, students were requested to conduct the workability of sustainable concrete by simulation of slump test. Interestingly to noted that most of students were able to demonstrate the experiment by using the appropriate tools at home in order to attain the objective of the engineering problem given. Criteria on the evaluation of this type of assessment include understanding the purpose of the experiment, recognise the correct apparatus, handle and conduct the experiment by following the standard of procedure. In comparison with F2F semester, some of students were not able to conduct the experiment well. This is probably because students could not comply with the standard procedures of experiment and weak on understanding of related theory that has been taught in lecture class.

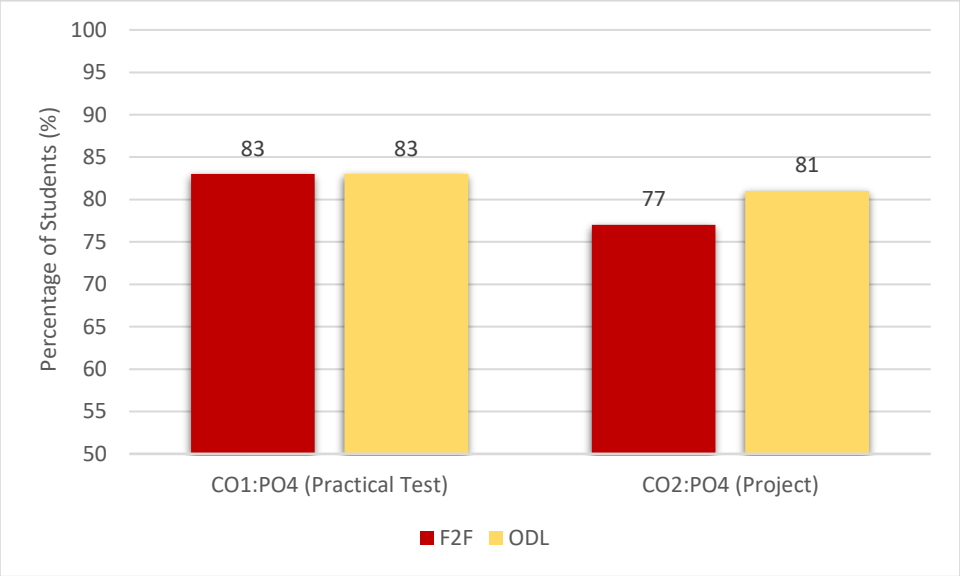


Figure 5: Comparison of average student's attainment during F2F and ODL

The average students' attainment for psychomotor skills for both COs and POs is shown in the Figure 5. The achievement for CO1:PO4 were assessed by practical test is constantly same for both teaching approaches which is 83%. In contrast, 4% rise for the attainment of CO2:PO4 that assessed by project from 77% during F2F to 81% during ODL. Overall, the student's achievement of practical test and project were attained the comparable score for semester F2F and ODL. Even though there are a little difference in percentage of attainment for Project between those two teaching approaches, it is still satisfactory as both approaches able to achieve 50% above (grade C).The assessment that are conducted during ODL may be different but it design to full fill the requirement of rubric and psychomotor taxanomy. This finding shows that the psychomotor skills were able to access through the online distance learning process for Structural and Material Laboratory.

Conclusion

Engineering students need to graduate with positive attributes to become competent engineers. Therefore, in engineering education, laboratory experiments or practical work can be integrated into the curriculum to provide students with engineering experience and practise prior to graduation. Students can perform well during open distance learning with a creative teaching approach to provide students with knowledge and practical skills and expose them to relevant issues in engineering, but face-to-face learning is the best approach to measure psychomotor skills for this course because each of the experiments can be done based on standards that are used in real industry or construction.

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