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ANALYSIS ON ONLINE DISTANCE LEARNING OF MECHANICAL ENGINEERING LABORATORY COURSE FOR ACADEMIC SUSTAINABILITY IN TERTIARY EDUCATION

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Abstract: *In previous years, laboratory courses are usually being conducted physically. This is because, the course requires hands-on learning such as access to specialized equipment, material, and experience. As the computer technologies evolves and the expansion of internet reachability, virtual laboratory was steadily developed for better accessibility, flexibility, safety and cost-effective. However, the global pandemic of COVID-19 has forces sudden implementation of laboratory online learning and created a new norm in the teaching and learning. This study aims to investigate the suitability of online learning of Mechanical Engineering laboratory course in the future. The investigation was done by disseminating a set of questionnaires to the target respondents. The validity and reliability of the survey questions were confirmed through a pilot test of 50 respondents by using Principal Component Analysis (PCA) and Cronbach Alpha (CA). The responses in five-Likert scale results were then further classified into three categories: Good, Non-decisive and Poor. The findings were compared against students' grades to validate the performance. The survey results indicated that the students gained good learning engagement (51%) and experience (46%), respectively. The suitability (64%), delivery (60%) and communication (44%) satisfy the 'Good' category hence affirmed the students' good online learning experience. The student's grades of the course exhibits correlation with the survey response. All the student passed the course with 8% A's, 34% B's and 58% C's.*

Keywords: *Distance learning, Laboratory, Learning environment, Online learning, and Tertiary education*

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Introduction

The online distance learning (ODL) has been forced to materialize due to COVID-19. During that time, educational institutions were not fully prepared but required to undergo the process since there is no other option. Educational institutions are grappling with the challenge of finding viable strategies to navigate this intricate situation within the short time span. These circumstances underline the urgent need for academic establishments to prioritize scenario planning (J. B. Rieley, 2020). The adoption of ODL has had a substantial impact on traditional in-person teaching methods (S. Pokhrel and R. Chhetri, 2021). In conventional teaching setups, students have the chance to directly interact with peers and instructors in a physical learning environment, fostering immediate communication, prompt feedback and boosting students' motivation and dedication to their studies (S. Stack, 2015).

Nonetheless, when educators engage in teaching within an online learning context, they encounter the inherent difficulty of establishing a robust community. This community revolves around nurturing shared learning, meaningful interaction and active participation among students and faculty in the virtual learning setting (Y. Lau et al., 2021). In the field of engineering, the shift to online learning introduces distinct complexities, particularly for courses and subject matter involving technical elements (S. Asgari et al., 2021). The geographical separation and absence of face-to-face interaction in online classes present hurdles for effectively transmitting knowledge and specialized skills through theoretical teaching models. With the emergence of Massive Open Online Courses (MOOCs), engineering educators face a new obstacle in delivering online education. Bridging the gap between theory and application, engineering students rely on interactive, hands-on learning opportunities to complement their theoretical classroom instruction (Ali S. Muhsan and Thar M. B. Albarody, 2019).

Literature Review

While a substantial amount of research has delved into the effects of online distance learning on student involvement and scholastic achievement (Ali S. Muhsan and Thar M. B. Albarody, 2019, S. Asgari et al., 2021), there exists a conspicuous gap in research when it comes to students' viewpoints on ODL within hands-on courses. Prevailing studies predominantly concentrate on overall online learning encounters or specific fields of study like chemical engineering or control engineering (D. Gillet et al., 2001, D. E. Santiago et al., 2022). Prior investigations have provided valuable insights into the benefits and obstacles tied to online learning. Nevertheless, there is a need for further exploration to thoroughly comprehend the distinct context of hands-on courses, where physical interaction and the cultivation of practical skills hold a pivotal significance.

To bridge the existing research gap and achieve a comprehensive comprehension of students' perceptions and experiences in online hands-on classes, mixed methods research consist of qualitative and quantitative approach will be utilized. The mixed methods research design encompasses a systematic process of gathering, analyzing, and merging qualitative and quantitative data, capitalizing on the unique strengths and advantages offered by each method (Creswell, J.W.,2014). In line with this research approach, the survey method serves as a valuable tool for data collection. It is defined as "the collection of information from a sample of individuals through their responses to questions." (J. Check and R. K. Schutt, 2011). Survey research encompasses a diverse range of data collection methods, with questionnaires and interviews emerging as the most prevalent approaches (J. Ponto., 2015). Surveys manifest in various formats, one of which encompasses internet-based surveys (N. C. Jenn, 2006), offering

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convenience and accessibility for participants especially during COVID-19 pandemic. The construction of a well-designed survey instrument involves careful consideration of various factors, including the selection and formulation of appropriate survey questions, the choice of response options, and the overall structure of the questionnaire. The meticulous design of the questionnaire holds paramount significance in facilitating the collection of precise data, thereby enabling the interpretation and generalizability of the results (N. C. Jenn, 2006). Furthermore, an integral aspect in the questionnaire design process involves constructing a conceptual framework (H. Taherdoost, 2019), wherein this study places particular emphasis on capturing students' attitudes and perceptions. To formulate a questionnaire, the researcher must initially determine the approach for data collection (H. Taherdoost, 2018). The Likert scale is likely to be used as it presents a straightforward construction method and is expected to yield a highly reliable measurement scale (H. Taherdoost, 2019).

To ensure the questionnaire is reliable and valid, it is imperative to conduct a feasibility study. A feasibility study can be described as a "preliminary investigation conducted on a smaller scale to evaluate research protocols, assess the effectiveness of data collection instruments, test sample recruitment strategies, and refine other research techniques in preparation for a larger-scale study" (P. W. Steward,1999). To further ascertain the reliability and validity of the questionnaire, conducting specific tests becomes crucial. One widely employed method to evaluate the validity of a questionnaire is the application of Principal Component Analysis (PCA). By subjecting the survey data to PCA, researchers can identify underlying factors or constructs that explain the variation in respondents' responses, thereby assessing whether the survey items effectively measure the intended constructs (I. T. Jolliffe and J. Cadima, 2016). Moreover, ensuring the questionnaire's reliability is equally essential, and one common approach for this purpose is the use of the Cronbach's alpha coefficient. The Cronbach's alpha coefficient provides a measure of internal consistency by assessing the degree of interrelatedness among the survey items (M. Tavakol and R. Dennick, 2011).

Gaining a deep comprehension of students' perspectives and adjustments to ODL in hands-on courses can yield invaluable insights. These insights can guide the creation of exceptionally effective teaching approaches and support systems. A more profound understanding can be achieved with the participation of students. The study aims to observe the perception on ODL for laboratory course at the School of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. The observation was made through distributing questionnaire to the student enrolled in the course. Then, the result obtained by the respondent of the semester is compared with the responses. Finally, the conclusion is drawn on the needs of better ODL with regards to laboratory course, in future.

Methodology

Development of Questionnaire

To obtain information related to respondent’s experiences and perception towards ODL, the questionnaire was created by using online form, utilizing five Likert-scale to measure agreement or disagreement and open-ended questions for qualitative feedback. Other than the demographic observation, the question discovers the nature of the laboratory course, learning platform, monitoring, communication and assessment method, and opinion on the challenges and suitability ODL implementation on the course.

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Pilot Run

A pilot run was conducted to test the validity and reliability of the questionnaire. The questionnaire was distributed to 50 respondents taking the laboratory course namely Engineering Workshop Practice, Manufacturing Processes, Thermofluids, Applied Mechanics and Computer Aided Design. The questionnaire was distributed via messaging applications by the class instructor and student representatives. Respondent was guided with instructions in answering the questionnaire.

Reliability and Validity of Questionnaire

After the pilot run, the reliability of the questionnaire was tested using Principal Component Analysis (PCA) and validity of the questionnaire was tested with Cronbach's Alpha coefficient. Once the reliability and the validity of the questionnaire is achieved, the questionnaire was distributed.

Data Collection and Analysis

It took about two weeks to gather the responses from the respondent registering the courses in the semester. Later, analysis on the responses was done and, in this paper, focus is given specifically on Manufacturing Processes course. Interpretation on the findings was conducted and the results is presented in relation to the research objectives. Limitations is discussed together with strategies for betterment.

Results and Discussion

Reliability and Validity of Questionnaire

There were 38 of 52 items in the questionnaire measured, consisting of all Likert-scale questions. The results on the PCA through Kaiser-Meyer-Olkin shows the sampling adequacy was 0.664, just above the recommended value of 0.6. On the other hand, the reliability analysis via Cronbach's Alpha exhibits satisfactory level at rating of 0.954.

Characteristics of the Laboratory Course

The goal of the Manufacturing Processes laboratory is to enhance students' ability to turn design into physical products. The course offers students the practical experience in various manufacturing techniques like welding, cutting, casting, and machining. By actively participating in diverse manufacturing tasks, students acquire insights into diverse materials, production methods, and quality assurance procedures. During the ODL, delivery method was through online demonstration and video on the principal of the processes. Then, the student needs to develop a computer numerical control (CNC) programming to simulate a simple machining process in realizing the output of a given design.

Analysis on Responses

The 52 items in the questionnaire were grouped into several domains. Here, six main domains are highlighted, and the descriptions are given in Table 1.

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Table 1: Classification of Questions in The Questionnaire and The Descriptions

Domains	Descriptions
Opinion on Learning Engagement	This domain reflects the respondents' perception on their level of engagement in ODL.
Opinion on Learning Experience	This domain reflects the respondents' overall perception on their learning experience.
Online Distance Learning Suitability	This domain reflects the respondents' perception on the suitability of ODL for their specific needs.
Online Distance Learning Delivery	This domain reflects the respondents' perception on the type of delivery of ODL.
Online Distance Learning Communication	This domain reflects the respondents' perception on the type of the communication during ODL.
Recommendation for Improvement from Students	This domain reflects the respondents' recommendations for improvements in ODL.

The five Likert scale used in this study are Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree and Not Applicable. Then, from the responses received, the results were classified into three main categories: Good, Non-decisive and Poor. Where, Good is the combination of responses on Strongly Agree and Agree, Non-decisive is the combination of responses on Neutral and Not Applicable and Poor is the combination of responses on Disagree and Strongly Disagree. Classifying the responses provides distinct situation on the respondents' opinion towards each domain. It also allows better comparison between domains and assist in clarifying trends in the data.

Figure 1 below, shows the overall responses obtained. The learning engagement to the course refers to the participation of the respondent towards the course. As in Figure 1a, 51% of the respondent are in ‘Good’ condition. This shows that the respondents like the course, discipline, proactive, enjoy and actively participated during the course. Respondent’s learning experience refers to the ability to access to related software or gain required skills. Figure 1b shows that 46% respondent agrees they received ‘Good’ experience during the course. This positive perception indicates the satisfaction on the course's learning experience event though in a remote setting. However, there are 32% of ‘non-decisive’ and 22% of Poor responses since the absence of hands-on experiments and direct interaction with physical equipment impacted the learning experience.

Learning suitability refers to learning materials used during the lesson, teaching delivery method, learning activity and assessment. The 64% responses recommended Good as presented in Figure 1c. This shows that the approaches taken by the instructors are suitable and can be accepted by the respondents. On the other hand, 34% of the respondents chooses Non-decisive and Poor. To tackle the issues, it is best to consider the teaching approach which involves interactive simulation or virtual experiments. With this, the respondents can gain a better understanding on the course.

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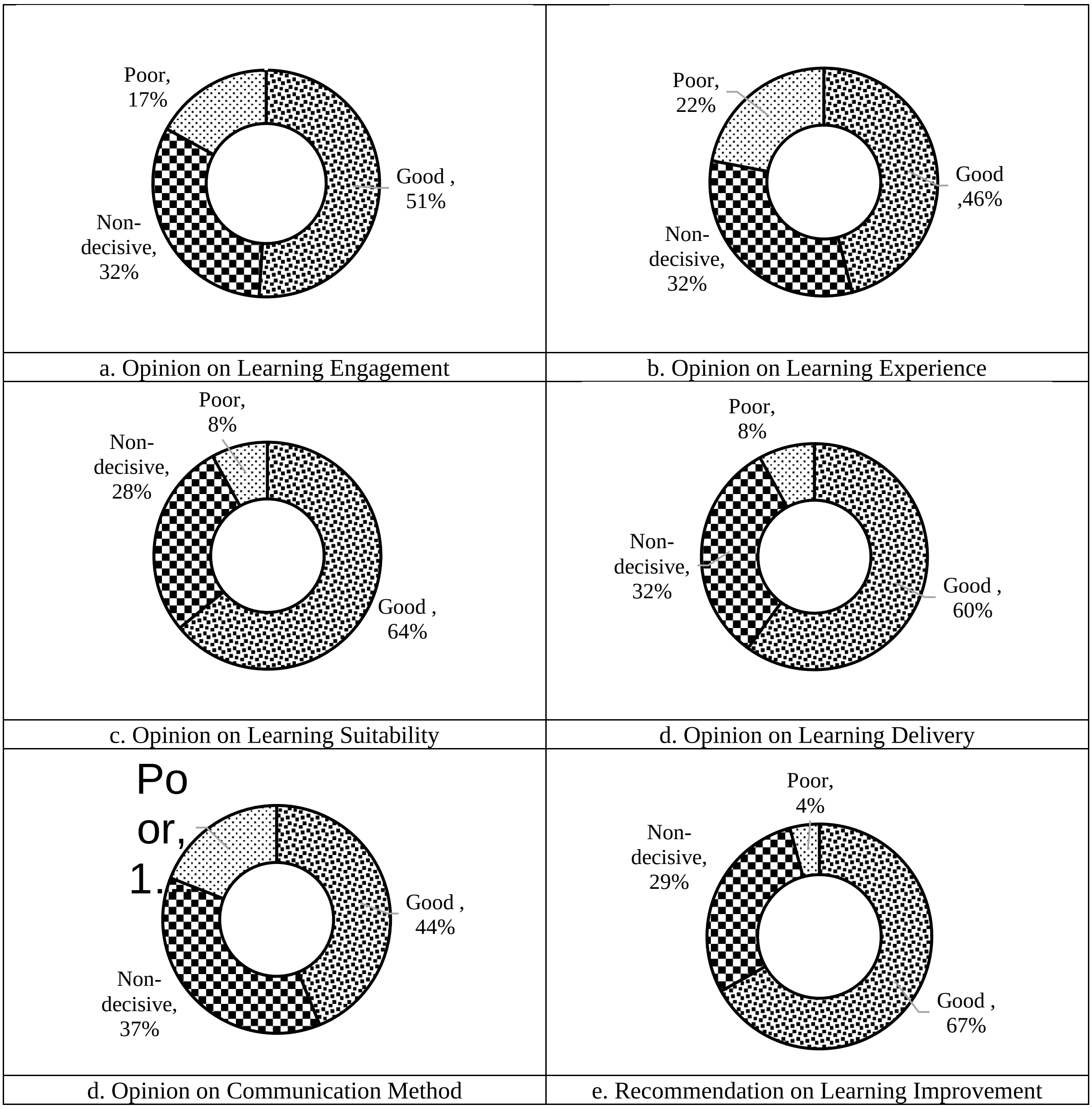

a. Opinion on Learning Engagement
b. Opinion on Learning Experience
c. Opinion on Learning Suitability
d. Opinion on Learning Delivery
d. Opinion on Communication Method
e. Recommendation on Learning Improvement

Figure 1: Responses From Respondent

Figure 1d shows the opinion on learning delivery. For the domain, the questions are about training delivery method employed by the trainer such as live lecture, recorded video, recorded video with presentation slides or only lecture note. 60% of the respondents are satisfied with the method by selecting Good. To facilitate the delivery method, additional resources can be added together with improving the clarity of recorded lectures or incorporating interactive elements in the delivery.

Efficient communication plays a pivotal role in resolving uncertainties, seeking help, and fostering cooperation. In the survey, communication method between the instructor and students were observed. It was found that 37% selected 'non-decisive' and 19% addressed Poor communication as shown in Figure 1e. There are various communication methods and platform available. However, the respondent found there were still lacking communication. By understanding the factors contributing to the indecisive response and preferable communication platform can offer valuable insights into the matter and enhance platform utilization.

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A total of 67% respondents chose Good regarding to the potential in enhancing the ODL method. For the betterment in understanding the course, augmented or virtual reality, game-based experiment, simulation-based experiment, and cloud-based system can be exploited.

Observation on the Results Obtained by the Respondents

Although the respondents were generally very positive with the domain asked in the questionnaire, observation of the results obtained by the respondents was also done to investigate the correlation between the two. It was found that, all the respondents passed the course with most C's. The overall achievement can be seen in Figure 2. This suggests that a significant number of respondents encountered difficulties comprehending laboratory tasks, adhering to report guidelines, and navigating the simulation software. These challenges likely impacted the overall course performance, leading to the grade distribution skewed towards the lower range of the grading scale. The results also give evidence that there is needs in improving the online learning program for the course in order to enhance the understanding of the future student. To address the issue, clearer guidelines for laboratory reports, enhanced guidance on using simulation software and improved communication channels to foster better engagement and understanding can be implemented.

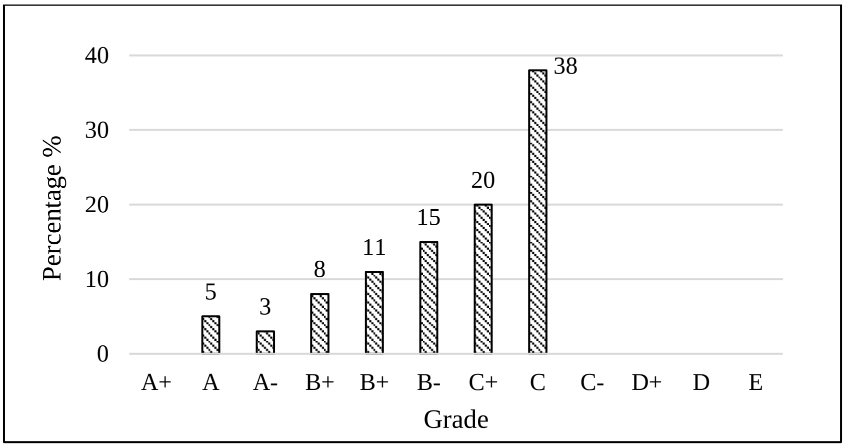

Figure 1: Results for Manufacturing Processes Laboratory Course

Conclusion

The observation of the ODL implementation on Manufacturing Processes laboratory shows the respondent agrees to most of the domain mainly the learning engagement, learning suitability and learning delivery. Those domains obtained 'Good' responses with more than 50% agreeing. However, responses on learning experience and communication method only received about 40% 'Good' review. This show that respondent prefers hands-on experience and direct interaction with physical equipment. As a replacement to physical interaction, advanced technology such as augmented or virtual reality can be introduced. Access to communication platform agreed by all the respondent is crucial to maintain decent network among the respondent and instructor. The result obtained by the respondent is aligned with the 'Good' review on the ODL implementation. However, the result can be improved through better guidelines for laboratory reports, enhanced guidance on using simulation software and improved communication channels.

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