E-learning versus face-to-face civil and environmental engineering education: A case study of the COVID-19 pandemic

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Abstract. The Malaysian Government implemented a countrywide lockdown due to COVID-19, which also affected the educational institutes. Under these circumstances, the e-learning educational strategy was initiated for the resuming of educational activities. A need for the study was devised and performed to assess the students’ perspective on this transition from face-to-face learning to e-learning for the effective implementation of the system. Students’ feedback data was evaluated for the January 2020 semester, which was collected before the pandemic and the September 2020 semester, which was collected during the pandemic by the end of the semester. Both data were analysed by adopting parametric Student’s t-test and non-parametric Mann-Whitney U test. Overall, it is concluded that students were comfortable with the e-learning educational system. However, the effectiveness of the e-learning system is dependent on the course type and requirements. This study will help the instructors to evaluate and improve their teaching strategy for the e-learning educational system by the preview of students for the deficiencies, in comparison to face-to-face learning, as the current lockdown situation is uncertain due to the COVID-19 pandemic.

1 Introduction

On March 11, 2020, the World Health Organisation (WHO) declared a pandemic emergency named COVID-19 around the world. Following this, the United Nations (UN) stated that this pandemic had affected 58 million students from their regular educational routine by depriving them of face-to-face learning [1]. In response to the aforementioned circumstances, the Malaysian Government implemented a movement restriction order around the country, effective from March 18, 2020, and suspended all the activities, including the closure of educational institutes. This scenario forced many Malaysian educational institutions to initiate online educational classes and adopt effective virtual educational tools as the end of the pandemic was uncertain. The idea of online education is not new, as it has been derived from distance learning that has been adopted for decades for educational purposes [2]. However, the recent pandemic re-stated and established the online

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education system by providing the educational institutes with the opportunity for effective teaching [3].

Teaching is defined as “giving information to an apparent aim” and “preparation of activities that make learning easy requires the equipment and the duty of being guided”. Learning is a part of education, and educational processes are recommended to have active attendance, continuous with equal learning opportunities for students and educators [4]. The COVID-19 pandemic has initiated a debate among educators regarding the effectiveness of face-to-face education and online education systems. Both points of view exist among the research community. Some criticise the traditional face-to-face education system as it ignores the individual differences of students and educators, promotes passive learning, and lacks critical thinking [5]. Other groups believe that online education systems are unsuccessful for hardcore learning and teaching problems, especially related to practical and laboratory experiment works [6]. However, e-learning is one of the latest approaches of this century, which adds to students' productivity and accountability by allowing them to analyse, discover, and attain high learning skills. It is the advanced form of education with interaction-oriented and student-centred learning opportunities irrespective of location supported by digital technologies [3,7].

Several studies explored the COVID-19 effects on the educational system under distinct circumstances. [1] investigated the students' perception, from Algerian University, on the abrupt transition of education classes to online learning during the COVID-19 pandemic. However, students’ response toward online learning was less optimistic than traditional learning practices, and students were unhappy with this digitised pedagogy. [3] performed a study to highlight significant achievements and challenges during the implementation of online learning in China. Responses were collected from students as well as instructors. It was concluded that both students and instructors were more comfortable and satisfied with classroom education than online education learning, as it has many rigorous formalities to be followed. Contrary to these aforementioned studies, [8] and [9] investigated the effects of the COVID-19 pandemic on the educational system in the Zambia and the USA, respectively. Both studies concluded digital learning with positive outcomes during the pandemic situation. Likewise, [10] investigated the effects of the transition from traditional face-to-face learning to e-learning for effective solutions in this pandemic. The study concludes that the applications provided by Google are economical and effective available solutions. Moreover, [11] compared the perception of the instructors on online teaching experiences and expectations. Results were concluded by conducting two surveys from 200 Dutch educators; a positive attitude and significant change was observed in the perception of educators towards usage of technologies, in post-COVID-19 period, for lessons. It was also concluded that educators' prior experience and gender, plays a small role towards effective implementation of Information and Communications Technology (ICT).

The Civil and Environmental Engineering Department, Universiti Teknologi PETRONAS, Malaysia, also shifted to e-learning systems after the lockdown of educational institutes due to the COVID-19 pandemic. Initially, difficulties were faced for the effective implementation of e-learning as the students were not trained and familiar with online strategies and tools. However, online learning procedures were normalised and improved with time and effectively applied during the September 2020 semester. This scenario devised a need for the study to assess and evaluate the education provided to the students via online systems compared to previous traditional face-to-face teaching so that deficiencies can be identified and mitigated till the ‘work from home’ restrictions would last due to pandemic. Therefore, the undergraduate engineering class was selected to assess the adopted online education system compared to the previous face-to-face educational system by the end of the September 2020 semester. The feedback for the January 2020 semester, which was conducted before the pandemic emergency under the face-to-face
educational system, was already available for the same class. Both feedbacks were based on the same Course Experience Questionnaire (CEQ), which was designed to collect the students’ responses after each semester to evaluate teaching effectiveness under the preview of the students. In this study, both feedbacks were compared and analysed to assess the e-learning educational system by the preview of students for its effectiveness compared to face-to-face learning, to identify deficiencies and implement improvements, if required.

2 Study methodology

This study is quasi-experimental, and it has been performed on the engineering class of the Civil and Environmental Engineering Department, Universiti Teknologi PETRONAS, Malaysia, for their January 2020 and September 2020 semesters’ feedbacks. The January 2020 feedback was collected by the end of the semester but before the COVID-19 pandemic, and students’ preview was the representation of the face-to-face educational system. However, September 2020 feedback was collected after the COVID-19 pandemic, and students’ feedback responses represented their preview on e-learning education. In both surveys, the same CEQ forms were adopted for data collection. This comparison aims to analyse the students preview on this transition of the education system from face-to-face learning to e-learning. Figure 1 shows the flowchart adopted for this study.

The CEQ model is based on 35 questions which is the modified form of the questionnaire designed under the guidelines in [12–17]. The assessment of the questionnaire is based on the 5 points Likert response scale [18]. The collected data were analysed for overall reliability using Cronbach’s alpha [19] for each semester responses. Moreover, to analyse the varying responses of students between face-to-face education and e-learning, the Student's t-test [20] and Mann-Whitney U test [21] were applied for the comparison and assessment of students’ preview on this transition.

![Fig. 1. Study flowchart](https://doi.org/10.1051/e3sconf/202234705007)
3 Results

Firstly, both collected feedbacks were evaluated for reliability by applying Cronbach’s alpha test, i.e., to check the credibility of the responses of the collected feedbacks [22]. Therefore, the Cronbach’s alpha test was performed separately for the overall collected responses for each semester feedback. The Cronbach’s alpha value for January 2020 semester for the CEQ based survey was found to be $\alpha = 0.943$, and for September 2020 semester $\alpha = 0.969$, which show excellent values [23,24], and these results show that the collected surveys were reliable/credible for further analysis. This study aims to observe the preview of students on this transition to e-learning studies compared to face-to-face learning due to the COVID-19 pandemic. As data behaviour for each item seemed distinct; therefore, both parametric and non-parametric tests were selected to execute data analyses effectively. Theoretically, parametric tests make assumptions about the parameters of the population distribution from which the sample is drawn, and mostly the population data is assumed to be normally distributed. In contrast, non-parametric tests are “distribution-free” and, as such, can be used for non-Normal variables. Therefore, both (parametric and non-parametric) tests conditions were considered to keep the study spectrum broad. The Student’s t-test (parametric test) and the Mann–Whitney U test (non-parametric test) were performed between two surveys (January 2020 and September 2020) to analyse and identify the significant difference in the collected responses.

3.1 Student’s t-test

The Student’s t-test is a parametric test, and it is defined as a “type of statistical test that is used to compare the means of two groups” [25]. Feedback on both educational systems was compared using a two-tailed Student’s t-test for the same engineering class based on the same CEQ survey. Table 1 illustrates the CEQ items, which have been found with significant differences in values with $p<0.05$.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>T-Test Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q14 (a)</td>
<td>The KNL (What we KNOW, What we NEED, What to LEARN): I am familiar with the KNL procedure.</td>
<td>2.08</td>
<td>0.017</td>
</tr>
<tr>
<td>Q15</td>
<td>The workload in PBL for courses become too heavy.</td>
<td>2.04</td>
<td>0.013</td>
</tr>
<tr>
<td>Q34 (b)</td>
<td>For the weekly problem solving, I spend my time in: Searching the literature.</td>
<td>2.04</td>
<td>0.007</td>
</tr>
</tbody>
</table>

The above outcome can be illustrated that students overall have the same educational experience in e-learning sessions as they had in traditional face-to-face educational sessions. However, the students’ perception varied in a few areas, i.e., Q14(a) related to KNL tables, Q15 related to workload, and Q34(b) related literature searching.

3.2 Mann–Whitney U test

The Mann-Whitney U test is non-parametric, and it is defined as “the Wilcoxon rank-sum test, tests for differences between two groups on a single, ordinal variable with no specific
distribution” [26]. In the execution of this test, feedback for January 2020 semester was marked as group 1 and September 2020 semester as group 2. Ranked data were compared for both groups for identifying CEQ items showing statistically significant differences with p<0.05, and the following outcomes were attained, as shown in Table 2.

**Table 2.** Results summary for items with varying behaviour for independent, Mann–Whitney U test (p<0.05).

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item Description</th>
<th>Mann-Whitney U</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q14 (a)</td>
<td>The KNL (What we KNOW, What we NEED, What to LEARN): I am familiar with the KNL procedure.</td>
<td>61.50</td>
<td>0.015</td>
</tr>
<tr>
<td>Q 15</td>
<td>The workload in PBL for courses become too heavy.</td>
<td>58.00</td>
<td>0.014</td>
</tr>
<tr>
<td>Q 34 (b)</td>
<td>For the weekly problem solving, I spend my time in: Searching the literature.</td>
<td>55.00</td>
<td>0.011</td>
</tr>
</tbody>
</table>

This test gave interesting outcomes that the items identified in the parametric Student’s t-test with significance difference, the Mann–Whitney U test identified the same CEQ items. These outcomes validate the overall analysis procedure and identify the areas needing special consideration.

To study these highlighted areas in detail, the descriptive statistics of these specific items for both semesters’ (January 2020 and September 2020) CEQ surveys were evaluated for further in-depth analysis.

### 3.3 Descriptive statistics of highlighted items of CEQ

The identified CEQ items were evaluated for their descriptive statistics (DS), i.e., frequency percentage, mean, and standard deviation (SD) for each highlighted CEQ item. Table 3 illustrates the DS for the January 2020 survey of identified CEQ items, and Table 4 shows the DS for the identified CEQ items of the September 2020 survey.

**Table 3.** Descriptive statistics of identified CEQ items from the January 2020 survey.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Frequency Percentage</th>
<th>Mean</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Neutral</td>
</tr>
<tr>
<td>Q14 (a)</td>
<td>-</td>
<td>-</td>
<td>3.23</td>
</tr>
<tr>
<td>Q 15</td>
<td>6.45</td>
<td>3.22</td>
<td>51.61</td>
</tr>
<tr>
<td>Q 34 (b)</td>
<td>-</td>
<td>6.45</td>
<td>19.35</td>
</tr>
</tbody>
</table>
### Table 4. Descriptive statistics of identified CEQ items from the September 2020 survey.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Frequency Percentage</th>
<th>Mean</th>
<th>Std. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Neutral</td>
</tr>
<tr>
<td>Q14 (a)</td>
<td>-</td>
<td>-</td>
<td>8.3</td>
</tr>
<tr>
<td>Q15</td>
<td>-</td>
<td>-</td>
<td>33.3</td>
</tr>
<tr>
<td>Q34 (b)</td>
<td>-</td>
<td>-</td>
<td>8.3</td>
</tr>
</tbody>
</table>

### 4 Discussion

The purpose of this study was to analyse and highlight areas in which students have felt difficulty during e-learning educational programs compared to face-to-face learning. Therefore, conducted feedbacks, i.e., pre-pandemic and post-pandemic, were compared by considering parametric and non-parametric tests adopting CEQ survey forms. Comparing data for two surveys gave interesting analyses and results. It was observed that both tests highlighted the same items for the significant differences in responses. Moreover, it was also noticed that the items for which students were feeling uncomfortable during January 2020 semester (face-to-face educational system) their response was better for those items in September 2020 semester (e-learning education), i.e., Q15 regarding workload, and for Q34(b) regarding literature searching. The aforementioned outcomes show that during the e-learning classes phase, students were more relaxed for the study workload compared to the previous face-to-face education period. Moreover, students were getting more time and opportunity for literature searching via the internet and e-books. However, Q14(a) responses regarding KNL tables were less positive for e-learning education than face-to-face education. One of the main reasons for this was as students were not much keen to use them as they adopted in the previous semester due to the presence of the instructors.

One of the greatest hindrances, for the students and instructors, in e-learning education with the traditional educational system is their inability to communicate and see each other face-to-face. Researchers have shown varying outcomes in support or against e-learning compared to face-to-face education. However, in this study, the outcomes have shown that students didn’t feel much difficulty adopting the e-learning system. Students’ preview of this online educational system was almost the same as face-to-face in the previous system. However, instead of a few activities, students found themselves more active in the e-learning atmosphere than the previous traditional system. Students were relaxed regarding the workload, unlike last semester, and they were getting more opportunities for literature searching in problem-solving exercises compared to the previous system. Based on this study, it can be determined that the e-learning system is effective as the traditional face-to-face system, but this condition is very much dependent on the strategies, technologies and tools being adopted to support this flow. However, the results may vary based on the course structure, such as for laboratory works and practical experimentations, e-learning education has disadvantages [3]. Overall, research communities agree that e-learning is the better option for resuming educational activities until this pandemic ends.
5 Conclusion

After implementing the countrywide lockdown in Malaysia, the educational institutes shifted to online educational systems via e-learning technologies. However, this shifting from the face-to-face educational system to the e-learning system developed the need to get insight into students’ reactions and preview on this transition. Based on the outcomes, the online education processes can be improved in light of highlighted deficiencies as educational institutes' re-opening is uncertain until the end of this pandemic. Therefore, an engineering class was selected for the feedback collection, which had already been given the CEQ survey in the previous semester, and again responses were collected following the same CEQ format. Overall, the outcomes revealed that traditional and e-learning educational systems have almost the same effectivity with minor variations, i.e., significant differences in responses were observed for items covering course workload, literature searching, and usage of KNL tables. However, the implementation of the e-learning system depends on the nature of the course (theoretical and practical), technology type, and the tools being adopted. In this pandemic, e-learning is the best available option, with a live-interaction facility between students and instructors, till this pandemic ends.

References

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