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# The Impact of Long-Term Online Learning During the Pandemic on The Decline of Students' Cognitive Performance

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**Abstract**

The trend toward online learning and assessment is seen as having greatly benefited higher education, especially during the COVID-19 pandemic. However, its effectiveness is seen to have a large impact on the students' performance. Hence, this study aimed to investigate the factors that affect students' cognitive performance during an extended period of online learning. The data were collected from one course (Electronics 2) offered to second-year students of the Diploma in Electrical Engineering (Electronics) for a period of four semesters: March–July 2019, March–July 2020, March–July 2021, and March–July 2022. Statistical data analysis was carried out using Single Factor ANOVA and a Tukey HSD post-hoc test in Microsoft Excel. The findings of the study have shown that the cognitive achievement of students is greatly affected by online learning and assessment compared to face-to-face methods. Students need more time during online learning to learn and understand lessons, in the long run, this is the main factor that causes students' motivation to decrease. As a result, it has a negative impact on the cognitive development and achievement of students. Based on the findings, academic institutions need to review the learning and assessment methods from online to hybrid or face-to-face which can be beneficial for both lecturers and students.

**Keywords:** Online, Face-To-Face, Assessment, Cognitive, Student Performance, Motivation

## Introduction

In December 2019, a pneumonia outbreak started in Wuhan and has infected thousands of people in over 200 countries worldwide. Consequently, the rapid global spread of COVID-19 has been directly attributed to the transition in teaching and learning methods from face-to-face (F2F) to online learning (OL).

OL, also known as electronic learning (e-learning), open learning, open distance learning (ODL), web-based learning, computer-mediated learning, blended learning, and mobile learning (m-learning), is the use of a computer or other device that is connected to a network, most frequently a mobile network, to enable learning at anytime and anywhere. OL is classified into two methods, namely synchronous and asynchronous. Synchronous OL means that students and lecturers attend class sessions on the schedule, at the same time, although they are at a distance, and classes cannot be rescheduled. While asynchronous OL allows students to access lesson materials whenever it is convenient for them and there are no live video lectures (Dhawan, 2020).

OL has been proven to be beneficial in self-directed learning, capable of developing new competencies, and encouraging lifelong learning (Dhawan, 2020). Students' actual performance in online learning, is also influenced by their learning preferences (Hanafi et al., 2022). Additionally, students with high task value, e-learning motivation, and self-efficacy preferred studying in blended learning environments (Keskin & Yurdugul, 2020), where blended learning allows students to get help and support more easily than online learning (Lim et al., 2007).

Exams are important in testing students' cognitive performance. In Malaysia, all accredited engineering programs have used Bloom's taxonomy as one of the main assessment components in the implementation of outcome-based education (OBE). OBE is believed to improve the structure of the educational curriculum. Bloom's taxonomy is a hierarchical model in a taxonomy of learning that divides learning into three psychological domains: cognitive, affective, and psychomotor (Anderson & Krathwohl, 2001). It provides a framework for determining the complexity and specificity of a course outcome, course assessment, and course evaluation.

The cognitive domain includes mental skills to produce knowledge. The cognitive learning domain framework, as shown in Figure 1, was used as a reference in the development of student assessments. The assessment given to students must be proportionate to their understanding and knowledge. Student achievement must be measurable, verifiable, and clearly improvable.

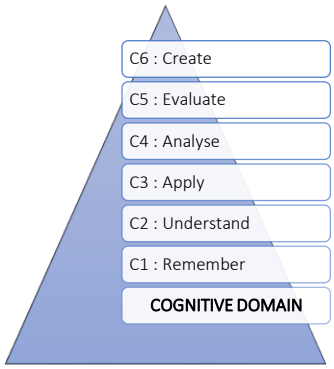


Figure 1: Bloom's Taxonomy (Revised) for Cognitive Domain Learning (Anderson and Krathwohl, 2001)

In general, cognitive assessment is seen as easier to assess; however, mastery in the cognitive domain is often difficult for students to achieve. Most students in higher education face difficulties with mental mindset, metacognition, self-regulation, student fear and mistrust, insufficient prior knowledge, misconceptions, ineffective learning strategies,

transfer of learning, selective attention constraints, mental effort, and working memory constraints (Freda et al., 2021).

Cheating is often associated with exams, whether online or paper-based (F2F). Online exams have been found to open more opportunities for students in that direction (Bhattacharya et al., 2022). Cheating during exams, such as through remote desktop, screen sharing, conducting internet searches, or online conversation (Noorbehbahani et al., 2022).

According to Comas et al (2021), there is a significant increase in internet searches aimed at cheating on exams, especially online exams. The study has shown that the impact of the COVID-19 pandemic on integrity is not limited to the education sector alone. Researchers also discovered that online learning was less efficient than F2F learning in achieving student learning outcomes (Arias et al., 2018; Albalushi et al., 2022).

This paper focuses especially on the cognitive performance of an electrical engineering course. The next objective is to study the factors that contribute to students' cognitive performance during the implementation of online learning.

## Materials of Study

### Course Background

A summary of the six levels of Bloom's taxonomy in the cognitive domain for the Diploma in Electrical Engineering (Electronics) programme at Universiti Teknologi MARA (UiTM) is shown in Figure 2. The cognitive distribution of the domain has been divided into three categories: Level I (C1 to C2), Level II (C3 to C4), and Level III (C5 to C6). Electronics 2 (ELE242) is one of the compulsory courses offered in this programme. This course is taken in the second year of the fourth semester, with the distribution percentage as follows: Level I (30–50 percent), Level II (50–65 percent), and Level III (0–5 percent). Meanwhile, the cognitive assessments for the course are divided into three instruments: Test 1 (15%), Test 2 (10%), and the final examination (50%). In addition, there are also other assessments, including those in the psychomotor and affective domains.

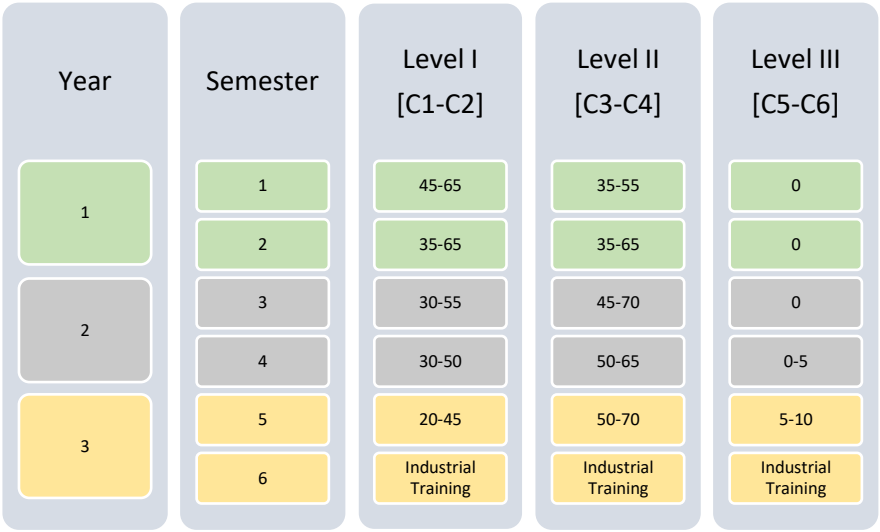


Figure 2: Percentage of Cognitive Domain Distributions for Diploma in Electrical Engineering (Electronics)

**Teaching and Learning (TnL) and Assessment Methods**

Various TnL delivery methods were used during the semesters of March–July 2019, March–July 2020, March–July 2021, and March–July 2022. For the March–July 2019 semester, TnL and assessment were conducted via the F2F method. In March–July 2020 and March–July 2021, TnL and assessment were conducted via online learning (asynchronous) where the lecturers and students were located outside of the campus and in different places (hometown). Meanwhile, for the March–July 2022 semester, the TnL and assessment were done using a synchronous online method with the additional use of video conferences and an interactive online whiteboard. Apart from that, lecturers and students were on campus. Table 1 summarizes the TnL and assessment methods from March–July 2019 until March–July 2022.

Table 1
*Comparison of TnL and Assessment methods from March-July 2019 to March-July 2022*

| Semester | TnL Method | Assessment Method |
|---|---|---|
| March-July 2019 | F2F | F2F |
| March-July 2020 | Online Learning (Asynchronous) | Online |
| March-July 2021 | Online Learning (Asynchronous) | Online |
| March-July 2022 | Online Learning (Synchronous) | F2F |

**Course Performance Level**

The course outcomes were measured and reported in the Continuous Quality Improvement (CQI) report at the end of the semester as a countermeasure to improve the course. The standard key performance indicator (KPI) set by the faculty is 50%. Furthermore, in this study, the cognitive performance levels are classified into "Excellent", "Good", "Satisfactory", "Fair", and "Weak", as shown in Table 2.

Table 2
*Performance Level Category based on Percentage Marks obtained for Cognitive Performance*

| Performance Level | Marks Range (%) |
|---|---|
| Excellent | 75-100 |
| Good | 60-74 |
| Satisfactory | 50-59 |
| Fair | 30-49 |
| Weak | 0-29 |

**Methodology of Study**

**Data Collection**

For the study, cognitive scores from four semesters were analysed according to different cohorts. Students taking this course (Electronics 2) for the first time. The data that have been used in this analysis refer to student scores through continuous summative assessment of the course, which is limited to the cognitive domain only. Therefore, it only involves assessment through Test 1, Test 2, and the final exam. The number of students per semester refers to the sample size, n. The semesters covered in this analysis were March–July 2019 (n = 40), March–July 2020 (n = 43), March–July 2021 (n = 37), and March–July 2022 (n = 35).

**Statistical Analysis**

Statistical analysis was conducted using the Data Analysis ToolPak add-in in Microsoft Excel. In identifying performance differences in the cognitive domain, Single Factor ANOVA and Tukey HSD post-hoc tests were used. The significance level, or p-value, was set at 0.05.

**Research Hypothesis**

Hypotheses for statistical analysis for this study have been identified as follows:
The null hypothesis, $H_0$: There is no statistically significant difference in cognitive attainments between semesters.
An alternative hypothesis, $H_1$: There is a statistically significant difference in cognitive attainments between semesters.

**Results**

This study aimed to investigate the factors that affect students' cognitive performance during an extended period of online learning.

**Cognitive Attainments**

TnL delivery and assessment methods are completely traditional face-to-face (F2F) in March–July 2019. However, in the year 2020, when the COVID-19 pandemic first emerged, academic institutions began using online learning as a measure to aid the government's efforts to break the COVID-19 outbreak's chain of transmission. Online learning has been implemented at UiTM starting from the March–July 2020 semester. Due to the ongoing spread of the COVID-19 disease, the use of online learning is seen to have continued for several semesters.

Figure 3 illustrates the cognitive achievement of this course using different TnL and assessment methods across four consecutive semesters: March–July 2019, March–July 2020, March–July 2021, and March–July 2022. The findings clearly show a linear trend of decline in cognitive achievement. Worse still, in the March–July 2022 semester, there has been a critical decline in cognitive achievement, which is below the KPI by 50%.

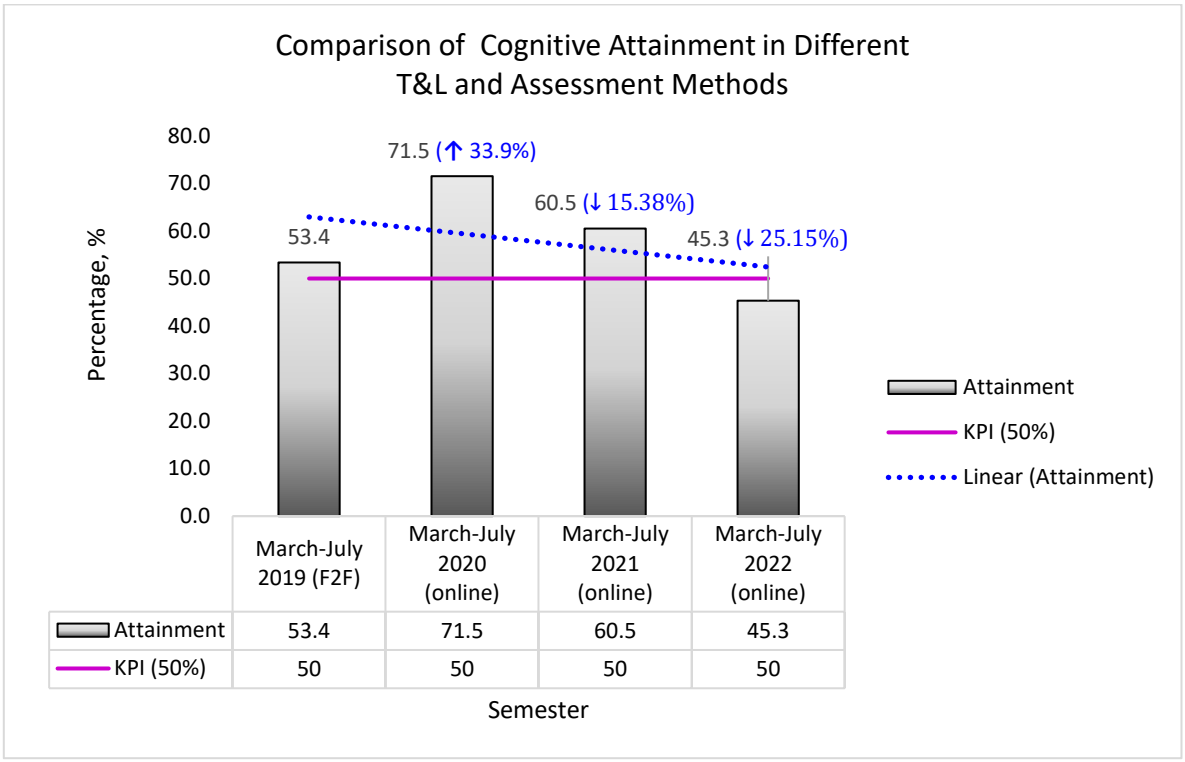


Figure 3: Cognitive Attainment from semester March–July2019 to March–July2022

Figure 4 shows the percentage of students' cognitive performance levels between "Excellent" and "Weak". The linear trend line graph reveals that the number of "Excellent" students has decreased significantly, while the number of "Weak" students has increased dramatically.

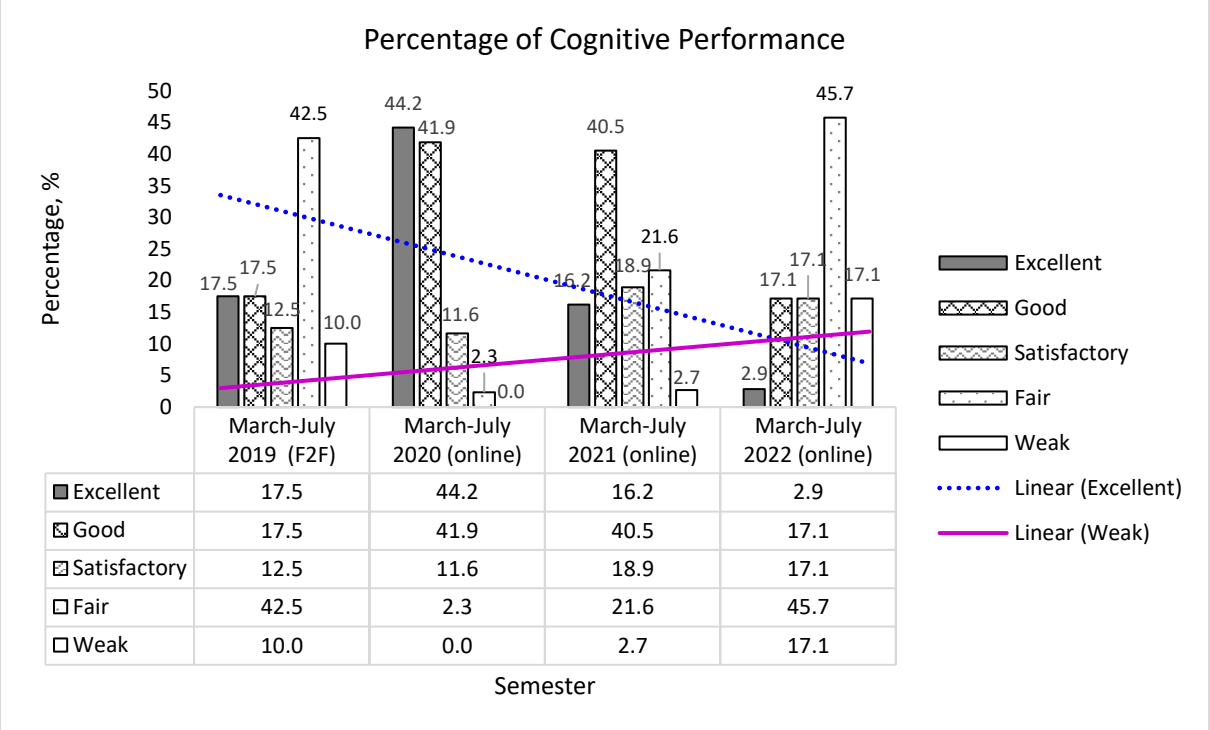


Figure 4: Percentage of Cognitive Performance from semester March–July 2019 to March–July 2022

**Statistical Analysis Results**

Single Factor ANOVA and Tukey HSD post-hoc tests, were used to investigate the factors that contributed significantly to the decline in students' cognitive attainments.

Table 3 shows the results of Single Factor ANOVA, which is used to compare the mean values between groups. The results revealed that there was a statistically significant difference in cognitive performance among the four semesters ($F(3, 151) = [19.848]$, $p < 0.05$). Whereby the F statistic is greater than the critical value of F ($19.848 > 3.913$). Therefore, the null hypothesis, $H_0$, was rejected. This confirms the hypothesis that there is a statistically significant difference in cognitive achievement between semesters with reference to TnL and assessment methods. When there were significant differences in the ANOVA test, the Tukey HSD post-hoc test was also performed to further analyse the data. With that, factors that influence cognitive attainments between semesters can be identified.

Table 3
*ANOVA Single Factor Results*

| *Groups* | *n* | *Sum* | *Mean* | *Variance* | *SD* |
|---|---|---|---|---|---|
| March-July 2019 (F2F) | 40 | 2135 | 53.375 | 424.907 | 20.613 |
| March-July 2020 (online) | 43 | 3076 | 71.535 | 115.445 | 10.745 |
| March-July 2021 (online) | 37 | 2239 | 60.514 | 189.812 | 13.777 |
| March-July 2022 (online) | 35 | 1591 | 45.457 | 247.256 | 15.724 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *p-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 14456.22 | 3 | 4818.739 | 19.848 | 6.71E-11 | 3.914 |
| Within Groups | 36660 | 151 | 242.782 | | | |
| Total | 51116.22 | 154 | | | | |

Table 4 shows the Tukey HSD post-hoc results for multiple comparisons. The critical value obtained from the test is 3.670 at a significant level of 0.05. According to Table 4, it can be seen that there were significant differences in the mean cognitive scores between March–July 2019 (F2F) and March–July 2020 (online), ($p = 0.002$); March–July 2019 (F2F) and March–July 2021 (online), $p = 0.043$; March–July 2020 (online) and March–July 2022 (online), $p = 0.001$; and; March–July 2021 (online) and March-July 2020 (online), $p = 0.001$; where the p-values were less than 0.05 ($p < 0.05$).

On the other hand, no statistically significant differences in mean cognitive scores were seen between March–July 2019 (F2F) and March–July 2022 (online), $p = 0.289$; and March–July 2020 (online) and March–July 2021 (online), $p = 0.866$; where the p-values were greater than 0.05 ($p > 0.05$).

Based on the findings of the study, the p-values between groups were less than 0.05. Therefore, in conclusion, the TnL strategies were found to have contributed to the decline of cognitive achievement, including the decline of "Excellent" students and the improvement of "Weak" students.

Table 4
*Tukey HSD Results*

| *Group 1* | *Group 2* | *Q statistic* | *p-value* | *Significance p<0.05* | |
|---|---|---|---|---|---|
| March-July 2019 (F2F) | March-July 2020 (online) | 5.130 | 0.002 | p<0.05 | Significant |
| March-July 2019 (F2F) | March-July 2021 (online) | 3.755 | 0.043 | P<0.05 | Significant |
| March-July 2019 (F2F) | March-July 2022 (online) | 2.510 | 0.289 | p>0.05 | Non-significant |
| March-July 2020 (online) | March-July 2021 (online) | 1.057 | 0.866 | p>0.05 | Non-significant |
| March-July 2020 (online) | March-July 2022 (online) | 7.554 | 0.001 | p<0.05 | Significant |
| March-July 2021 (online) | March-July 2022 (online) | 6.065 | 0.001 | p<0.05 | Significant |

**Discussion**

The academicians found it more difficult to assess the level of engagement and comprehension among students in an online learning environment, particularly in the cognitive domain. Online learning may present more challenges for some students to succeed; therefore, students need to be highly self-motivated and disciplined. Different online learning experiences, according to Riaz et al. (2022), have an impact on cognitive performance. The findings in this study demonstrated that the TnL approach is also related to cognitive achievement.

The findings have shown that the overall performance of the course is extremely relevant to the distribution of marks, and the cognitive domain is the dominant domain for this course. The higher the distribution of assessment marks, the greater the impact on students' overall achievement (Noor et al., 2020). Thus, it is important to identify and solve every problem, such as a decrease in student achievement. It is a step towards improving the TnL activities in a course to improve student performance.

In this course, students have been subjected to F2F assessment for the first time in the semester of March–July 2022, as opposed to the previous semesters, for tests and final examinations. The results of the study found that cognitive performance has been seen to worsen. This has been closely related to the face-to-face (F2F) method in final exams, where students' motivation and self-confidence have affected their performance. It can be concluded that students have lost their self-confidence, which causes them to not be able to answer well in exams. The effects of this factor have directly lowered their cognitive achievement. Steinmayr et al (2019) revealed in their research that the most important factor in academic success is student motivation, and the most significant motivator for students is their own self-concept.

According to Kisacik et al. (2023), negative attitudes and dissatisfaction with e-learning may lead to a decrease in academic performance. Whereas, Toprak et al (2010); Yahya et al (2023) discovered that e-learning, including online assessment evaluations, encountered legal

concerns, particularly regarding plagiarism and cheating attempts made by the students, as opposed to F2F methods.

Based on the findings of the study, the TnL approaches have been one of the factors that contributed to the decline in cognitive achievement in this course and also had an impact on the number of excellent and weak students. The extended period of online learning, from March–July 2020 to March–July 2022, is a factor that has worsened student achievement because it has resulted in a decrease in students' motivation and focus (Bhattacharya et al., 2022; Zakirai@Zakaria et al., 2021). Similar findings were made by Yahiaoui et al (2022), who discovered that e-learning had a substantial impact on student motivation and outcomes. There are contradictory views by Riaz et al (2022), who discovered a significant positive correlation between the online learning experience and cognitive performance. However, most of the lecturers or academicians preferred blended learning after experiencing various experiences and the impacts of e-learning. This is supported by a study by Lapitan et al (2021), who found that blended learning methods were beneficial for both lecturers and students.

## Conclusion

TnL and assessment methods have directly affected the cognitive achievement of students. Online learning may be more challenging for some students, and it requires a high level of self-motivation and discipline. Our findings indicate that the extended periods of online learning and the sudden shift to F2F assessment declined cognitive performance. The decline in achievement has also been influenced by self-efficacy, which includes students' motivation during the learning process and their self-confidence during exams. These factors have an impact on the student's academic performance and cognitive development.

As a matter of fact, after going through various experiences with the implementation of online learning, many researchers and academicians still agreed on F2F learning and assessment methods. This is because F2F was more effective than online learning in achieving student learning outcomes. Hence, academic institutions need to review the learning and assessment methods from online to hybrid or face-to-face, which can be beneficial for both lecturers and students.

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