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Students' Performance in Basic Civil Engineering Courses During and After the COVID-19 Pandemic

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Abstract: *The COVID-19 pandemic necessitated significant modifications in educational approaches to improve the student's academic achievements. This research aims to assess the academic performance of students in basic civil engineering courses during and after the pandemic. The study focused on students taking critical civil engineering courses (Solid Mechanics, Fluid Mechanics and Soil Mechanics) within the Diploma in Civil Engineering program. The analysis covered two student groups from the 2020 and 2022 academic years, which represent the periods during and after the pandemic. Additionally, teaching methods were entirely online during the pandemic and completely in-person afterwards. Student performance was evaluated using descriptive statistics by examining the pass rates and grade distributions for the courses. In brief, the findings indicated that students performed better in these core courses during the pandemic compared to after. These insights may assist educators in selecting effective teaching materials and assessment methods to enhance student outcomes in the post-pandemic era.*

Keywords: COVID-19 Pandemic, Basic Course, Civil Engineering Education, Students' Performance

1. Introduction

Civil engineering is a crucial branch of engineering. This discipline tackles various issues through the design, construction, and maintenance of our residential and commercial environments. Hence, to provide students with strong fundamentals, they first need to study basic courses in civil engineering. Solid Mechanics, Fluid Mechanics and Soil Mechanics are the fundamental subjects included in the academic plan of most civil engineering programs.

In 2020, the coronavirus COVID-19 outbreak disrupted life around the world, including the educational system. Due to this event, universities and colleges need to transition from traditional in-person classes to digital platforms to ensure continued education. Goudeau et al. (2021) highlight that remote learning became the prevalent approach during the lockdown as in-person interactions were severely restricted. This shift is critical to civil engineering education since this field is more suited for face-to-face (F2F) learning because of its hands-on nature and emphasis on the practical application of engineering knowledge.

Numerous prior studies have examined student performance during and after the COVID-19 pandemic. However, there remains a scarcity of research specifically comparing student outcomes in fundamental courses before and after the pandemic. The issue is important to analyze because students' competence and understanding in basic courses will be used in later courses and in engineering practice. As such, this study aims to evaluate civil engineering diploma program students' performance in basic courses during and after the COVID-19 pandemic.

1.1 Research Questions

The key research inquiries can be outlined as follows:

i. What is the trend of students' performance for the basic courses in the Civil Engineering Diploma program during and after the COVID-19 pandemic?
ii. Is there any significant difference in performance during and after the COVID-19 pandemic?

2. Literature Review

A study conducted by Santiago et al. (2021) revealed that students' academic performance improved when the distance education method was employed during the COVID-19 pandemic. In addition, Gonzalez et al. (2020) investigated how COVID-19 impacted students' ability to learn independently, and the findings suggested that the lockdown had a notably positive influence on students' performance. Similarly, Yu et al. (2021) observed comparable outcomes by utilizing administrative data from student grade tracking systems. Based on the collected data, they determined that online education had a beneficial effect on exam performance in a Chinese middle school.

In comparison, Mendoza et al. (2021) reported that the COVID-19 pandemic has negatively impacted the students' performance in mathematics and other subjects. The finding is further supported by Realyvásquez et al. (2020), who discovered that the transition to online learning during the pandemic led to academic challenges and significant mental exhaustion because of the heightened workloads. Furthermore, based on data from macroeconomics students in the United States, Brown & Liedholm (2002) found that students who attend in-person classes generally achieved higher test scores than their online counterparts. In addition, Figlio et al. (2013) provided evidence suggesting that traditional classroom settings have a beneficial impact on academic performance compared to online formats.

As opposed to these 2 outcomes, Said (2021) observed no variation in students' academic performance before and during the COVID-19 pandemic. His results, which were based on quiz scores, coursework grades, and final exam results through a T-test, revealed no statistically significant differences. Similarly, Reisetter et al. (2007) reported no disparity in learning outcomes between students engaged in online education and those attending in-person classes. In other words, their research indicated that both groups achieved equivalent learning outcomes regardless of the instructional method employed.

2.1 Description of Course

The observation was conducted for the basic courses of Solid Mechanics (ECS226), Fluid Mechanics (ECW231) and Soil Mechanics (ECG243) that can be found in the Civil Engineering Diploma program at Universiti Teknologi MARA. These courses are core subjects taught to first-year students (ECS226) and second-year students (ECW231 and ECG243). Students need to thoroughly understand the content of these courses because their knowledge

will be required in later courses. For example, students must pass Solid Mechanics (ECS226) first, as it is a prerequisite for Basic Structural Analysis. Similarly, students must pass Fluid Mechanics (ECW231) before registering for Hydraulics, and they must pass Soil Mechanics (ECG243) before being allowed to register for Soil Engineering.

2.1.1 Solid Mechanics (ECS226)

This course covers the concept of stress, strains about one-dimensional and two-dimensional elements, torsion of circular sections, shear force, bending moment, shear stress, bending stress, and deflection in a beam. Also, this course provides the application of Euler's Buckling theory to calculate the critical buckling load of a column. The course addresses SDG No. 4, Quality Education.

2.1.2 Fluid Mechanics (ECW231)

This course begins with the introduction of fluid characteristics and fluid properties, followed by the fundamental concepts of fluid statics, fluid dynamics, and their applications in civil engineering. Students will learn about the continuity, energy, and momentum equations, along with the differences between ideal and real fluids, as well as inviscid and viscous flow. The course addresses SDG No. 9, Industry, Innovation, and Infrastructure.

2.1.3 Soil Mechanics (ECG243)

This course focuses on the core concepts of soil mechanics to provide an in-depth understanding of effective stress, a key principle in civil engineering. The curriculum explains how effective stress influences soil consolidation and shear strength characteristics. Students will explore various topics, including soil's physical attributes and classification, water movement through soil, soil shear strength, and soil compaction and consolidation processes. The course addresses SDG No. 9, Industry, Innovation, and Infrastructure.

2.2 Delivery method

The ECS226, ECW231 and ECG243 courses each have a total of 4 contact hours, consisting of 3 hours of lectures and a 1-hour tutorial. Students from the 2020 cohort participated in these courses entirely online, with all instruction and assessments conducted remotely, without any need to visit the university campus. According to Hodges et al. (2020) and Anggraeni & Novianty (2021), online learning during the pandemic is a temporary shift in teaching delivery due to crisis conditions. During these difficult periods, all the Civil Engineering Diploma program lecturers at Universiti Teknologi MARA were required to attend training to help them prepare to conduct online classes. This online teaching uses both synchronous and asynchronous methods. Lecture classes are conducted synchronously using video conference software such as Google Meet or Webex. All students are taught live online according to the original timetable, while tutorial classes are run asynchronously. For the asynchronous method, lecturers upload tutorial questions and exercises into Google Classroom. Most lecturers prefer to use Google Classroom compared to other platforms because it is user-friendly and free (Chung et al., 2020). However, lecturers who are not very proficient in Information Technology (IT) choose to use simpler methods such as WhatsApp or Telegram. This is due to the large digital divide among lecturers of various ages (Shafie et al., 2019). Students are more interested in the asynchronous method because it is more flexible in terms of accessing tutorial questions and exercises and deadlines for submitting assignments (Rai1 et al., 2024).

The delivery mode for the 2022 batch is a fully conventional F2F delivery method. In this period, lecturers deliver lectures and tutorials in the classroom based on a timetable. According to Marold & Haga (2003), F2F education provides more benefits, such as encouraging

interpersonal interaction among students and between students and instructors, allowing students to engage in social learning behaviour and less distraction during learning and teaching sessions. The main advantage of the F2F learning method is the social aspect, which includes the direct involvement of students individually or in groups (Heilporn et al., 2021). Moreover, F2F classes are more beneficial for students who are not very independent and less disciplined (Arias et al., 2018).

2.3 Assessment

The ECS226, ECW231 and ECG243 courses were undergoing similar assessments. During the COVID-19 pandemic (2020 batch), all the assessments were done through an online platform. The details of assessments during the 2020 batch are shown in Table 1. The assessment consists of test 1 (cognitive domain), test 2 (cognitive domain), assignment (cognitive domain), and quiz (cognitive domain). Test 1 and test 2 are assessments that were used as replacements for traditional F2F final examinations. They were conducted online as closed-book exams through the platform at the time set by the lecturer. Students needed to fill out a student pledge form during test 1 and test 2 to prevent cheating. Students also had to open their video during the session to answer test 1 and test 2 in writing so that the lecturer could see them answering the exam. According to Agnew & Hickson (2012), lecturers have chosen various alternative options to replace the F2F final exam. Some have chosen online, open-book exams (Fuller et al., 2020), timed assessments and online exams (Kaisar, 2023), while others have used written assignments or oral examinations (Alqurshi, 2020).

Table 2 shows the assessment summary after the COVID-19 pandemic (2022 batch). The evaluation is composed of 60% from the final exam, which measures cognitive skills, and 40% from coursework components. Within the coursework, 30% is derived from tests evaluating cognitive abilities, while 10% comes from assignments, also focusing on cognitive skills. Both the final exam and the tests were administered in person under closed-book conditions. Normally, final exams and test patterns do not test students' thinking and analytical ability as they are more geared towards memory tests (Idnani et al., 2021).

Table 1: Types of Assessment During 2020 Batch (During COVID-19 Pandemic) for ECS226, ECW231 and ECG243

During COVID-19 pandemic (2020)	Test 1	Test 2	Assignment	Quiz
Percentage (%)	20	40	30	10

Table 2: Types of Assessment During 2022 Batch (After COVID-19 pandemic) for ECS226, ECW231 and ECG243

After COVID-19 pandemic (2022)	Final Examination	Test	Assignment
Percentage (%)	60	30	10

3. Methodology

This study focuses on two groups of students from the academic years 2020 and 2022, with the aim of examining their three-year university experience. The 2020 group engaged in entirely online learning during the COVID-19 pandemic, while the 2022 group attended classes fully in-person post-pandemic. The reason the 2021 batch was not included in this study is due to their hybrid learning experience, where they had to transition from online to F2F instruction when the pandemic started. Additionally, the enrollment figures for the ECS226, ECW231 and ECG243 courses for both the 2020 and 2022 groups are presented in Table 3 and Table 4,

respectively. Compared to batch 2020, the number of students who registered was much smaller in the 2022 batch.

Table 3: Number of Registered Students During 2020 Batch (During COVID-19 pandemic) for ECS226, ECW231 and ECG243

During COVID-19 pandemic (2020)	ECS226	ECW231	ECG243
New students	295	280	286
Repeat students	14	24	8
Total	309	304	294

Table 4: Number of Registered Students During 2022 Batch (After COVID-19 pandemic) for ECS226, ECW231 and ECG243

After COVID-19 pandemic (2022)	ECS226	ECW231	ECG243
New students	65	63	61
Repeat students	8	16	1
Total	73	79	62

To achieve the objective of this study, students' results for these courses during and after the COVID-19 pandemic were obtained from the Examination Unit, Academic Affairs Division. The overall achievement for the courses, consisting of percentages passed and percentages based on grades, was analyzed to evaluate the students' performance.

Furthermore, a comprehensive examination that used the t-test methodology was carried out to determine if there was a marked difference in performance between the periods before and after the COVID-19 pandemic. In this analysis, the p-values were utilized to determine the statistical significance of observed patterns. In general, each t-test is associated with a p-value to represent the likelihood that the observed results occurred by chance. When the p-value is less than or equal to the predetermined significance level, usually set at 0.05, the results are considered statistically significant. In contrast, when the p-value exceeds this threshold, the results are considered not statistically significant and less meaningful (Goulden, 1956).

4. Results and Discussion

Figure 1 illustrates the students' performance in the ECS226, ECW231 and ECG243 courses, showing the pass rates both during and after the COVID-19 pandemic. The findings indicated that the trend of student performance for basic courses in the Civil Engineering Diploma program decreased after the COVID-19 pandemic. Specifically, the ECW231 course displayed a significant reduction in the passing percentage compared to the ECS226 and ECG243, which was 9.76%. In addition, the percentage of students who passed these three courses was higher during the COVID-19 pandemic (2020). These results align with the findings of Santiago et al., (2021), Gonzalez et al. (2020), and Yu et al. (2021), which indicate that student performance improved during the COVID-19 pandemic. The increased engagement in learning and a higher perception of success among students contributed to this enhancement.

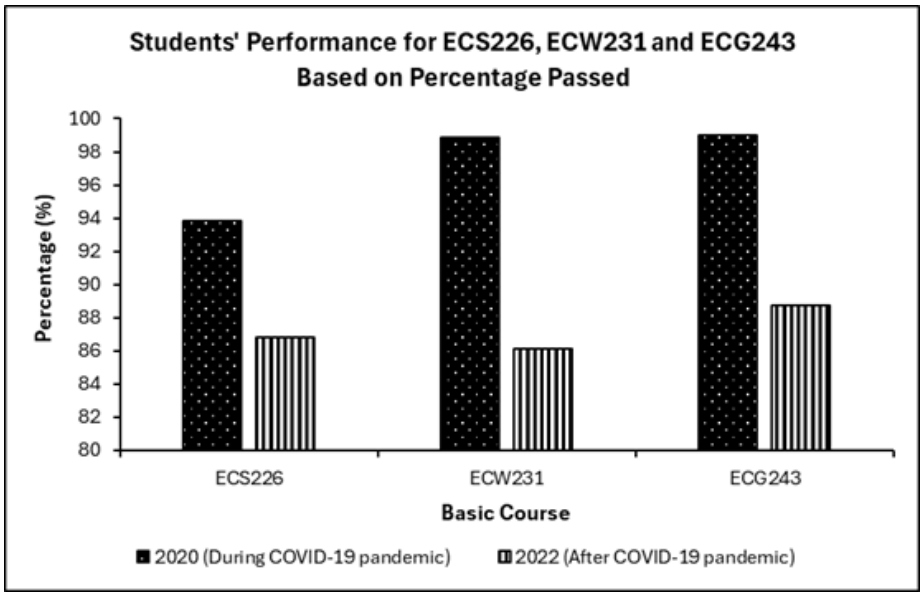

Figure 1: Students' Performance for ECS226, ECW231 and ECG243 Based on the Percentage Passed

The shift in assessment methods also impacts student performance. Following the COVID-19 pandemic, a larger portion of the assessment (60%) was allocated to the final exam. This change posed challenges for many students, with only a few managing to achieve high scores in the full F2F final exam. In contrast, during the COVID-19 pandemic, the final exam was substituted with two assessments: test 1 (20%) and test 2 (40%). If students do not score well on test 1, they can still improve their performance on test 2. Differences in student performance due to different assessment types provide an opportunity for academics to rethink their strategies and the appropriateness of the types of assessment currently in use, whether they can be sustained for the long term or need to be changed.

Figures 2, 3 and 4 highlight a significant positive impact of the COVID-19 pandemic on students' performance in ECS226, ECW231 and ECG243, as measured by their grades. At Universiti Teknologi MARA, the passing grade for courses in the Civil Engineering Diploma program begins with a grade of C. Figure 2 shows that students enrolled in ECS226 achieved a higher percentage of grades that range from B- to A during the pandemic in 2020, compared to the period after the pandemic in 2022. Similar trends were also observed in the ECW231 and ECG243 courses. For ECW231 and ECG243 (Figures 3 and 4), student performance during the pandemic was notably better, with grades starting from B to A. These observations suggest that students who participated in online education during the COVID-19 pandemic in 2020 managed to achieve higher passing grades than those who engaged in on-campus education after the pandemic in 2022. Despite the online delivery method during the pandemic, the use of learning management tools such as MOOCs and pre-recorded videos by educators has been determined to significantly aid students' learning, which, in turn, led to better scores in these courses. This is because the ability to rewatch recorded lectures provided students with more flexibility in their study habits and helped them understand the courses better.

Figure 2 shows that the largest percentage of students obtained an A- for the ECS226 course during the pandemic (2020). Conversely, after the COVID-19 pandemic (2022), grade C appeared as the highest grade. For ECW231 (Figure 3), most students attained B+ grades during the pandemic (2020), but after the event (2022), most students got C grades. Meanwhile, Figure 4 shows that most students obtained B grades for the ECG243 course during the COVID-19 pandemic (2020) and B- grades after the event (2022). In summary, it can be

concluded that the percentage of students obtaining a good passing grade during the COVID-19 pandemic was higher than after the COVID-19 pandemic. During the COVID-19 pandemic (2020), after the online class session ends, each student must fill out a survey to assess their satisfaction and understanding of the topic studied. Through feedback provided by students, instructors will always try to improve online teaching in order to enhance the learning experience. However, this survey was not conducted during F2F learning after the COVID-19 pandemic (2022). As such, the instructors were unable to identify and address specific areas where students needed additional support and improvement.

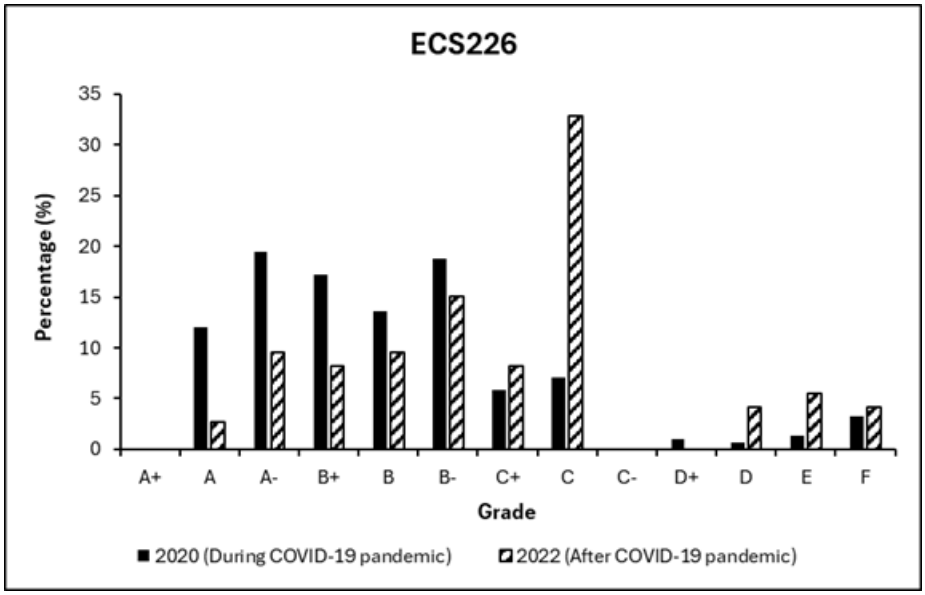

Figure 2: Students' Performance for ECS226 is Based on Grade

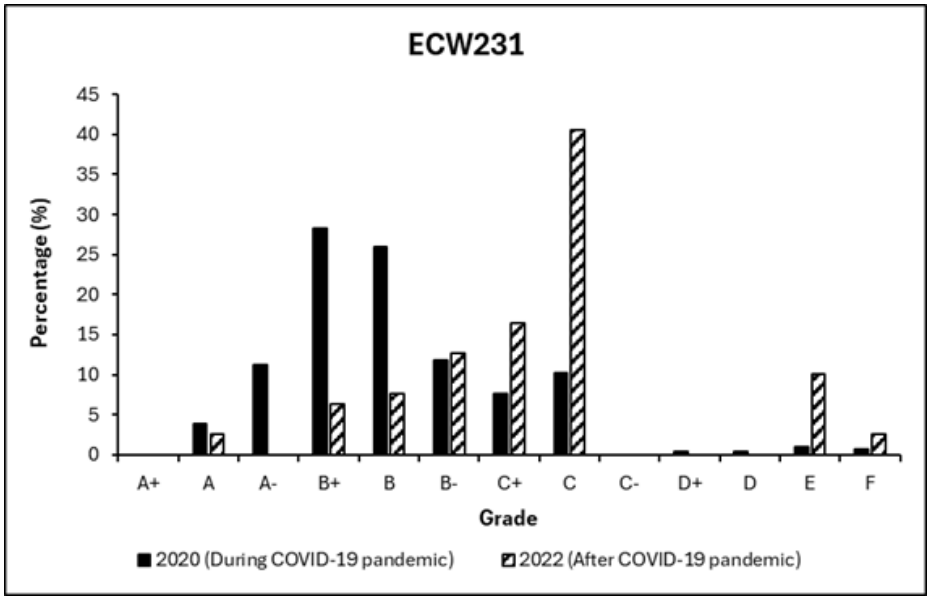

Figure 3: Students' Performance for ECW231 is Based on Grade

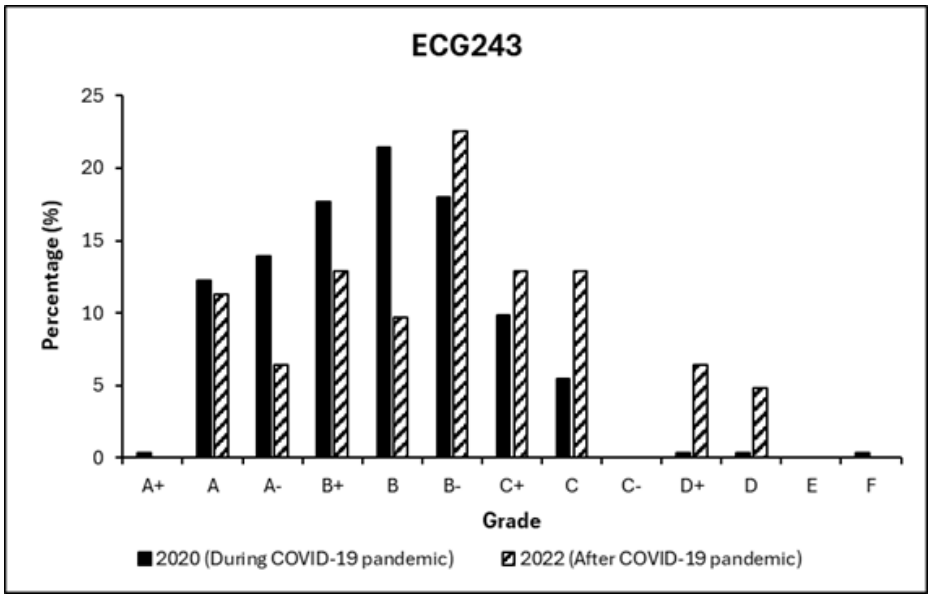

Figure 4: Students' Performance for ECG243 is Based on Grade

Table 5 presents a detailed examination of ECS226, ECW231 and ECG243, with a focus on their p-values. The results of the t-test suggest that there was no statistically significant difference in the performance of ECS226, ECW231 and ECG243 between the COVID-19 pandemic period in 2020 and the post-pandemic period in 2022 since the p-value exceeded 0.05.

Table 5: Descriptive Analysis (p-value) Attained by ECS226, ECW231, and ECG243

Basic course	p-value
ECS226	0.001
ECW231	0.007
ECG243	0.002

5. Conclusion

This study found that students achieved better results in basic civil engineering courses during the COVID-19 pandemic compared to after the pandemic. The COVID-19 pandemic caused students to change their learning strategies to adapt to online learning. As a result, both students and educators tried to improve their efficiency to avoid dropping out of online learning. In this period, some guidelines were also prepared for better quality teaching and online assessment.

The student's performance in basic civil engineering courses differed between during and after the COVID-19 pandemic. The percentage of students who passed and the percentage who obtained passing grades were higher during the COVID-19 pandemic compared to after the pandemic. However, the difference was not statistically significant.

This study focuses only on basic courses for the Diploma in Civil Engineering program at Universiti Teknologi MARA. Based on the limitations of this study, it is highly recommended that data analyses be increased by studying the performance of students in basic civil engineering diploma programs from other higher education institutions. Additionally, future research should focus on the factors that caused students' performance in basic civil engineering courses during the COVID-19 pandemic to be better than after the pandemic.

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