

# The influence of in-person and on-line modes of instruction on academic performance in engineering capstone design courses: a comparative study based on non-parametric statistics

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**ABSTRACT:** The Covid-19 pandemic has compelled educational institutions to transit, wholly or partially, from the in-person mode of instruction to on-line. However, there is a paucity of information on the academic performance of students in engineering-based capstone design courses via the on-line mode of instruction as compared to in-person. Therefore, the focus of this comparative study was on the influence of in-person and on-line modes of instruction on students' academic performance in capstone design projects in engineering. Descriptive and non-parametric (the Mann-Whitney and the Kruskal-Wallis) tests were carried out. The outcome of the Mann-Whitney  $U$  test with a  $p$ -value of 0.960 at a  $z$ -value of 0.052 and the Kruskal-Wallis test with a  $p$ -value of 0.744 at a  $z$ -value of 1.238 strongly indicates that the academic performance of engineering students in capstone design courses is not significantly different whether the mode is on-line or in-person. The use of blended on-line and in-person modes of instruction for capstone design courses is highly recommended in order to forestall possible future disruptions of Covid-19, other pandemics and natural disasters.

## INTRODUCTION

The performance assessment of students plays an immense role in determining their academic achievements in a given programme or course, and provides a database that can be utilised in developing improvement strategies [1-4]. It has been widely reported that the mode of educational instruction can influence the academic performance and achievement of students in various courses or programmes [5-10].

In the recent time, there is keen interest among stakeholders in educational institutions in how students' performance differs when the on-line mode of instruction is employed as compared to in-person. For instance, the study of Helms focused on students' performances in psychology based on the face-to-face mode (F2F) of instruction as compared to on-line instruction [6]. The outcome of the study revealed that students taught on-line had lower grade point averages and were more likely to fail the course compared to those instructed F2F [6]. A similar study was conducted for environmental science students by Paul and Jefferson [8]. However, with respect to gender or class rank, it was shown that there was no significant difference in student performance between the F2F and on-line modes of instruction.

Since the emergence of the Covid-19 pandemic, it has become necessary to transit, wholly or partially, from the in-person mode of instruction to on-line in many educational institutions [11]. Sequel to the foregoing, there is a growing interest among teachers/lecturers, students, parents, policy makers and other education stakeholders in the impact of the on-line mode of instruction on student academic performance and achievement. Therefore, several studies have been conducted in this regard [11-13]. Due to the Covid-19 pandemic, protocols were put in place to ensure that makerspaces and capstone design activities transited from the F2F to on-line format [14].

Problems encountered by engineers are often complex and necessitate innovative and creative solutions to be devised and developed. To enable creative solutions, it is extremely crucial for engineers to develop several alternative solutions and think outside the box [15][16].

The relevance of a capstone design project course for improving the skills, knowledge and competencies of engineering graduates cannot be overemphasised. As a matter of fact it is critical to outcome-based education and a core requirement of the Washington accord [17-20]. For instance, Tsenn investigated the effects of the Covid-19 pandemic on mechanical engineering capstone design students' self-efficacy and projects delivery [14]. The author found that there was no significant difference between the engineering design self-efficacy of students that were taught F2F as compared to those instructed on-line [14].

However, Tsenn also demonstrated that the on-line delivery mode of a capstone design course can marginally, but nevertheless positively influence the overall satisfaction of students and that it can positively impact their academic achievements. In the literature reviewed for this study, there was a paucity of information on the academic

performance of students in engineering-based capstone design courses in universities from South Pacific Islands [14]. Hence, this study is an attempt to compare the effect of in-person and on-line modes of instruction on students' academic performance.

## METHODOLOGY

Relevant data were collected on students' performance in two capstone design courses from the Department of Building and Civil Engineering, and the Department of Electrical Engineering and Mechanical Engineering in one of the universities in South Pacific Islands. Descriptive analysis and measure of central tendency statistical tests were first carried out on the data. Non-parametric analyses (using the Mann-Whitney and the Kruskal-Wallis tests) were carried out after a preliminary normality test indicated the non-suitability of parametric tests. Data on grades were obtained for 411 students enrolled in the Capstone Design 1 course, and 332 students enrolled in the Capstone Design 2 course. All the statistical analyses carried out were based on the following two research questions drawn for this study:

Research question 1 (RQ1): Does the mode of instruction significantly influence the academic performance of engineering students in the Capstone Design 1 course?

Research question 2 (RQ2): Does the mode of instruction significantly influence the academic performance of engineering students in the Capstone Design 2 course?

## RESULTS AND DISCUSSION

Results are presented and discussed based on the two research questions drawn for this study.

In regard to RQ1, Figure 1 suggests that the on-line mode of instruction might influence a better academic performance than the in-person mode of instruction. Also, considering the modal score as a measure of central tendency, the modal grade for on-line learning is A-, while that of in-person learning is B. This further suggests that the virtual mode of instruction may influence academic performance in a better way than in-person learning.

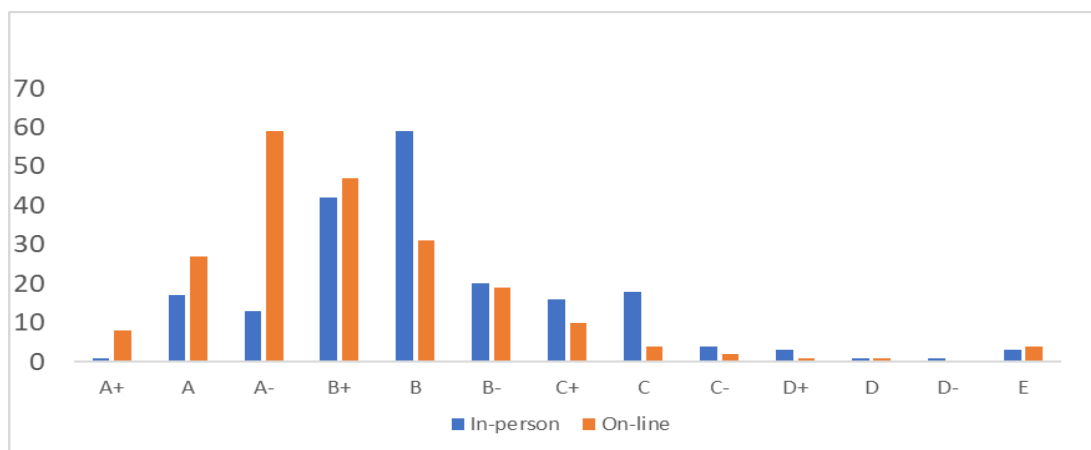


Figure 1: Grade distribution in the Capstone Design 1 course in virtual and in-person learning.

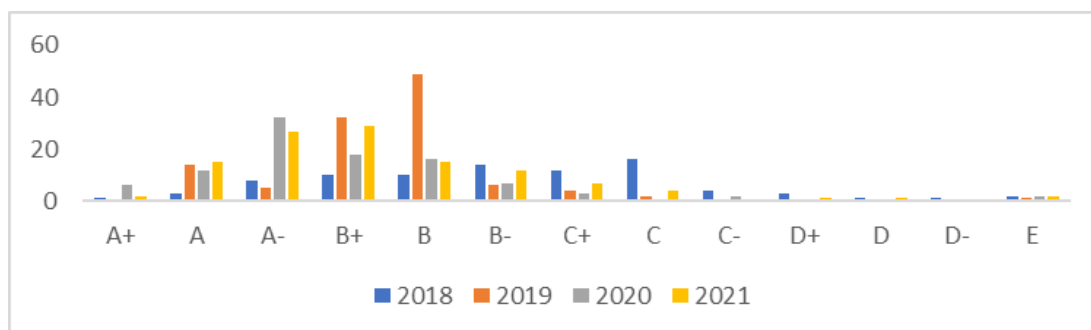


Figure 2: Grade distribution in the Capstone Design 1 course across four years.

Also, Figure 2 suggests that students performed better in the year 2020 and 2021 during the Covid-19 era when on-line learning was the primary mode of instruction. It can also be mused from Figure 2 that the poorest performance of students in the Capstone Design 1 course was in 2018. The findings reported here are considered a corroboration to the report of Tsenn that showed that the on-line delivery mode can positively influence the academic achievements of students [14]. The foregoing findings may be attributed to the versatility of on-line learning with various skills improvement software, applications and other resources capable of enhancing capstone design projects delivery.

## Normality Test

The Kolmogorov-Smirnov test of normality at  $t(26) = 0.205$ ,  $p$  value = 0.006, which is less than  $p$  value = 0.05 yields a non-significant result, and therefore violates the normality assumption. Also, the Shapiro-Wilk test of normality at  $t(26) = 0.802$ ,  $p$  value < 0.001, which is less than  $p$  value = 0.05 yields a non-significant result, and therefore also violates the normality assumption. The normality plots in Figure 3 and Figure 4 (the Q-Q plots and box plot) also show evidence of the violation of the normality assumption. Hence, a non-parametric test was used for analysis of the data.

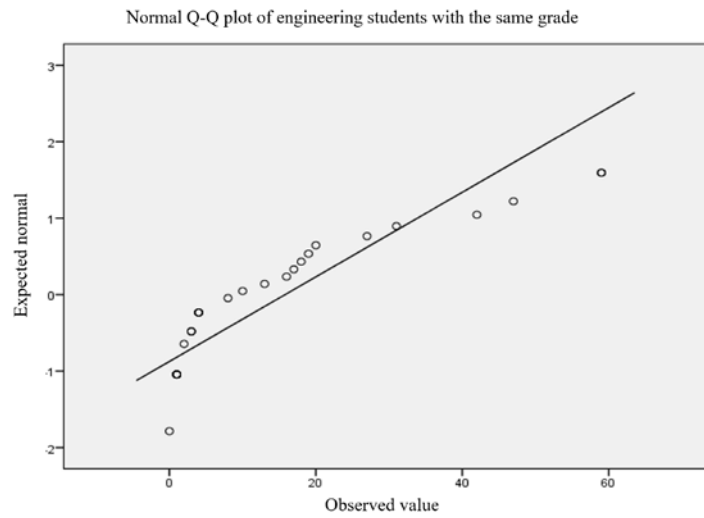


Figure 3: Q-Q plots test for the normality assumption.

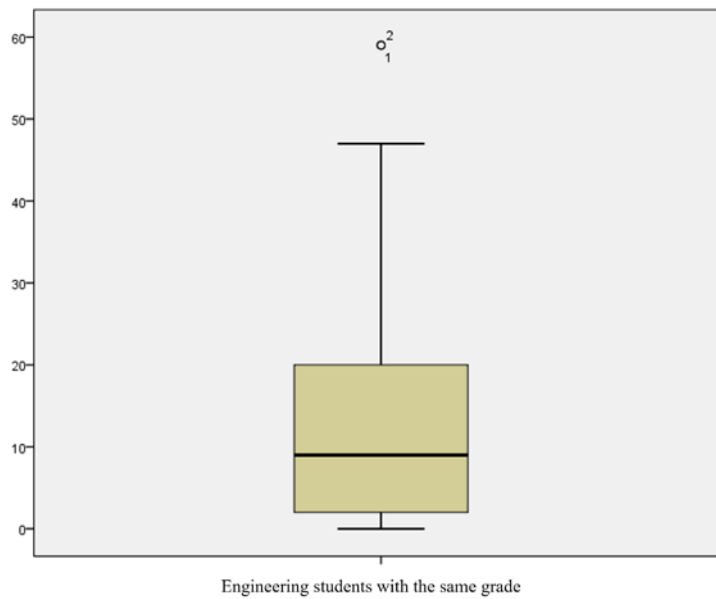


Figure 4: Box plots test for the normality assumption.

## Non-parametric Statistical Test

Table 1 presents the mode of instruction and academic performance of engineering students in the Capstone Design 1 course (Mann-Whitney test summary).

Table 1: Test results.

Independent-samples Mann-Whitney $U$ test summary	
Mann-Whitney $U$	85.500
Wilcoxon $W$	176.500
Test statistic	85.500
Standard error	19.413
Standardised test statistic	0.052
Asymptotic sig. (2-sided test)	0.959
Exact sig. (2-sided test)	0.960

From Table 1, the Mann-Whitney  $U$  test with the  $p$ -value of 0.960 at the  $z$ -value of 0.052, which is greater than the  $p$ -value of 0.05 indicates that the mode of instruction whether on-line or in-person does not affect the academic performance of engineering students in the Capstone Design 1 course. The Mann-Whitney  $U$  value is 85.500.

From Table 2, the Kruskal-Wallis test with the  $p$ -value of 0.744 at the  $z$ -value of 1.238, which is greater than the  $p$ -value of 0.05 indicates that the academic performance of engineering students in the Capstone Design 1 course is not significantly different from one another across the years. The results obtained imply that the on-line mode of instruction does not cause adverse effects on students' academic performance, if at all there was not clear evidence to infer that it yielded a better academic performance in the Capstone Design 1 course.

Table 2: Mode of instruction and the academic performance of engineering students from 2018 to 2021 in the Capstone Design 1 course (Kruskal-Wallis test summary).

Independent-samples Kruskal-Wallis test summary	
Test statistic	1.238
Degree of freedom	3
Asymptotic sig. (2-sided test)	0.744

In regard to RQ2, Figure 5 suggests that the virtual mode of instruction might influence a better academic performance than the in-person mode of instruction. Also, considering the modal grade as a measure of central tendency, the modal grade for virtual learning is A, while that of in-person learning is B+. This also suggests that the virtual mode of instruction may influence a better academic performance than in-person learning. Also, Figure 6 suggests that students performed better in the year 2020 and 2021 than in 2018 during the Covid-19 era when virtual learning was the primary mode of instruction. This again corroborates the findings by Tsenn [14].

The available opportunity for diverse skills improvement software, applications and other resources that have the potential for enhancing capstone design projects delivery for students may be attributed to findings implied from Figure 5 and Figure 6. However, Figure 6 suggests that the performance of students was best in 2019 which was an in-person experience. The obtained better performance in 2019, which was a non Covid19 era and when in-person mode was used as compared to the on-line delivery is contrary to the submission of Tsenn [14]. Although the actual reason for this better performance in 2019 is not ascertained, it may be due to the fact that a critical component of Capstone Design 2 course is better learned via in-person mode of instruction.

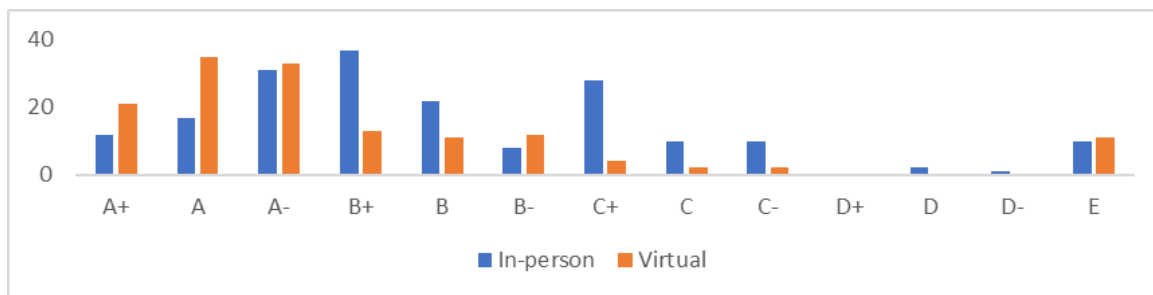


Figure 5: Grade distribution in the Capstone Design 2 course in virtual and in-person learning.

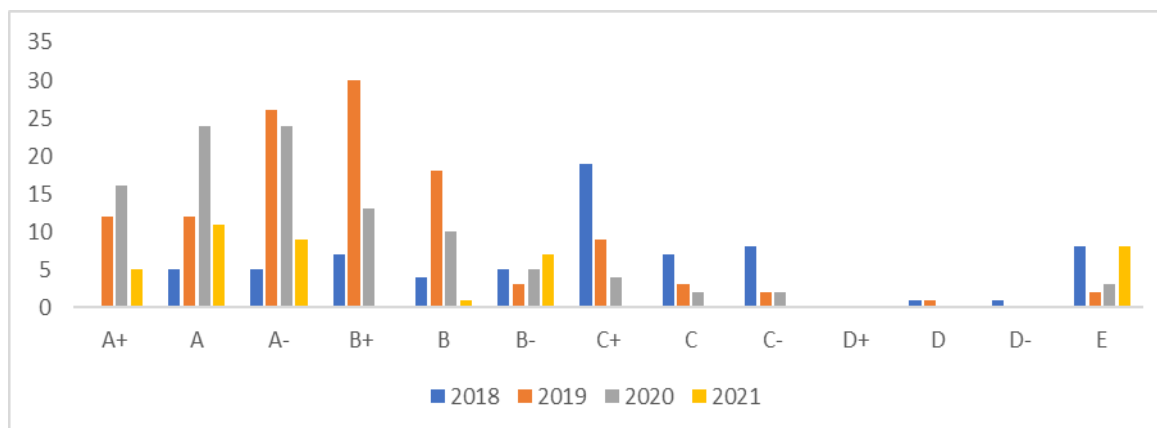


Figure 6: Grade distribution in the Capstone Design 2 course across four years.

This is an indication that further statistical tests, such as a normality test are required. Normality tests help to determine whether a parametric or non-parametric statistical approach is suitable and can confirm the significance of the difference that exist between the effects of in-person and on-line modes of instruction for the Capstone Design 2 course.

## Normality Test

The Kolmogorov-Smirnov test of normality at  $t(26) = 0.185$ ,  $p$  value = 0.023, which is less than  $p$  value = 0.05 yields a non-significant result, and therefore violates the normality assumption. Also, the Shapiro-Wilk test of normality at  $t(26) = 0.880$ ,  $p$  value = 0.006, which is less than  $p$  value = 0.05 yields a non-significant result, and therefore also violates the normality assumption. The normality plots similar to that of Figure 3 and Figure 4 (the Q-Q plots and box plot) showed evidence of the violation of the normality assumption. Hence, the need for a non-parametric test.

## Non-parametric Statistical Test

Table 3 presents the mode of instruction and academic performance of engineering students in the Capstone Design 2 course (Mann-Whitney test summary).

Table 3: Test results.

Independent-samples Mann-Whitney $U$ test summary	
Mann-Whitney $U$	72.000
Wilcoxon $W$	163.000
Test statistic	72.000
Standard error	19.433
Standardised test statistic	-0.643
Asymptotic sig. (2-sided test)	0.520
Exact sig. (2-sided test)	0.545

From Table 3, non-parametric statistical data that followed a similar pattern with that of Table 1 was obtained. The Mann-Whitney  $U$  test with the  $p$ -value of 0.545 at the  $z$ -value of -0.643, which is greater than the  $p$ -value of 0.05 indicates that the mode of instruction whether on-line or in-person does not affect the academic performance of engineering students in the Capstone Design 2 course. The Mann-Whitney  $U$  value is 72.000. A non-parametric statistical data that followed a similar pattern with that of Table 2 was obtained.

Table 4: Mode of instruction and academic performance of engineering students from 2018 to 2021 in the Capstone Design 2 course (Kruskal-Wallis test summary).

Independent-samples Kruskal-Wallis test summary	
Test statistic	4.258
Degree of freedom	3
Asymptotic sig. (2-sided test)	0.235

From Table 4, the Kruskal-Wallis test with the  $p$ -value of 0.235 at the  $z$ -value of 4.258, which is greater than the  $p$ -value of 0.05 indicates that the academic performance of engineering students in the Capstone Design 2 course is not significantly different from one another across the years. As for the Capstone Design 1 course, the findings presented here imply that the on-line mode of instruction does not adversely affect students' academic performance if there is no obvious evidence to infer that it comparatively leads to an improved academic performance in the Capstone Design 2 course.

## CONCLUSIONS

With non-adverse effect implications of the on-line mode and with inspiration drawn from Brown and Tunnicliffe [15], engineering capstone design courses can be redesigned to incorporate breakout rooms in Zoom, Google Meet, Google Docs and other available and upcoming on-line breakout meeting applications. This approach will stimulate sharing of innovative concepts/ideas among students enrolled in capstone design courses. It also has the potential for aiding hitch-free supervision, progress monitoring and continuous assessments/grading.

The deployment of on-line mode for capstone design courses can aid to cushion the impacts of Covid-19 disruptions. The continuous use of a blended on-line and in-person mode of instruction for engineering capstone design courses is recommended, so as to forestall possible future disruptions of the Covid-19 pandemic, other pandemics and natural disasters.

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