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A Comparative analysis of Undergraduate Education in Online Versus in-Person Business Analytics Course

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A Comparative analysis of Undergraduate Students' Performance in Online Versus in-Person Business Analytics Course

Summary

The purpose of this study is measuring the effectiveness of online teaching for a quantitative course by comparing the student learning outcome in online versus in-person classes. Distance education has been gaining popularity for decades, due to its flexibility and affordability. Higher education institutions have been increasingly adopting this delivery method by offering courses in hybrid, online mode, or starting completely online programs on learning management platforms. COVID-19 pandemic, quarantine and prolong public health concerns introduced anxiety in learning environment and created a turning point for education institutions in terms of course offerings and promoting distance learning programs. This course delivery method has been relatively new and challenging for many faculty and students. Teaching quantitative subjects adds to complexity of online education.

This study is a comparative analysis of distance and in-person learning in an undergraduate business analytics class. Individual and teamwork performance of on-campus students measured and from 2015 to spring 2020, then compared to students in online classes form 2020 to 2025. Data collected and analyzed from 1245 students in 39 classes, all taught by the same professor. Twenty classes in this study were in-person and 19 online. Course topics include visualization, population sampling, hypothesis testing and test of means, time series analysis, simple and multiple regression, logistic regression, and optimization. All online and in-person classes used the same resources and tested on similar material. Student grades from eight quizzes, two exams, and eight group assignments were used in this study.

Student performance analysis outcome demonstrated difficulties in classes where all students should learn data analysis in remote settings during the COVID-19 campus closedown. After the campus reopening, since both online and in-person classes were available, students could enroll in classes based on their preferences. During this period, overall online student performance improved that could be the effect of enrollment in online classes by choice.

Group assignment activities were monitored and evaluated by professor. Teamwork and communication between the students were affected in online classes compared to on-campus students. The difference of mean between two groups is only 3.7 percentage points, which is not a wide gap. This relatively small difference indicates the familiarity of contemporary students with communication technology and their readiness to engage and cooperate in a remote setting.

Literature review

In a 2024 comparative study of educational modalities change by Alarifi and Song, final test score analysis was used for measuring student achievement by comparing pre-pandemic, in-person and online classes during the COVID-19 pandemic. This study covered four courses and provided mixed results. While initial observations indicated lower scores from online classes, factoring in other variables including class size, gender, and admission scores demonstrated better achievements in online classes for three courses and one for in-person (1). A 2021 comparative study of online versus in-person student learning motivations found different levels of expectation and motivations between graduate and undergraduate students enrolled in online classes. While graduate students showed higher levels of discipline and self-motivation in studies when moved to online learning environment, they recommend additional virtual activities to enhance undergraduate student motivation and encourage student-to-student interaction (2). A 2023 study of online course experience during the pandemic considered the consequences of anxiety on student performance, learning, and integrity. This study included two large, introductory classes after the campus returned to regular activities and found significant difference in student exams' outcome from those exams taken online (3). A survey study of undergraduate students who took online classes between 2019 and 2023 at a state university compared course modalities versus perceived efficacies and self-regulation, and if they vary by their preferred modality of online or face-to-face classes. Qualitative and quantitative data analysis indicates that student preferences have shifted from in-person to equal distribution across modalities. Support for self-regulation and need for in-person interaction comparing to flexibility of online classes were the highlights of this study (4). Another study at a college of education collected data through interviews with lecturers about their strategies for planning lectures online even beyond the COVID-19 lockdown, and differences observed across modals.

Online teaching challenges were identified as quality of online lectures compared to in-person, technical difficulty connecting to the school learning management system by some students, lack of interaction on the online platform for students who were not familiar with online learning environment or did not have self-regulating skills required for this mode of education (5). A study of different delivery styles on undergraduate student learning outcomes in 2024 compared before and after pandemic results, including in-person 2018-2019 and blended 2020-2021 classes. In a ten-module undergraduate course, one module did not show significant difference, two modules positively and seven modules were negatively affected. Overall, most individual module marks decreased in blended classes (6). A study of graduate level introductory statistics course collecting four years of data from concurrent in-person and online classes demonstrated slightly lower average midterm grades for online classes, though there was no significant differences between the mean homework, final exam, and overall course grades between the two groups (7). A study of the quality and extent of online education in the United States (8) found that 40.7% of schools offering online courses believe that students are more satisfied with online classes compared to traditional classes, and only 3.1% of the schools disagreed with that statement. Medium and large schools reported higher satisfaction and the small schools the lowest. The same study found that 53.6% of schools believe online education is critical to their future. Majority of academic leaders in this study believed that online learning is equal or even superior to face-to-face instruction. Another comparison of online and on-campus (9) concluded that students appreciated online learning for its clear and coherent structure of the material, supporting self-regulated learning, and distributing information. Preference of face-to-face classes was due to providing a shared understanding and interpersonal relations established. A study of learning preferences during the COVID-19 pandemic (10) found that student preferences for online courses to be based on the course subject, perceived to be easier, as well as provide higher flexibility, comfort, and convenience. In contrast, more difficult subjects, and those in the student's major discipline of study, are preferred to be taken in-person.

Course and Data Collection

Data collected from a 300-level Business Analytics course in the core undergraduate curriculum of the College of Business. This is a 3 credit-hour course with a one credit-hour, prerequisite lab

of spreadsheet analytics.Spreadsheet is the major software used in this course. Additional visualization software like Tableau is also used. The course topics include descriptive, predictive, and prescriptive analytics methods. Data collection and cleaning, visualization, sampling, time series analysis, test of means, regression analysis, and linear programming are major topics in this course. Most students enrolling in this class are at junior level and from programs with different levels of statistics and quantitative methods skills that add to the challenge of teaching and student learning experience. Major class assignments' format is mini project analysis by teams of students. Teams present their analysis reports in class, followed by a discussion on the solution quality. Online students record a video presentation for instructor evaluation. All teams submit a written report of their findings and their entire quantitative analysis. The major difference between the two course delivery models is in student and instructor interactions. Students in asynchronous online classes use a discussion forum for peer-to-peer communication and contacting their instructor. Weekly question and answer video sessions were scheduled for online classes. All online classes access videos explaining theoretical concepts, demonstrate step-by-step problem-solving steps, exercises, and software training. Students take one quiz per course module, a midterm, and a final exam. Teamwork projects account for 50% of the student grades, exams for 35%, quiz and class participation each 7.5%.

Data Analysis

Grades were collected from 1245 students in 39 classes between fall 2016 and summer 2025. Most grades belong to students in online classes (822) and remaining (423) from in-person students. Average class grades in all four categories; quizzes, group assignments, midterm, and final exam were compared using standard tests of means. Online course material development benefited from previous experiences in graduate level courses by the same professor. The initial expectation was to create equal learning opportunities for students in both course modalities and achieve comparable learning outcomes, though some challenges in online course delivery model were expected due to the limited online learning experience by most undergraduate students. All hypotheses of this study were stated based on the same perception and expectations.

Standard tests of mean were used for comparing the means of data series in online and in-person classes. Available options include parametric and nonparametric tests. Parametric tests like t-test and z-test, and in case of multiple groups ANOVA have more power than nonparametric tests like Wilcoxon, Mann-Whitney, and Kruskal-Wallis. Parametric tests rely on basic assumptions like random sampling, homoscedasticity, and normal distributions while nonparametric tests work based on ranks and do not depend on specific distributions. Parametric tests have priority due to their power. Before using these tests, all data were tested for their assumptions. Shapiro-Wilk test of normality, and Levene's test of homoscedasticity were used to determine the proper test of means for all four evaluation categories.

Comparing quiz grades between online and in-person classes

The first hypothesis of this study was based on the expected difference of average quiz scores between the two groups.

H_0: Mean online quiz scores equal the mean in-person quiz scores

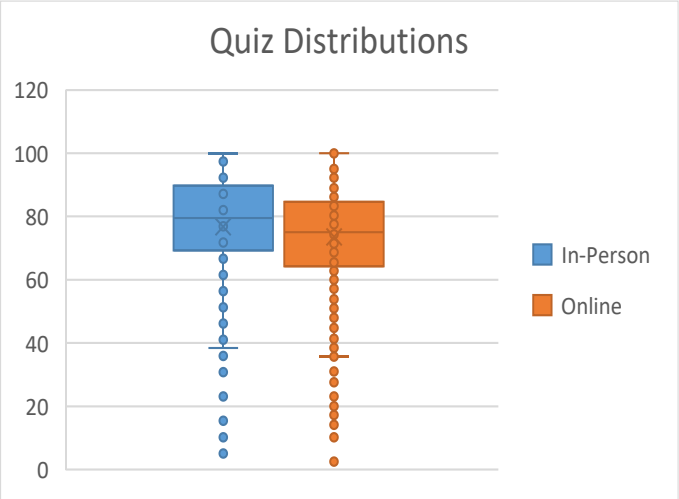
H_1: Mean online quiz scores are not equal to the mean in-person quiz scores

Quiz scores were tested for homoscedasticity and normal distribution, using Levene's test and Shapiro-Wilk test respectively. Levene's F test statistic of 0.005 and *p-value = 0.94* fails to reject the null hypothesis. We can consider a non-significant difference between the variances of online and in-person classes quiz grades. This test confirmed meeting the first assumption of a parametric test. A Shapiro-Wilk test of normality however, on the same scores generated a statistic value of 0.946 and *p-value = 8.70E-21*. These numbers indicate severe deviation of the data distribution from normal. Based on these results a nonparametric, Mann-Whitney test conducted that produced a test statistic value of 197054 and *p-value = 9.49E-05*. This p-value is the evidence to reject the null hypothesis of the test of means and conclude that mean quiz results from online and in-person classes are statistically different. Table (1) shows a summary of quiz scores' tests and results where mean quiz scores from in-person classes is 3.2 percentage points higher than online classes. Figure (1) demonstrates quiz scores distributions. Online class scores clearly show a lower median and relatively close concentration and interquartile range with in-person classes.

Table 1: Quiz score tests

In-Person N	821
Online N	423
In-Person Mean	76.7
Online Mean	73.5
Delta	-3.2
Shapiro-Wilk W	0.95
Shapiro-Wilk P-Value	8.70E-21
Levene's F-value	0.005
Levene's P-Value	0.94
Mann-Whitney U	197054
Mann-Whitney P-Value	9.49E-05

Figure 1: Quiz score distributions



Comparing group projects grades between online and in-person classes

Group projects are assigned to teams of five students. Each team has two to three weeks to complete the data analysis, prepare a professionally formatted report, submit the entire data analysis and presentation. Each group earns a grade shared by all team members. The following hypothesis was stated for testing the means of group assignments.

H_0: Mean online group project scores equal the mean in-person group project scores

H_1: Mean online group project scores are not equal to the mean in-person group project scores

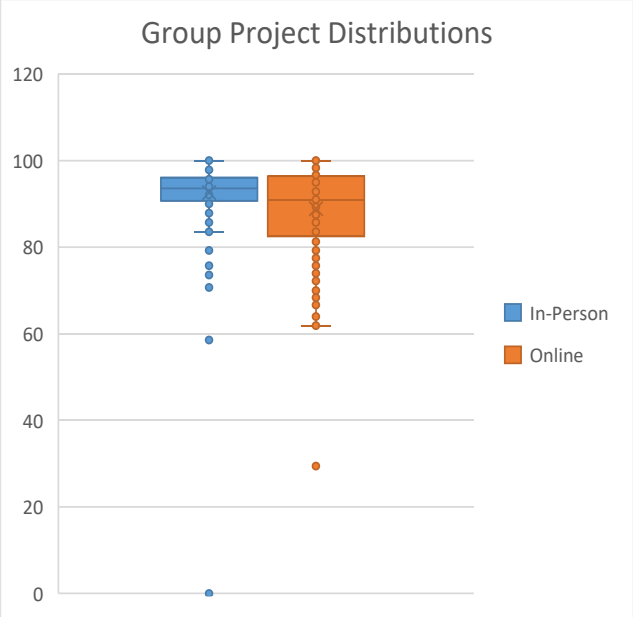
Group project scores also were tested for normal distribution and homoscedasticity, using Shapiro-Wilk and Levene's test. Levene's F value of 87.1 and *p-value = 4.58E-20* means we can reject the null hypothesis of the unequal variance test and consider the variances of group project scores in online classes significantly different from in-person students. Shapiro-Wilk test of normality on the group project scores has a statistic value of 0.853 and *p-value = 1.80E-*

32. This test result indicates a significant deviation from normal distribution. Since none of the basic assumptions of parametric tests were met, a nonparametric Mann-Whitney test of means conducted that produced a *U* test statistic of 211639 and *p-value = 2.29E-10*. The conclusion is that the mean group project results from online and in-person classes are statistically different. Table (2) shows a summary of group project score tests and results. Average in-person group projects score of 92.6 is 3.7 percentage points higher than online classes of 88.9. Figure (2) demonstrates group project scores distributions. Online class scores show a lower median and much larger spread (variance =426.5) compared to in-person classes (variance = 382.7). The mean difference of group assignments is however, 3.7 percentage points. On-campus students meet in class and have face-to-face meetings when working on their projects. Online students often do not have the same opportunity, which can be one of the factors impacting their group assignments' outcome.

Table 2: Group Project tests

In-Person N	423
Online N	821
In-Person Mean	92.6
Online Mean	88.9
Delta	-3.7
Shapiro-Wilk W	0.853
Shapiro-Wilk P-Value	1.80E-32
Levene's F-value	87.1
Levene's P-Value	4.58E-20
Mann-Whitney U	211639
Mann-Whitney P-Value	2.29E-10

Figure 2: Group project score distributions



Comparing midterm exam grades between online and in-person classes

The hypothesis stated for testing the means of midterm exams also stated based on the expected performance by students in both modes.

H_0: Mean online midterm exam scores equal the mean in-person midterm exam scores

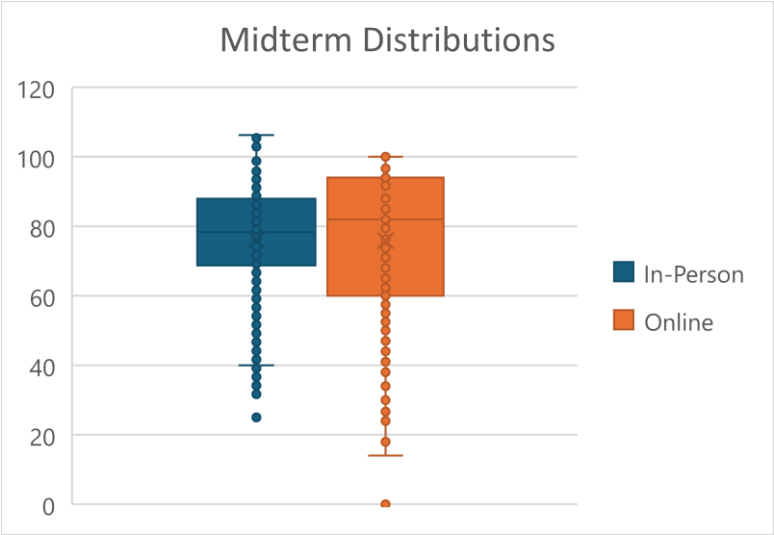
H_1: Mean online midterm exam scores are not equal to the mean in-person midterm exam scores

Midterm exam scores were tested for normal distribution and homoscedasticity, using Shapiro-Wilk and Levene's test. Levene's F value of 48.37 and *p-value = 6.11E-12* allows us to reject the null hypothesis of the unequal variances test and consider the variances of midterm scores in online classes significantly different from in-person. This means the first assumption of a parametric test was not met. A Shapiro-Wilk test of normality on the group project scores generates a statistic value of 0.853 and *p-value = 1.80E-32* that rejects the null hypothesis of normal distribution. Since none of the basic assumptions of parametric tests were met, a nonparametric Mann-Whitney test of means conducted that produced a *U* test statistic of 129042 and *p-value = 0.06*. This p-value is close to the tests' significance level of 0.05. The fact that midterm exams of the online classes are only 0.2 percentage points lower than in-person class means (75.9 vs 76.1), we may safely conclude that mean midterm exam scores from both course delivery methods are about the same. In fact, had we met the parametric test assumptions, a t-test would not generate a p-value beyond the significance level. Table (3) shows a summary of midterm exam scores tests and results. Figure (3) shows the distribution of these scores for both online and in-person classes. Online class scores show a higher median and much larger spread (variance =80.7) compared to in-person classes (variance = 45.2).

Table 3: Midterm exam tests

In-Person N	423
Online N	821
In-Person Mean	76.1
Online Mean	75.9
Delta	-0.2
Shapiro-Wilk W	0.934
Shapiro-Wilk P-Value	2.02E-21
Levene's F-value	48.37
Levene's P-Value	6.11E-12
Mann-Whitney U	129042
Mann-Whitney P-Value	0.06

Figure 3: Midterm exam score distributions



Comparing final exam grades between online and in-person classes

Like the previous 3 measures, the hypothesis for testing the means of final exams stated based on the expected performance by students in both modes.

H_0: Mean online final exam scores equal the mean in-person final exam scores

H_1: Mean online final exam scores are not equal to the mean in-person final exam scores

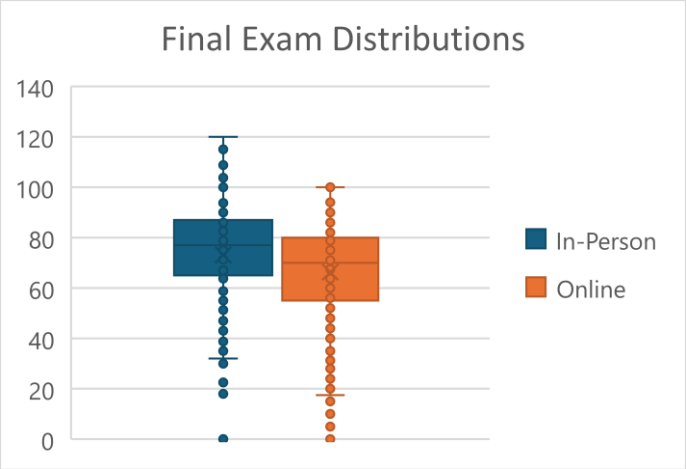
Final exam scores also tested for normal distribution and homoscedasticity, using Shapiro-Wilk and Levene's test. Levene's F value of 2.61 and *p-value = 0.11* fail to reject the null hypothesis of the unequal variance test and conclude that the variances of group project scores in online classes are not significantly different from in-person students. This means the first assumption of a parametric test is met. A Shapiro-Wilk test of normality on the group project scores generates a statistic value of 0.975 and *p-value = 5.60E-14* that indicate severe deviation from

normal distribution. Since one of the basic assumptions of parametric tests was met, a nonparametric Mann-Whitney test of means conducted that produced a *U* test statistic of 210118 and *p-value = 1.17E-09*. This p-value is statistically significant for rejecting the null hypothesis. The difference of 6.48 points between the final exam of online and in-person classes is the largest difference among all measures tested. Table (4) shows a summary of final exam scores tests and results. Figure (4) shows the distribution of these scores for both online and in-person classes.

Table 4: Final exam tests

In-Person N	423
Online N	821
In-Person Mean	73.11
Online Mean	66.27
Delta	-6.48
Shapiro-Wilk W	0.975
Shapiro-Wilk P-Value	5.60E-14
Levene's F-value	2.61
Levene's P-Value	0.11
Mann-Whitney U	210118
Mann-Whitney P-Value	1.17E-09

Figure 4: Final exam score distributions



The student learning outcome trend

Online classes in this study began at the start of the COVID-19 lockdown therefore, the effects of this stressful period on students should be considered. Numerous reports have documented the pandemic's impact on students' education and mental health. A similar effect on academic performance was observed during the Great Recession of 2007–2009.

From 2020 to 2022, overall college enrollments declined, including a 21 percent drop in two-year colleges and a 6 percent drop in four-year college entry (11). The abrupt transition to remote learning reduced instructional time, and many students struggled to adapt to this unfamiliar learning mode. Moreover, the isolation associated with lockdowns led to mental health issues that further hindered the learning process (12). Even popular coping mechanisms, such as increased engagement with social media, were not particularly beneficial to academic performance (13).

These challenges were global. For instance, a survey at a Spanish university showed that more than 21% of students experienced moderate to extremely severe anxiety, while 34% and 28% reported depression and stress, respectively (14).

In the present study, noticeable changes in student performance emerged immediately after the lockdown, as well as later when campuses reopened and normal class activities resumed. The anxiety and confusion associated with the early lockdown period can explain the sharp decline in average class scores during the summer and fall semesters of 2020. However, even after this initial drop, lower average scores on quizzes and final exams persisted.

Part of this decline can be attributed to the universal shift to remote learning, which some students were not prepared to handle. After campuses reopened, online class grades gradually improved. One likely explanation is selective enrollment: students who were uncomfortable with online learning enrolled in in-person classes, while students who preferred or had prior experience with online learning chose online sections.

Figure 5 illustrates the trends in class mean scores before and after the pandemic. All classes offered after the pandemic through summer 2025, were online. Summer 2020 is marked as start of the online classes by a vertical dashed line. Overall trend on all graphs is identified by a polynomial solid line. Except for final exams, these trend lines do not demonstrate a

significant change, even though the statistical test results of three measures are significant. Mean final exam scores also show improvement after 2023.

Figure 5: Student evaluation scores in-person classes before COVID-19 lockdown and online classes since the beginning of the lockdown

Conclusion, limitations and future studies

Data analysis results show at least practically significant differences across all four assignment and exam categories. The smallest difference appears in the midterm exam with the average midterm score in online classes being only 0.2 percentage points lower than in in-person classes. In contrast, final exams showed the largest gap between the two class modes, with a difference of 6.48 percentage points.

This discrepancy can be partly explained by the fact that the first half of the semester typically covers introductory and relatively easier material, whereas the second half focuses

on more challenging topics and methods. All topics are then included in the comprehensive final exam. Lower online class final grades demonstrate the need for more resources in teaching challenging topics. These resources include documentation, solved examples, and video recordings showing step-by-step problem solving.

Another consideration is that after the lockdown—and even after fall 2022, when the campus reopened—many students who were unprepared for or uninterested in online learning did not have access to in-person class options, or chose online courses due to safety concerns. Such factors may have negatively affected their performance. This issue will not be present when future data are collected from concurrent online and in-person classes.

This study confirms the challenges of teaching quantitative material online, as reported in previous research. Although statistically significant differences were observed, online students during the stressful COVID-19 lockdown scored only a few points lower than students in pre-lockdown in-person classes. These findings, obtained under particularly difficult learning conditions, suggest that online instruction can be effective when students are provided with adequate resources and support.

A limitation of this study is the lack of concurrency between the two instructional modes. All in-person classes were taught before the 2020 lockdown, while all online classes were offered afterward. During the semesters immediately following the lockdown, students in online courses were learning under different conditions, which may have influenced the results. Since Spring 2026, the author has resumed teaching on campus while continuing to teach online. A future research will collect data from concurrent online and in-person classes. Improving grades in online classes since 2023 is a positive sign that post-COVID conditions will demonstrate even closer results between online and in-person classes.

Another important factor to consider in a future study is students' program of study. This course is required across all departments in college of business. Each section of the course includes students from a wide range of disciplines. Departments differ in their analytical and statistical expectations, so students may enter the course with varying levels of quantitative preparation. Including majors in future analyses will help more accurately assess the effectiveness of online instruction.

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