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The Effect of Delivery Modality on Student Performance in a Quantitative Business Course

Claude R. Superville*, PhD, FRSS, FIMA[1]And Marion S. Smith, PhD[2]
[1]*Professor, Management Science, Texas Southern University, Houston, Texas*
[2]*Associate Professor, Management Science, Texas Southern University, Houston, Texas*
**Corresponding author*

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ABSTRACT: Business Statistics I, MGSC 239, is a quantitative undergraduate business course offered at a public university in Houston, Texas. In 2024, this course was taught as a face-to-face lecture-based course, as a hybrid course combining face-to-face lectures and live online lectures, and as an online asynchronous course with archived recorded lectures. This article explores the effect of differences in the delivery modalities, face-to-face live, hybrid and online recorded lectures, on student performance. Original data sets are included in the article, so students may reproduce the results as an active learning activity in a second undergraduate Business Statistics course or a first graduate Statistical Analysis course.

Keywords: delivery modalities, face-to-face, hybrid, asynchronous, active learning

I. INTRODUCTION

The benefits and limitations of online instruction, when compared to classroom-based face-to-face (F2F) instruction, has been researched and debated for a number of years. There appears to be a blurred dichotomy between two schools of thought. There are educators whoposit that the personal touch of a live instructor and F2F classroom interactions among students is essential to the college learning experience, particularly so for students whose secondary education learning experiences have not fully prepared them for college (Ramsden and Entwistle, 1981). Brown (1996) and Hara and Kling (2000) suggest that students in the online environment may experience isolation, confusion and frustration that adversely affect the efficacy of their learning.

Another school of thought advocates for online instruction suggesting that online participation may be less intimidating to students who tend to be more reserved in a classroom. McLaren (2008)advises that student learning is enhanced by the quality and quantity of interactions, both student to student and student to instructor interactions, which exist in the online environment.

Differences in student performance, in the F2F, hybrid and online environments, has also been well researched without a clear conclusion of which modality is best suited for student learning. Carmel and Gold (2007) advise that there is not a statistically significant difference in student performance between F2F and hybrid modes of instruction. Helms (2014) suggest that online students have significantly lower grade point averages (GPAs) that F2f students. Other authors advise that statistically significant differences existed in student performance between online and traditional courses (Atchley, Wingenbach, and Akers, 2010; Faux and Black-Hughes, 2000; Paden, 2006; Shoenfeld-Tacher, McConnel, and Graham, 2001).

This paper explores the existence of a difference in student performance among students taughtF2F, fully online, and in hybrid mode in a quantitative undergraduate business course, Business Statistics I. Student performance datafrom sections of the course offered F2F, online and as a hybrid of F2F and online lecture formatsin 2024 are used in the analysis.This study assumes that student performance is variable while student knowledge is fixed from semester to semester. Results of this case study may not be extendable to other larger delivery modality studies since the student performance observationsin each of the three groups of data are nonrandom.Original data sets are included so students may reproduce the results as an active learning activity in a second Business Statistics course.

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II. DATA SETS

TABLE I: DATA

Grades Fall 2024 FTF	Grades Fall 2024 Online	Grades Fall 2024 Hybrid
37.58	58.87	63.33
66.49	6.05	84.37
73.49	97.27	47.83
87.38	94.21	85.59
64.08	74.45	15.80
96.42	53.21	65.53
65.23	57.39	22.50
84.31	93.90	48.61
73.63	32.51	91.84
74.28	43.19	59.49
82.41	82.85	78.41
96.31	44.49	61.09
87.29	95.12	70.07
88.38	93.16	45.02
90.97	97.25	37.48
88.65	84.22	28.97
45.91	59.11	75.21
81.89	86.88	15.80
84.48	88.78	88.00
68.94	83.65	62.88
85.98	77.60	77.96
31.75	44.85	70.18
67.42	66.01	79.39
74.80	95.44	35.04
93.94	78.51	33.24
91.92	82.89	76.63
84.22	80.03	87.18
85.71	92.09	11.92
74.53	95.29	61.36
81.79	66.43	90.86
81.86	59.57	89.43
80.89	83.34	63.33
76.16	82.80	84.37
80.79	6.20	47.83
71.24	90.79	85.59
96.42	83.49	15.80
83.51	83.51	65.53
80.56	22.78	22.50
52.89	93.36	48.61
93.18	81.30	91.84
37.58	62.70	59.49
66.49	85.78	78.41
73.49	45.36	61.09
87.38	68.12	70.07
64.08	36.91	45.02
96.42	71.90	37.48
65.23	82.40	28.97
84.31	88.51	75.21

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73.63	91.34	15.80
74.28	84.87	88.00
82.41	78.28	
96.31	88.87	
87.29	49.91	
	58.87	

Table I displays student performance scores for sections of the course offered F2F, online and as a hybrid of F2F and online in 2024. Table II shows descriptive statistics for student scores across the modalities. Note that the mean scores for the F2F and online sections are substantially higher than the mean score for the hybrid section of the course, possibly due to the existence of at least five outlier scores on the low end in the hybrid group. There also appears to be less variation in the score of the of the FTF group when compared to online and hybrid groups.

TABLE II: DESCRIPTIVE STATISTICS

	Grades Fall 2024 FTF	Grades Fall 2024 Online	Grades Fall 2024 Hybrid
Mean	77.69135	72.22239	60.03138
Standard Error	2.382252	3.151603	4.441537
Median	81.82513	82.39796	63.32853
Mode	#N/A	#N/A	15.79521
Standard Deviation	15.06669	22.94401	24.72943
Sample Variance	227.005	526.4277	611.5449
Kurtosis	2.073492	1.060799	-0.89645
Skewness	-1.39903	-1.25097	-0.54408
Range	64.67323	91.22112	79.92153
Minimum	31.74937	6.0475	11.915
Maximum	96.4226	97.26862	91.83653
Sum	3107.654	3827.787	1860.973
Count	40	53	31

III. METHODOLOGY

The key research questionof this study is:
Is there a difference in the student performance scores of students taught F2F, online and in hybrid modes?
Expressed statistically:
H_O: $\mu_{F2F} = \mu_O = \mu_H$(mean student performance is the same across different delivery modalities)
H_A: at least one μ is different

TABLE III: ONE-WAY ANOVA (COMPLETED RANDOMIZED DESIGN)

Groups	*Count*	*Sum*	*Average*	*Variance*
Grades Fall 2024 FTF	40	3107.654	77.69135	227.005
Grades Fall 2024 Online	53	3827.787	72.22239	526.4277
Grades Fall 2024 Hybrid	31	1860.973	60.03138	611.5449

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5599.33	2	2799.665	6.207366	0.002714	3.07114
Within Groups	54573.78	121	451.023			

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Total	60173.11	123				

Assuming significance level α = .05.
F= 6.207, p = 0.0027
Decision: Since p < .05, reject Ho.
Conclusion: Student performance scores for at least one modality, is different.
Table III reveals a One-Way ANOVA Testof the equality of the student score means across modalities. In evaluating the equality of means, the F test statistic is 6.027 with a corresponding p-value of 0.0027. At a 5% significance level, a statistically significant difference exists among the mean students' scores of students taught F2F, online and in hybrid modalities.

Although One-Way ANOVA may indicate that a significant difference exists among mean scores, it does reveal which mean score for a specific modality is different. To determine which mean score is different, a multiple comparisons test, such as the Tukey HSDTest may be used.
Tukey HSD tests for significant pairwise differences among means.Significant differences in mean scores may be revealedby comparing confidence intervals on the difference in means or by comparing differences in means to critical mean scores.

FIGURE I: TUKEY HSD CONFIDENCE INTERVALS

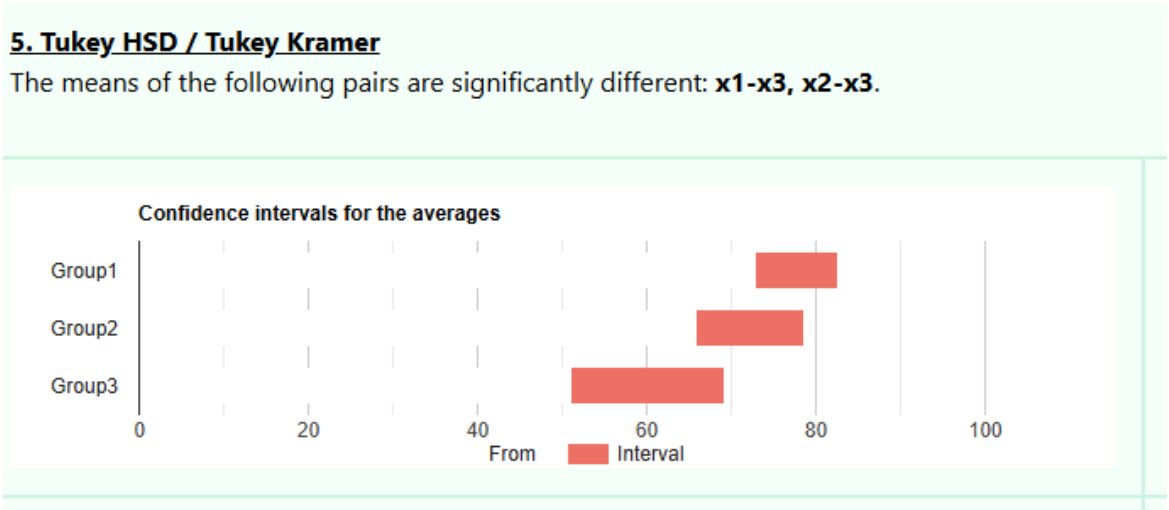

Figure I display confidence intervals (CI) on the differences in means for F2F (x_1), hybrid (x_2) and hybrid (x_3). Note that there no overlap in the CI on x_1 and x_3 and marginal overlap in the CI on x_2 and x_3 indicating that mean scores for F2F and hybrid groups are different as are the mean scores for online and hybrid groups. Figure 1 and Table IV are partial output from entering the performance scores into an online calculator:
One Way ANOVA Calculator and Tukey HSD: ANOVA Calculator - One Way ANOVA and Tukey HSD teshttps://www.statskingdom.com/180Anova1way.htmlt

TABLE IV: TUKEY HSD TEST RESULTS

Pair	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value	Group	x2	x3
x1-x2	5.4695	3.1452	1.739	-5.085	16.024	10.555	0.4381	x1	5.47	17.66
x1-x3	17.659	3.5933	4.9145	5.601	29.718	12.058	0.002	x2	0	12.19
x2-x3	12.19	3.3955	3.59	0.7954	23.584	11.395	0.033			

Table IV displays the mean pairwise differences compared to Tukey's criticalvalues. At the 5% significance level, significant differences exist in mean scores for F2F and hybrid groups and for the

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online and hybrid groups as evidenced by the p-values, 0.002 and 0.033 respectively. Meanstudent performancescoresoffered in F2F and online modalities are significantly higher than scores in the hybrid course.

ASSUMPTION OF THE STUDY

One assumption of the One-Way ANOVA test is the equality of variances across groups. Yet ANOVA is known to be robust from violations of the assumptions that underpin the test.Would a violation of the assumption of equal variance among the three groups be enough to affect the result from the ANOVA test?

To evaluate the equality of variances across the three course modalities, a Bartlett's test is applied to the data sets:

Ho: Are variances the same across course delivery modalities

Ha: variance of at least one modality differs

Using a Bartlett's test online calculator (Statolohttps://www.statology.org/bartletts-test-calculator/gy):

Test Statistic B=1.82

p-value=0.40206

At a 5% significance level, there is not a significant difference in the variances among course delivery modalities. The assumption of equality of variances is not violated so the results of the ANOVA test is valid.

IV. CONCLUSIONS

This article has explored the effect of delivery of instructionand course content in a face-to-face classroom environment, delivered entirely online and delivered in a hybrid mixof face-to-face and online lecture formats,in an undergraduate quantitative business course. The results of this case study reveal a significant difference in student performance across delivery modalities. Student performance in sections of the course offered in face-to-face and online modalities, aresignificantly higherthan student performance in the hybrid offering of the course. It should be emphasized that this is a single case study than may not be extendable to other larger studies that consider delivery modality differences on student performance. A supplemental objective of this article is to offer students an active learning activity that may be reproduced in a second business undergraduate Business Statistics course or an initial graduate Statistical Analysis course.

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