Assignment 4: A/B Testing

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Introduction
In this report, we are going to conduct A/B testing to analyze different attributes that can affect student learning. All SPSS outputs are included in the appendix.

Hypotheses
Hypothesis #1: Students will spend more time in class if the course doesn't have lecture recordings than if there are lecture recordings that students can watch later (in other words, does lecture recordings affect the time students spend in class).

We think that hypothesis #1 will be true because if the course is recording lectures that students can watch later, then less students have incentive to come to class. Here, time spent in class is dependent variable Y1 and whether lecture is recorded or not is an independent variable.

Hypothesis #2: Students will get a higher GPA if the class is in-person and has higher attendance points (10%) than if the class is on Zoom with no attendance points (in other words, do lecture location and attendance points interact in their effect on the student GPA).

We think hypothesis #2 is true because we think that students pay more attention when in class if the lecture is in-person and more students will attend class if there are attendance points that can hurt their course grade if they don't attend class. Both higher attention in class and higher attendance can help them do better in the class and thus, they will get higher GPA. Here, GPA is the dependent variable Y2. In-person class and attendance points are independent variables.

Experiment Setup
Independent variables:
- Lecture location:
  - Zoom
  - In-person
  - Hybrid
- Recorded:
  - Yes
  - No
- Attendance points:
  - 0% of course grade
  - 5% of course grade
  - 10% of course grade

Dependent variables:
- Y1: How long they stay in class (minutes)
- Y2: Student performance (GPA)

We are assuming that the university is conducting an experiment where they are interested in studying how different factors such as lecture location (in-person or zoom) and attendance points affect student learning. We are going to use a completely randomized design. There are 18 combinations such as (Zoom, Yes, None), (In-person, No, 5%), etc. Once all students have enrolled in the courses, professors in each course will randomly choose one of these 18 combinations (choice is not dependent on how the course is taught in the past years and we are assuming that very few students will drop after the first day).

After assigning one of the 18 combinations to each course, we are going to measure how long students stay in a class, meaning if the lecture is 2 hours long, how many minutes they attended the lecture. Another variable that we are going to measure is student GPA for determining student performance and learning. To track these dependent variables, we are going to keep a record when a student comes to class and when leaves and their GPA for that quarter.

MANOVA Analysis

The output for the Multivariate Tests is shown in appendix figure 2. Our analysis shows that there is no significant interaction between the three independent variables that can have some effect on the dependent variables. As per Wilks' Lambda, if we look at the p-value of interaction between the three independent variables (location * recorded * attendance), then we found that the p-value is 0.053 which is not less than the statistically significant p-value of 0.05 and thus, the interaction is not significant. We also found that the interaction between recorded and attendance as well as the interaction between location and recorded don't have a significant effect on the dependent variables because the p-values of 0.869 and 0.457, respectively, are higher than the statistical significant p-value of 0.05. Also, if we look at the independent variables individually, then we found that all of them have p-values greater than 0.05 which means they are not having a significant effect on the dependent variables (appendix figure 2).

However, if we look at the interaction between location and attendance, then the p-value is 0.021 which means that the interaction is significant and the interaction has a significant effect on the dependent variables. And if we look at the lecture location factor in appendix figure 4, we can see that hybrid lecture is the best option that shows the greatest effect on the dependent variable GPA. If we look at the attendance factor in appendix figure 5, we can see that attendance points of 5% towards course grade has the greatest effect on the dependent variable GPA. If we just look at this information, we can conclude that our hypothesis #2 is not valid because we claimed that in-person lectures and 10% attendance points will have the highest effect on GPA. However, one thing that we need to take into account is that the p-values for these Zoom and 5% attendance points are a lot higher than the statistically significant p-value of 0.05 and thus, the data doesn't tell us much about which type is better. Thus, our data doesn't tell us much to validate our hypothesis #2.

For hypothesis #1, we found that the independent variable recorded has a p-value of 0.928 which means that it is not statistically significant and is not having any significant effect on the dependent variables (appendix figure 2). Additionally, if we look at appendix figure 3, we can see that independent variable Recorded and dependent variable LecTime has a p-value of 0.987 which is greater than the statistically significant p-value of 0.05. This means that the recorded variable doesn't have a significant effect on the dependent variable lecture time. Thus, we don't have enough evidence to validate our hypothesis #1 and thus, out hypothesis #1 is not valid.

Conclusion

Our experiment included different courses and each course randomly chooses one of the available 18 choices. Because there are many choices, we needed to do the experiment at a large scale so that each choice is at least selected by 1 or 2 courses. Thus, this type of experiment can be done in large universities such as UCI that offer hundreds of courses each quarter. Also, we will have to wait for the end of the quarter to summarize our results. Therefore, these kinds of experiments are not easy to conduct and require a lot of resources. Overall, our analysis doesn't show much significance due to which we didn't have much evidence to validate our hypotheses.

Appendix

Figure 1:

General Linear Model

Between-Subjects Factors

		N
location	hybr	311
	in-p	361
	zoom	328
recorded	no	523
	yes	477
attendance	.00	342
	5.00	328
	10.00	330

Figure 2:

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.860	3013.574[b]	2.000	981.000	.000
	Wilks' Lambda	.140	3013.574[b]	2.000	981.000	.000
	Hotelling's Trace	6.144	3013.574[b]	2.000	981.000	.000
	Roy's Largest Root	6.144	3013.574[b]	2.000	981.000	.000
location	Pillai's Trace	.003	.778	4.000	1964.000	.539
	Wilks' Lambda	.997	.778[b]	4.000	1962.000	.539
	Hotelling's Trace	.003	.778	4.000	1960.000	.540
	Roy's Largest Root	.003	1.395[c]	2.000	982.000	.248
recorded	Pillai's Trace	.000	.075[b]	2.000	981.000	.928
	Wilks' Lambda	1.000	.075[b]	2.000	981.000	.928
	Hotelling's Trace	.000	.075[b]	2.000	981.000	.928
	Roy's Largest Root	.000	.075[b]	2.000	981.000	.928
attendance	Pillai's Trace	.007	1.608	4.000	1964.000	.170
	Wilks' Lambda	.993	1.606[b]	4.000	1962.000	.170
	Hotelling's Trace	.007	1.605	4.000	1960.000	.170
	Roy's Largest Root	.004	2.031[c]	2.000	982.000	.132
location * recorded	Pillai's Trace	.004	.911	4.000	1964.000	.456
	Wilks' Lambda	.996	.911[b]	4.000	1962.000	.457
	Hotelling's Trace	.004	.910	4.000	1960.000	.457
	Roy's Largest Root	.003	1.465[c]	2.000	982.000	.232
location * attendance	Pillai's Trace	.018	2.257	8.000	1964.000	.021
	Wilks' Lambda	.982	2.261[b]	8.000	1962.000	.021
	Hotelling's Trace	.018	2.266	8.000	1960.000	.021
	Roy's Largest Root	.017	4.109[c]	4.000	982.000	.003
recorded * attendance	Pillai's Trace	.001	.313	4.000	1964.000	.869
	Wilks' Lambda	.999	.313[b]	4.000	1962.000	.869
	Hotelling's Trace	.001	.313	4.000	1960.000	.869
	Roy's Largest Root	.001	.530[c]	2.000	982.000	.589
location * recorded * attendance	Pillai's Trace	.016	1.923	8.000	1964.000	.053
	Wilks' Lambda	.985	1.922[b]	8.000	1962.000	.053
	Hotelling's Trace	.016	1.922	8.000	1960.000	.053
	Roy's Largest Root	.011	2.755[c]	4.000	982.000	.027

a. Design: Intercept + location + recorded + attendance + location * recorded + location * attendance + recorded * attendance + location * recorded * attendance

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Figure 3:

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	lectime	30.176[a]	17	1.775	1.380	.138
	gpa	64073.364[b]	17	3769.021	1.452	.105
Intercept	lectime	3997.586	1	3997.586	3106.803	<.001
	gpa	8099893.89	1	8099893.89	3119.820	<.001
location	lectime	.455	2	.228	.177	.838
	gpa	7209.092	2	3604.546	1.388	.250
recorded	lectime	.000	1	.000	.000	.987
	gpa	391.089	1	391.089	.151	.698
attendance	lectime	4.532	2	2.266	1.761	.172
	gpa	7688.221	2	3844.110	1.481	.228
location * recorded	lectime	.983	2	.491	.382	.683
	gpa	7429.618	2	3714.809	1.431	.240
location * attendance	lectime	14.455	4	3.614	2.809	.025
	gpa	16826.515	4	4206.629	1.620	.167
recorded * attendance	lectime	.333	2	.166	.129	.879
	gpa	2544.462	2	1272.231	.490	.613
location * recorded * attendance	lectime	8.427	4	2.107	1.637	.163
	gpa	23506.849	4	5876.712	2.264	.061
Error	lectime	1263.559	982	1.287		
	gpa	2549536.79	982	2596.270		
Total	lectime	5353.734	1000			
	gpa	10907668.3	1000			
Corrected Total	lectime	1293.735	999			
	gpa	2613610.15	999			

a. R Squared = .023 (Adjusted R Squared = .006)

b. R Squared = .025 (Adjusted R Squared = .008)

Figure 4:

Post Hoc Tests

location

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) location	(J) location	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
lectime	hybr	in-p	-.0455	.08776	.863	-.2515	.1605
		zoom	.0038	.08978	.999	-.2069	.2145
	in-p	hybr	.0455	.08776	.863	-.1605	.2515
		zoom	.0493	.08653	.836	-.1538	.2524
	zoom	hybr	-.0038	.08978	.999	-.2145	.2069
		in-p	-.0493	.08653	.836	-.2524	.1538
gpa	hybr	in-p	1.7665	3.94208	.895	-7.4866	11.0196
		zoom	5.7740	4.03281	.325	-3.6921	15.2400
	in-p	hybr	-1.7665	3.94208	.895	-11.0196	7.4866
		zoom	4.0075	3.88682	.557	-5.1159	13.1308
	zoom	hybr	-5.7740	4.03281	.325	-15.2400	3.6921
		in-p	-4.0075	3.88682	.557	-13.1308	5.1159

Based on observed means.
The error term is Mean Square(Error) = 2596.270.

Figure 5:

attendance

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) attendance	(J) attendance	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
lectime	.00	5.00	.0316	.08767	.931	-.1741	.2374
		10.00	.1703	.08753	.127	-.0352	.3757
	5.00	.00	-.0316	.08767	.931	-.2374	.1741
		10.00	.1386	.08844	.260	-.0690	.3462
	10.00	.00	-.1703	.08753	.127	-.3757	.0352
		5.00	-.1386	.08844	.260	-.3462	.0690
gpa	.00	5.00	-5.1705	3.93788	.388	-14.4137	4.0728
		10.00	.0286	3.93178	1.000	-9.2003	9.2575
	5.00	.00	5.1705	3.93788	.388	-4.0728	14.4137
		10.00	5.1991	3.97277	.391	-4.1261	14.5243
	10.00	.00	-.0286	3.93178	1.000	-9.2575	9.2003
		5.00	-5.1991	3.97277	.391	-14.5243	4.1261

Based on observed means.
The error term is Mean Square(Error) = 2596.270.