

# WESLEYAN

UNIVERSITY

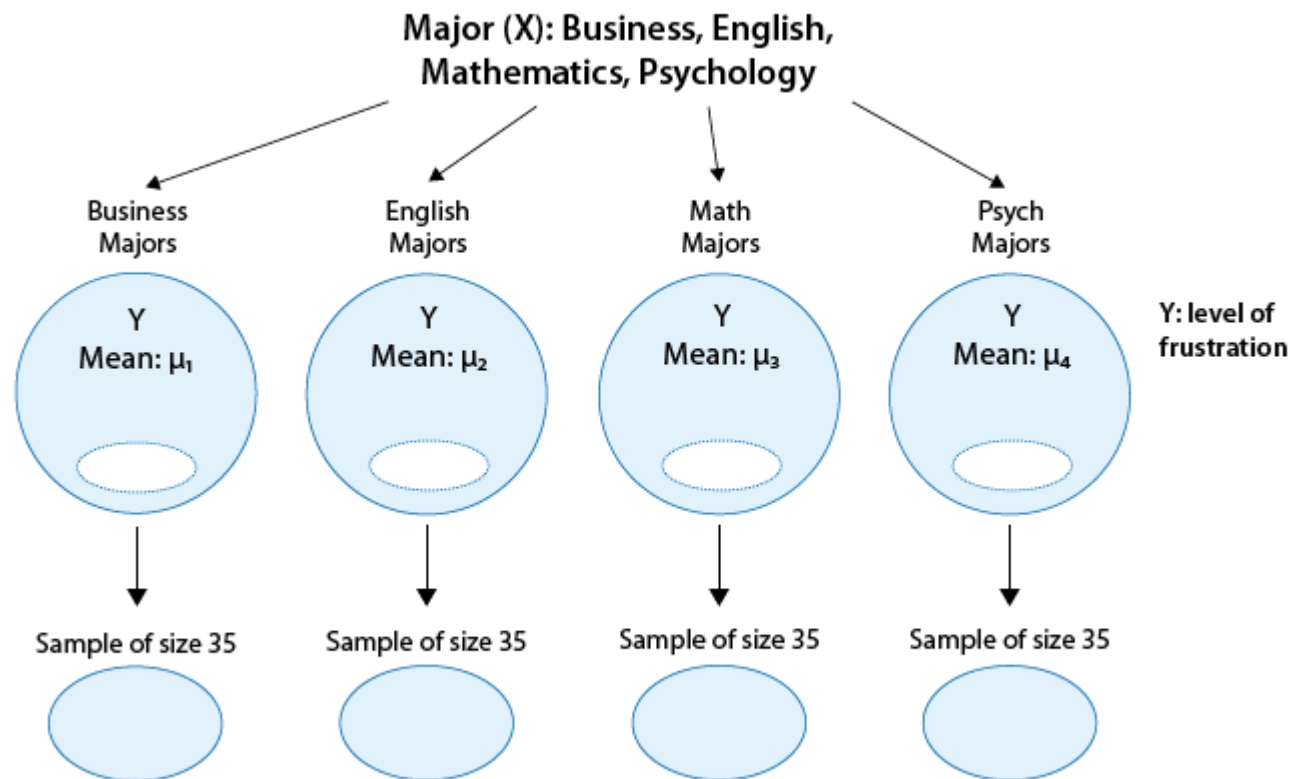
A word cloud featuring the words "ANALYSIS" and "VARIANCE" in various sizes and orientations, set against a blue background with wavy lines. The words are arranged in a dense, overlapping pattern, with "ANALYSIS" and "VARIANCE" being the most prominent. The colors of the words range from dark blue to light blue, and the font is a clean, sans-serif typeface. The overall effect is a dynamic and visually engaging representation of the two words.

Analysis of Variance

		Response	
		Categorical	Quantitative
Explanatory	Categorical	$C \rightarrow C$	$C \rightarrow Q$
	Quantitative	$Q \rightarrow C$	$Q \rightarrow Q$



# Is “academic frustration” related to major?



## Step 1 and 2: Stating hypotheses and identifying the sample

$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$$

*H<sub>a</sub> : not all the  $\mu$ 's are equal*

It turns out that:

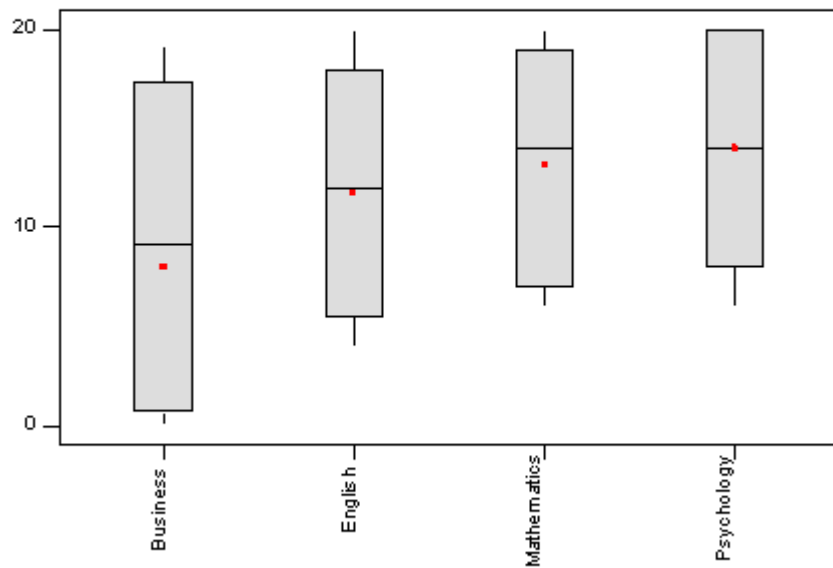
- \* The sample mean frustration score of the 35 business majors is:  $\bar{y}_1 = 7.3$
- \* The sample mean frustration score of the 35 English majors is:  $\bar{y}_2 = 11.8$
- \* The sample mean frustration score of the 35 math majors is:  $\bar{y}_3 = 13.2$
- \* The sample mean frustration score of the 35 psychology majors is:  $\bar{y}_4 = 14.0$



# Same mean differences, difference variability

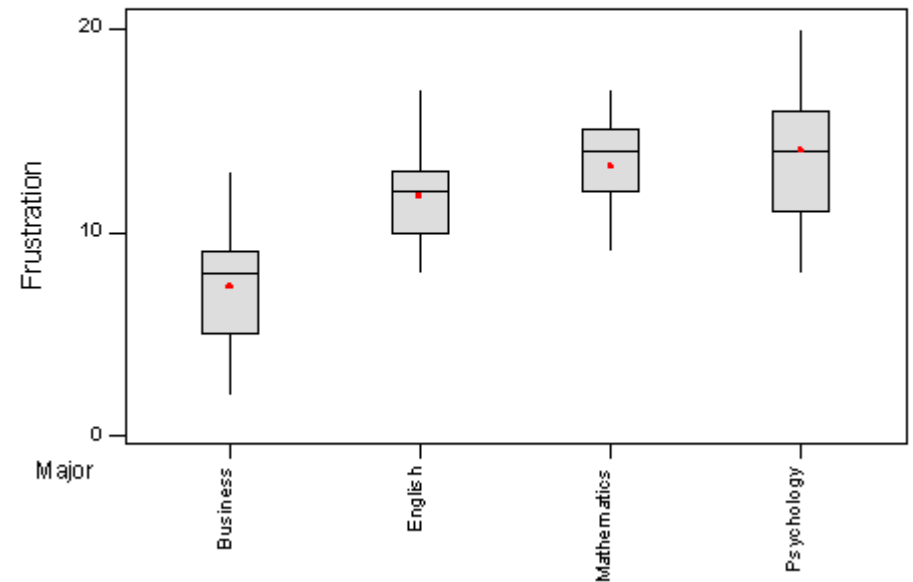
Boxplots of Frustration by Major

Scenario #1



Boxplots of Frustration by Major

Scenario #2



$$F = \frac{\text{VARIATION AMONG SAMPLE MEANS}}{\text{VARIATION WITHIN GROUPS}}$$



## Step 3 and 4: Assessing the evidence and drawing conclusions

### One-way ANOVA: Frustration Score versus Major

Source	DF	SS	MS	F	P
Major	3	939.85	313.28	46.60	0.0001
Error	136	914.29	6.72		
Total	139	1854.14			

S = 2.593    R-Sq = 50.69%    R-Sq(adj) = 49.60%

Level	N	Mean	StDev
Business	35	7.314	2.898
English	35	11.771	2.088
Mathematics	35	13.200	2.153
Psychology	35	14.029	3.082

$H_a$ : not all the  $\mu$ 's are equal



Categorical  
(1=Present/0=Absent)



Quantitative  
(Range 1-2940)



$$H_0 : \mu_1 = \mu_2 = \mu_3 = \mu_4$$

$H_a$  : *not all the  $\mu$ 's are equal*



The image features a solid blue background with several thin, light blue, wavy horizontal lines that create a sense of movement. In the lower-left corner, the Wesleyan University logo is displayed in white. The word "WESLEYAN" is in a large, serif, all-caps font, and the word "UNIVERSITY" is in a smaller, sans-serif, all-caps font directly beneath it. A dark blue horizontal bar runs along the bottom edge of the image.

WESLEYAN  
UNIVERSITY

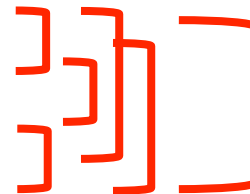
A word cloud visualization of the terms 'POSTHOC', 'Tests', 'S', 'PastHac', and 'T'. The words are arranged in a dense, overlapping pattern, with 'POSTHOC' and 'Tests' being the most prominent. The colors are primarily blue and teal, with some white and light blue accents. The font sizes vary, with 'POSTHOC' and 'Tests' being the largest. The overall shape is roughly rectangular, with the words filling the space.

## When do I need a post hoc test?

$H_a$ :  $\mu_1, \mu_2, \mu_3, \mu_4$  not all equal

1.  $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$
2.  $\mu_1 = \mu_2 = \mu_3 \neq \mu_4$
3.  $\mu_1 = \mu_2 \neq \mu_3 = \mu_4$

Level	N	Mean	StDev
Business	35	7.314	2.898
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## Why not test multiple ANOVAs examining each pair?

Remember that we accept 'significance' and reject the null hypothesis at  $P \leq 0.05$  (i.e. a 5% chance that we are wrong)

Performing multiple tests therefore means that our overall chance of committing a type I error is  $> 5\%$ .

# Tests	Comparison $\alpha$	Familywise $\alpha$
1	.05	.05
3	.05	.14
6	.05	.26
10	.05	.40
15	.05	.54

Which post hoc test do I use within ANOVA?



## Critical Difference

LSD

Low

Tukey

Moderate

Scheffe

High

# Bonferroni Adjustment

Bonferroni adjustment) is to divide  $0.05/c$  (number of comparisons)

3 comparisons is  $0.05/3$ , so that  $\alpha$  for each test = 0.017.

# WESLEYAN

UNIVERSITY

A word cloud shaped like a graduation cap, featuring the words "SIX" and "ASSIGNMENT" in various sizes and orientations. The words are arranged to form the silhouette of a mortarboard, with "SIX" and "ASSIGNMENT" being the primary terms. The colors are primarily dark blue and teal. The word cloud is positioned at the bottom of the slide, below the Wesleyan University logo.