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MARCH 29 – APRIL 1
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USERS PROGRAM

Examining the Impact of Discussion Activities on Student Understanding in Introductory Statistics

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Rachael N. Becker
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This study aims to examine the impact that voluntary participation in online discussion activities has on students' understanding of statistical concepts in an undergraduate statistics course. A study of 90 undergraduate students enrolled in an introductory statistics course was conducted. The Levels of Conceptual Understanding in Statistics (LOCUS) assessment was utilized to measure students' conceptual understanding in statistics. Form 1 of the 23 question Intermediate/Advanced online version of LOCUS was administered as a pre-test at the start of the 16-week course. Form 2 of the 23 question Intermediate/Advanced online version of LOCUS was utilized as the post-test after completion of the course. A statistical analysis of the difference between pre- and post-test data was completed in SAS® using propensity score matching techniques.

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Intro

Motivation:

- Engage students in a large lecture class
- Create an environment where questions are encouraged

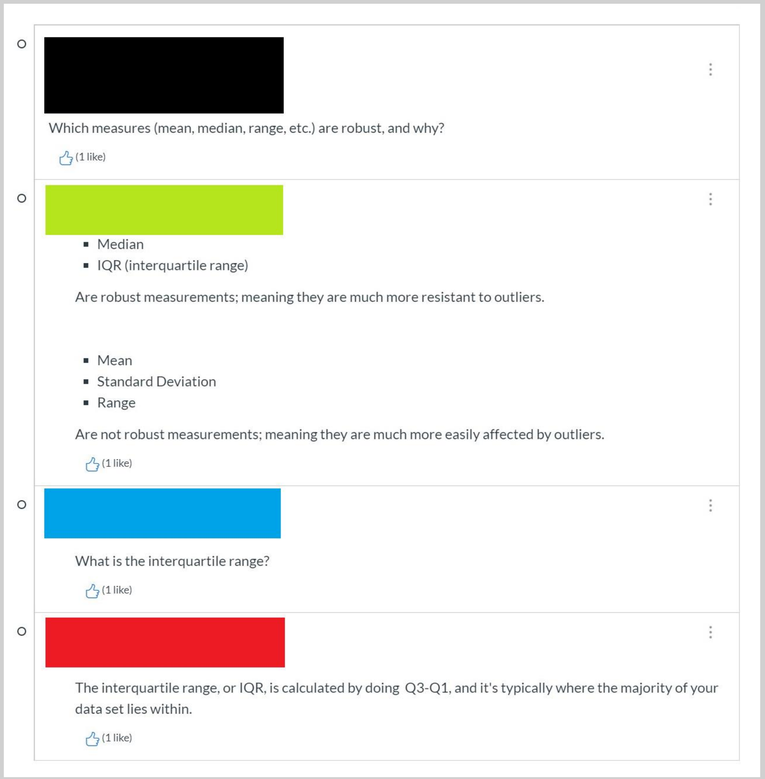
Literature:

- Focus on discussion boards in online statistics courses
- Encouraging statistical writing and thinking through journals and discussions
- Scaffolded discussions

Research Question

Does voluntary participation in discussion board activities increase learning gains for students in an introductory statistics course?

Example Discussion



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Data Collection

- $n = 90$ undergraduate students in introductory stats
- Online LOCUS Assessments
- Class Activities
- Survey Results

Continuous Variables

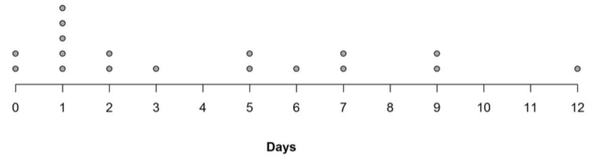
- **Pretest score** on LOCUS Assessment
- **Posttest score** on LOCUS Assessment
- Grades for **Exam 1 to Exam 4**
- Grades for **Homework 1 to Homework 10** (dropped from model
- Grades for **Lab 1 to Lab 14** (dropped from model)
- Grades for **Quiz 1 to Quiz 10** (dropped from

Categorical Variables

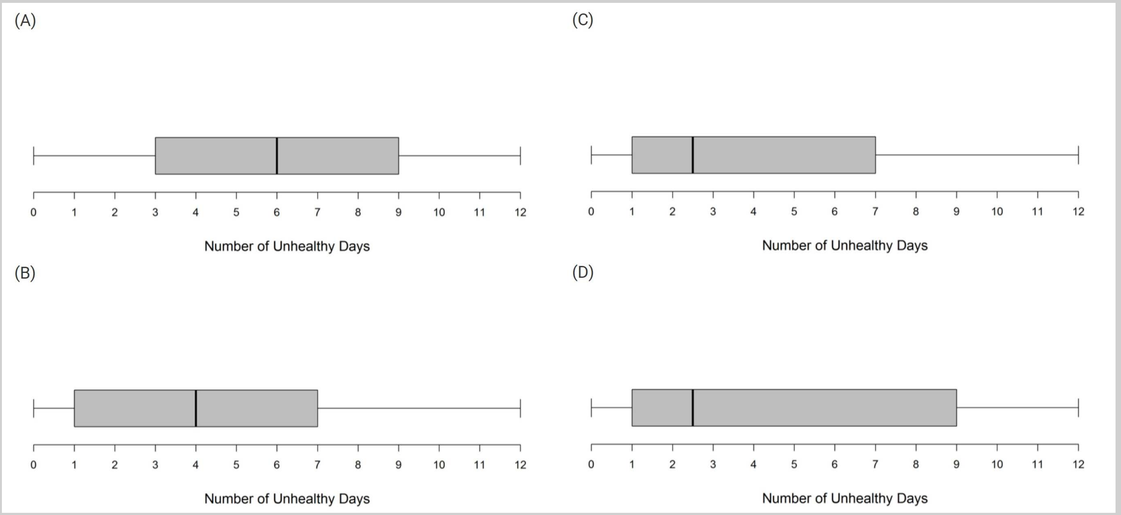
- **Academic Program** (6 categories as defined by school)
- **Gender** (2 categories provided as free response to a survey)
- **Double Major** (3 categories: No, Yes, and Did not answer)
- **Academic Level** (4 categories: Freshman, Sophomore, Junior, and Senior)

Question:

Researchers were interested in looking at air quality in different regions of the United States. The following dotplot represents the number of days in a certain month that the air quality was unhealthy for eighteen cities in the Midwest.



Which of the following is the boxplot for these data?



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Using Propensity Scores to Match

- Creating a comparable "control" group
- Utilizes logistic regression
- Matched based on probability of being in the discussion group

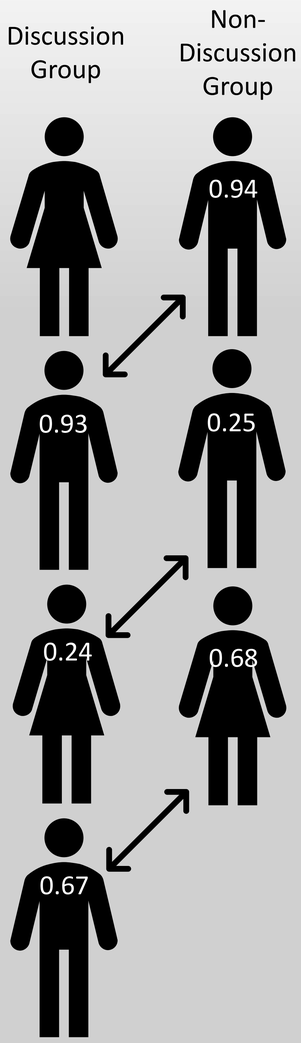
Logistic Model

$$\widehat{logit} = 6.1 - 0.05(PreLOCUS) + 0.03(Exam1) + 0.03(Exam2) + 0.02(Exam3) - 0.07(Exam4) - 3.7(PreMajors) - 17.4(Education) + 7.9(Arts) - 3.5(Business) + 7.9(Engineering) - 0.7(Gender) - 0.6(SingleMajor) - 0.1(DoubleMajor) + 1.0(Freshman) - 0.1(Sophomore) - 0.8(Junior)$$

Source of Macro Code and Calling Macro

Used the macro found in Fraeman's (2015) A General SAS® Macro to Implement Optimal N:1 Propensity Score Matching Within a Maximum Radius

```
%psmatch_multi(pat_dsn = prop_score_discussion,
pat_idvar = ID,
pat_psvar = PropensityScore,
cntl_dsn = prop_score_no_discussion,
cntl_idvar = ID,
cntl_psvar = PropensityScore,
match_dsn = matched_pairs1,
match_ratio= 1,
score_diff = 0.10
);
```



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Examining the Equivalency Between the Groups

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Before Matching

- **Categorical Variables**
  - Percentages are unequal
    - Females, Pre-Majors, Students with a single major, and Sophomores are over represented
- **Continuous variables**
  - Means between the two groups appear roughly equivalent

Table 1
Frequencies and Means for Variables Before Matching

	Discussion Group		Non-Discussion Group	
Variables	Frequency	Percent	Frequency	Percent
Gender				
Female	21	72.41	29	54.72
Male	8	27.59	24	45.28
Academic Program				
Pre-Majors	27	93.10	44	83.02
Education	1	3.45	0	0
Arts	0	0	1	1.89
Business	1	3.45	1	1.89
Engineering	0	0	1	1.89
Sciences and Humanities	0	0	6	11.32
Double Major				
No	21	72.41	31	58.49
Yes	5	17.24	12	22.64
Did Not Answer	3	10.34	10	18.87
Academic Level				
Freshman	16	55.17	34	64.15
Sophomore	10	34.48	13	24.53
Junior	3	10.34	5	9.43
Senior	0	0	1	1.89
	Mean (SD)	Median	Mean (SD)	Median
LOCUS Pretest	55.10 (13.30)	57	54.47 (15.67)	52
Exam 1	80.86 (14.58)	85	82.55 (11.95)	85
Exam 2	82.34 (9.83)	84	82.34 (10.85)	80
Exam 3	77.38 (16.73)	80	77.36 (14.93)	80
Exam 4	87.86 (10.21)	90	86.06 (9.84)	87

After Matching

- **Categorical Variables**
  - Percentages are roughly equal
  - A lot of categories and a small matched sample
- **Continuous variables**
  - Means between the two groups appear roughly equivalent, smaller sample size might be an issue

Table 2
Frequencies and Means for Variables After Matching

	Discussion Group		Non-Discussion Group	
Variables	Frequency	Percent	Frequency	Percent
Gender				
Female	14	70	12	60
Male	6	30	8	40
Academic Program				
Pre-Majors	19	95	18	90
Education	0	0	0	0
Arts	0	0	1	5
Business	1	5	1	5
Engineering	0	0	0	0
Sciences and Humanities	0	0	0	0
Double Major				
No	13	65	13	65
Yes	4	20	5	25
Did Not Answer	3	15	2	10
Academic Level				
Freshman	14	70	12	60
Sophomore	5	25	5	25
Junior	1	5	3	15
Senior	0	0	0	0
	Mean (SD)	Median	Mean (SD)	Median
LOCUS Pretest	54.65 (14.41)	57	54.10 (14.99)	50
Exam 1	80.50 (13.95)	85	78.50 (13.09)	80
Exam 2	83.00 (9.96)	84	81.80 (10.97)	80
Exam 3	78.20 (16.68)	80	79.80 (13.22)	80
Exam 4	87.00 (10.44)	86.5	87.65 (8.41)	87

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```
PROC TTEST DATA = WORK.FINAL;
        CLASS Dis2more;
        VAR diffLOCUS;
RUN;
```

The TTEST Procedure

Variable: DiffLOCUS

Dis2more	N	Mean	Std Dev	Std Err	Minimum	Maximum
0	20	2.4500	10.5405	2.3569	-26.0000	17.0000
1	20	7.3000	9.6415	2.1559	-9.0000	26.0000
Diff (1-2)		-4.8500	10.1010	3.1942		

Dis2more	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
0		2.4500	-2.4831	7.3831	10.5405	8.0160	15.3952
1		7.3000	2.7877	11.8123	9.6415	7.3322	14.0821
Diff (1-2)	Pooled	-4.8500	-11.3164	1.6164	10.1010	8.2550	13.0180
Diff (1-2)	Satterthwaite	-4.8500	-11.3180	1.6180			

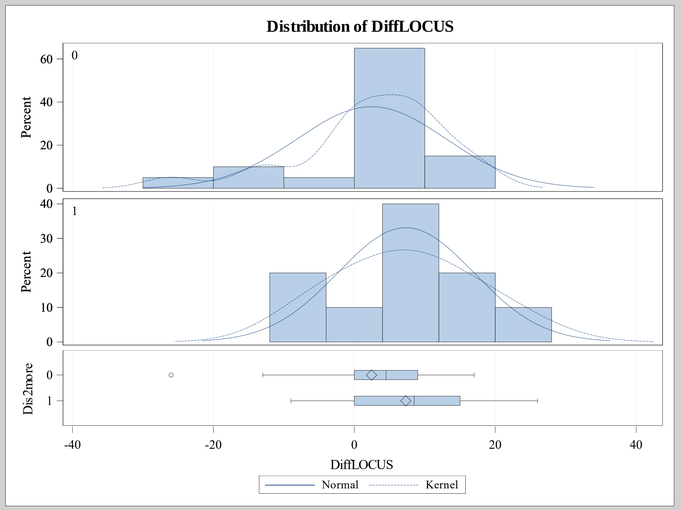
Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	38	-1.52	0.1372
Satterthwaite	Unequal	37.702	-1.52	0.1373

Equality of Variances				
Method	Num DF	Den DF	F Value	Pr > F
Folded F	19	19	1.20	0.7015

PROC TTEST

- Hypotheses:
  $H_0: \mu_{control} - \mu_{discussion} = 0$
  $H_1: \mu_{control} - \mu_{discussion} \neq 0$
- Equality of Variances:
  - Fail to reject null that they are unequal
  - Use Pooled method
- T-value (p-value):
  $t = -1.52\ (0.1372)$
- Conclusion: Fail to reject the null, not a significant difference between groups.

Issues



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Limitations

- Small study
- Lack of demographic information
- Hard to define participation threshold

Conclusions

- Voluntary participation in online discussion activities did not significantly increase student learning gains

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The LOCUS assessments can be found at https://locus.statisticseducation.org/

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