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The Impact of In-Class Worksheets on Student Learning

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MOTIVATION

Student engagement and knowledge retention are common challenges in college classes, especially in STEM fields. To improve these items, I strive to use active learning techniques to

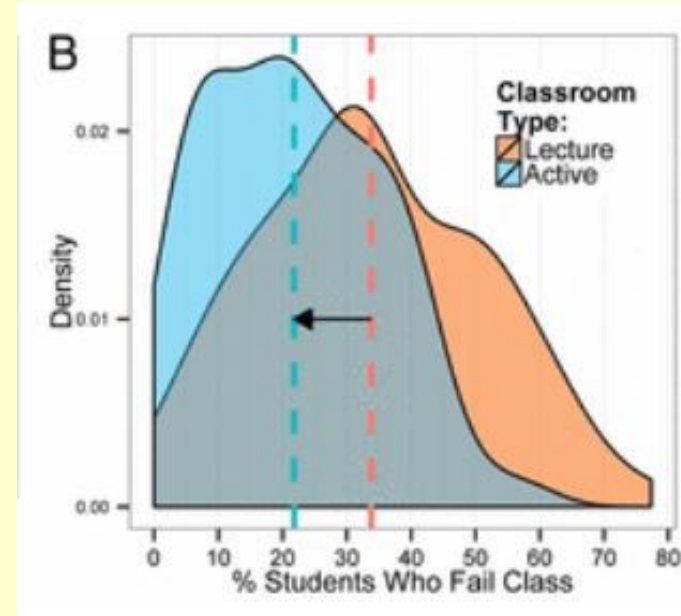
- encourage students to succeed and help them reach their full potential by engaging them with the material presented.
- increase student's interest in the subject matter
- create an interactive classroom environment with a sense of community where the students participate in activities that require them to think about and comment on the material presented.
- facilitate independent, critical and creative thinking
- increase student success rates

OBJECTIVE

The purpose of this project is to determine whether the implementation of active learning techniques, such as effectively designed in-class worksheets, will result in an improvement in student performance.

LITERATURE REVIEW

- Students learn more when they participate in the process of learning, whether it's through discussion, practice, review, or application ([Grunert, 1997](#)).
- When active learning is included in university lectures, it results in a decrease in the failure rates, from 33% to 22%.

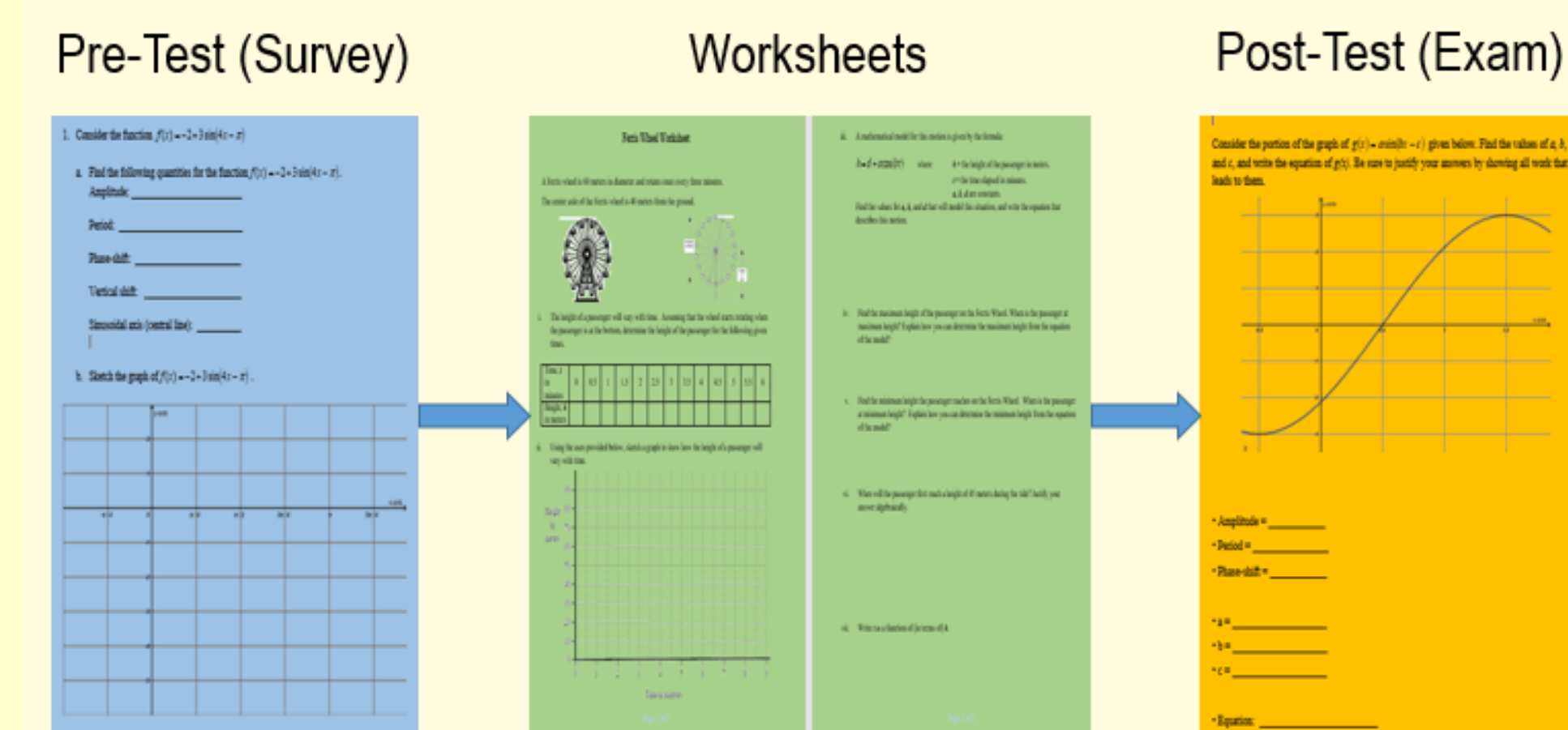


The types of active learning used in this study included "occasional group problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs". ([Freeman et al., 2014](#))

- According to several studies the use of well-designed worksheets have a positive impact on the students' learning. To ensure their effectiveness, the design of the worksheets is critical ([Sasmaz-Oren & Ormanci, 2012](#)).
- Despite the additional time required to create them, and the difficulty in estimating how much time the students would require to complete them in class, worksheets are an effective tool to engage students during class. These costs could be mitigated over time and outweighed by the benefits for both instructor and student ([Wyels, 2019](#)).

METHODS

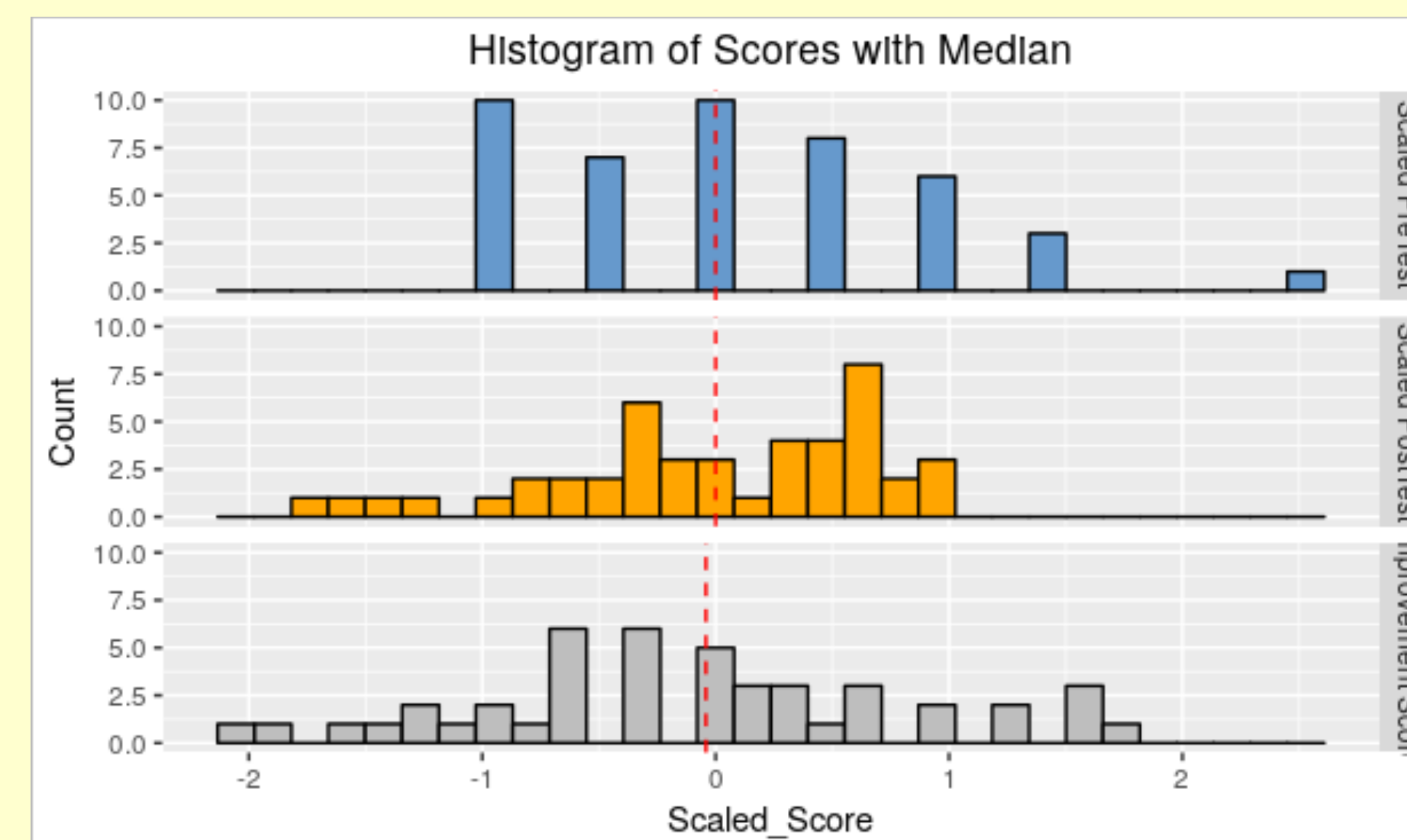
The study was conducted during the Spring 2019 semester on two sections of Precalculus (a total of 72 students) by assigning a pre- and post-lesson concept assessments in trigonometry in the form of a survey and exam respectively. The intervention consisted of in-class worksheets based on the student learning outcomes for the concepts addressed in the pre-test. Two of the worksheets administered were collected and graded.



To determine the effect of the worksheets, an improvement metric was created.

$$\text{Improvement} = (\text{Post-Test}) - (\text{Pre-Test})$$

Because of the difference in scales, both Pre-Test and Post-Tests were separately center- and range-scaled. As shown in the faceted histogram below, both metrics were non-normal, and thus non-parametric statistics were used: median (dashed red line) and IQR.



ANALYSIS

Two statistical analyses were conducted.

Firstly, the following were compared:

- completion of worksheet 1 (fixed categorical)
- completion of worksheet 2 (fixed categorical)

Secondly, the following were compared:

- worksheet 1 score
- worksheet 2 score
- section (fixed categorical)

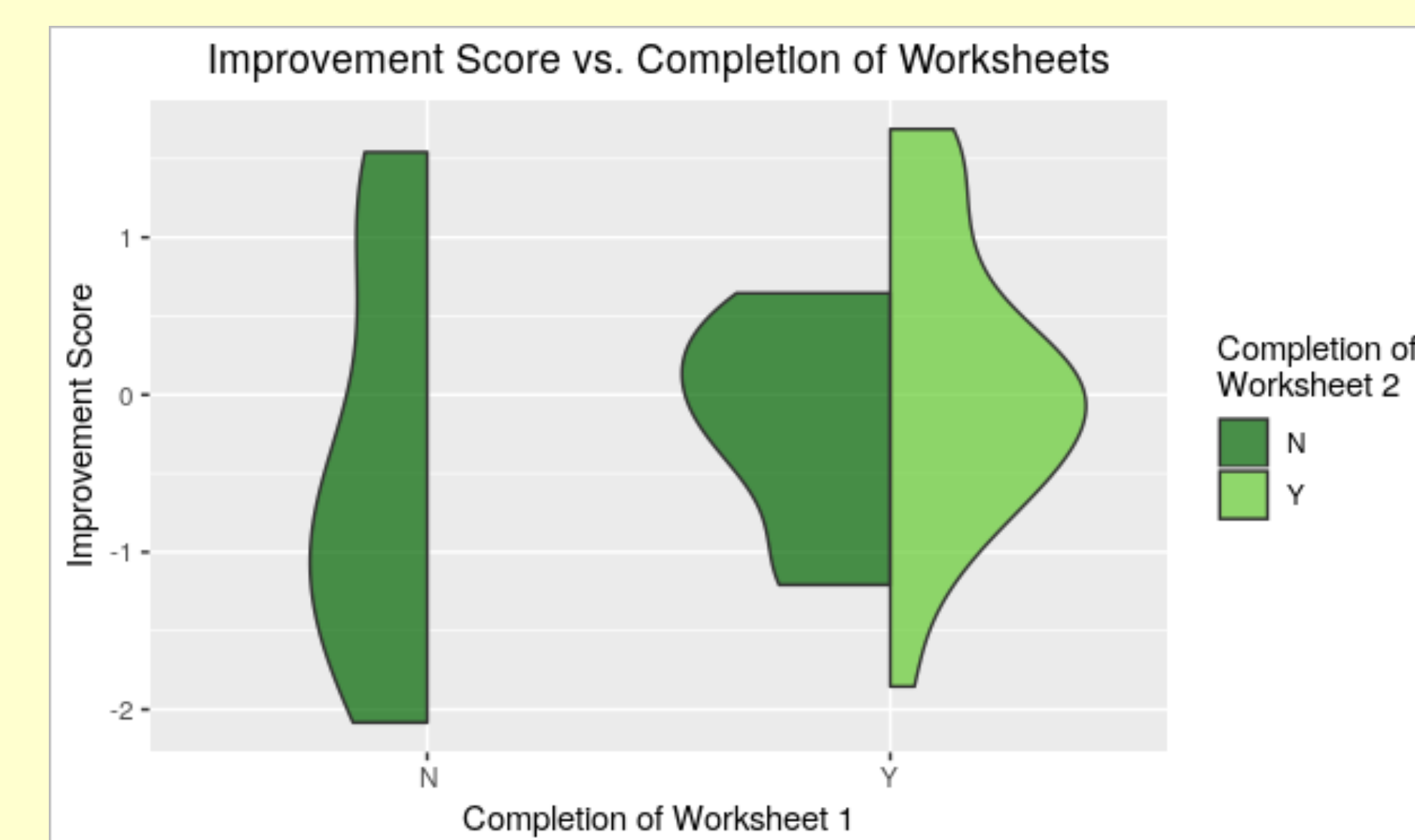
Each analysis was conducted with two methods:

- the GLM was constructed with only first order terms
- The terms in the GLM were chosen using stepwise model selection by AIC with the initial model, including first order terms and first order interaction terms.

ANOVA was used to judge significance of terms. The analysis was unbalanced due to the difference in size of the two class sections, and the fact that not all students completed some of the worksheets or the Pre-Test.

RESULTS

A violin plot of the improvement score was created to visualize the distributions' shapes.



The subset of students who did not complete worksheet 1 and did complete worksheet 2 (Completion of Worksheet 1 = N and Completion of Worksheet 2 = Y) is not depicted because of its small size.

Worksheet Completion

Based on the analysis of fixed terms using ANOVA on the completions of the worksheets and sections as first order terms, the completion of the worksheets was not found to be significant ($\alpha=0.05$).

Worksheet Scores

From the analysis of the worksheet scores as predictors of improvement, a stepwise construction of the GLM yielded the following model:

$$\text{Improvement} \sim \text{Worksheet 1} + \text{Worksheet 2} + \text{Section} + \text{Worksheet 2} * \text{Section}$$

With the ANOVA table for the final model:

	Estimate	SE	t-value	p
(Intercept)	0.32962	1.62362	0.203	0.84108
Worksheet 1	0.37857	0.09941	3.808	0.00103
Worksheet 2	-0.36442	0.17347	-2.101	0.04791
Section	-5.80910	2.04966	-2.834	0.00994
Worksheet 2: Section	0.60520	0.23045	2.626	0.01578

Although the model demonstrates significance in all terms selected, because of the small subset sizes and the difference in significance between the terms, and per the principle of parsimony/"Ocham's razor", it was decided to proceed with the single order model with the following ANOVA table:

	Estimate	SE	t-value	p
(Intercept)	-2.45319	1.38525	-1.771	0.09043
Worksheet 1	0.35622	0.11154	3.194	0.00419
Worksheet 2	-0.02252	0.12910	-0.174	0.86308
Section	-0.47217	0.30071	-1.570	0.13064

The linear model,

$$\text{Improvement} \sim \text{Worksheet 1}$$

is shown below with the Worksheet 1 as the predictor.



CONCLUSIONS

- The completion of the worksheets did not have a significant impact on student learning.
- Of the students that did complete the worksheets, the worksheets score was a significant predictor of improvement.

FUTURE WORK

Future studies should investigate why the completion of worksheet was not a significant factor. Its likely cause is that motivation to complete the worksheets was not comparable to the typical graded component of the class, i.e. it did not have the same graded weight as the Post-Test (exam). This may have led to smaller sample sizes and lower accuracy of the worksheet scores.

AKNOWLEDGEMENTS

All analyses were conducted in R (R Development Core Team, 2010), with libraries MASS (Venables, W. N. & Ripley, B. D., 2002), ggplot2 (Wickham, H., 2016), and plyr (Wickham, H., 2011).

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