

An Analysis of the Flipped Classroom Approach for “Math-phobic” Students

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ABSTRACT

This paper examines the impact of video examples utilized in a flipped class style to facilitate active learning and improve the learning outcomes of self-professed math-phobic students in an introductory econometrics course. The course in question is entitled “Applied Regression” and was taught at a small liberal arts college between 2013 and 2016. The results indicate both positive student perceptions and performance on problem sets and exams. This paper extends the literature on flipped classes by documenting its benefit for self-professed math-phobic students and its applicability to an advanced applied statistics course.

INTRODUCTION

This paper examines the impact of video examples utilized in a flipped class style to facilitate active learning and improve the learning outcomes of self-professed math-phobic students in an introductory econometrics course. The flipped class approach was implemented to engage and motivate students who were hesitant and in some cases fearful of the course material but who were required to complete the course to obtain their degrees. This paper extends the literature on flipped classes by documenting its benefit for self-professed math-phobic students and its applicability to an advanced applied statistics course.

LITERATURE REVIEW

The Flipped Class Methodology

Active learning is defined as “anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes,” (Felder & Brent, 2009). The flipped classroom trend has gained traction in academia in recent years as a way to incorporate active learning because, as Norman and Wills (2015) explained, the flipped class structure allows instructors to easily integrate active learning strategies without the need to sacrifice course material due to time constraints. Specifically, Bishop and Verleger (2013) define the flipped classroom as, “an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom.” In order to investigate the pedagogical benefits of a flipped class, Brame (2013) examined flipped classes with respect to Bloom’s taxonomy. He explained the benefits as follows: “If the students gained basic knowledge outside of class, then they need to spend class time to promote deeper learning. The key is that students are using class time to deepen their understanding and increase their skills at using their new knowledge.” This is particularly true in math based courses such this course. For example, Yamarik (2007) compared two economics courses, one taught in traditional lecture format and one with cooperative learning, and found that student’s performance on exams was higher in the latter. Similarly, both Love, Hodge, Grandgenett & Swift (2014) and Kinnari-Korpels (2015) found improved student outcomes in flipped linear algebra and

calculus courses respectively. Furthermore, Touchton (2015) found that student performance in his statistics for political science course increased particularly in “difficult, applied areas emphasized in class.” Student perceptions of the flipped class approach have been more mixed. In a 2013 editorial for Insider HigherEd, Carl Straumsheim provided a link to students’ social media posts regarding flipped classes which was less than flattering. On the other hand, both Love et al. (2014) and Norman and Wills (2015) reported positive student reactions.

Math-Phobia

Math-phobia is a heightened form of math anxiety which is defined as a feeling of fear, tension, panic and/or helplessness associated with the manipulation of numbers and mathematical problem solving in both academic situations as well as everyday life. (Bisse, 1994; Fiore, 1999; Richard & Suinn, 1972). Perez-Tyteca et al (2009) found that six out of every ten college students in Spain experienced math anxiety. Even more astonishingly, Burns (1998) contends that two thirds of U.S. adults “fear and loath” math.

The National Council of Teachers of Mathematics recommends that instruction should allow different learning styles and emphasize thinking rather than rote memorization of formulas (NCTM, 2000). A flipped class with video examples enables these by allowing for more class time to be spent working through varied examples to establish the necessary problem-solving skills using the relevant technology. Moreover, Furner and Duffy (2002) advocate the use of interactive computer based work to “take away the pressure and anxiety associated with worksheets and traditional practice.”

MY CLASS AND ITS REDESIGN

I taught the applied regression course at a small liberal arts college in the Midwestern part of the United States between 2013 and 2016. The course was an upper level business course for students majoring in finance, economics and marketing. In 2013 and 2014 it was a requirement but in 2015 it transitioned to an elective course. The course underwent several name changes over the years. Prior to my arrival it was known as: applied econometrics and research methods; during my tenure it was called applied research methods and finally, applied regression. The consensus of business faculty was that students feared the mathematical content of the course. It is my understanding that the name changes were intended to help resolve this issue. Casual conversations with students at the start of the class confirmed their anxiety regarding the mathematical content of the course. Despite the fact that basic statistics was a prerequisite for this class, many students reported that they were “not math people” and consequently worried about their performance in the class. My classification of the students as “self-professed math phobic” stems from these conversations; however, no formal assessment of math-phobia was administered.

The course covered simple and multiple linear regression as well as various model transformations and logistic regression using Excel, SPSS and Minitab. I used chapters two through ten of Deilman’s “Applied Regression Analysis: A Second Course in Business and Economic Statistics” (Deilman, 2004). The course was sixteen weeks during which three non-comprehensive exams covering roughly three chapters each were administered. Students were also required to complete six problem sets (roughly two per exam) to reinforce the concepts and practice with different data applications or computer programs.

I taught the course for the first time in Spring, 2013, which was the “pre-Flip” course. Class time was divided equally between PowerPoint based lectures and in class examples from the textbook. The end of semester course evaluations were “OK” (overall course evaluation score of 3.2 vs. the college mean of 3.4), but one of the common comments I noticed, especially from the stronger students, was that while they had learned the programs and the mathematical techniques they weren’t sure if they were ready to apply them in a broader context. I implemented the flipped structure to allow more in class examples. This way students could see these statistical techniques can be used in marketing and finance

as well as medicine and a host of other disciplines.

The flipped structure was introduced in Spring 2014. "Post-Flip" the PowerPoint lectures and examples were posted online and class time was devoted to additional examples. Usually we would do one example as a class (everyone following along on their individual computers) then the students would do an additional example or two individually or in groups, finally we would discuss the outcomes. These examples were drawn from the text, the Journal of Statistics Education's data archive and academic and professional papers from a variety of disciplines. Consistent with the active learning literature the focus of the discussions was on the problem-solving process rather than the final solution. For example: Why might we suspect heteroscedasticity based on the data? Based on the residuals? How do we test for it? Which test is best? How do we resolve it? Which method is best? Etc.

I recorded my PowerPoint lectures using Camtasia 7, the lectures averaged 30 minutes. I also recorded separate videos of the examples illustrated in the PowerPoint lectures in Excel, SPSS and Minitab so that students could follow along using their chosen program(s). These videos averaged 3 minutes. All of the videos were posted to YouTube on a specially created YouTube channel. Each chapter was posted on Canvas, the university's online learning management system as a separate page. Each page provided links to the lecture and example videos as well as the data for the examples covered in class and external links for follow up study. The students were required to watch the video lecture prior to the start of each new chapter and take an online quiz covering the concepts discussed in the lecture. Specific example videos were assigned as we progressed through the chapters. The purpose of this set up was to insure a strong theoretical grasp of the concepts before getting tied up in the tedium of the computer programs processes.

STUDENT RESPONSE AND OUTCOMES

The pre-flip group consisted of twenty students in the Spring, 2013 semester. The post-flip group consisted of students in the 2014, 2015 and 2016 Spring semesters (the course is only taught once per year). These classes consisted of twenty-five, twenty-three, and twenty-two students respectively. As mentioned previously, student performance was evaluated on the basis of three non-comprehensive exams covering roughly three chapters each and six problem sets, roughly two per exam. Post-flip students also took end of chapter quizzes to ensure they were watching the lectures; however, these grades will not be considered in the analysis since there were no comparable quizzes administered in the pre-flip course.

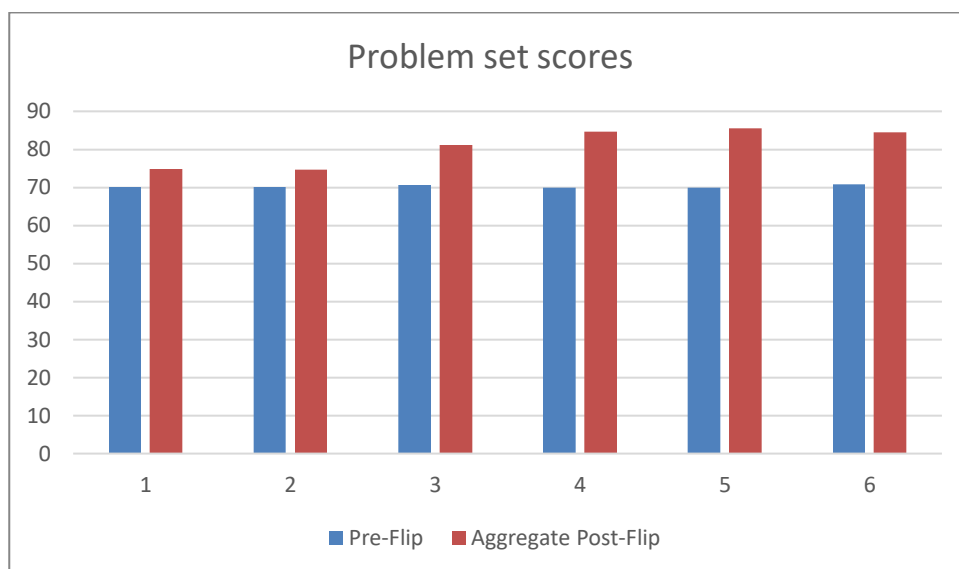
The most dramatic improvement was seen in the student's problem set scores which were on average 10% points higher ($p=.0003$) for the flipped class. For consistency, the same problem sets were used every semester (although some data observations were changed to prevent cheating). As one reviewer accurately noted, the problem set scores "pre-flip" all average approximately 70%, this is pure coincidence. The scores themselves ranged from 50-100 for each of the problem sets as documented by the large standard deviations. The dramatic decrease in the standard deviations of scores combined with the increase in average scores supports the usefulness of the flipped class approach. Table 1 and Graph 1 present the aggregate "post-flip" group; however, the results were similar when compared for each course.

Student performance in both the pre and post flip improved between the first and second exams, likely as the students settled into the course and the use of the various computer programs. On average all students' exam scores increased significantly on the second exam compared to the first, but the result was more dramatic for the post-flip groups (pre-flip $p=.01$, post flip $p= 6.11594E-22$). Performance on the final exam was also significantly positively affected by the flip as shown in Table 2 and Graph 2 below. These results support the hypothesis that the flip class structure benefited the students.

**TABLE 1
PROBLEM SET COMPARISONS**

Pre (N=20)						
	PS 1	PS2	PS3	PS4	PS5	PS6
mean	70.10	70.10	70.60	69.85	69.90	70.75
stdev	10.22	10.24	10.49	10.72	8.62	11.67
Aggregate Post (N=70)						
	PS 1	PS2	PS3	PS4	PS5	PS6
mean	74.84	74.66	81.09	84.57	85.47	84.53
stdev	1.75	1.50	1.46	1.02	0.98	1.02

**GRAPH 1
PRE-FLIP AND POST-FLIP PERCENTAGE PROBLEM SET SCORE COMPARISONS**

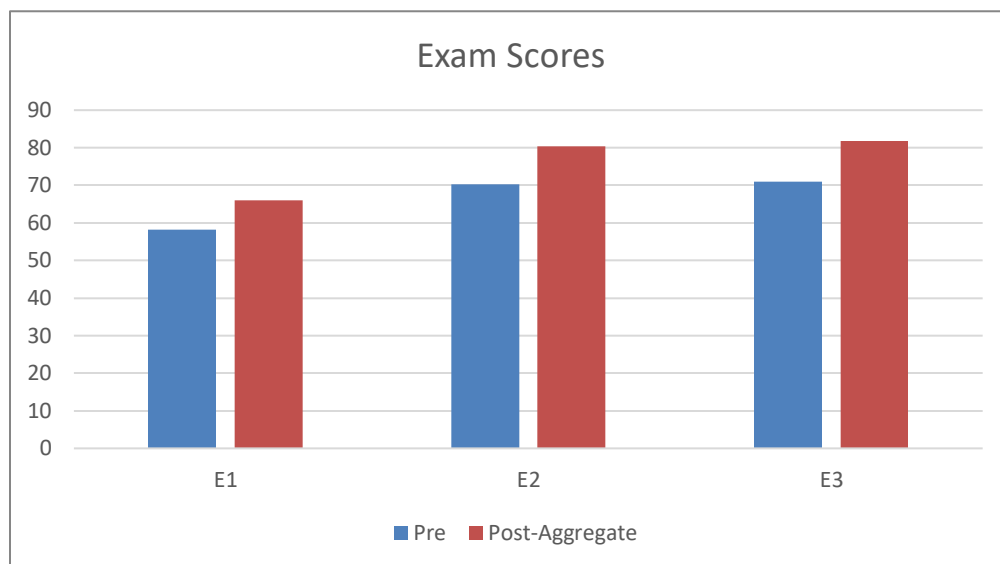


An anonymous survey distributed to students in each course after the first exam revealed that approximately 65% of students watched “most or all of the required videos.” Interestingly this percentage remained roughly constant during all 3 semesters of the flipped class set up. The end of course evaluation asked students to rank the helpfulness of the videos on a scale of 1 (not helpful) – 5 (very helpful). The overall average was 4.45 with 88% of the students selecting a 4 or 5. These results are consistent with Norman and Wills (2015) who found that 85% of their students preferred to “watch videos before class and then do practice problems in class.”

**TABLE 2
FINAL EXAM SCORE COMPARISONS**

	E1	E2	E3
Pre	58.15	70.25	71.05
Post-Aggregate	65.97	80.33	81.84
p-value	0.00	0.00	0.00

**GRAPH 2
PRE-FLIP AND POST-FLIP FINAL EXAM PERCENTAGE SCORE COMPARISONS**



Student Comments:

- “I am not a math or computer person but I had to take this class to graduate. I was very surprised at how well I actually understood everything, even though I hadn’t done so well in my stats class. I think the videos helped because we got to spend much more time working on examples in class.”
- “I am not that great at math so this class really scared me. I liked that we did so many examples in class because I could ask questions and the videos were like having (my professor) there to ask questions when I was studying or doing the problem sets”.
- “I really liked the class set up because I could work at my own pace. I usually feel like I can’t ask questions in class when everyone else seems to like get it but this way I could watch the videos as many times as I wanted.”
- “The videos really helped for the problem sets. I liked how I could pause them and then do the same steps because I SPSS kinda freaked me out at first.”

CONCLUSIONS, ISSUES AND CAUTIONS

While this experience does suggest that a flipped class approach did improve the overall performance of self-described math-phobic students, there are two main issues with this study. First the improvement in student performance may be driven more by stronger students self-selecting into the course after it was dropped as a requirement in 2014. Second, there was no formal math-phobia diagnostic administered. The classification of these students as math-phobic comes purely from tangential evidence based on my interactions with them. A follow up study utilizing a math anxiety metric such as the Abbreviated Mathematics Anxiety Scale (Hopko et. al., 2003) is warranted.

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