Analysis of Traditional and Flipped Teaching in Elementary Statistics

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Abstract
Flipped learning is defined by flippedlearning.org to be, "a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment..." The purpose of our study is to investigate the effectiveness of flipped teaching compared to traditional teaching in undergraduate introductory statistics courses. The data is from seven Elementary Statistics classes taught at the Slippery Rock University (SRU), where some classes were traditional and the others flipped. Results from a statistical analysis comparing the two teaching pedagogies are given in the paper.

Key Words: Flipped teaching, new teaching pedagogy, flipped vs traditional

1. Background

To improve the student learning outcomes, new and different pedagogies are used in teaching Science, Technology, Engineering, & Mathematics (STEM) courses. Flipped classrooms are one such approach. Kathleen Fulton (2012) proposed the following 10 justifications in support of flipped teaching: 1. Students move at their own pace, 2. Doing "homework" in class gives teachers better insight into student difficulties and learning styles, 3. Teachers can customize and update the curriculum, and provide it to students 24/7, 4. Students have access to multiple teachers' expertise, 5. Teachers flip professional development by watching each other's videos and learning from each other, 6. Classroom time can be used more effectively and creatively, 7. Parents have a window into the coursework, 8. Student achievement is increasing, so is interest and engagement in higher-level math, 9. Learning theory supports the new approaches, 10. The use of technology is flexible and appropriate for 21st-century learning.

2. Introduction

Elementary Statistics1, offered by the department of mathematics and statistics is the first statistics course most students at SRU register to fulfill their Mathematics/statistics requirement. On average about five sections of the Elementary Statistics1 is offered each semester and this is about 300 students. The students are from a range of different majors; exercise science, psychology, public health, environmental science, mathematics are some of the majors. About three years ago two professors including myself, decided to teach the course using the flipped teaching pedagogy. Prior to that, I taught the course in a traditional classroom setting. I was interested to find out if the flipped teaching

pedagogy in my Elementary Statistcs1 course was more effective than the traditional teaching. It was difficult to gage by just looking at the exams, homework and other assignments as the class sizes were different, and in certain semesters some of the sections of Elementary Statistis1 were clustered where most of the students were from a certain major. Due to these reasons a proper statistical analysis was needed to investigate the effectiveness of flipped teaching compared to traditional. The Elementary Statistics1 classes taught by me in a traditional setting had a class size of either 30 or 45. The flipped classes had class sizes of 30, 35, or 60. All the Elementary Statistics1 courses are one semester long, and three credit hours. The Elementary Statistics1 courses, traditional and flipped, considered in this study were taught by me.

2.1 Elementary Statistics1 – Traditional Teaching

The lecture is delivered face-to-face. The final course grade is a weighted average of the 3 exams, homework assignments, quizzes, and the Minitab projects (statistical analysis using the Minitab software).

2.2 Elementary Statistics1 – Flipped Teaching

I record my lectures on a Microsoft Surface Pro with Camtasia and upload the videos onto D2L (Desire2Learn) platform. Students watch the lesson video prior to the class. This is part of their homework. During the face-to-face class period a worksheet related to the lesson video will be given to the students. Students are encouraged to work in groups or they may work alone. There are one to three student assistants helping me during the class depending on the class size. The student assistants are mostly mathematics majors in their junior or senior year. The students will raise their hands if they have questions from the work sheet and either a student assistant or I will attend to these questions. Once the students have successfully completed the worksheet it is recorded for a completion grade. Apart from the daily worksheets completed during class there is an online homework assignment for each lesson video. Students are given two days to complete the online assignments. During the semester there will be several Minitab assignments and three exams. The exams are in-class paper exams. The final course grade is a weighted average of the daily worksheets, online homework, Minitab projects, and the three exams.

3. Method

IRB approval was acquired to use the data from seven Elementary Statistics1 courses starting from fall 2013 through spring 2015. Descriptive analysis was performed to understand the data. Sample size breakdown was looked at by semester, pedagogy, gender, and the year in school. Summary statistics were calculated for the final course grade by the pedagogy, gender, year in school, and by semester. Inferential analysis was conducted with hypothesis testing and multiple regression. Hypothesis testing was to investigate if the final course grades for the traditional and flipped teaching were from the same population and if the final course grades for Males and Females were from the same population. Finally, a multiple regression was run to see if the variation in final course grade can be explained using pedagogy after adjusting for gender, semester, and the year in school. The final course grade was examined before and after standardizing with in the course. Race was not included in the analysis as the diversity was minimal.

4. Results

There were total of 274 students in the sample. Breakdown of the sample size by pedagogy is given in Table 1, by semester is given is Table 2, by gender is given in Table 3, and by the year in school is given in Table 4.

Table 1: Students by Pedagogy

Pedagogy	n	%
Traditional	194	70.8%
Flipped	80	29.2%
Total	274	

Table 2: Students by Semester and Pedagogy

Semester	n	Pedagogy
Fall 2013 – section 1	30	Traditional
section 2	29	Traditional
Spring 2014 – section 1	28	Traditional
section 2	29	Traditional
Fall 2014 – section 1	48	Traditional
section 2	30	Traditional
Spring 2015 – section 1	28	Flipped
section 2	52	Flipped

Table 3: Students by Gender

Gender	n	%
Male	119	43%
Female	151	55%

Table 4: Students by Year in School

Year in School	n	%
Freshman	104	38%
Sophomore	107	39%
Junior	46	17%
Senior	10	4%
Post Bac	1	0.40%

Table 5 gives the summary statistics for the final course grade by pedagogy, and Table 6 is by gender, and Table 7 is by semester. The Graph1, Graph2, and Graph3 correspond to tables 5, 6, and 7 respectively. The distributions were looked at for the final course grade as well as the standardized final course grade and the corresponding results for tables 5, 6, 7 had similar distributions.

Table 5: Final course grades by pedagogy

	Flipped	Traditional
Mean	77.4	78.9
Median	81.1	82.1
SD	13.4	17.2
n	80	194

Graph 1: Final course grades by pedagogy

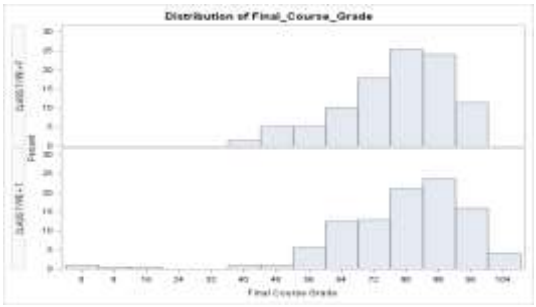


Table 6: Final course grades by gender

	Female	Male
Mean	82.1	75.8
SD	12.5	14.9
n	150	116

Graph 2: Final course grades by gender

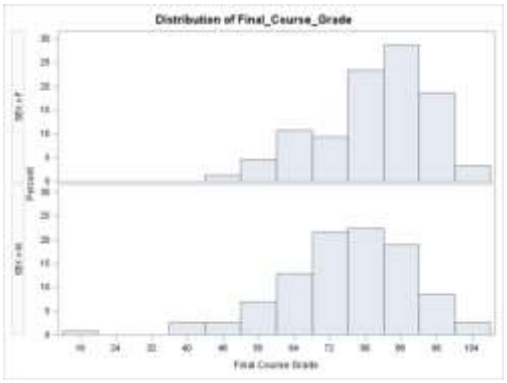
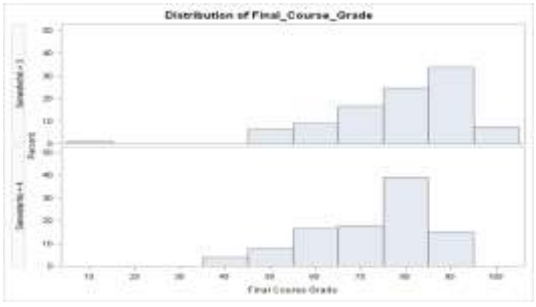
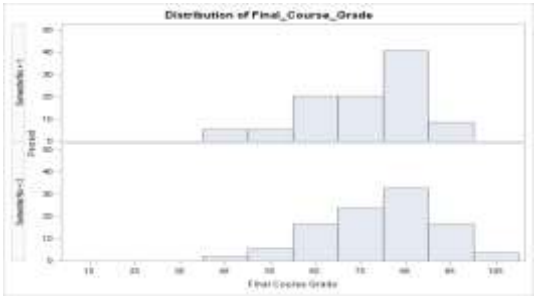


Table 7: Final course grades by semester

	Fall 2013	Spring 2014	Fall 2104	Spring 2015
Mean	76.2	79.2	83.7	77.4
SD	12	13.1	15.6	13.4
n	59	55	77	79

Graph 3: Final course grades by semester





The non-parametric hypothesis testing to investigate if the final course grades by pedagogy are from the same population gave a p value of 0.1330. The non-parametric

hypothesis testing to investigate if the final course grades by gender are from the same population gave a p value of 0.0002. The multiple regression with the final course grade as the response variable and the pedagogy, gender, semester, and the year in school as predictors gave an R^2 value of 0.1059 and the only statistically significant predictor was gender with a p value of <.0001.

5. Discussion

The table 1 shows that there are altogether 274 students in the study and 194 of them are from the traditional teaching method and only 80 from flipped teaching method. We need to keep in mind that the flipped sample size is much smaller compared to the traditional when we compare the two pedagogies. Table 3 shows that 55% of the students are female and 43% are male. Table 4 shows that majority of the students taking Elementary Statistics 1 at *SRU* are freshman and sophomores. Table 5 and Graph1, shows that the grade distributions for the two pedagogies are very similar with the average final course grade for flipped teaching is 77.4% and 78.9% for traditional, and the corresponding standard deviations are 13.4 and 17.2. The median grades are almost the same with a 1 point difference. The hypothesis testing to compare the mean final course grades from the two pedagogies gives a p value of 0.1330 indicating that we do not have enough evidence to say that the mean grades are from two separate populations.

Table 6 and Graph 2 give the final course grade distribution by gender and we see that female students have a higher average (82.1%) compared to male students (75.8%) with the corresponding standard deviations 12.5 and 14.9. Hypothesis testing to compare the mean final course grades by gender gives a p value of 0.0002 indicating that there is a statistically significant difference in the mean final course grades between the female and the male students. Table 7 and Graph 3 show that the final course grade distributions by semester are similar.

The results from the multiple regression with the final course grade as the response variable did not produce a statistically significant difference in the student performance (final course grade) for the two pedagogies after adjusting for the gender, semester, and the year in school.

For this sample of flipped and traditional data from the Elementary Statistics 1 course taught at *SRU* we did not find a difference in the student performance by pedagogy. Prior to making a conclusion regarding the results we observe in this study, there are few adjustments/improvements that can be done in the future. A larger sample size; preferably a larger group of flipped students thus the number of students in the two pedagogies are similar can give a better comparison of the two methods. In the future, data from other instructors who teach the same course will be included in the study as well as students SAT/ACT scores.

Another consideration is to use a different tool to measure the student learning. A tool that measures the "gain factor" might be a better tool than the final course grade to capture student learning. With the assistance of a student researcher I am attempting to develop a tool that will be administered to each Elementary Statistics1 class at the beginning and the end of the semester to calculate the gain factor for each student.

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