A COMPARISON BETWEEN A FLIPPED-LEARNING CALCULUS CLASS AND A SEMI-TRADITIONAL CLASS

Bill Blubaugh, Professor
School of Mathematical Sciences
University of Northern Colorado
501 20th Street Campus Box 122
Greeley, Colorado 80639
bill.blubaugh@unco.edu

Virtually my entire professional career I have been interested and involved in technology's use to improve mathematics instruction at the secondary and college levels. So my being interest in flipped learning when I first hear about it was no surprise. What motivation me to want to teach a flipped learning class and to compare it with my regular class, which I teach often, were the following. First, as I just mentioned, teaching with technology has always been a primary focus since my dissertation on comparing the effects of learning a computer programming language on mathematical problem solving skills, many years ago. Second, I had made videos, using my *iPad*, explaining the solutions to quiz and test problems in the same course last year, so student could view them whenever and as often as they needed. Another primary reason for developing the videos last year was to save class time. Third, I had the opportunity to work with another instructor, a doctorial student in educational mathematics, who had experience in teaching a flipped learning class.

Demographics of Two Classes

I taught two sections of Topics in Calculus during the Fall 2014 semester and collected data from both. One section was team-taught by myself and my co-instructor using a flipped learning model and the second section I taught in my usual fashion, a combination of group work and mini-lecture. Each class met in the early afternoon on Mondays, Wednesdays and Fridays for 50 minutes and over a period of 16 weeks. The flipped learning class consisted of 37 students and my semi-traditional class had 32 students. Both classrooms consisted of nearly-round tables, with 3 to 6 students per table.

Nature of Flipped Classroom

Students were required to view the internet videos contain in their course through *Blackboard* at any time of their choice before coming to class. They were also to complete the "guided notes" that accompanied each video. Hard copies of the guided notes were handed out in class in advance of that assignment and were also posted in *Blackboard* in case they forget to get a hard copy in class. The primary purpose of the guided notes was to help them concentrate and focus on the lectures of the videos. When students came to class they sat at their tables and then first checked their "guided notes" responses with other students at their table. Their responses, which were required on the guided notes pages, were written while watching the videos. My co-instructor checked to see if they had completed the guided notes before coming to class and recorded a few

points for each student based on completion. After they went over the guided notes in their groups they spent the rest of class time working on assigned problems from the textbook. This is typically done outside of class, thus completing the flipped or reversal nature of flipped learning. A few times, but rarely, when a topic was most difficult for the students one of the instructors would spend a few minutes to re-teach the topic. During most of class time the instructors floated about the rooms responding to student questions.

Nature of My Semi-traditional Classroom

Students were asked to write the problem numbers on the board that they had questions when entering the classroom. Questions regarding the out-of-class assigned problems were also asked for and address during class time. The typical class, after addressing previously assigned problems, consisted of a short lecture, followed by handouts to be completed in class by the individual student or by small groups working together on the problems. Different students were then asked to sharing their work with the entire class, usually using a document camera with projection. Sometimes I would go over an item or two on a handout.

Information on Students of Flipped Learning

We usually refer to the course as "Business Calculus" rather than Topics in Calculus as almost all the students are business majors. The breakdown of the 37 students by year in school for this section was as follows. Freshmen: 2, Sophomores: 16, Juniors: 14 and Seniors: 5. The Breakdown of the last math course taken, by year it was taken, by grade received in the course was as follows.

Last Math Course Taken (# of students)	In the Year	Grade
• College Algebra: 27	2014: 9	A: 18
• Statistics: 5	2013: 17	B: 9
• Calculus: 2	2012: 6	C: 5
• Trigonometry: 1	2011: 1	D: 2
• Geometry: 1	2010: 1	? : 3
• Retaking the Course: 1	2009: 1	

Also of the 37 students, 6 had prior experience with flipped learning.

Information on Students of Semi-Traditional Learning

Again, almost all students were business majors. The breakdown of the 32 students by year in school for this section was as follows. Freshmen: 5, Sophomores: 15, Juniors: 14 and Seniors: 0. In general, this was a little younger group, based on year in school, than the flipped learning class. The breakdown of the last math course taken, by year it was taken, by grade received in the course was as follows.

Last Math Course Taken (# of students)	In the Year	Grade .
• 21: College Algebra	2014: 12	A: 8
• 4: Statistics	2013: 12	B: 18
• 4: Calculus	2012: 9	C: 6
• 1: Functions	2011: 1	D: 0
• 1: Trigonometry		F: 1
• 1: Retaking the Course		Dropped: 1

Information Together (Flipped Learning, Traditional Learning)

- Freshmen: (2, 5) Sophomore: (16, 15)
- Juniors: (14,14) Seniors: (5, 0)

Last Math Course Taken (# of students)	In the Year	Grade .
• (27, 21) College Algebra	2014: (9, 12)	A: (18, 8)
• (5, 4) Statistics	2013: (17, 12)	B: (9, 18)
• (2,4) Calculus	2012: (6, 9)	C 5, 6)
• (1, 1) Trigonometry	2011: (1, 1)	D: (2, 0)
• (1, 1) Geometry, Functions	2010: (1, 0)	F: (0, 1)
• (1, 1) Retaking the Course	2009: (1, 0)	? : (3, 0)

Below are seven questions and categories of student responses from the Final Questionnaire taken anonymously online after completion of the course. The number of students with each response is underlined.

Question #1: How much time do you spend each week preparing for class (studying, reading, homework, office hours, tutor lab, videos, etc.)?

Flipped Class
Less than 2 hrs.: 3 2-4 hrs: 13 5-6 hrs: 7 7 hrs. or more: 3

Traditional Class
Less than 2 hrs.: 2 2-4 hrs: 15 5-6 hrs: 5 7 hrs. or more: 0

Question #2: About how often do you work with other classmates outside of class to study or prepare for class assignments/exams? What do you do to study or prepare for class assignments/exams?

They all spent some out-of-class time together working on their group projects. Their responses to "how often" ranged from all the time to never. Noticed not all students responded to this question. From those who did respond, the number of students is underlined.

Flipped Class

- For project work only: 5

- For tests and quizzes only : 5

- Total number of time during the semester that they met:
  Never: 5 once: 1 twice: 3 4-5 times: 3 many-many times: 5

Traditional Class
- For project work only: 3
- For tests and quizzes only: 8
- Total number of time met: Weekly - 4, often - 2, no frequency given - 3

Question #3: How did things go for you in the class? What went well? What challenges did you face?
Their responses ranged from "things went well" to "awful, everything was a challenge." The number of students in each response grouping preceeds their group response.

Flipped Class
- 10: Things went well, went ok, or went better than expected
- 8: Not a fan of flipped learning
- 4: Everything went bad, saw no need of the classroom, and class was unproductive
- 3: Had a problem with video learning
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Traditional Class
- 15: Things went great, well, good or ok
- 3: Homework was biggest challenge, especially grading
- 1: A few single comments, they varied a lot, no indication from them

Question #4: What did you do to prepare for tests?
The number of students in each response group precedes the general group response.

Flipped Class
- 8: Went over homework problems
- 4: Reviewed notes and study guide
- 7: Went over quizzes, practice exams and/or work sheets
- 3: Went over practice videos
- 2: Studied (A bit vague here)
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Traditional Class
- 8: Went over previous quizzes and tests
- 7: Read the chapters and/or practice problems at the end
- 6: Read study guide, review sheet, class notes
- 4: Looked over or reworked homework problems
- 4: Studies with others

Question #5: What aspects of the course were most helpful to you?
The number of students in each response grouping precedes their general group response.

Flipped Class

- 5: Working homework problems in class
- 4: Ease of access to instructors
- 4: Videos outside of class
- 3: Group work
- 3: Notes and study guides
- 3: aving 2 instructors
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Traditional Class

- 7: Handouts/Worksheets
- 4: Working problems at the table
- 4: The Instructor
- 2:Textbook
- 2: Lectures

Question #6: What aspects of the course were least helpful to you?
The number of students in each response grouping precedes their general group response.

Flipped Class

- 4: Having a flipped classroom
- 4: Videos
- 3: Homework in class
- 3: Nothing
- 2: Video note guides
- 2: Classroom noise/group work was a distraction for me
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Traditional Class

- 12: Homework grading
- 5: Nothing, everything was helpful
- 2: Lectures
- 1: A few different things

Question #7: Do you have any suggestions for improving the course?
The number of students in each response grouping precedes their general group response.

Flipped Class

- 11: Don't continue with flipped classrooms
- 5: No suggestions
- 3: Improve video sources
- 3: Modify class time – some lecture, some video, some homework problems
- 2: Have one instructor only

Traditional Class

- 7: Don't have TA grade homework
- 5: No, everything was helpful
- 3: Less homework
- 1: A few different unrelated things

The follow are comparison grades from textbook assignments/homework, quizzes, tests, final examination scores as well as attendance to class.

Class Averages of Total Points from a Possible 100 on Assignment Grades 1 - 5

- 78.3: Flipped Class
- 62.3: Traditional Class
- 0.002: T-test value

What accounts for this significant difference in favor of flipped learning is possibly due mainly to the amount of time spend in class on working the assigned problem from the textbook?

Class Averages of Total Points from a Possible 100 on Quizzes 1 – 4

- 81.9: Flipped Class
- 62.3: Traditional Class
- 0.078: T-test value

What accounts for this near significant difference can be debated. It might be due to the differences between the two learning models of classroom instruction. It might be due to the maturity level of the flipped learning class, number of seniors vs. number of freshmen. It might also be due to the fact that the grades achieved in their previous math course was higher for the flipped learning class then the traditional learning class.

Attendance Comparisons

- Flipped Class: Missed from 0 to 18 classes
- Traditional Class: Missed from 0 to 22 classes
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Average Number of Classes Missed

- Flipped Class: 6.43 classes per student
- Traditional Class: 4.74 classes per student

(A very few students missed a lot of classes, lowering the class averages)

- T-test value: 0.12

Although not statistically significant, notice that more classes were missed by the flipped learning class than by the traditional learning class. Several possible explanations are: The flipped learning students received sufficient information from the videos and preferred working along than coming to class and working with others on the

assignments. Some students of the flipped learning class thought that little was accomplished in class and it was a waste of time to attend. The traditional class may have enjoyed and/or found class time to be more valuable than did some students of the flipped learning class.

Below are test grade comparisons of class averages on the two regular tests and the final exam as well as a comparison of total points in the course between the flipped learning and the traditional learning classes.

Test 1

- 88.76: Flipped Class
- 48.88: Tradition Class
- 0.053: T-test value

What accounts for this near significant difference is possible the same as quiz result differences. It might be due to the differences between the two learning models of classroom instruction. It might be due to the maturity level of the flipped learning class, number of seniors vs. number of freshmen. It might also be due to the fact that the grades achieved in their previous math course was higher for the flipped learning class then the traditional learning class as some of the material tested was somewhat a review from previous courses.

Test 2

- 78.31: Flipped Class
- 78.75: Traditional Class
- 0.440: T-test value

What accounts for this insignificant difference is also debatable. For one thing the mathematics content of Test 2 was more challenging than Test 1 and virtually new to all students.

Final Exam

- 89.92: Flipped Class (from a possible 150 points)
- 87.83: Traditional Class
- 0.303: T-test value

What accounts for their similar scores is debatable. It could be than there was no treatment effect on the exam.

Total Course Points, Including a Group Project

- 507.53: Flipped Class (from a possible 525 points)
- 480.38: Traditional Class (from a possible 525 points)
- 0.052: T-test value

What accounts for this near significant difference in total points is possibly due to the difference in the two methods of instruction. But it could also be related to the maturity level differences and/or the mathematics capability level of the two classes as the flipped learning had a better grade performance in their previous math course than did the traditional students. Their project grades were virtually the same in both classes.

The six students who had experiences in a previous flipped classroom had all recently been involved in a College Algebra flipped classroom on campus within the past year. Two of these 6 students dropped our flipped learning class at the beginning of the semester. We don't know why they dropped. Was it because they did not like the flipped learning instructional model? Possibly. Other students make it very clear they did not like flipped learning and would have preferred a traditional class. When these students registered it was not identified as a flipped learning class. In regard to the four students who did complete the course, their average performance was almost exactly the same as the average of the rest of the class in all assessment areas.

What I have learned from the experience is that we should give students the option, in advance of registration, to choose the format of a course that have multiple sections that are taught in differ ways as students have different learning styles and some of them do have a definite preference to instructional methods. So when student register for a course I think that we should identify the type of instruction to be used for each section of the course. I also learned that it is important to match the format of the course with the "nature" of the instructor. For me personally, I still prefer my "regular" way of teaching. However, I will modify it to include aspects of the flipped learning by possible providing video lectures in Blackboard so they can view them before class, if they choose. I also learned that if a positive difference in performance occurred in favor of the flipped learning class we should note that performance and attitudes don't always match up. As many students in the flipped class did not like this method of instruction, but obviously performed well.