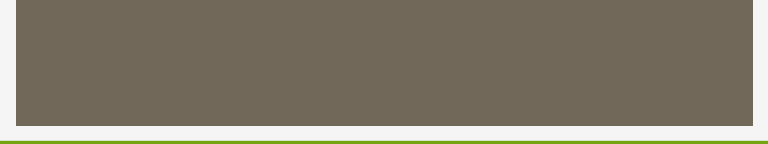


**Measuring
the
Effectiveness
of Flipped vs.**

**Traditional
Instruction in
Calculus**

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Investigating alternative forms of instruction in the Calculus classroom utilizing a flipped classroom design.

Purpose

- The goal of the proposed project was to improve classroom instruction for all students especially those from underrepresented groups in STEM fields. To meet this goal, we investigated the differences between calculus students enrolled in a traditional style calculus course and those enrolled in a restructured format of the same course utilizing a flipped classroom model of instruction.

Defining Terms:

- Hybrid
- Blended
- Flipped
- Inverted



- Primary dimensions: Instructional location, Delivery medium (person/technology), Instruction type (lecture/activities), Synchronicity (group/individual)

Research Questions:

- 1: How well did students master the calculus concepts in the flipped vs. lecture-based model of instruction?
- 2: How did students in flipped and lecture-based classes view their calculus classroom experience?
- 3: How did instructors describe their experiences teaching flipped vs. lecture-based classes?
- 4: Were there any difference in student attendance in flipped vs. lecture-based classes?

Participants

- 100 students enrolled in four sections of Calculus 2.
- Two sections taught in the traditional format (control group); two sections implemented the flipped format (experimental group).



Rationale (why this study?)

- To focus more on meeting the needs of diverse student populations, with the intention of increasing content knowledge and the success rate of students
- The flipped classroom design was selected because it allows for interactivity and insight into student learning and performance.
- Professors were able to use in-class time to engage students in activities such as small group problem solving, peer interactions, and experiential learning activities;
- Active learning exercises have been shown to significantly improve educational outcomes.
(Deslauriers, Schelew and Wieman, 2011; Topping, 1998; Mazur, 2009)

Data

- Pre-Post Calculus Test
- Survey designed to capture students experience in the learning environment.
- Faculty interview focused on teaching and planning for various learning environments.
- Classroom observations/video tapes
- Attendance records will be used to measure students' dedication to class sessions.

Participants

	Flipped class Number (%)	Lecture class Number (%)
Total number of students enrolled in course	51	45
Female students ¹	32 (62.7)	10 (22.2)
Completed the course ¹	45 (88.2)	39 (86.7)
Completed survey ¹	44 (86.2)	33 (73.3)
Took Calculus 1 at the University ²	23 (52.3)	17 (51.5)
Took AB Calculus prior to attending the University ²	30 (68.2)	20 (60.6)
Took AB Calculus but not Calculus 1 at the University ²	18 (40.9)	12 (36.4)
Took BC Calculus (which covered the content of this course) ²	4 (9.1)	4 (12.1)

Learning Modalities

	Lecture-based Calculus Class	Flipped Calculus Classroom
Prior to class:	Students read sections in the textbook prior to the lecture and made notes on vocabulary and theorems, for about half of the topics in one lecture class only. No other preparation was expected.	<ol style="list-style-type: none"> 1) Students watched 20-minute videos including a combination of existing videos available online and supplementary videos made by course instructors where existing videos were insufficient, 2) Students completed video guides made up of 5-10 questions on definitions, formulas, and other basic material, while watching the video, and 3) Students completed problem sets of 2-4 tutorial style problems for some topics.
During class:	Students watched demonstrations of calculus procedures performed by their instructor.	<ol style="list-style-type: none"> 1) Students began with poll everywhere quizzes of 2 - 4 questions per topic, assessing basic material followed by instructor-led review of answers (1/3 of class period), 2) Students worked through problems in groups (1/3 of class period), and 3) Students presented solutions and explained their reasoning to peers (1/3 of class period).
Instructor Role:	Delivered lectures, answered questions by working out solutions on the board.	<p>Worked with small groups of students to answer questions and support student learning (2/3 of class).</p> <p>Demonstrated solutions, delivered mini-lessons (Instructors spent less than one-third of the class period on lecture.)</p>
Assessment:	Students were assessed using exams, quizzes and homework problem sets.	Students were assessed using exams, quizzes and homework problem sets.

1. How well did students master content?

	Flipped	Lecture	pvalue for means
Pretest score mean (stdev)	9.12 (1.75)	9.30 (2.53)	0.73
Posttest score (stdev)	13.33 (2.68)	13.25 (2.28)	0.87
Difference between pre and posttest scores	4.21 (2.78)	3.95 (2.29)	0.65
Difference between pre and posttest scores, male students	4.69 (3.05)	3.73 (2.34)	0.29
Difference between pre and posttest scores, female students	3.94 (2.63)	4.67 (2.05)	0.42

2: How did students view their calculus experience?

- Flipped classes (63.6%) agreed that the videos greatly enhanced their learning, and a similar number (59.1%) agreed that reading the book greatly enhanced their learning.
- Students in both flipped and lecture classes valued WebAssign homework, lectures, and in class problem solving.
- More students in the flipped classes thought that in class discussions with peers greatly enhanced their learning (72.7% in the flipped classes and 57.6% in the lecture classes).
- Students in the flipped classes were less positive about the overall format of the class: only 53.5% of students in the flipped classes compared to 81.8%.
- A majority of students in both types of classes thought that they would prefer a lecture class if given a choice, although 41.9% of students in the flipped classes, compared to 12.1% of students in the lecture classes.
- One statistically significant result from this study came from students enrolled in the lecture classes who reported that the lecture format greatly enhanced their learning.

3: How did instructors describe their experiences?

- Both instructors agreed that the flipped class format enabled them to interact with students.
- The instructors differed in their assessment of the benefits of the technology used for instruction.
- Instructors agreed that some content was more appropriate for delivery via video than others.

4: Were there any differences in student attendance?

- Attendance was high in both classes, but lower in the flipped classes. 88.6 % vs 90%
- Students in the flipped and lecture classes spent similar amounts of time outside of class time.
- About 86% of students in the flipped classes reported watching at least half of the videos; 53% reported watching 75% or more and only 30% reported watching 90% or more.
- About 63% of students in the flipped class reported reading at least half the sections of the book covered in the class, 44% reported reading 75% or more of the sections, and 23% reported reading 90% or more of the sections. The corresponding figures for students in the lecture classes were 52%, 42%, and 26%.

Discussion:

- Suggest using homework and in-class or at-home quizzes to motivate students to watch videos in advance to better prepare for classroom discussions.
- The flipped model provided the instructors with significantly more class time to emphasize important concepts and/or engage students in problem-solving exercises while the online videos provided students with important background information
- Learning outcomes between the two teaching methodologies were essentially the same, that students in the new format "pay no price" for this mode of instruction in terms of pass rates, final exam scores, and course grades.

Discussion:

- More research is needed to study the depth of learning that occurs in small group problem solving and interactions between faculty-and-student and student-to-student.
- Results from this study suggest that a blended type of learning would be optimal for learning calculus concepts with a strategic use of video content concepts.
- Course redesign is very labor intensive for the instructors but offers an opportunity to reengage students, increase their motivation, and improve outcomes for students.

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