

# FLIPPING THE CLASSROOM: AN EMPIRICAL STUDY EXAMINING STUDENT LEARNING

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## ABSTRACT

*Flipping the classroom is the latest reported teaching technique to improve student learning at all levels. Prior studies showed significant increases in learning by employing this technique. However, an examination of the previous studies indicates significant flaws in the testing procedure controls. Moreover, most studies were based on anecdotal observations and not quantitative methods of analysis.*

*This studied examined the true learning improvements attributed to the flipped classroom method. The results indicate that flipping the classroom did improve the test scores for 14% of the students and 88% of the students self-reported that the flipped classroom resulted in more effective learning. However, overall class test scores did not support that flipping the classroom improved the entire class. In fact, 81.5% of the students showed no significant improvement and 3.7% showed lower test scores using the flipped classroom method.*

*The flipped classroom does have the benefit of increasing time on task for the student by using technology to increase learning time outside the classroom. However, this technique is only effective because students spend more time learning the material. Any method that gives more time to learn the material will result in increased learning. The true value of the flipped classroom appears to be not in the method but in the use of technology to increase the time students spend learning.*

## INTRODUCTION

“Flipping the classroom” are the latest buzzwords in academics from K-12 to college teaching. Flipping the classroom is where instruction is moved outside the classroom giving time in the class to increase the depth of learning. The current technique is to place resources online, such as video lectures, allowing the student to learn the material before entering the classroom. The classroom time is now spent working with the students and answering questions to further student knowledge.

There are repeated claims that this technique improved student learning at all levels. However, an examination of peer reviewed research articles shows no empirical support for these claims. Moreover, the results claimed in non-peer reviewed articles are suspicious because the research data is undocumented and only descriptive statistics were reported.

This paper examines the effectiveness of flipping the classroom on a freshman college class under controlled conditions using a paired sampling technique. Through controlled standardized testing, the learning results of flipping the classroom are properly evaluated.

## LITERATURE REVIEW

Although flipping the classroom may have taken place in similar forms, the first published article on flipping the classroom using modern techniques of online videos was in 2002 (Foertsch, Moses, Strikwerda, & Litzkow, 2002). In the study, online videos and accompanying material replaced traditional lectures. Lecture time was used for interactive discussion and problem solving. Students self reported liking the learning method better than the large traditional lecture classroom setting. However, no research was done on whether this improved student learning.

The Khan Academy in 2006 progressed the idea of moving learning outside the classroom by founding a non-profit educational website that offered 4,000 micro lectures on various academic subjects (Khan Academy, 2013). The venture was funded by the Gates Foundation to make education more available to the public through online resources. Although the Khan Academy does not offer the flipped classroom teaching, the Khan videos were the basis of many flipped classroom experiments that later developed.

With the flipped learning method developing, Strayer (2007), examined how students felt about the new learning environment. In his dissertation, Strayer surveyed college level students in statistics courses at Ohio State University. Although Strayer found students were uncomfortable with the learn methods, Strayer never examined whether student learning increased using the flipped classroom method.

In 2012, the research on flipping the classroom took off, mostly due to the work of Bergmann and Sams in their journal article "Before you flip consider this" and their book, *Flip Your Classroom*. The journal article detailed the history of flipping the classroom and gave guidelines for academics on how they could use this technique (Bergmann & Sams, *Before you flip, consider this*, 2012). A full-length book followed up the journal article giving examples of the flip technique (Bergmann & Sams, *Flip Your Classroom*, 2012). The articles and book gave detailed instructions to implement a flipped classroom and why flipping would improve student learning. The specific reasons given for flipping the classroom are: students don't feel classroom time is being dumbed down, the digital world changed how students learn, students are becoming multitaskers, increased student-teacher interaction, increased student-to-student interaction, increased student-to-world interaction, students can work ahead or at own pace, instruction time is flexible to fit into student's schedule and when student is most alert, gives instructor more one-on-one time with struggling students, aids special needs students by allowing repetition of lecture or slowing of lecture, allows instructors to cover more material in class, leverages technology to increase student interaction or active learning, allows teachers to get to know students better, allows students of different abilities to learn in the same class, aids in classroom management, allows parents to help and monitor student activity, and aids students who miss classes due to illness or other factors (Bergmann & Sams, *Flip Your Classroom*, 2012).

Brunsell (2011), verified some of Bergmann and Sams work finding that flipping his chemistry class increased one-on-one interaction and student learning. However, Brunsell's work relied on anecdotal observation and not quantitative methods of analysis. In 2012, Berrett described the process of flipping the classroom and reported that it increases interactive learning, group work and peer instruction. However, he provided no research to confirm his statements.

From 2010-2012, there were a number of articles that reported on personal experiences with flipping the classroom. Alvarez (2010), described its use in high school physics courses. Ogurek (2010), used an early Dunn and Dunn learning style model in elementary school classes.

Corbyn (2012), used MOOC (Massive Open Online Courses) as the out of class online lectures. Stephens (2012), used social media to supplement out of class learning. In addition, Semple (2013), examined teaching library science in a flipped version. However, none of these works analyzed if student learning increased because of using this new method.

It seemed that flipping the classroom was generating its own buzz in learning journals. Both the *Economist* (*Flipping the Classroom*, 2011) and *Phi Delta Kappan* (*Flipping Classrooms*, 2011) magazines did short stories about the techniques. The magazines touted this as the new and upcoming method of learning but provided little supporting evidence of its effectiveness.

The teaching website [www.techlearning.com](http://www.techlearning.com) attempted to quantify the impact that flipping the classroom had on teachers and students through an online survey. Their self reported results indicated that teacher job satisfaction improved by 88%, student satisfaction improved by 80% and 67% of students reported better test scores (*What Do Teachers Who've Flipped Their Classrooms Have to Report*, 2012). However, no data or testing procedures were provided in the one page graphic summary of the results they published.

All this hype appears to be based on one research study that showed student learning increased in a flipped classroom. The study is Fulton's (2012) journal article on "The Flipped Classroom: Transforming Education at Byron High School." A review of this study showed a serious fault in controlling related variables. In 2010, Byron High School was trying to increase student scores on standardized exams without increasing cost to the school. The teachers flipped the classroom and developed online instructional videos for students to watch before class. Then during class, teachers did more one-on-one problem solving. The results reported a 9.8% increase in calculus scores, a 6.1% increase in precalculus scores and a 5.1% increase in algebra scores. In addition, end of grade State math competency scores increased from 29.9% to 65.6% using the flipped classroom (Fulton, *The Flipped Classroom: Transforming Education at Byron High School*, 2012). On the surface, these results seem remarkable. However, there was also a change in textbooks at the time. Before the flipped classroom experiment, teachers complained the math textbooks being used were outdated and did not contain the material that the State exam tested. When the teachers created the instructional videos, they based the instruction on the material that was on the State exam and not what was in the outdated textbook. Therefore, one group used outdated textbooks that did not cover the material being tested. The other group used the online instruction tailored to the exam questions. This major

change in instructional quality is not accounted for in the research. One is left wondering if the improvement was due to better instructional material or the teaching technique of flipping the classroom.

The Fulton study is also suspect because it did not use any analysis technique in reporting the results. The results were reported as simple descriptive statistics of class means. However, an examination of the available data indicates wide variances within the control and test groups. The mean scores varied over time and the control and test group results crossed at several points. This wide swing in variance would probably cause a t-test of means to be insignificant.

The literature review strongly indicates that no real research has been done to verify that flipping the classroom increases student learning. Most articles only describe the experience or are reprints. This has led to a split opinion in academia if this technique is beneficial to student learning. Some critics attacked the technique on several fronts to include the digital divide issue that students do not have necessary access at home and that increasing the school workload at homework negatively affect the student and family time (Nielsen, 2012). Based on the conflict and lack of literature support, it is important to empirically examine if flipping the classroom increases student learning.

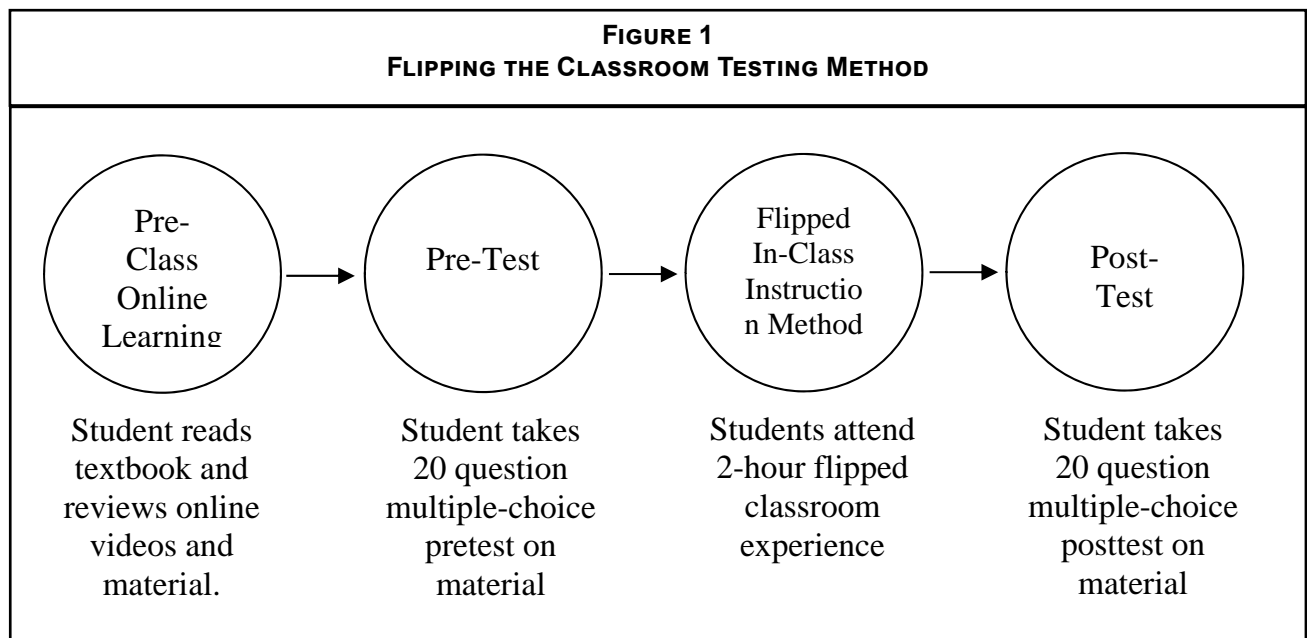
**METHODOLOGY**

Increased learning from flipping the classroom takes place in two main areas, the pre-class work where students view online videos and material and the advanced in-class work

that furthers the understanding of the material. The pre-class learning is similar to any online program available. Therefore, the added learning, espoused in the flipped method, occurs during the advanced in-class time.

To accurately measure the increase in learning taking place in class, a pre and post-test technique is used. Starting three days before the class, students can access the Blackboard online learning system and view videos and online material at their own pace. In addition, the textbook material is always available for the student. Within that three-day period, the students take a standardized exam on the material at a time of their choosing. The students then attend the in-class learning session. In the two-hour class, a short (10-minute) overview of the key material is given. Students then work in groups to address the advanced application of the material. This is done through group work, simulations, case studies and problem sets. The instructor works with groups and individuals one-on-one to answer questions and direct learning to key objectives. Selected groups then present their work to the class for open class discussion defending their optimal solutions. Class size was kept small (n=30) to allow the instructor enough interaction time. Within three days after the in-class time, the student takes a standardized post-test on the material. Figure 1 represents the study process.

To neutralize grading bias, the pre and post-test are multiple-choice questions taken randomly from the book publishers test bank. Analysis of the results is done using multiple sources of measure. For quantitative results and to analyze overall success, the class mean of the pre and post-tests are analyzed using a paired two-sample means t-test. Further breakdown of the results examine each in-



dividual student’s pre and post-tests using the same-paired two-sample means t-test. This yields the percentage of students who showed increased learning from the flipped classroom technique. Qualitative results are obtained using two sources. Instructor observations are the first source. During the in-class time, the instructor observes learning demonstrated by the students. Secondly, students were given an end of class survey asking to rate the class, learning style and knowledge acquired. The survey contains both numerically scored and open ended questions to gain further insights.

### RESULTS AND ANALYSIS

The total number of students who completed the study was 27. The study contained 21 pre and 21 post-tests giving 567 control data points and 567 testing data points for the paired sample testing. Each lesson module correlated with one chapter of the course textbook, which averaged approximately 20 pages of material in the freshman level marketing field. The course length was 11 weeks with two, two-hour class meetings per week for a total of 44 hours of in-class flipped instruction. Table 1 lists the results for the individual students and Table 2 is a summary of class results.

The results indicate that 14.8% of the students showed significant knowledge gains from the flipped classroom instruction and 81.5% showed no significant improvement. There was even one student that showed a significant decrease in performance from the flipped classroom.

The overall class mean increased by 1.48 percentage points but the increase was not significant at the 0.05 level.

Observation by the instructor indicated the following: students were better prepared to discuss material in class, students appeared to show deeper understanding of the material based on their verbal discussions of the topic, and groups presented and defended case solutions better than previous classes not using a flipped classroom.

Open ended questions on the student survey indicated that 88% of the students felt the flipped classroom was a more effective learning style. Students cited an increased interest in learning, more in-class interaction and class projects that resulted in a deeper understanding of the material.

The student survey contained eight critical questions to access how a flipped classroom affected the student. Scoring for the Likert scale responses were compared to previous scores for this class and the instructor. Table 3 examines the eight questions and if the flipped classroom scored better or worse than previous non-flipped classroom courses.

**TABLE 1  
SUMMARY OF INDIVIDUAL RESULTS**

Student	Pre-Test Mean	Post-Test Mean	Mean Improvement	t-test Significance
1	76.75	81.00	4.25	0.158
2	74.00	80.53	6.53*	0.037
3	69.25	66.50	-2.75	0.226
4	50.42	50.53	0.11	0.494
5	69.33	67.78	-1.56	0.362
6	82.75	87.38	4.63	0.229
7	75.50	80.24	4.74	0.079
8	80.00	74.72	-5.28*	0.045
9	74.75	78.33	3.58	0.141
10	65.25	71.50	6.25	0.058
11	77.50	79.71	2.21	0.307
12	33.00	33.57	0.57	0.463
13	82.69	68.42	-14.27	0.063
14	81.67	78.81	-2.86	0.204
15	75.75	72.86	-2.89	0.196
16	74.00	77.14	3.14	0.120
17	68.53	75.48	6.95*	0.047
18	73.75	70.24	-3.51	0.247
19	58.75	66.67	7.92*	0.045
20	78.24	77.22	-1.01	0.425
21	61.92	59.00	-2.92	0.320
22	74.29	80.48	6.19	0.056
23	77.00	77.62	0.62	0.416
24	58.53	64.76	6.23	0.104
25	76.84	78.33	1.49	0.319
26	76.19	79.29	3.10	0.135
27	78.57	86.94	8.37*	0.008
Class Avg.	71.30	72.78	1.47	0.160

\* Note: the increase is not significant at the 0.05 level.

Student survey results showed increases in that the materials were presented in logical order, greater material availability and good use of class time. This is consistent with prior observations in the flipped classroom. However, student scores decreased in several areas.

<b>Overall Class Mean Score Increase</b>	<b>1.48 Percentage Points *</b>
Percentage of Students With Significant Mean Score Improvements	14.8%
Percentage of Students with No Significant Mean Score Improvements	81.5%
Percentage of Students With Significant Mean Score Declines	3.7%
* indicates significant change in mean at the 0.05 level of significance	

<b>Question</b>	<b>Results for Flipped Classroom</b>
The course material was presented in a logical order.	10.0% increase
The assigned readings helped me to learn the course material.	10.0% decrease
The way the course was organized helped me to learn the material.	11.0% decrease
The instructor presented a variety of activities that got me involved in learning.	9.0% decrease
My scores on the exams, homework, and other graded assignments accurately reflected how much I actually learned.	14.0% decrease
The exams, homework, and other graded assignments were fair.	4.0% decrease
Materials for out-of-class learning activities were available when needed.	3.3% increase
The instructor consistently made good use of the entire class period	10.5% increase

Students' scores decreased by 10% on the usefulness of the reading material. This may be due to the students thinking this referred only to the textbook and not the available online material. Therefore, on the next survey a more specific question needs to be crafted to evaluate the usefulness of the online material since 45.5% of the students specifically mentioned that the online material was one of the key components in their learning.

It is interesting that there was an 11% decline on student perception that the format of the flipped classroom did not help them learn the material when 88% of the students specifically mentioned that the flipped classroom was effective in increasing their understanding of the material. There seems to be a numeric disconnect between the students written comments and their numeric score they selected.

The key finding was that there was a 14% decrease in the student score that the testing used accurately measured what they learned and a 4% decline in test fairness scores. Although 70% of the final grade was measured using traditional multiple-choice exams, 30% of the grade was based on in-class presentations and project work.

### CONCLUSION

Flipping the classroom did improve the test scores for 14% of the students and 88% of the students self-reported that the flipped classroom resulted in more effective learning. However, overall class testing scores do not support that flipping the classroom improved the entire class. In fact, 81.5% of the students showed no improvement and 3.7% showed lower test scores using the flipped classroom method.

There appears to be conflicting data between self-reported learning and actual measured learning taking place. One reason may be the standardized testing method that is commonly employed. Does standardized multiple choice testing accurately measure deeper learning? Although this is a question relevant to the study, it is beyond the scope of the research.

In general, the flipped classroom is not showing the significant increases in learning reported by the Byron High School study. Although flipping the classroom does work for some students, it does not appear to increase learning in all students as reported.

Although this was a small study and sample size is a concern, the testing method was tightly controlled to measure only the increases in learning from the flipped classroom and not the pre-work or additional out of class work required of the students. It makes logical sense, that any method that increases time spent learning would increase material understanding. It appears that the flipped classroom works by increasing the total time a student spends on the material. Therefore, the flipping the classroom method does not significantly increase learning but using technology to increase learning time does.

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