Lecture capture technology: does it make a difference on college student achievement?

Debra S. Bruxvoort

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Lecture capture technology: does it make a difference on college student achievement?

Abstract
Lecture capture technology allows professors to record live lectures for students to view after class. That same technology can be used to pre-record lectures for student viewing before class so that the class session can be used for other learning activities. This is referred to as the flipped classroom model. Most previous studies on the effect of lecture capture technology have focused on student perceptions and self-reported data and took place at large universities. This quantitative study collected multiple measures in an experimental design to compare the academic performance of 54 undergraduate students in three sections of the same course taught by the same professor at a small college. One section had access to recordings before class, one had access after class, and one had no access. Results showed that students with access before class received slightly higher scores on quizzes, tests, and final course grade, although only the difference in test scores was statistically significant. Especially noteworthy was the lackluster use of recordings by students in the traditional lecture capture section, and the extraordinary level of viewing compliance by students in the flipped class section. The results of this study suggest that lecture capture technology may have a positive effect on student learning when used to support the flipped classroom model.

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LECTURE CAPTURE TECHNOLOGY: DOES IT MAKE A DIFFERENCE
ON COLLEGE STUDENT ACHIEVEMENT?

A Graduate Review
Submitted to the
Division of Instructional Technology
Department of Curriculum and Instruction
In Partial Fulfillment
Of the Requirements for the Degree
Master of Arts
UNIVERSITY OF NORTHERN IOWA

by
Debra S. Bruxvoort
June 2012
This Review by: Debra S. Bruxvoort

Titled: Lecture Capture Technology: Does It Make a Difference on College Student Achievement?

has been approved as meeting the research requirement for the

Degree of Master of Arts.

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Abstract

Lecture capture technology allows professors to record live lectures for students to view after class. That same technology can be used to pre-record lectures for student viewing before class so that the class session can be used for other learning activities. This is referred to as the flipped classroom model. Most previous studies on the effect of lecture capture technology have focused on student perceptions and self-reported data and took place at large universities. This quantitative study collected multiple measures in an experimental design to compare the academic performance of 54 undergraduate students in three sections of the same course taught by the same professor at a small college. One section had access to recordings before class, one had access after class, and one had no access. Results showed that students with access before class received slightly higher scores on quizzes, tests, and final course grade, although only the difference in test scores was statistically significant. Especially noteworthy was the lackluster use of recordings by students in the traditional lecture capture section, and the extraordinary level of viewing compliance by students in the flipped class section. The results of this study suggest that lecture capture technology may have a positive effect on student learning when used to support the flipped classroom model.
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**Introduction**

When Jennifer came down with the flu, she could barely get out of bed and going to class was out of the question. Because her professor used lecture capture technology, she was able to watch the video recording of the session she missed to catch up with the rest of the class when she recovered.

Jennifer's roommate is taking a course in which the professor uses lecture capture technology in a different way. Her professor records the lecture ahead of time in his office or home, and students are assigned to watch the recordings, or video podcasts, before coming to class. The face-to-face class session is then used for other learning activities.

Lecture capture systems--technology that simplifies the recording, processing, storage, and distribution of lectures along with accompanying slides and other media--are becoming more prevalent on college campuses. In fact, analysts have predicted that the market for lecture capture systems will quadruple by 2013 (Ramaswami, 2009, p. 21). Commercial systems such as MediaSite, Panopto, and Tegrity are helping colleges and universities provide students with a study tool that allows them to watch lectures they missed or to review all or part of a lecture that they didn’t understand the first time (Educause Learning Initiative, 2008).

That same technology can be used to “flip” the classroom by recording the videos ahead of time—a pedagogical model in which “lectures are the homework, and homework becomes classwork” (“Flipping the Classroom,” 2011). Lage, Platt, and Treglia (2000) called this “inverting the classroom” in their study of an undergraduate economics course. Bergmann and Sams (2012) pioneered the practice at the high school level in 2007. More recently, the flipped classroom concept has gained national attention through the work of
Salmon Khan, who developed thousands of instructional videos now collected into an Internet repository called the Khan Academy (Tucker, 2012).

Lecture capture systems are resource-intensive and require an ongoing commitment by both the institution and its faculty. That commitment is difficult to sustain without some assurance that students will achieve greater academic success because of this technology. However, research conducted thus far on the impact of lecture capture technology has focused largely on student perceptions and attitudes; few have measured actual student achievement, especially when used in conjunction with the flipped classroom model.

Therefore, I studied the academic performance of students in three sections of an undergraduate exercise science course taught by the same professor. One section was given access to lecture recordings after each class (traditional lecture capture). Another section was required to view lecture recordings before each class (flipped classroom). The third section had no access to lecture recordings. By doing so, I attempted to determine the effect of lecture capture technology on student achievement in a traditional classroom setting on a small college campus.
Review of the Literature

In order to focus on the most recent research, most of the articles selected for review were published during or after 2008. Relevant articles involved face-to-face courses in an undergraduate setting. Literature which studied the effect of traditional lecture capture (students given access to the recording after class) is described first. Those sources were discovered by searching Google Scholar, ERIC (EBSCOhost), Academic Search Premier (EBSCOhost), and Wilson Web databases with the following descriptors and keywords: lecture method, higher education, educational technology, video, attendance, student, podcast, vodcast and webcast. Examining the reference lists of selected articles led to the discovery of additional relevant sources.

Following the literature review of the effect of traditional lecture capture, the flipped classroom model (students given access to the recording before class) is explained, and research studies that examine its effect on student achievement are described.

Traditional Lecture Capture

When professors record their in-class lectures and make them available on a course website after the lecture, students have another learning resource at their disposal. For those students who choose to take advantage of this study tool, the following research indicates that their academic performance may improve.

For example, a study conducted at the undergraduate level with students in an introductory Materials Science and Engineering course in the fall of 2008 found that students benefitted by viewing the recordings. A statistically significant positive correlation (p = <0.01) was found between students’ use of the recordings and their final grade after controlling for GPA. Supplemental screencast recordings such as homework explanations
were also provided to the students and it is likely that they contributed to the positive results. Students perceived the actual lecture recordings to be valuable since 89% of the students responding to an end-of-course survey agreed that they had a “deeper understanding of the material discussed in lecture because of the lecture recordings” (Pinder-Grover, Millunchick, Bierwert & Shuller, 2009).

Likewise, 158 students in seven undergraduate math courses benefitted from lecture capture recordings, according to a study by Cascaval, Fogler, Abrams, and Durham (2008). Along with recordings of their current courses, students were given access to lectures from previous courses for the purpose of reviewing prerequisite concepts. The cumulative data from the seven courses indicated that lecture capture added significant value to the learning process regardless of course level, instructor’s teaching style, and student age, gender, or interests. Over half (51%) of the 51 students who responded to an end-of-course survey felt that their grade for the course would have been lower had they not had access to the lecture recordings. Understandably, students in the more difficult math courses valued the recordings more highly than students in classes perceived to be less difficult.

Although engineering and mathematics courses might seem especially suited for lecture capture, studies show that students in other disciplines may benefit as well. For example, in a study conducted with two sections of an introductory psychology course, one section had access to lecture recordings and the other did not. Results showed that the section with access obtained small but statistically significant higher overall course grades than students in the other section. The researchers concluded that “posting lecture presentations to supplement a traditional college class was associated with a small, positive effect on academic achievement” (Hove & Corcoran, 2008, pp. 93-94).
Although Larkin (2010) did not measure student performance, her study reports that over 68% of the students in an occupational therapy class found the recorded lectures to be helpful or extremely helpful. Even the students who had not viewed any recordings valued their availability “just in case” they were needed. According to a similar study in a medical radiation course, 80% of the students responding to a questionnaire felt that the recordings had improved their learning (Scutter, Stupans, Sawyer & King, 2010). A 2009 study by von Konsky, Ivins and Gribble indicated that 53% of the respondents in a software engineering course believed the recordings contributed to their learning.

Traphagan, Kucsera, and Kishi (2010) studied two sections of a geology course, one section with access to webcasts (lecture recordings), and the other without. Results indicated that viewing the recordings had a positive and significant effect on two out of three course assessments. They concluded that webcast viewing was associated with higher performance.

Not all studies found positive effects, however. Joordens, Le, Grinnell and Chrysostomou (2009) found that students who frequently paused the recordings and students who both attended lectures and viewed them online actually showed lower performance in two math courses. The researchers believed that the lower performance might have been due to using the recordings to memorize steps rather than to understand concepts—an unsuccessful learning strategy.

**The Flipped Classroom**

A search of Google Scholar, *ERIC (EBSCOhost)*, *Academic Search Premier* (*EBSCOhost*), and *Wilson Web* databases for the years 2008 through 2012 using variations of the key words “flipped classroom,” “inverted classroom,” “video podcasts,” and “vodcasts” returned few empirical studies. This is likely due to the fact that the practice has only
recently attracted attention, primarily at the K-12 level. The vast majority of articles described the potential benefits of the flipped classroom model with occasional anecdotal evidence of improved student achievement.

For example, Brunsell and Horejsi (2011) describe how the flipped classroom model frees up class time for discussions and hands-on activities. It is also conducive to greater customization and differentiation of instruction by using class time to tutor students on concepts they do not understand (Brunsell and Horejsi, 2011; Gannod, Burge, and Helmick, 2008; Tucker, 2012; Miller, 2012). This can facilitate higher-order thinking, deeper engagement and understanding of the subject matter by the students (Kolowich, 2011; Strayer, 2007).

According to Bergman and Sams (2012), Brunsell and Horejsi (2011), Gannod, Burge, and Helmick (2008), and Tucker (2012), one of the greatest benefits of the flipped classroom model is increased interaction between teacher and students and between the students themselves. The instructor’s role changes from “sage on the stage” to “guide on the side” (Bergmann and Sams, 2012; Berrett, 2012; McDaniel and Caverly, 2010; Hughes, et al., 2011). This creates a classroom environment in which students take greater responsibility for their own learning and are actively engaged in constructing their own knowledge (Gannod, Burge, and Helmick, 2008; Schaffhauser, 2009; Toto and Nguyen, 2009).

At the same time, the flipped classroom is an easy model to get wrong, according to Educause (2012). Making the recordings and carefully integrating the out-of-class and in-class components takes time and commitment on the professor’s part. Instructors need
access to the technology tools required to create quality recordings, and students need access to computers and the Internet in order to replay the recordings.

Besides that, students sometimes resist the student-centered approach of the flipped classroom. According to Young (2009), "Students have been socialized to view the educational process as essentially passive. Initial response is generally negative until students start to understand and see how they learn under this new system." Students must be actively engaged and can no longer passively receive material in class (Berrett, 2012). This can result in students feeling “unsettled” because of the variety of learning activities in lieu of listening to the traditional lecture (Strayer, 2007).

According to Educause (2012), the flipped classroom model brings about a shift in priorities from merely covering material to working toward mastery of it. However, research studies that measure student mastery by comparing actual student achievement under the flipped classroom model to student achievement under the traditional lecture model are rare. Even so, there are some studies that have similar characteristics or that can inform the current study.

Walker, Cotner, and Beerman (2011) compared two sections of a postsecondary introductory biology course in which 35 students in one section had access to 20 traditional lecture capture recordings, and 48 students in the other section had access to 11 specially-prepared vodcasts (video podcasts). They found that the vodcast group achieved significantly higher scores on an end-of-term knowledge test. However, the final course grades were no different between the two sections. Although this study is somewhat similar to the current study, the flipped classroom model was not employed. The students in the vodcast group
were not required to watch them before class, and the two class sections were taught exactly the same.

Hill and Nelson (2011) conducted a study in which 24 students in a biogeography and conservation course were given access to six optional video podcasts about exotic ecosystems. Although student perceptions were positive about the usefulness of the vodcasts, there were no significant differences in exam scores for that cohort when compared to previous cohorts. The researchers concluded that the vodcasts would have been more effective if they had been incorporated into a collaborative learning context rather than students using them in isolation. This study and the one by Walker, Cotner, and Beerman (2011) indicate that the recordings themselves are not what make the difference in student achievement. Rather, the difference lies in the pedagogy that is used in conjunction with the recordings.

Gannod, Burge, and Helmick (2008) explained their experience with piloting the inverted, or flipped, classroom model in a software engineering course. Students watched 3-6 hours of lecture per week outside of class, and spent class time actively engaged in learning activities. Although they did not include any achievement data, they reported student response to the inverted classroom model as overwhelmingly positive.

Toto and Nguyen (2009) explored students’ perception of the flipped classroom in two sections of an industrial engineering course. They recorded two lectures and required students to watch them before class. A brief quiz was administered at the beginning of each of the two class sessions as incentives to view the recordings ahead of time. The students completed a survey at the end of the class sessions and at the end of the course. The 74 students indicated that they preferred spending class time for problem solving and hands-on
activities. At the same time, they preferred a face-to-face lecture over a recorded lecture. Student preferences indicated that 30-minute recordings were optimal, and the flipped model could be used 25-50% of the time.

Schullery, Reck, and Schullery (2011) describe how they approached the challenge of low student engagement in a very large introductory business course by moving to a hybrid model. They moved the lectures online and met face-to-face once per week in 24-person sections for discussion and active learning activities based on the out-of-class videos and readings. Responses to 863 student surveys indicated that a clear majority of students favored the new format.

Professors in three disciplines each flipped one class session in a study by Corliss, Reilly, Henson, and Heidenreich (2012). In two out of the three class sessions, students who watched the pre-recorded lecture performed significantly better on both a pre- and post-test than students who did not view the pre-recorded lecture (p < .01). Although the study covered only three occurrences of the flipped classroom model, they concluded that there are four key components to a successful implementation: 1) the delivery of out-of-class content; 2) in-class active learning activities; 3) instructor advocacy for the instructional method; and 4) alignment of all activities to the course learning objectives.

Based on the literature, lecture capture technology appears to be a potentially valuable educational tool for students when used in both the traditional lecture capture model and in the flipped classroom model. Because quantitative data to support that conclusion is scarce, this study attempts to measure the effect of lecture capture technology on the academic performance of college students.
Methodology

Participants

The participants in this study were traditionally-aged sophomore, junior, and senior students at a small, private liberal arts college in the Midwest. The 54 students (53.7% male, 46.3% female) were enrolled in a Sports Nutrition course during fall semester, 2011. Over half (62.9%) of the students were athletes, which meant that they would occasionally miss class for travel to off-campus competitions.

Procedure

Three sections of the same 200-level course were compared. Each section was taught by the same professor and met face-to-face on Mondays, Wednesdays, and Fridays. The 8 a.m. class (n=14) received no treatment and served as the control group. The professor delivered a traditional lecture using PowerPoint slides. The 9 a.m. class (n=22) was required to watch a specially-recorded video lecture before class (the flipped classroom model). During class sessions, the professor engaged the students in various interactive activities in place of traditional lectures. For the 2 p.m. class (n=18), the professor delivered a traditional lecture accompanied by PowerPoint slides. Those students had access to the lecture recording after each class session was over (traditional lecture capture).

Table 1

Participant characteristics by course section

<table>
<thead>
<tr>
<th>Section</th>
<th>Time</th>
<th>Count</th>
<th>Male</th>
<th>Female</th>
<th>GPA</th>
<th>Athletes</th>
<th>Non-Athletes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treatment</td>
<td>8 a.m.</td>
<td>14</td>
<td>9</td>
<td>5</td>
<td>2.953</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Watch lecture before class</td>
<td>9 a.m.</td>
<td>22</td>
<td>6</td>
<td>16</td>
<td>3.098</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Access to lecture after class</td>
<td>2 p.m.</td>
<td>18</td>
<td>14</td>
<td>4</td>
<td>2.756</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Totals/Average</td>
<td></td>
<td>54</td>
<td>29</td>
<td>25</td>
<td>2.947</td>
<td>34</td>
<td>20</td>
</tr>
</tbody>
</table>
When students registered for the course, they were not aware of the study or the planned treatments. Immediately prior to the semester, random assignment was used to determine which section would receive which treatment, and it was announced to the students on the first day of class. Students had the option to change to a different section prior to the add/drop date if they did not like the treatment their original section was going to receive. No one did so.

The institutional review boards of both the participants’ institution and of the researcher’s institution approved the study. Each student was given an informed consent form describing the study and potential risks. Neither the professor nor the researcher knew which students did not consent to participate in the study. Student names were removed from the data by a third party before being made available to the researcher.

Because this study was based on a convenience sample, caution should be used when generalizing the results of this study to other populations.

Measures

Pre- and post-tests. Shortly after the beginning of the semester after the drop/add date had passed, a 100-item multiple-choice pre-test was administered to all three sections. At the end of the course, the same instrument served as a post-test.

Quizzes and tests. During the semester, a short quiz was administered at the beginning of most class sessions. The quizzes covered the content of the readings assigned to all three sections and the pre-recorded lectures assigned to the flipped class section. Five tests were also administered over the course of the semester. The quizzes and tests were identical for all three sections.
Course grade. The final course grade was determined and weighted as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes (17 total) and attendance*</td>
<td>8%</td>
</tr>
<tr>
<td>Abstracts and research paper</td>
<td>20%</td>
</tr>
<tr>
<td>Assignments</td>
<td>12%</td>
</tr>
<tr>
<td>Tests (total of 5, including final exam)</td>
<td>60%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Students with unexcused absences received a zero on the daily quiz.

Lecture capture viewing statistics. The professor used Panopto Focus (http://www.panopto.com) to record the lectures in his office for the flipped section, and in the classroom for the traditional lecture capture section. Links to the recordings were automatically populated into that section’s website in Blackboard 9, the college’s learning management system (http://www.blackboard.com).

The Panopto management console allows tracking of student viewing statistics, so at the end of the course those records were examined to determine which students had watched which videos. The 15 required videos for the flipped section ranged in length from 6 minutes to 43 minutes, with a mean of 28 minutes. The 18 videos of the lecture-captured section ranged in length from 19 to 43 minutes, with a mean of 30 minutes. Only the lecture part of the 50-minute class period was recorded; administrative activities were not.

End-of-course survey. At the end of the semester, students in the two sections that used lecture capture were asked to complete an anonymous survey about their experiences using the recordings. The professor will use the results to make adjustments to his use of lecture capture in future courses, and the student comments were helpful in understanding the empirical data from this study.
Results

To determine the effect of lecture capture technology on student academic achievement, a comparison was made between three sections of the same course: no access to recordings, access to recordings before class, and access to recordings after class. One-way analysis of variance calculations were used to calculate student achievement on daily work, unit work, and course grade. Viewing statistics from the lecture capture server were used to determine the student usage of the recordings.

Cumulative GPA was used to determine if the sections were equivalent in regard to academic ability. A one-way ANOVA showed that there was no significant difference (p > .05) in the mean GPA between the three class sections (F=2.06; p=0.138).

Quiz scores measured students’ daily work. Since the quizzes were administered at the beginning of the class period, and students in the flipped classroom section had the benefit of watching the lecture before each quiz, we expected those students to have the highest cumulative quiz scores. Although their quiz scores were higher than the other two sections, the difference was not significant (p > .05), as shown in Figure 1.

Figure 1: Quiz Scores versus Class Type

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Type</td>
<td>2</td>
<td>361.3</td>
<td>180.6</td>
<td>2.26</td>
<td>0.115</td>
</tr>
<tr>
<td>Error</td>
<td>51</td>
<td>4082.0</td>
<td>80.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>4443.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 8.946  R-Sq = 8.13%  R-Sq(adj) = 4.53%

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>Individual 95% CIs For Mean Based on Pooled StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>22</td>
<td>76.24</td>
<td>9.221</td>
<td>(-----------------------------------------------)</td>
</tr>
<tr>
<td>Trad LC</td>
<td>18</td>
<td>70.756</td>
<td>8.735</td>
<td>(-----------------------------------------------)</td>
</tr>
<tr>
<td>Control</td>
<td>14</td>
<td>71.300</td>
<td>8.768</td>
<td>(-----------------------------------------------)</td>
</tr>
</tbody>
</table>

Pooled StDev = 8.946
Test scores measured students’ understanding of each unit. Because class sessions of the flipped section had the benefit of extra reinforcement and application of the lecture content, we expected the flipped class section to perform better on the tests, illustrating a deeper understanding of the concepts. Results showed that the difference between the sections was significant (p < .05), although only slightly higher than the control group, as shown in Figure 2.

**Figure 2: Test Scores versus Class Type**

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Type</td>
<td>2</td>
<td>644.1</td>
<td>322</td>
<td>4.35</td>
<td>0.018</td>
</tr>
<tr>
<td>Error</td>
<td>51</td>
<td>3779.1</td>
<td>74.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>4423.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 8.608  R-Sq = 14.56%  R-Sq(adj) = 11.21%

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>22</td>
<td>86.250</td>
<td>7.843</td>
</tr>
<tr>
<td>Trad LC</td>
<td>18</td>
<td>78.817</td>
<td>9.998</td>
</tr>
<tr>
<td>Control</td>
<td>14</td>
<td>85.964</td>
<td>7.786</td>
</tr>
</tbody>
</table>

Pooled StDev = 8.608

Course grades measured student learning over the course of the semester. Because test scores comprised 60% of the course grade, we expected the flipped class would have higher course grades, followed by the traditional lecture capture section. The mean of the flipped class was higher than the other two sections, and the mean of the traditional lecture capture section was higher than the control group. However, the differences between the three groups were not significant (p > 0.05), as shown in Figure 3.
The results of the post-test scores showed a 44% improvement over pre-test scores with very little difference between the sections. The post-test was administered immediately following the final exam at the end of the semester and students knew that it had no bearing on their course grade. The proctor reported that some students completed the test in a very short amount of time, calling into question the validity of the results. Therefore, we determined that the best measures of student achievement were quiz scores, test scores, and final course grades.

In addition to student scores, student viewing data from the Panopto lecture capture system was examined. The viewing records showed that only four students out of eighteen in the traditional lecture capture section viewed a total of five recordings between them, even though over 60% of the students in that section (which met at 2 p.m.) were athletes who occasionally had to miss class for travel to athletic competitions.

At the opposite end of the spectrum were the viewing statistics for the flipped class section. The lecture capture system logged 289 actual views out of 330 potential views (22 students x 15 videos), representing an 87.5% viewing rate by this group of students. Half of
the students watched all fifteen required pre-recorded videos, and all students watched over half of them, as shown in Figure 4. The logs also indicate that in most cases the students watched the full recordings and not just parts of them.

Figure 4

Pre-recorded lectures viewed by students
Number of students: 22
Number of required pre-recorded videos: 15
Discussion

When considering the effect of lecture capture technology on student achievement, we compared three sections of the same course: one had access to recordings before class, one had access to recordings after class, and one had no access to recordings. After examining quiz scores, test scores, course grades, and video viewing statistics, the results suggest that lecture capture technology can have a positive effect on student achievement in an undergraduate course at a small college, particularly under the flipped classroom model.

The flipped class had the highest mean score on all three measures. The difference in test scores was significant and may indicate increased learning because of the in-class activities. It also had higher quiz scores and end-of-course grades than the other two sections, although the results were not significant, perhaps because of the small sample size.

Because of the very low usage of the recordings by the traditional lecture capture section, no conclusions can be drawn about the effect on student achievement when students have access to the recordings after class. That section met in the afternoon and students occasionally missed class for athletic travel. If those students had taken advantage of the recordings as a study tool there may have been a greater difference between it and the control group. The fact that the students did not take advantage of the resource indicates a lack of need or a lack of motivation since there was no course requirement to do so. This is confirmed by a comment on the student survey: “I didn't think about it and if I missed I got the PowerPoint. That's much faster.”

An important finding of this study was the level of compliance by the flipped section in watching the required videos ahead of class. Even though the quiz scores were worth just 8% of their final course grade and 64% of the students were busy athletes, they did what they
were required to do and viewed the recordings before class. In fact, several students watched some of the recordings more than once. According to Dr. D. Pavlat (personal communication, May 14, 2012), “That level of compliance is huge. It’s like telling your team to go work out before they come to practice...and they do!” This bodes well for other professors who are considering adopting the flipped classroom model since its success is dependent upon students having the required content knowledge before they come to class.

For the students in the treatment sections, this was their first experience with traditional lecture capture and with the flipped classroom model. Even though they complied, student reaction to the flipped classroom model was mixed. Some of the comments on the student survey reflect the “unsettledness” described by Strayer (2007), indicating that there is a learning curve for students in adjusting to the flipped classroom model. There is also a learning curve for instructors, who must rethink and retool how they teach when adopting the flipped classroom model. There needs to be an alignment of all activities to the course learning objectives, as recommended by Corliss, et al. (2012), with the in-class activities applying and building upon the lecture content.

The finding of this study regarding the positive effect of the flipped classroom model on student achievement is consistent with other research. I have not encountered another study in which various measures of academic achievement were compared in three sections of the same course taught by the same professor. To insure enough data for the traditional lecture capture group, future studies should consider requiring students who miss class to view the recorded lectures, since course requirements appear to influence whether or not students take advantage of the lecture capture resources. If a pre-test/post-test model is used,
it also needs to be a course requirement and carry some weight so that students will take it seriously.

A major limitation of this study was the small sample size. There were 22 students in the flipped section, 18 in the traditional lecture capture section, and 14 in the control group. Another limitation was the lack of instructor experience with the flipped classroom model. Future studies should consider using larger samples and, to more fully realize the effect of the flipped classroom model, with a professor who has been through at least one semester using the model. That said, an important strength of this study is the fact that it took place in a live educational setting with a professor who had little experience using lecture capture technology and no experience with the flipped classroom model. This may mean that it accurately reflects the results that other professors will encounter the first time they incorporate the use of lecture capture technology into their courses.
Summary

This study found that lecture capture technology when used in a flipped classroom setting may have a positive impact on student academic performance. Students in the flipped section had slightly higher scores on quizzes and tests and received higher course grades than students in the other two sections. Although only the test score differences were statistically significant, the results do indicate the model's potential to impact student learning.

Especially noteworthy was the 87.5% compliance by the students in the flipped section in watching the assigned videos before class. Because the success of the flipped model depends on students being prepared for class, this may be encouraging to instructors who are considering adopting the flipped classroom model.

Students in the traditional lecture capture section watched very few recordings. Because of the small class size and low usage, there was not enough data to determine how access to recordings after the lecture might impact student achievement. This may be due to the fact that they were not required to view the recordings, and students who missed class used other mechanisms to catch up.

Although this study attempted to quantify the effect of lecture capture technology on student achievement, it should be noted that the technology itself does not produce the effect-effective pedagogy does. As Miller (2012) explains, "The focus should be on teacher practice, then tools and structures. The flipped classroom is one way to help move teachers toward better teaching but does not ensure it" (para. 8).

The flipped classroom model is most successful when it is closely tied to curricular goals, and out-of-class learning materials are closely aligned with in-class activities without being redundant (Corliss, et al., 2012). Although the pedagogical shift from "sage on the
stage” to “guide on the side” may cause students some initial discomfort, it can increase student learning through active engagement with the subject matter, with the instructor, and with each other. When that happens, lecture capture technology is a worthwhile investment.
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