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Video Supported Flipped Classroom

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This paper addresses the use of video for a flipped classroom with a case study. The instructor makes the lecture videos available to the students prior to class, and utilizes the class time for discussion and student questions. We evaluate this approach with an introductory psychology course that was taught repeatedly in a traditional way and as a lecture video supported flipped classroom. The evaluation is based on assessing i) student perception of this instruction model, ii) teaching and course evaluations, iii) instructor satisfaction, vi) student performance, and v) video usage analytics. An overwhelming majority of students stated that they prefer this combination of video and class discussions to a traditional class. The instructor expressed a higher level of satisfaction for this style of a flipped classroom over a traditional classroom. However, confounding variables in the structuring of the course prevent us from making firm conclusions about student performance.

Keywords: Educational technology, flipped classroom, instructor perspective, lecture videos, student perspective

INTRODUCTION

STEM classes are generally taught using a traditional face-to-face lecture style. However, research supports the idea that student centered learning approach helps students understand the concepts better compared to a didactic style teaching centered approach. Lord and Camacho, (2007) conducted a survey on the attendees of Frontiers in Education (FIE 2006). The conference reported that only 36% of respondents think traditional lecture is a good teaching approach, although 60% of the respondents reported that they still teach that way. This result clearly indicates that faculty members using traditional lecture courses do not necessarily like or believe in the method.

Flipped classrooms have gained significant attention in recent years. Flipped learning is 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 where the educator guides students as they apply concepts and engage creatively in the subject matter (Hamdan et al., 2013). The main goal of flipped learning method is to promote active learning using various student centered activities such as group work, debates, peer-review, self-review and case studies (Crouch and Mazur, 2001; Lage et al., 2000). In a face-to-face class the instructor delivers lectures to the student in a monological and "sage on the stage" style, whereas in a typical flipped classroom, learning material is posted on a Learning Management system (Tucker, 2012). Students are required to watch the videos and/or read the materials before coming to the class. The in-class time is used for engaging students with various activities such as discussions, quizzes and problem solving - individually or in a group. Students take the ownership of learning by taking part in active learning activities (Pierce and Fox, 2012), while learning the basic material at their own pace and schedule. Flipped classrooms also empower instructors to develop different learning experiences appropriate for each student, thereby allowing personalization (Bergmann and Sams, 2012). The idea of a flipped classroom is also supported by several pedagogical theories, such as Blooms Taxonomy. The higher order tasks such as Applying, Analyzing, Evaluating and Creating are done in the classroom in the presence of the instructor and peers. And the lower order tasks such as remembering and understanding happen outside the class.

Even though the concept of a flipped classroom is not new, instructional technology is becoming more sophisticated allowing methodologies that were not feasible even a few years ago. The work in this paper is enabled by the fact that high quality recorded lecture videos that partially simulate an actual lecture can now be easily created with minimum cost by an instructor.

This paper presents our experience in flipping a STEM course, specifically an introductory course on *Physiological Psychology*. The methodology is supported with ICS Videos, a technology that eases access to the content of interest in a lecture video with topic based indexing and textual search. The course was taught in traditional style for 3 offerings over 3 years, and then taught with a flipped classroom for another 3 offerings over 3 years. The evaluation involves student surveys, instructor interviews, video analytics, and student performance. The model and technologies received high marks from the students. This paper presents an experience report that is directly relevant to any instructors looking to flip STEM courses, or looking to improve a flipped class.

This paper is organized as follows. Section II discusses prior work related to video supported flipped classroom. Section III presents the ICS videos framework that is employed to support flipped classroom. Section IV explains the methodology used for teaching a specific flipped STEM course. Section V presents the results of the evaluation of this flipped classroom based on student experience, instructor experience, video analytics, and student performance. Section VI contains conclusions.

RELATED WORK

Flipped classrooms, if used properly, can produce many positive effects on STEM students, such as student performance, student success, mastery over the subject, personalization, improving student innovation, student cohesion, task orientation, and cooperation. The shifting of direct instruction outside the class allows for active learning, such as project and problem based learning (Overmyer, 2007). Related work supports the fact that flipped classrooms allow students to move at their own pace. At the same time, instructors understand student difficulties and learning styles better, and can customize and update the curriculum quickly leading to a more creative and effective classroom. Student achievement, interest, and engagement are usually higher (Fulton, 2012). Shumski (2014) reported that several leading higher education institutions have implemented flipped classrooms with positive results. It was discovered that flipped classrooms lead

to increased student engagement (Bergmann and Sams, 2012; McLaughlin and Glatt, 2013; Stone, 2012) and more instructor satisfaction and freedom (Aronson et al., 2013; Bergmann and Sams, 2012; O'Flaherty and C. Phillips, 2015). The very nature of a flipped classrooms, such as having preparatory work done before coming to the class and engaging more in class, improves student ownership of their learning.

A number of studies have indicated that a flipped classroom leads to better student performance and thereby improved learning (Love et al., 2014; McLaughlin and Glatt, 2013; O'Flaherty and C. Phillips, 2015; Strayer, 2012; Tune et al., 2013). However, two studies (Butt, 2014; Strayer, 2012) reported that students in a flipped classroom may not be satisfied in the beginning; with the structure and responsibilities in the course, and also with a new domain of the learning environment with challenges and unclear goals. But this can ultimately be beneficial for them and can positively affect them by turning them more aware of the content and their own cooperative learning process. Additionally, studies have shown that flipped classroom decreases DFW percentage (Ds, Fs, withdrawals) (Ryan and Reid, 2015). Often critics argue that flipped classroom leads to the reduction of importance of a teacher by posting videos online. However, they often ignore the fact that recorded videos lectures are not the only point of a flipped learning method, but also effectively designing and using the face-to-face class in a more efficient way that enhances student engagement (Overmyer, 2007). The work presented in this paper leverages the existing research on flipped classrooms to develop a case study in flipped STEM coursework that can serve as a model of flipping with state of the art video technologies.

BACKGROUND

Video of classroom lectures is a versatile learning resource. Often Tablet PCs, which allow free mixing of prepared (PowerPoint) viewgraphs with hand annotations and illustrations, are employed for teaching and simultaneous recording of lectures. Advantages include excellent resolution, as the video consists of PC screen shots, and low video production cost, as no camera or operator is needed. The videos typically include whatever the professor is projecting on the screen (e.g., PowerPoint slides, animations, annotations, formulas, algorithms, or drawings) and the instructor's voice. A major weakness of the video format is the inability to quickly access the content of interest in a video lecture. ICS videos: videos enhanced with Indexing, Captioning, and Search capability were designed for quick access

to video content. Indexing adds logical index points, each in the form of a snapshot representing a video segment that can be accessed directly; Captioning adds the transcript of the video lecture in a separate panel; Search enables identification of video segments that match a keyword provided by the user. A snapshot of the player highlighting the key features is shown in Figure 1. The framework is discussed in detail in (Tuna et al., 2011; Tuna et al., 2012; Tuna et al., 2015).

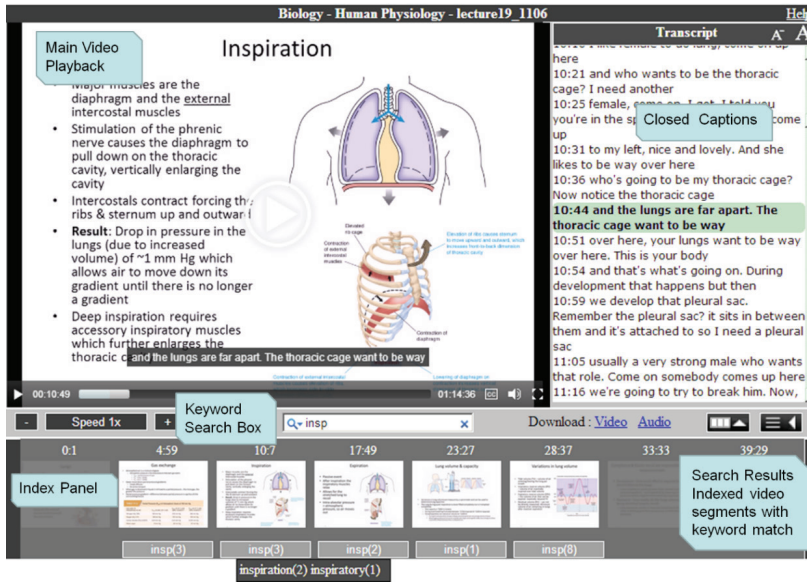


Figure 1. A snapshot of the ICS video player used for flipped classroom.

In previous studies with ICS videos (Tuna et al., 2012; Tuna et al., 2017), students were asked to rate the importance of lecture videos in comparison to other resources made available by faculty, including professors' lecture notes, students' own notes, and the textbook assigned for each class. The results are shown in Figure 2. The students gave the highest ratings for professors' lecture notes, 84.0 percent of the students considered them to be *very important*, followed by lecture videos, with 63.6 percent of students reporting that this resource was *very important*. The results support earlier studies that have shown that providing full or *complete* lecture notes can be beneficial to students (Babb and Ross, 2009;, Grabe, 2005; Grabe and Christopherson, 2005).

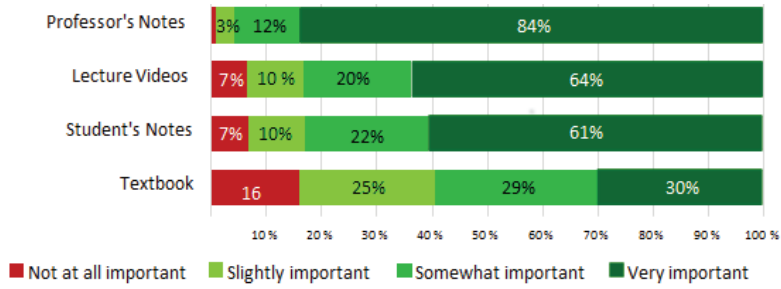


Figure 2. Student ratings of the value of studying resources.

Figure 3 shows how students used the videos. The most common usage of videos was reviewing the material that was difficult, or reviewing to prepare for quizzes and exams. Videos were also used as a replacement for attending the class. In our studies, the student attendance did not decrease with the availability of videos.

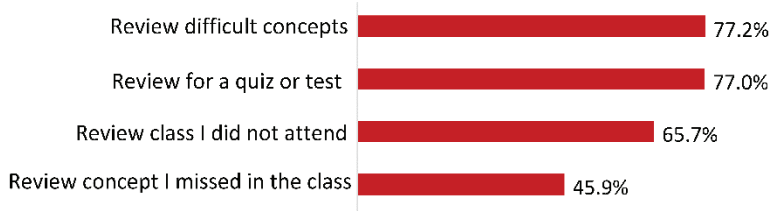


Figure 3. Student-selected purpose of video use.

Previous research presented clearly demonstrates that i) PC based video lectures are a very valuable student resource, ii) the framework developed to enhance videos with indexing and search features is efficient, effective, and a significant improvement over the state-of-the-art, and iii) indexing and search capability significantly enhance the value of lecture videos.

CASE STUDY: VIDEO SUPPORTED FLIPPED STEM CLASSROOM

This paper is based on our experience with flipping a STEM class at the University of Houston with the help of ICS videos framework. The course is *Physiological Psychology*, a junior undergraduate level class taught by one of the authors (Leasure) with a typical enrollment a little over 100. The class was offered in a traditional face to face style prior to Fall 2013. The reason to explore a new pedagogical style was to improve the learning ex-

perience and learning outcomes. University of Houston is a large urban university with a diverse student body. Many students commute to reach classrooms, often for an hour or longer. The students in the class had a variety of skill sets and knowledge bases. For all the above reasons, students are likely to benefit from flexible access to class content.

The basic methodology employed in the flipped classroom was that the students learn and predigest core class content from lecture videos at their own pace before coming to the class. The classroom time is spent addressing student questions and covering application of the material in the lectures. The specific instructions given to the students were as follows:

- Watch lecture videos posted online using the ICS platform.
- After watching a video, take a 10 minutes break.
- After the break, work on worksheets without looking at the videos. Review the video again if needed.
- Come to the class with questions.
- A closely related topic will be covered in the class. The background information learned from the video and worksheets is required to understand the class content.

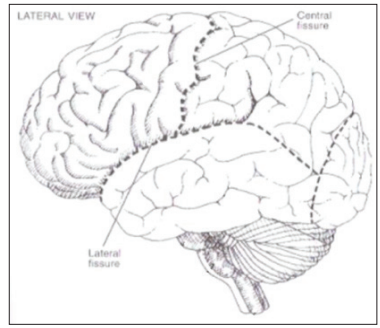
We explain some of the details of the flipped class methodology outlined above. The lecture videos posted online were recordings of actual classes taught in a previous semester, or similar recording made specifically for the class. They were PC recordings containing viewgraphs (typically PowerPoint), live annotations, and audio from the instructor. ICS videos provides a platform for the students to easily access content of the lectures. Videos are segmented by topics and keyword search inside a single lecture as well as across the lectures in the class is supported. Details are discussed in section III.

As part of the pre class activities, the instructor also provides worksheets for each recorded lecture that is posted online. An example worksheet is shown in Figure 4. Each worksheet contains exercises and/or diagrams designed to help the student learn the information, and sample questions for testing their knowledge. Students are required to complete the worksheet after they watch the recorded lecture. The instructor provides guidelines for using the worksheets. After watching a video, students are advised to take a short break of 10 minutes, and then attempt to complete the worksheet. If they have difficulty in answering any of the questions, they are advised to identify and re-watch the relevant parts of the video[1]. If the students have any questions regarding the worksheet or the content of the video lecture, they are encouraged to bring them to the class.

[1]However, students are advised not to do the worksheets while watching the videos. Because, we believe solving worksheets while watching videos does is not a good practice for learning.

STRUCTURE OF THE BRAIN

In the diagram, label the four lobes of the brain and the cerebellum. In addition, name one major function associated with each. Feel free to use color if you wish. As we progress through the semester, use this worksheet to fill in more information, like specific gyri or functions of the different lobes as we cover them.



REVIEW QUESTIONS

1. Dorsal is to ventral as _____ is to _____.
   a. side: edge
   b. behind: above
   c. top: bottom
   d. back: front

2. Cats puff themselves up with they are frightened. What nervous system allows them to do this?
   a. somatic
   b. parasympathetic
   c. enteric
   d. sympathetic

Figure 4. Worksheet example used for reviewing course material after watching the video.

In class, the instructor answers the questions about the recorded lectures and also goes over the worksheet. Subsequently, the instructor moves on to a related interactive discussion. Typically, this portion of the class is employed to discuss a topic which builds on, or is an application of, the concepts in the video lecture. For example, if the topic of a lecture is Development & Plasticity, then the class discussion may be on Brain Damage & Repair.

As part of the assessments, there are three regular in-class exams and one comprehensive final. The exams are of multiple choice in nature. Only the final exam is mandatory. Students are also given chances to earn extra credits.

EVALUATION

The purpose of the evaluation was to understand the impact of flipping of the *Physiological Psychology* course on student learning and student experience, as well as instructor experience. The evaluation was based on the following: i) student surveys conducted to evaluate the lecture videos and flipped classroom, ii) standard instructor and course evaluations mandated by the university, iii) video usage analytics, and iv) interview with the instructor. We discuss these aspects of evaluation.

Student Surveys

Customized student surveys were conducted to develop an understanding of the overall perceived value of the video lectures as well as the value of video supported flipped classroom. Such surveys have been administered for over 7 years for a variety of traditional courses enhanced with videos (Tuna et al., 2017). Figures 5-8 show the responses to the surveys for the *Physiological Psychology* course from Fall 2013, Fall 2014 and Fall 2015 semesters.

Figure 5 shows that an overwhelming majority of students watched all or almost all the videos. This is an expected result as the course is closely tied to videos. Figure 6 shows that students overwhelmingly watched videos before the corresponding classes and before tests and exams. A majority of students also agreed that they watched videos after the corresponding classes for the purpose of reviewing.

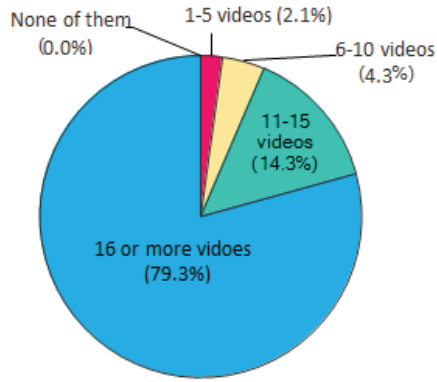


Figure 5. Question: "How many videos did you watch out of 18 videos?"

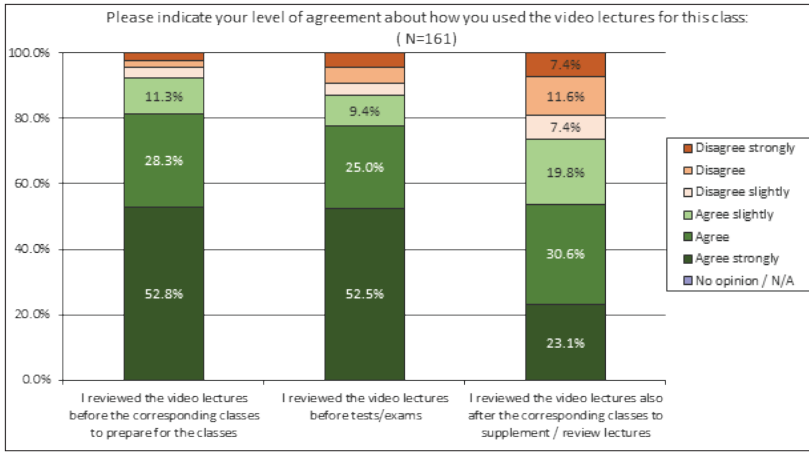


Figure 6. Question: "How did you use the videos for the class?"

The students were also queried about their opinion of the content of the lecture videos. The results plotted on Figure 7 clearly indicate that the students perceive the videos to be informative, interesting, of appropriate length, and they consider the content of the lectures to be appropriate for the video format.

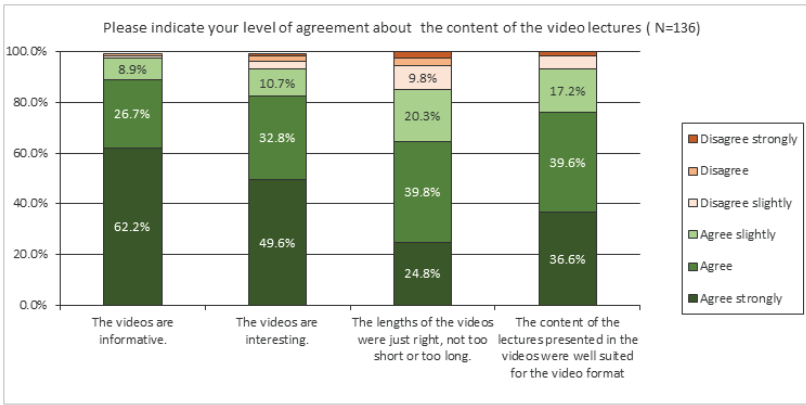


Figure 7. Question: "How was the content of the videos?"

The students were asked a set of survey questions about the dynamics of video supported flipped classroom. The survey responses are plotted in Figure 8. Almost all students agreed that the review of video lectures was

important to follow classroom discussions; this is expected but does verify that the organization of the class worked as designed. Around 80% of students agreed to various degrees that the video was a faster and more effective way to cover material than a face to face lecture. There was a similarly positive agreement to the question that this combination of video and in-class discussion was preferable to a traditional classroom. Hence, it is fair to say that the students were very enthusiastic and positive about this video supported flipped class.

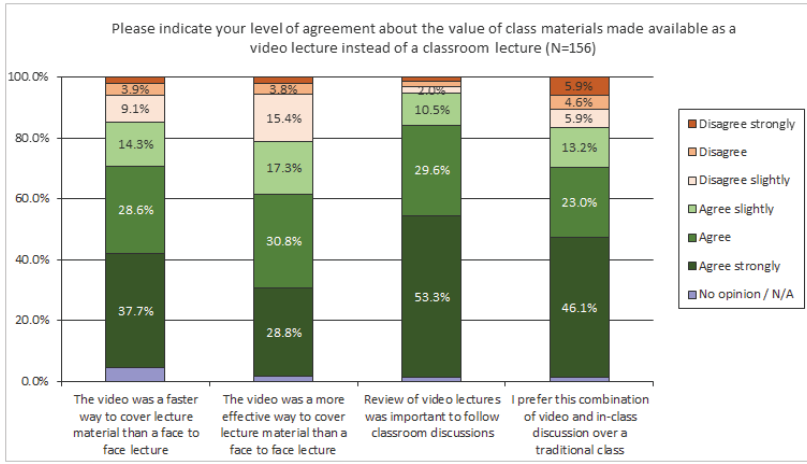


Figure 8. Question: "What is your view about flipped classroom?"

In addition to the rating questions, students also had the opportunity to leave open ended comments. We present a sampling of comments that are representative of the comments received:

"Great and interesting way to do lectures. You have your own time and pace to write down your notes. Also, get to hear your professor lecture for however many times you want before an exam."

"I think every class should use this way to teach. It helps cater to students who learn in different ways, and is especially great for students who have really busy lives. However I don't believe this way of teach would be as effective WITHOUT the face to face class time, and for student who only watched the lectures I feel they didn't get as much out of it as the student who went to class. This way of teaching leaves most of the class to go over any and every students question and as a refresher of what we learned. This is especial important in classes that have a large number of students. I truly believe this is the way to teach, coming from someone who failed the class

the first time and is more than likely coming out with a B this semester."

"Great tool for studying and the difference between me passing and failing this class, and really being able to understand the material. Good job, and thank you for your hard work and dedication!"

"The videos were accessible and informative. However, the combination of attending lecture for 3 hours per week, watching over an hour of video every week, and then studying the material learned was too much of a time commitment for one class. Many UH students work over 20 hrs/week. I found the videos very difficult to keep up with."

"The indexing feature, in my opinion, is one of the best parts regarding this video player. It separated the lecture into reasonably sized sections and made it easy to know where to pick a lecture back up if I had to stop watching for a while."

"Videos helped to improve our learning."

Course/Instructor Evaluations

Like most universities, University of Houston has a standard course evaluation process. The students fill an evaluation form that includes scoring the course and the instructor on various metrics, as well as responses to open ended questions. We analyzed the course evaluation forms for all the sections of the *Physiological Psychology* course that are covered in this study. Evaluations for all sections prior to flipping were combined, as were evaluations after flipping.

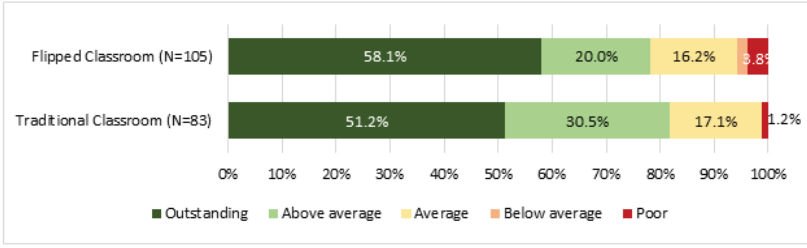


Figure 9. Question: "The overall quality of the course is:"

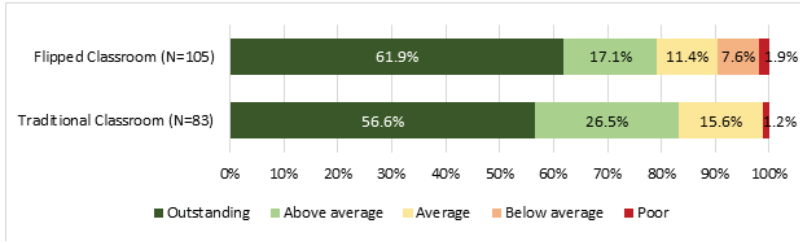


Figure 10. Question: "The overall teaching effectiveness of this instructor is:"

Figures 9 and 10 summarize the numerical scores on the overall quality of the course and the teaching effectiveness of the instructor. First, we note that all teaching evaluations are very positive. Transitioning from traditional to the flipped formats, the percentage of students rating the course quality as well as the teaching effectiveness of the instructor as "Outstanding" rose modestly, by 7.1% and 4.3%, respectively. At the same time, the negative ratings also rose slightly. We should be cautious that the course has been evolving over time, and flipping is not the only thing that changed. We cannot draw a clear conclusion, except that the results are overall positive, but some students probably have negative feelings about a flipped classroom.

Another survey question of interest is the perceived workload in a course as compared to other courses. The results plotted in Figure 11 show that the perceived workload was slightly lower for the flipped classroom as compared to the traditional classroom.

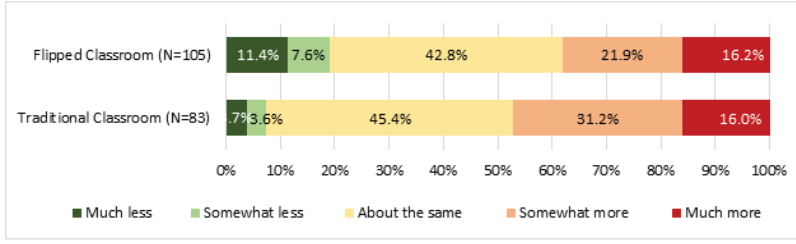


Figure 11. Question: "Compared to other courses at the same level, the amount of work I did was:"

There is also a question in the evaluation that investigate how many classes were missed by a student. The results are plotted in Figure 12. A small fraction of students, around 10% reported missing a quarter or more of the classes with a flipped classroom, as compared to fewer than 2% for a traditional classroom. This is not unexpected as it becomes possible to keep

up with a class through lecture videos in the flipped classroom. However, the interesting observation is that an overwhelming majority of the students (around 90%) missed none or only a few classes with the flipped classroom. Hence, posting lecture videos does not lead to large numbers of students not attending classes.

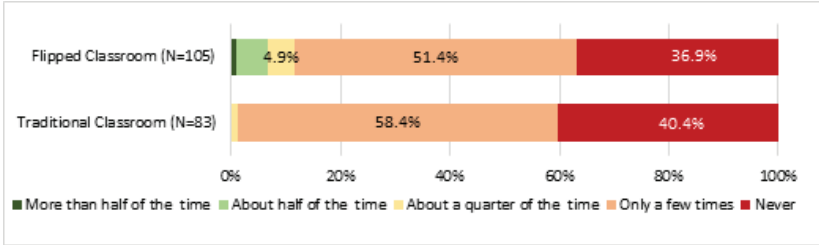


Figure 12. Question: "How often did you miss class?"

Finally we analyzed the comments left by students that related to the lecture videos or the flipped classroom format. The comments were overwhelmingly positive and broadly similar to the comments in the optional video survey we reported earlier in this section. We list a few sample comments here that reflect a large fraction of the comments that were received.

"I love the fact that she provided video lectures to the material we need to study. That gives the opportunity to have the lectures at home or wherever at any time."

"Having the class flipped, the video player worked well and it was very helpful to be able to pause, change the speed and rewatch the videos. I highly recommend following the flipped format for the future classes. I wish more classes were taught this way."

"I really liked that the class was "flipped", meaning we watched the full lectures at home and then in class we clarified topics and discussed advanced topics based on the lecture. This gave us time to absorb the material and the ability to go over something again if we wanted. I also think the material was very interesting and Dr. Leasure presented it in an engaging manner. She encouraged class participation and went over concepts again if students were confused."

"Maybe instead of making students watch separate lectures online just have them taught in class it just creates more confusion."

Instructor Experience

As part of the evaluation, we interviewed the instructor about her perception and experience teaching this course in the flipped format. She was able to cover more material and provide more training in applying the material learned. The workload was reported to be similar to a traditional class, although the time was spent differently. And she reported that it was more satisfying and fun to teach the flipped class. Following is a paraphrased interview with the instructor.

1) *Your subjective perception of what they learned in class with flipping that is different from what they learn in the regular lecture?* In my flipped class, I am able to cover more material than in a traditional lecture-based class. Students watch the recorded lecture, digest it, and answer questions on a worksheet that I provide them. Then in class, we apply the material they learned in the recorded lecture to a closely related topic. This both extends what they learn and helps them consolidate information via its application.
2) *Your workload in teaching a flipped class?*
   My workload is the same, it is just distributed differently. I record my lectures during the summer in a traditional-format, small class. I upload all those lectures, prepare worksheets for each and also prepare slides for the related material that we will cover in class. By the time the semester starts, I have got everything done, and the class drives itself.
3) *Your experience teaching a flipped class. Is it more or less pleasant than the traditional lecture class?* For me, teaching a flipped class is more fun. For one thing, the students ask more informed questions than they do in a traditional lecture (probably because they have had time to digest the material), and sometimes those informed questions spark some discussion. Another reason a flipped class is more fun is that the closely related material that I teach in class is stuff that I usually did not get to cover in a traditional class. The closely related material (for example, brain repair mechanisms) is usually cutting-edge stuff that we would get to in the traditional course only if we had time. Now, we always have time!

Video Analytics

In an attempt to further understand the learning habits of students in a lecture video driven flipped classroom, we analyzed the usage patterns of lecture videos from system logs. The results from Fall 15 are plotted on Figure 13. The graph shows the total number of weekly lecture video accesses over the semester, and marks the dates of the tests and exams during the course. The key observations are as follows:

- The videos are accessed routinely over the semester, as expected for a flipped class.
- There is an increase in the usage of videos immediately prior to tests, and a large increase in video usage prior to the final exam.

These observations support our perception of how students employ videos in a flipped class.

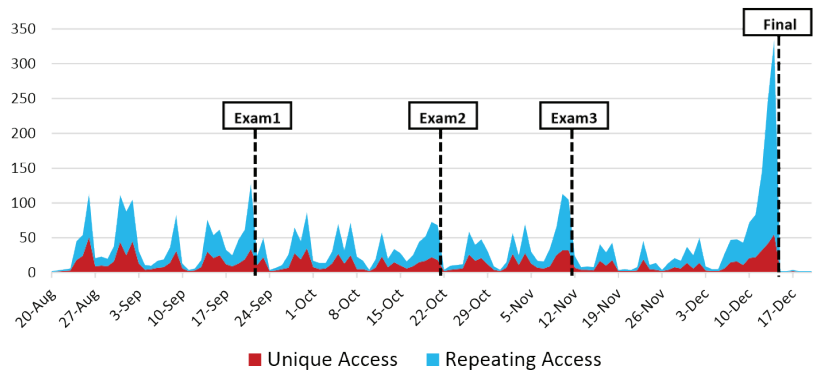


Figure 13. Video access pattern for fall 2015: unique and repeating video accesses.

Grades and Scores

Table 1 reports grade distribution for the section of Physiological Psychology class taught by Dr. Leasure between 2010 and 2015 - 3 times in the traditional format and 3 times in the flipped format. The results show that the students did significantly worse in the flipped class format versus the traditional format, which was very discouraging. However, further investigation revealed that the causes were unrelated to the flipping of the class. They were largely attributed to a change in the structure of this class

whereby the tests during the semester were made optional and only the final was mandatory. Coincidentally this change was introduced at precisely the same time as the flipping of the class. Hence we are unable to draw any conclusions about the impact of flipping on student grades. However, there is no doubt that flipping is not the reason for a substantial worsening of the grades that was reported. In fact, as a result of this study, the course instructor has decided to reverse the practice of optional tests. We hope to report on the impact on grades in the future without this confounding variable. While we are not able to draw any conclusions about the impact of flipping on grades from this study, it is important to note that all aspects of a course must be rethought when it is flipped.

Table. 1
Grade distribution of Physiological Psychology class for different semesters

	Traditional classroom			Flipped classroom		
	Spring 2010	**Fall 2010**	**Spring 2012**	**Fall 2013**	**Fall 2014**	**Fall 2015**
A	25 (27%)	22 (14%)	12 (14%)	24 (15%)	16 (8%)	4 (6%)
B	26 (29%)	39 (24%)	28 (31%)	29 (17%)	42 (22%)	16 (22%)
C	18 (20%)	48 (30%)	19 (21%)	39 (24%)	49 (26%)	12 (17%)
D	7 (8%)	25 (16%)	12 (14%)	44 (26%)	33 (17%)	19 (27%)
F	3 (3%)	16 (10%)	14 (16%)	29 (17%)	39 (21%)	17 (24%)
W	12 (13%)	9 (6%)	4 (4%)	2 (1%)	11 (6%)	3 (4%)
Total	91	159	89	167	190	71

CONCLUDING REMARKS

This paper presents a case study of flipping a STEM course with ICS Videos; an advanced video technology that allows students to access content of interest in a lecture video with indexing and search. The course *Physiological Psychology* was taught three times as a traditional course and 3 times as a flipped course over the course of 6 years. The course structure involved student viewing lectures before every class, and the class meetings were spent on answering questions and applying the knowledge learned from the video lectures.

The result from the evaluation showed very high satisfaction among the students. Course and instructor evaluations were very positive, and overall modestly improved from traditional classroom to a flipped classroom. The

instructor reported similar time investment for the traditional and flipped version of the class, but a higher level of satisfaction with the flipped class. The impact on grades with flipping could not be established because of a confounding variable, namely the removal of mandatory quizzes during the semester. Nevertheless we believe the course methodology is successful, and can serve as a model for other STEM courses.

Acknowledgments

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