Access Patterns and Learning Outcomes associated with Online Videos in a "Flipped Classroom" in a minority-serving post-baccalaureate program.

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Abstract:

This study investigates the impacts of assigned online videos on student learning. In an introductory biology course, students watched 7 short (~20 min) online videos for a digestion unit, combined with active learning in class. By tracking access, one-third of students were found to be avid watchers, viewing each video twice, while two-thirds of students were poor video watchers, watching ~ 30% of video content. Test performance in this "flipped classroom" was only marginally better than in a previous cohort taught traditionally, and poor video watchers did not significantly perform worse than avid watchers (they appear to have used other resources). Nearly all surveyed students had very positive feelings about the flipped classroom. In a biochemistry class, students watched 8 short (~20 min) introductory videos followed by a quiz, over one semester. Video watching was consistently above 80 %, and, on a final exam, students performed equally well on pre-lecture video questions and questions on basic material taught in class. These data suggest videos work well to teach introductory material and free up class precious time, are generally well-received, but only utilized by about 1/3 of students if viewing burden is heavy or students are not incentivized.

I. Subject/Problem

Research in science education suggests that active learning strategies, including in-class problem solving, case studies, and problem-based learning, result in greater student engagement and satisfaction, and may increase learning (National Research Council, 2012; American Association for the Advancement of Science, 2011; Allen, Donham & Bernhard, 2011).

Online course components serve a similar purpose. Riffell and Sibley (2004) found that replacing a lecture course with a hybrid course that included online assignments in lieu of lecture led to increased student engagement. McFarlin (2008) found that student grades improved by 10% when a traditional lecture course was replaced with a hybrid course including course materials and activities on a Course Management System (CMS). Similarly, Moravec, Aguilar-Roca & O'Dowd (2010) found that student test performance increased when materials were introduced in online assignments and expanded on with problem-solving activities during lecture.

Data such as these have led to increased interest in a *flipped classroom* model of teaching, recently popularized by Salman Khan of the "Khan Academy" (Berrett, 2012; Sparks, 2011), in

which rote content learning and lecture activities are moved onto online modules. This allows class time to be spent on problem solving or other active student engagement strategies. However, little is known how students engage with such modules.

In this study, patterns of access to assigned online videos were examined in a biology and biochemistry course taken by pre-medical majors. Videos were used in two different ways: as complete replacement for in-class lectures (for one unit of the biology course) and as "pre-lectures" used throughout the semester to learn/review basic material before class (biochemistry course). Besides tracking time spent by students on each video in both courses, student performance on units utilizing online videos was compared to student performance when students were taught in a more traditional manner. The study had four research aims: 1. To determine the extent to which students in the course accessed videos; 2. To determine if immediate quizzing on video topics increased student compliance in watching assigned videos; 3. To determine student interest in video instruction; and 4. To determine if students performed differently on tests of material taught in-class versus online.

II. Study Design and Methods

The study was performed in two courses taught in a post-baccalaureate premedical program: an introductory biology course, and a special topics course in biochemistry (medical approaches to biochemistry).

Video presentation and assessment of learning outcomes: In the biology course, part of a team-taught 3-semester introductory biology/physiology sequence, this study focused on a unit on the digestive system. In a quasi-experimental design over two semesters, cohorts of ~30 students were taught a two-week unit on digestion using either a traditional or flipped teaching model. To determine cohort similarity, we compared previous semester GPA in three identical courses taken for the post-baccalaureate program as well as performance on a standardized test for students in both cohorts. In the traditional semester (spring 2012), material was presented via PowerPoint presentations, and notes were provided to students. In the flipped classroom method (spring 2013), lecture material was placed online as seven short (10-25 min) instructor-produced videos, supplemented with a copy of the video Power-point and instructor notes. Classroom time was spent focused on a case study, problem solving, question/answer sessions and group work. In both iterations of the course, students took an identical 6-item passage based exam at the end of the unit (as part of a larger midterm encompassing other units; exams were not returned).

In the biochemistry course, 15 students were enrolled in spring 2013. Students were required, through the course of the semester, to watch 8 brief (~20) minute instructor-produced "pre-lecture" videos and for each take a 30 minute, 10 point multiple-choice online quiz as part of their course grade (13% of total grade). At the end of the semester, student took a closed book, multiple-choice comprehensive final exam. For this exam, an internally controlled study design was used in which performance of the same student cohort on introductory material covered in pre-lectures was compared to their performance on introductory material not covered in pre-lectures.

Access pattern analysis. Student usage of online videos in both courses was tracked using the "Desire-2-Learn" (D2L) Course Management System (CMS). The time each video was accessed by each student (in minutes) was recorded. To compensate for different video running times (between 10 and 25 minutes), each access time was converted to a percentage of the video length. The percentages of students that accessed each video were also tabulated. In addition, the authors determined whether each student had downloaded the accompanying PowerPoint files for each video by checking file access logs on D2L.

Attitudes survey. Students in the 2013 biology class were asked to anonymously complete a 16-item Likert-scale survey of attitudes towards online videos and active-classroom activities. Students ranked items from 1 (definitely disagree) to 5 (definitely agree). The survey included subscales for interest in online learning and interest in an active classroom, with some items reverse-coded. In addition, students were asked to rank which resources they used most in preparing for course exams. Students could rank up to 9 items from 1 (most used) to 9 (least used) but were asked to leave the item blank if they did not utilize the item (*e.g.* a paid tutor).

All statistical analyses were performed in PASW Statistics 18 (IBM) or Excel v11.6.6 (Microsoft, Inc.).

III. Analysis and Findings

The purpose of the current study was to better understand student engagement with online videos that accompany the flipped classroom instructional model. We aimed to determine to what extent students utilized assigned videos, if the use of the videos increased student interest, and the impact of videos on course performance. Students were assigned online videos in two separate courses: an introductory biology class and a biochemistry seminar course.

A. Biology Course. In the biology course, students were assigned the videos to watch outside of class, while class time was used for active engagement with material. Seven videos were

assigned with an average runtime of 17 min. Students expected to watch videos prior to class periods utilizing active learning strategies (over a 2 week span), but compliance was not monitored or tested. In the previous year, the same material had been taught traditionally, using assigned readings and lecture.

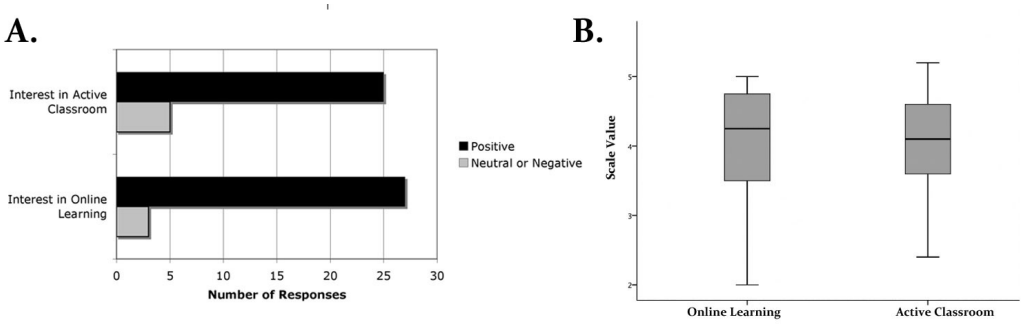

Fig. 1. Interest in online learning. A. Number of positive and neutral/negative responses on online learning survey (N=30). B. Distribution of average Likert-scale values for online learning and active classroom metrics.

When students were surveyed regarding attitudes towards the flipped classroom, results were overwhelmingly positive **(Fig. 1)**. The online interest metric averaged student responses to four items (e.g. online lectures are helpful to my learning; I get more out of online lectures than traditional lectures); the active classroom metric was an average of five items (e.g. in-class activities are helpful to my learning; classroom activities are a waste of time [Reverse coded]). Over 80% of students had positive responses, and the average Likert-scale value for both metrics was ~ 4 on a 5 point scale).

Although students professed to like online videos, we aimed to determine how frequently they were actually utilized. When video access times were measured, the average video viewing time across all videos for the 2013 biology cohort was 82% of the combined video length, suggesting a high viewing rate. However, **Fig. 2** also indicates that no more than 60% of students accessed any one video, and video access rates decreased with each subsequent video. On average, each video was accessed by about 39% of students. If the viewing patterns of the most engaged students (those watching at least 5 of the 7 videos) are analyzed (N=9), a very different pattern emerges **(Fig. 3).** These "avid watchers" not only watched most or all videos, they spent an average of *more than double* the running time with each video. It thus appears that about 1/3 of the class used the videos a lot, and the rest of the class used them hardly at all.

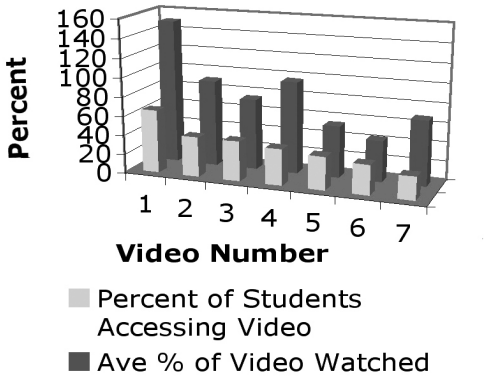

Fig. 2. Biology class video view patterns.

Next we examined how well the entire video cohort performed on a standardized test compared to the previous cohort. Because we compared two cohorts one year apart, we examined how well they were matched academically. We used three identical science courses (all part of the post-baccalaureate program (MP) taken by all students in the prior semester to calculate average GPAs, and also compared students' performance on the biology portion of MCAT Practice Exam 9 (AAMC), a computer-based test that we gave to all students under standard conditions at the start of the term.

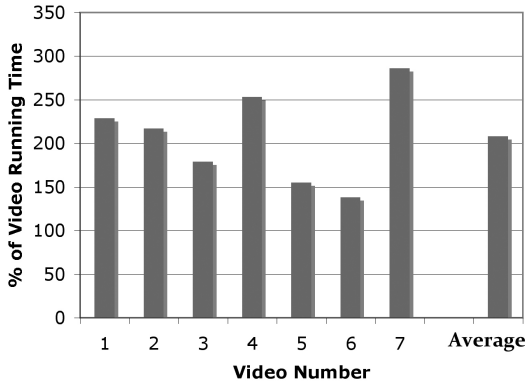

Fig. 3. Biology "avid watchers" view patterns.

The student cohorts were closely matched by GPA and performance on a standardized test (**Fig. 4A**). Then, to determine if biology students performed better with the flipped classroom, students in both years were given an identical six-item passage-based (MCAT style) exam at the end of the unit (exams were not returned). Students that were taught using the flipped classroom performed an average of 7% better on the digestion unit exam than students taught more traditionally (**Fig. 4A**). However, the sample size was too small to obtain statistical significance. In examining the six individual items, flipped-classroom students performed significantly better than traditional students

on two items ($p < 0.05$), moderately better on one item ($p = 0.07$), moderately worse on one item ($p = 0.10$) and about the same on two items ($p > 0.50$) (**Figure 4B**).

	2012	2013	p-value
Mock 9 MCAT Bio Score	7.43	7.43	p = 1.00
Prior Semester MP Science GPA	3.12	3.20	p = 0.51
Digestion Test Score	4 (67%)	4.41 (74%)	p = 0.18

Fig. 4A. Comparison of biology cohorts' exam performance.

Question	Year	Mean	Std. Dev	P-value
1	2012	0.81	0.40	
	2013	0.90	0.31	0.07
2	2012	0.44	0.50	
	2013	0.72	0.46	0.02
3	2012	0.84	0.37	
	2013	0.76	0.44	0.10
4	2012	0.75	0.44	
	2013	0.72	0.46	0.65
5	2012	0.41	0.50	
	2013	0.45	0.51	0.54
6	2012	0.75	0.44	
	2013	0.86	0.35	0.03

Figure 4B: Average item scores for individual digestion exam questions, 2012 and 2013 cohorts.

The performance of the "avid video watchers" (9 of 30 students) was then considered compared to poor or non-video watchers in the same cohort (rest of the cohort, 21 students). The difference in access time between these two groups was striking. While avid watchers averaged access time at 208% of the video run time (over all 7 videos), the rest of the cohort averaged only 32% of video run time (and only 15% of video run time if you leave the first video out of the analysis). In terms of academic performance, the results were mixed **(Fig. 5)**. Avid video watchers had slightly higher previous semester science GPAs and mock MCAT 9 biology scores, and performed slightly better on the unit exam. However, they scored more poorly on another mock

MCAT biology exam taken after the unit was completed. These data suggest that students may find different ways to learn effectively. Some non-video watchers may have effectively studied the material using only the PowerPoint file, or used suggested textbook reading, or additional instructor notes that were provided. Survey data of these students bears this out. When these students were asked to rank nine study tools from 1 (most important) to 9 (least important), overall they ranked instructor notes and textbooks as their top study tools. Instructor videos, other online videos and other online tutorials/animations were ranked 3-5, respectively.

	Avid Video Watcher	Poor/Non Video Watcher	p-value
Digestion Test Results	4.56	4.35	P = 0.76
MP science GPA	3.27	3.17	p = 0.38
Mock 9 bio results	7.67	7.30	p = 0.15
Mock 10 bio results	8.22	8.55	p = 0.45

Fig. 5. Comparison of avid and poor video watchers.

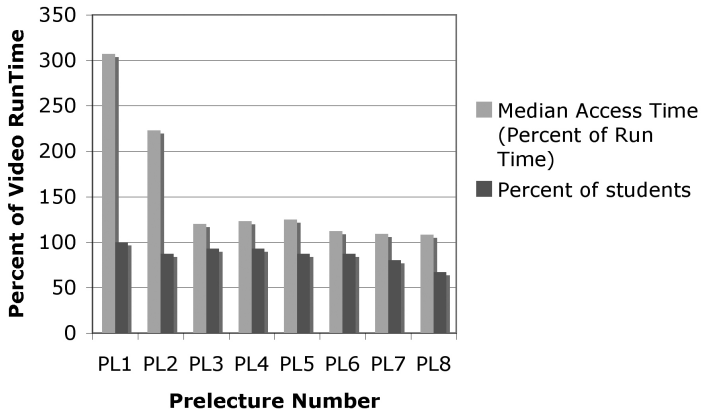

Fig. 6. Video access patterns for biochemistry students.

B. Biochemistry Course. The online videos were used somewhat differently in the biochemistry course. Eight videos were spread over one semester (rather than a short unit in the biology course), the intent was to cover introductory material only, and students were required to complete an online, 10-point quiz on each video prior to coming to class. To encourage individual work on quizzes, students had only one chance to access each quiz, quiz time was limited to 30 minutes, and questions were drawn from a bank so each student received a slightly different quiz.

The number of videos (8) was similar to the number used in the biology course (7), and the average length for videos in both classes was 17 minutes.

Median video access times and percent of students accessing each video are shown in **Fig. 6**. [Median rather than mean access times were used in this analysis because the population was small (N=15) and there were several extreme outliers in the access-time data]. Like the biology students, the biochemistry students watched (as measured by access time) the first video more than subsequent videos. However, while viewing dropped off precipitously after the first 2 videos, the median access times for all videos never dropped below 100%, and the number of students accessing the videos also stayed high throughout the semester, consistently above 80%. This suggests that quizzing is helpful in enforcing video watching.

Another factor that may have made a difference in access between the two courses is that the videos were also more spread over the semester in biochemistry than in the biology course. Students may thus have been less likely to suffer from being overwhelmed by having to watch multiple videos in a short time span. Finally, like in the biology class, students who did not watch the videos may have accessed the material by studying the accompanying Powerpoint slides only, since these could be accessed separately from the video. For the biochemistry class, in examining Powerpoint access patterns for the semester, it was found that in only 3 instances out of 120 (15 students x 8 PowerPoints) was the Powerpoint file *not* downloaded.

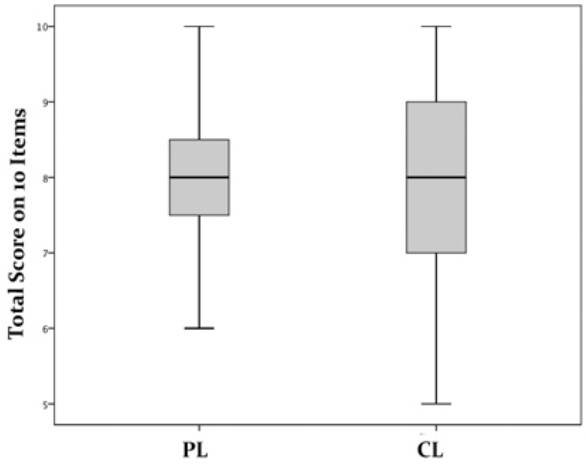

Fig. 7. Boxplot of score distribution on final exam Prelecture items (PL) and introductory material taught in class (CL).

Finally, we examined academic performance on basic material that was taught via video pre-lectures, and performance on material of similar difficulty not taught via video prelectures. The

closed book comprehensive final exam included 20 embedded multiple-choice items, 10 on material covered in pre-lecture videos (PL), and 10 items on introductory material covered in class (CL). Performance on the two question sets was nearly identical (7.93 PL vs. 7.87 CL, $p = 0.902$, **Fig. 7**). These data indicate that it is not detrimental to students to put basic material in online videos, and students can learn this material equally well via class time or outside of class with instructor videos. This should give instructors confidence to use the pre-lecture format to ensure all student have mastered basic material. The use of introductory videos in turn frees up class time, which can then be used to cover more complex concepts or questions.

While student reaction to pre-lecture videos in the biochemistry seminar was not formally studied, several student anecdotes bear out the utility of the pre-lecture format. While some students commented through the semester that they had seen much of the pre-lecture material before, other students with less biochemistry background gained confidence from the videos. These students felt more secure with the chance to review basic material at their own pace, which they said helped them "catch up" to peers that they perceived were better prepared for an advanced biochemistry seminar. Pre-lecture videos can thus help equalize a diverse student cohort, so everyone is properly prepared to gain the most from classroom time.

Results from this study are consistent with other published reports. The flipped classroom model with online course elements has proved popular with students. Garcia Biggs (2006) found that students had the highest overall satisfaction for hybrid, as compared to fully traditional, or fully online courses. Evidence for learning gains is more elusive. Dantes and Kemm (2008), like the current study, found that in a hybrid physiology laboratory course did not immediately translate to better test scores over a traditional curriculum, but did appear to help student master a deeper approach to learning. It may be that not all students utilize online resources in the same way, and student surveys in this project seem to bear this out. Johnson and Johnson (2006) suggest that individual students' learning styles affect their interaction with online environments, and that online environments are not universally preferred, depending on the activity and the learner type. This and other studies thus suggest that a variety of learning resources coupled with student empowerment to choose the resources that work best for them will be most effective approach to maximize learning for all students.

Study Limitations. Student attention to videos was inferred from access time recorded by the CMS. This method cannot account for student teams watching videos together, videos that are accessed

but not watched, or computers abandoned and left to run after videos are opened. Students were also given additional resources to learn information covered in videos, so total study time of the material could not be assigned from video access time alone.

IV. Contribution to Field

Classroom "flipping" is a relatively new approach and little is known about student behavior in terms how online resources are actually utilized. This study examines student access patterns of online materials in two different course circumstances, and provides valuable information about the frequency of access to assigned videos by enrolled students. It is notable that given the choice to use videos vs. other types of resources (e.g. textbooks), only about one-third of students consistently use videos as a learning tool. While this represents a minority of students, it may represent s group that would otherwise do poorly, and suggests that providing all students with a number of different resources will maximize overall student learning.

V. General Interest

We anticipate that this study will be of interest to NABT members teaching at the 2- and 4-year college and university level, and possibly to teachers of advanced high-school biology.

VI. References

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