

The Effectiveness of Video for Online Calculus Instruction:

Preliminary Report

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Abstract

Online courses are becoming routine at nearly every college in the nation. The ability of such courses to fully address multiple intelligences and learning styles has lead educators to at least conclude online delivery has high potential. It is important to compare learning outcomes between various online approaches and traditional coursework delivery and to discover best practices. This paper reports the results of a study of 12 sections of calculus offered from 2006 - 2010 at California State University, Chico. In half of the sections, a portion of the material was delivered by video online. The other sections followed the traditional classroom format, but were shown the same video in the face-to-face setting. Both section sets were given the same homework assignments and tests, including a common final instrument that has been used for the past 10 years. The results of testing and homework formed the basis for the comparison of the two section sets. We find that students who are delivered the video material face-to-face perform significantly better than those who view the video online.

Background

While distance learning is nothing new, the advent of the internet is revolutionizing the ways in which we retrieve information and learn. It is no surprise that online courses are proliferating at every level in our educational system. By 2010 over 4 million K-12 students were participating in some formal online learning program (Staker) . The market for preK-12 online learning grew at an annual rate of 16.8% between 2005 and 2010 (Adkins). To gain perspective, during the same time frame healthcare grew at the annual rate of 16.3%. In other words, the growth in online education at the preK-12 levels is phenomenal. In response, new online technologies specifically designed to enhance personalized learning are being developed at a rapid pace.

At the same time as the number of online offerings explodes, The US Department of Education reported in 2010 there “was the small number of rigorous published studies contrasting online and face-to-face learning conditions for K–12 students.” * This points to the continuing and critical need for solid research studies into the effectiveness and efficiency of various modes of online delivery. The purpose of this paper is to report on the results obtained from teaching calculus using a video presentation format in conjunction with an associated quiz that directly related to the content of the video. Between Fall 2006 and Spring 2010 two sections of the 4-unit first semester calculus course were taught each semester by the author. Six of the sections were taught in the traditional face-to-face fashion four days per week, one hour each day.

The other ten sections were taught face-to-face three of the four days, but the video was delivered online rather than in the classroom for the fourth day. Typically the video would be presented on Thursdays in the face-to-face sections and an associated pencil/paper quiz distributed that related directly to the content of the video. Usually the quiz would be collected at the end of the class period, but often it would be collected at the following Friday session. The sections who received the video online were required to print out and answer the same video quiz and bring it with them to class the following day.

2010-11 Update:

In the 2010-11 academic year the author modified his teaching format based on the results of the previous 8 semesters. The new format called for all face-to-face delivery, homework remained entirely online, and the weekly video lessons and associated quizzes were eliminated. At the end of this report a supplement will be provided indicating the performance on homework, weekly quizzes, and the final exam. All of this data is compatible with the data generated in the previous 8 semesters and serves as an indication of the degree to which instruction can be changed through careful research of existing methods.

Coursework Delivery

In the first academic year (2006-07) of implementing the hybrid program different classroom and online approaches were attempted. By the third semester of the project a consistent pattern of coursework delivery was established and maintained for the remaining study period consisting of 6 additional semesters starting in the fall of 2007 and ending in the spring of 2010.

Monday: The typical Monday lesson consisted of basic lecture for 30 – 40 minutes followed by problems presented to the class that they worked on in groups for the remaining 10-20 minutes of the 50 minute class. During this group work time the instructor would wander around the room monitoring the progress of the groups and answering any questions. Often the instructor would have successful groups write their solutions on the board, but typically there was not enough time for the students to present their work.

Wednesday: Each Wednesday both the hybrid and traditional groups would meet in the computer lab. For 6 of these class meeting they would work on a mathematica activity connected to the content of the week. Midterm exams would be given at 4 of these meetings and students were allowed to work on their online homework the remaining 5 sessions. Each of the 6 labs would be accessed as a mathematica notebook and students were usually required to work in pairs on the problems. The instructor would provide instructions on how to access the lab and how to answer the first few questions to get the class moving. Students who finished the lab early were allowed to leave, but most of the time students were not able to complete the lab in the time allowed. The instructor

allowed the students to return to the computer lab and continue their work until the end of the day at which time it would be retrieved and graded.

Thursday: From the first semester of the project, Thursday was always the day that a video lesson was presented. The instructor would show a video that would normally run uninterrupted for approximately 20 minutes. The videos were considered to be state-of-the-art and were produced by the University of Houston <http://online.math.uh.edu/HoustonACT/videocalculus/>. The instructor would frequently stop the video and query the class for both understanding and to maintain their attention. Poor student results on exams the first semester of the project prompted the development of the associated video quizzes to accompany the video for both the online and face-to-face cohorts. These video quizzes were first introduced in the spring semester, 2007 and scores that semester were combined with infrequent group activities and Mathematica labs. In all subsequent semesters the group activity scores were tracked separately. Students in the traditional group would attend class and be handed the video quiz that they were to answer during the class period while the hybrid group was expected to print out the quiz from the web, answer it and turn in their work at the Friday session. Problems worked out in the video were quite similar to the problems found on the associated video quiz and students would often write notes from the video on their quiz as relevant information became available. The video presentation would usually take 30-40 minutes leaving time for students to work together to finish and turn in the video quiz. Several times each semester the time available after the presentation would not be sufficient and students were then allowed to take the quiz home and return it the next day. The quizzes from both cohorts were collected on Fridays and graded with the same rubrics.

Friday: After dismal results the first two semesters the occasional group activity was institutionalized to a consistent pattern. Each of the 15 Fridays in the semester were dedicated primarily to this group quiz activity. The first 10-20 minutes of class would be used for short lecture and answering questions on the homework. The remainder of the class students would work in groups of 4 (sometimes more sometimes less) on a pencil and paper set of problems that covered the new material of the week. The typical quiz would consist of 5-6 problems and sometimes one of them would be a review problem. These problems were designed specifically to help acclimate the students to the pencil and paper style of the common final exam they would eventually take. Students were told that studying this set of 15 group activity quizzes would help them significantly in preparing for the final exam. At the end of the class period, or when a group finished the quiz, the instructor would toss a die and select a single group member's quiz for grading. All students in the group would receive the same grade as the one selected. Roughly 3 times a semester the material was so difficult or there was so little time that the instructor would allow the students to complete the quiz at home over the weekend. In these cases the instructor would collect the quizzes from each student and they would receive an individual grade.

Assessment

For each cohort in all of the final 6 semesters the assessment system remained the same. Students would receive grades in the following areas: Homework (45) , Video Quizzes (15), Group Quizzes (15), Mathematica Labs (6), Midterm Exams (4) and a Final Exam (1). Each midterm exam was given in the computer lab and replaced the weekly lab activity. Each midterm was taken online and consisted of a cross section of the same homework problems that students had been working online. Students were allowed to retake each of the midterm exams one time and the higher score would be used to form their grade. Mathematica labs were each worth 3 points and were combined with their video quiz scores, which then were combined with homework scores. Grades were then based on the following distribution:

Group Quizzes 15%:	Homework/Labs/Video Quizzes: 20%
Midterm Exams 40% (4 @ 10%)	Final Exam: 25%

For purposes of this study data was collected on all exams, homework scores, midterm exam scores, group quiz scores, and combined video quiz/mathematica lab scores. The reason for combining the lab with video quiz scores was to simplify the process since the labs only contributed a very small amount to the students' video score total. (18 out of 150 possible points.)

Cohort Formation:

Each semester a notation was provided in the online class schedule that some coursework would be accomplished online and that an internet connection would be required. The internet connection was required of all students in order to accomplish their homework, but not all students were required to view the Thursday video online. The size of each class varied from a low of 16 to a high of 32. At the beginning of each semester the instructor would select sections for applying the online Thursday lesson. The selections were essentially random and so no student was initially allowed to select their course based on the delivery format. While it is possible for students to change sections within the first four weeks of class, no students ever changed from one section to the other, although during the 8 semesters there were a handful of students who transferred out to another instructor's section and another handful that transferred in from another instructor's section. In some semesters both sections taught used only the hybrid format and in some semesters only the traditional format was taught. This design essentially eliminated the possibility for students to self-select one or another delivery format although they could decide whether or not to be in a course that required internet access.

The six traditional cohorts were the following:

F06, Sec 8; S07, Sec 6; F07, Sec 4; S08, Sec 3; S08 Sec 4; F08 Sec 2.

Four modified traditional cohorts provide a supplement to the study in the academic year 2010-11:

F10, Sec 3; F10, Sec 8; S11, Sec 4; S11, Sec 6

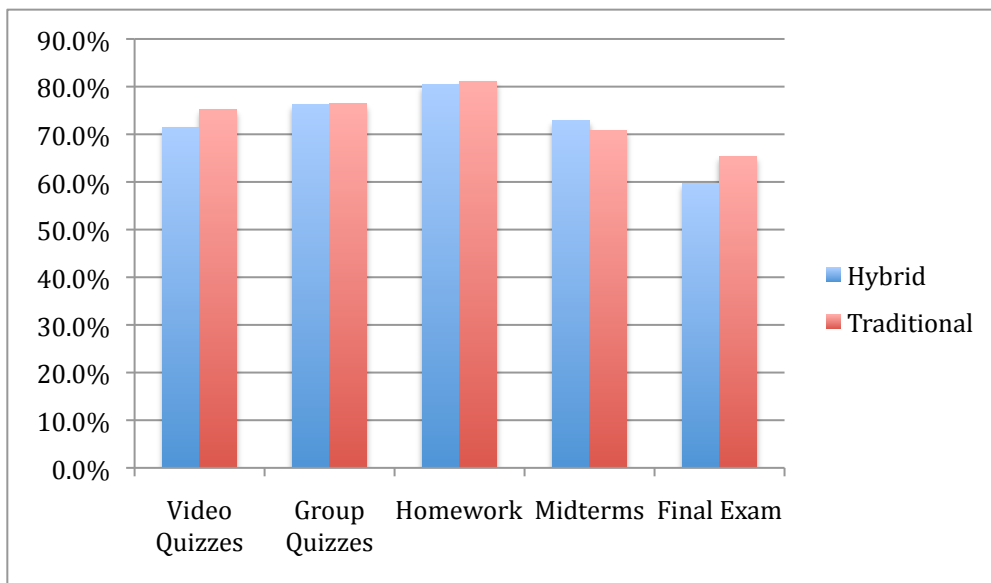
Those sections taught with the hybrid format consisted of the following:

F06, Sec 7; S07, Sec 5; F07, Sec 8; S09, Sec 3; S09 Sec 6; F09 Sec 6;
 F09, Sec 40; S10, Sec 1; S10, Sec 6;

The number of students in the hybrid group totaled 230, the traditional group 138. One of the strengths of this study is that all sections were taught by the same instructor with the same basic instructional format and style. We therefore obtain a high degree of control over many of the variables that might otherwise effect student performance.

Data and Results:

After the first semester (fall 2006) of this project the first traditional cohort earned an average score of 71.25% compared to an average score of only 56.95% for the first hybrid cohort. This large discrepancy prompted the formation of the quizzes associated with the Thursday video lessons. In the second semester (spring 2007) results were 62.38% for the traditional group and 53.55% for the hybrid group. It should be noted that lower scores for students taking Calculus I in the spring are common since those classes consist of both students not ready for calculus in the fall and those that failed the fall semester. We can see that the difference between the two cohorts improved somewhat in the second semester, but the traditional group still outperformed the hybrid group at a significant level. Summary data for all semesters is presented below:



	Video Q	Group Q	Homewk	Midterms	Final Exam
Hybrid	71.5%	76.3%	80.3%	72.7%	59.6%
Traditional	75.1%	76.4%	81.1%	70.8%	65.4%
T-Test	0.513	0.328	0.679	0.269	0.008

As can be seen from the chart and data above the traditional cohort outperformed the hybrid cohort in most measures except average midterm exam scores, though

the differences for most measures were not statistically significant. There is a significant difference in final exam scores between the traditional and hybrid cohorts. Under an hypothesis that the two populations have different means, the associated 2-tailed t-test value of .008 indicates rejection of the null hypothesis . We can safely conclude that students in the hybrid group will on average perform below the traditional group on the common final exam.

Discussion

The data in this report supports the notion that mathematics content is not effectively delivered by video to students who do not self-select that mode of online learning. The number of students in this study is not exceptionally large (368) and so despite the statistical significance it would not be too surprising if the results were contradicted by a subsequent study that follows even modest deviations from the process conducted here. For anyone who has tried to learn mathematics by viewing the type of narrated and animated powerpoint video presentation of the type used in this study, it is not a huge surprise that students have significant difficulty. We conclude that effective online delivery of mathematics will require more creative and interactive modes of delivery than found in the video lecture format. It is a bit surprising that the significance of the difference in video quiz scores, which relate directly to the video content, are not nearly so pronounced as the overall effect as measured by scores on the final exams. The causation of the amplification of the negative effect on the final exam scores represents an interesting question that is beyond the scope of this report. An important aspect of this study is that students did not self-select into the cohort that viewed the video online rather than face-to-face. This provides indirect evidence that self-selecting online delivery modes may prove to be an important factor in the ultimate educational success of the student in a particular course.

Data Supplement

In the academic year 2010-11 the learning format was changed based on the research conducted over the previous 10 semesters. Both the video lesson and the Mathematica lab were deleted from the lessons. Students continued to do their homework online, but the assignments were redesigned to include significant and carefully planned review problems. In some cases a student would see the same important problem as part of their homework as many as 5 times throughout the semester. In addition the instructor set aside 15-20 minutes of class time daily for the students to present solutions to homework problems. Scores earned on the presentations were added to their group quiz points. Because these courses did not include the video lessons, we have not included them in the original study. However we present the results of the modified classes in terms of the performance of the students compared to all others taking calculus from other instructors. Performance on a common final exam taken by all calculus students form the basis of the comparison.

	ALL OTHERS	HYBRID
COUNT	218	100
AVERAGE	104.3	130.5

T-tests confirm the statistical significance of these results and it is clear that the hybrid group using spiraled online homework and daily student presentations outperforms those from other sections.

References:

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