Instructional Videos in an Online Engineering Economics Course

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Abstract

The use of video lectures is a common method of delivering course content in online learning environments. Over time, our understanding of what makes an effective online video has evolved with advances in educational research and technology. In the past decade, free online video services such as YouTube have allowed widespread dissemination of instructional videos. Prevalence of high-quality instruction produced by organizations such as Kahn Academy has advanced our knowledge of effective video techniques and raised our students' expectations. Recent research has explored the elements of lecture videos and presentation styles that either contribute to, or detract from, student engagement. This paper explores one instructor's experience with teaching an online course in engineering economics multiple times, the original development of lecture videos and the subsequent editing and rework of those videos. Until recently, the effectiveness of the course videos was judged primarily from student feedback in course evaluations. However, the most recent version of our institution's learning management system allows collection of detailed student viewing data on the videos, including number of views, average view time and drop-off rates. Correlation between video viewing habits and student performance is explored and recommendations and lessons learned are provided.

Introduction/Background

Videos are a standard instructional element for most online courses, and as online education has grown, there has been a greater emphasis on defining best practices for video usage in online, live and hybrid delivery modes. Videos are used to deliver course content, provide illustrations of the topics discussed, or possibly feature external subject matter experts or supplemental film clips. The videos can be produced by the instructor of the course, be professionally produced (e.g., by the textbook publisher), or be drawn from publically-available sources, such as YouTube, the news media, or other websites. This paper explores the use of instructor-developed videos to deliver course content. We categorize these videos as either lectures or tutorials. In many engineering courses, including engineering economics, the instructor typically introduces a topic, provides some motivation for why the topic is important, covers the theoretical background, such as deriving equations, and then works problems to illustrate the use of the concept. We categorize the introduction, motivation and theoretical background as a "lecture" and working an example problem as a "tutorial."

The goal of this paper is twofold. First, we summarize the findings of other researchers with respect to what makes an effective instructional video, and as an illustration of those findings, use the set of videos produced by one of the authors for an online engineering economics course. In some cases, the videos follow the best practices advocated in the research, and in other cases, they do not. Second, we attempt to evaluate the effectiveness of the videos by considering both student comments about the videos and the students' online viewing habits.

The online course that motivated this paper is entitled Economic Decision Making, and has been taught on four different occasions by the first author at the University of Arkansas. This instructor has also taught similar engineering economics courses in traditional live classroom

settings a total of ten times. The original development of the online course took place in 2011, and the most time-consuming task in creating the course was the development of the instructional videos. The original set of videos was revised and supplemented during subsequent course offerings, and before the last course offering in the summer of 2014, the online course was significantly modified to align more with current best practices of online delivery. These modifications were a result of guidance from the second author, who is an instructional designer at the University of Arkansas. At that time, the videos were significantly edited, segmented and supplemented, primarily to improve their quality and shorten their duration. It was during this most recent offering that the latest version of the learning management system (Blackboard) allowed capture of student video viewing information. Our evaluation of student response to the videos is therefore based on student feedback from all four course offerings and video viewing data from one course offering.

Related Work

The transfer of knowledge in an educational setting has been the subject of research since the nineteenth century. However, according to Richard Mayer, a leading researcher in the area of educational psychology, and in particular multimedia learning, we know more about verbal learning (words) than we do about visual learning (pictures). We also know more about what makes a good live lecture than what makes a good video lecture.[1] Mayer defines the multimedia principle as the idea that "people learn more deeply from words and pictures than from words alone."[2] A multimedia instructional message integrates words and pictures in a way that is consistent with cognitive function and promotes learning, and is applicable to instructional materials in both printed and video form. When an instructor uses only text in a presentation (whether live or on video, through slides or other medium), the transfer of knowledge relies too much on the verbal-processing functions of the brain. Both the auditory input (the professor talking) and the visual input (the words on the slide) compete for the cognitive resources that help us process words. In other words, can you listen to the professor speak and read the words on the slides simultaneously? Not very effectively. You can much more easily process a visual image while listening to a verbal message. Mayer[2] has defined 10 evidence-based principles for the design of multimedia messages, which are included in Table 1.

Michael Alley, an associate professor of engineering communications at Penn State University has implemented some of Mayer's concepts, among others, in the development of an alternative use of presentation slides, which he calls the "Assertion-Evidence Structure."[3] Critics of Powerpoint presentations in general, but specifically the default structure of Powerpoint presentations, state that the typical bulleted structure oversimplifies material and reduces it to a list of bullet points that do not adequately convey the relationships between concepts and the message that the speaker is trying to convey. Alley and Neeley[3] present an alternative design of presentation slides that includes a sentence headline (the assertion) and visual images (the visual evidence). One of the most persuasive advocates for this presentation method is Melissa Marshall, who is a communications instructor within the Penn State College of Engineering, and whose four-minute TED Talk, "Talk Nerdy to Me," has garnered over one million views at www.ted.com.[4] The idea of building the presentation around the messages you're trying to convey and supporting the messages with visual evidence is something that can promote transfer of information and learning in both live presentations and video presentations.

Table 1: Mayer's Research-Based Principles for the Design of Multimedia Learning[2]

Principle	Description
Coherence principle	Reduce extraneous material – too much detail is distracting
Signaling principle	Highlight essential material
Redundancy principle	Do not add on-screen text to narrated animation
Spatial contiguity principle	Place printed words next to corresponding graphics
Temporal contiguity principle	Present corresponding narration and animation at the same time
Segmenting principle	Present information in learner-paced segments – chunking
Pre-training principle	Provide pre-training in the name, location and characteristics of key components
Modality principle	Present words as spoken text rather than printed text
Multimedia principle	Present words and pictures rather than words alone
Personalization principle	Present words in conversational style rather than formal style
Individual differences principle	Design effects are stronger for low-knowledge learners than for high-knowledge learners. Design effects are stronger for high-spatial learners than for low-spatial learners.

Guo et al.[5] attempt to draw a parallel between aspects of video production and student engagement by using video viewing data from four courses on the edX MOOC platform. They describe their study as a retrospective, where they reviewed data on courses that had already been taught and included over 6.9 million video watching sessions. They measured student engagement by viewing length of each video and whether the students attempted to answer post-video assessment questions. Through a combination of practitioner experience and evidence from their data collection exercise, the authors developed a set of recommendations to instructors and video production specialists (see Table 2).

In contrast to Mayer's work, Guo et al.[5] do not evaluate information transfer at all – there is no attempt to assess how much the viewers *learned* from the videos, just how long they watched and whether they attempted the questions at the end. And they admit that although they had a large amount of viewing data, they evaluated only four courses, with four different instructors. Additionally, students who take a MOOC are typically not as committed to learning the material as students who are paying for a course and being graded on their performance.

The principles of multimedia learning also influence standards for online courses. Quality Matters™ (QM) is a nationally recognized authority in quality standards for online courses. QM began as a Maryland Online FIPSE (Fund for the Improvement of Postsecondary Education) grant project in 2003 to develop a process to ensure quality and continuous improvement in online learning. The QM rubric is derived from best practices in instructional design and

research.[6] The review process is a faculty peer-review process centered on providing constructive feedback on the design of a course, not the delivery.

Table 2: Conclusions from a 2014 Empirical Study of Four MOOC Courses[5]

Video Production Recommendations
- Shorter videos are more engaging – recommend chunks of less than 6 minutes
o Shorter videos are higher quality
- Talking head is more engaging than just slides
o Alternate with slides
o A human face provides a more intimate and personal feel and broke up the monotony of PPT slides
o Record the instructor's head and then insert into the video at "opportune" times
- Informal setting is better than a professional studio or classroom lecture
o Instructor should use good eye contact
- Khan-style tutorials are more engaging
o If presentation slides must be used, sketch over the slides using a digital tablet
- Speaking rate should be relatively high – 160 words/min. This conveys enthusiasm.

Best Practices for Instructional Videos

The number of online education offerings is growing rapidly and therefore there is more guidance and empirical evidence from both researchers and practitioners. We focus on the few topics summarized below and use our course as an illustration. In some cases we adhere to the best practice, and in some cases we do not.

Keep Videos Short

One best practice in developing instructional videos for online courses that appears to be universally accepted is that videos must be short in length. Mayer defines the segmenting principle, which states that in order to not overload the learner's cognitive system, material should be divided into manageable "chunks."[2] He suggests that the ideal scenario is one in which the narrated presentation is presented in learner-paced segments, rather than as a continuous presentation. So, how do we define "short?" Guidance from multiple sources states that lectures should be limited to 20-30 minutes, however, Guo et al. state that video length was the most significant indicator of student engagement, and suggest that videos should be less than 6 minutes in duration.[5] They do, however, make a distinction between the length of lecture-style videos and tutorials, indicating that tutorials may need to be longer.

In the redesign of our online engineering economics course in the summer of 2014, the 20 pre-existing videos, which were an average of 33.4 minutes and totaled over 11 hours, were chunked into 63 videos, which were an average of 11.6 minutes in duration. Supplemental videos were added in areas where there was a need for further tutorial instruction, resulting in a total of approximately 12 hours of instructional videos in the latest version of the course. When videos are created in the future, it will be the goal of these authors to limit them to 10 minutes or less.

Create Effective Visual Slides

When producing a slide presentation for either online delivery or live presentation, it is important to include significant graphic elements, or pictures.[2,3] Research has shown that slides consisting primarily of text, accompanied by audio, overload the verbal-processing cognitive functions and therefore using bulleted slides hampers the listeners' ability to transfer information. Furthermore, people learn more deeply when they integrate text and pictures, thereby building both verbal and pictorial representations of the same material.[2] The slides from the lecture-style videos included in our example course are admittedly very text-heavy. Melissa Marshall convincingly demonstrates the assertion-evidence approach to presentation development,[4] and therefore the authors plan to move towards this approach during the next revision of the instructional videos.

Provide Focused Content

Instruction should not be technology-centered, but rather learner-centered. It is not the medium in which the content is delivered (video versus live presentation, or slide presentation versus talking head), but the pedagogy and the instructional method that results in learning.[7] Learning is facilitated by videos that are focused on specific learning objectives. Quality Matters™ Standard 4.1 states that all instructional materials (including videos) must contribute to achieving stated learning objectives.[6] Course delivery should be structured around a set of learning objectives.

While is important to maintain high production quality and make the material engaging and enjoyable to watch, it is more important to transfer knowledge that results in learning. A high quality, entertaining video without meaningful content is not going to engage learners in the long-term, nor contribute to the accomplishment of learning objectives. Mayer states that you can make your videos emotionally interesting, as in a Hollywood movie, but the goal should be that it is cognitively interesting, so that learning is achieved.[8]

In the redesign of the online Economic Decision Making course, the course content section was reorganized and expanded to more clearly define learning objectives and student expectations for each section of the course. Figure 1 shows a "bare bones" presentation of the Week 3 material used in the Fall 2012 course offering, where the students were given folders containing lecture slides and videos, without appropriate context. Figure 2 shows the same content section of the Summer 2014 course offering, where the motivation for the material, textbook references and related assignments accompany the lecture slides and videos.

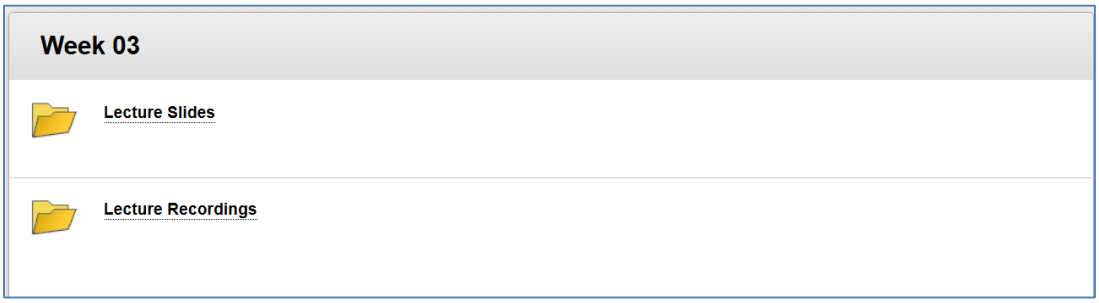

Figure 1: Week 3 course content from online course offered in Fall 2012

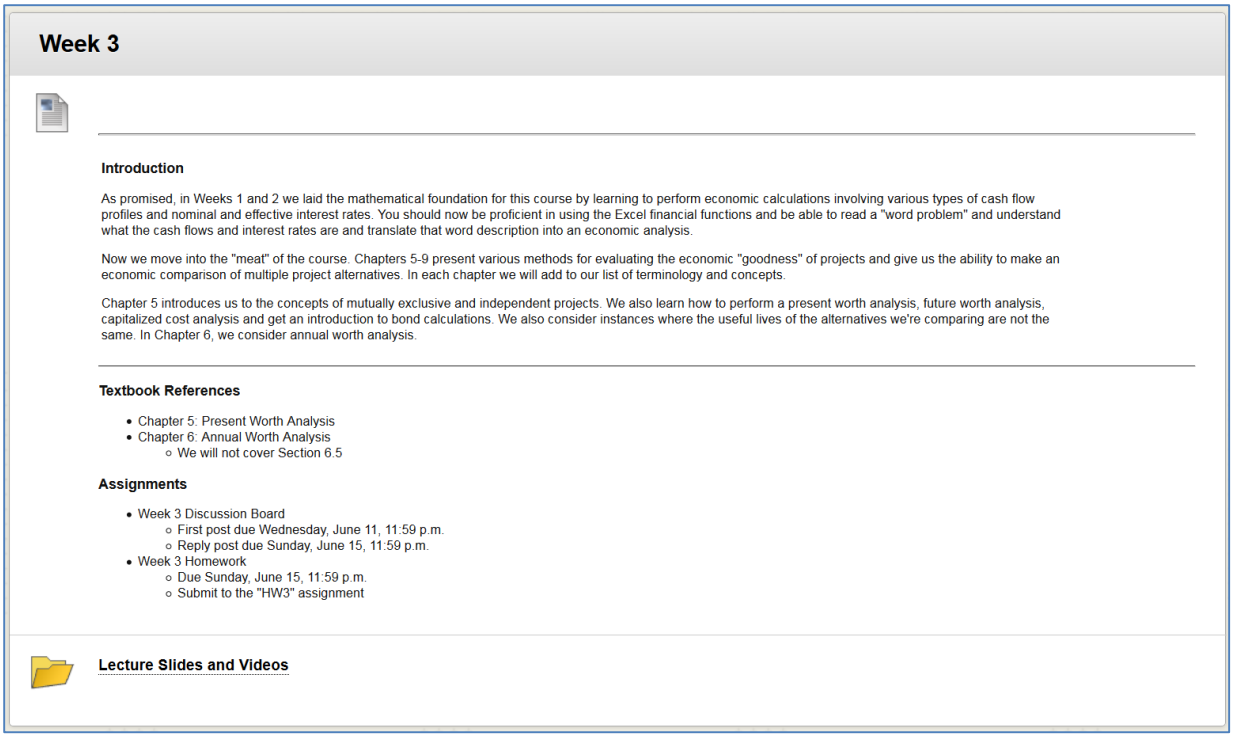

Figure 2: Week 3 course content from online course offered in Summer 2014

Overview the Video Content

Mayer's principle of pre-training states that educating the learner on key terminology and concepts before the instructional video improves learning.[2] For example, before beginning a lecture on replacement analysis, most instructors will define related terminology such as the *defender* and the *challenger*. In online delivery, pre-training the learner might also involve clearly indicating the content of the instructional video in text immediately preceding the video link, so that the learner has the appropriate perspective and motivation before viewing the video. Quality Matters™ Standard 4.2 states that *"the purpose of instructional materials and how the materials are to be used for learning activities should be clearly explained.*"[6]

In early offerings of our example course, the video links were presented to the students with no explanation of the video content, except that they pertained to particular chapters in the textbook (Figure 3). In the redesign of our course in the summer of 2014, these videos were edited, "chunked" into smaller segments and presented with text that explained the purpose and content of each video. The screen shot in Figure 4 shows three videos, approximately 10-14 minutes each, that take the place of the first video in Figure 3, Chapter 5 – Part 1, which is over 42 minutes in length. The first video in Figure 4 is an introduction to present worth analysis, which we classify in this paper as a "lecture." The next two videos are "tutorials" which walk the viewer through three example problems. We believe that reducing the length of the videos and providing clear guidance on video content made the videos more useful to students and increased their viewing time.

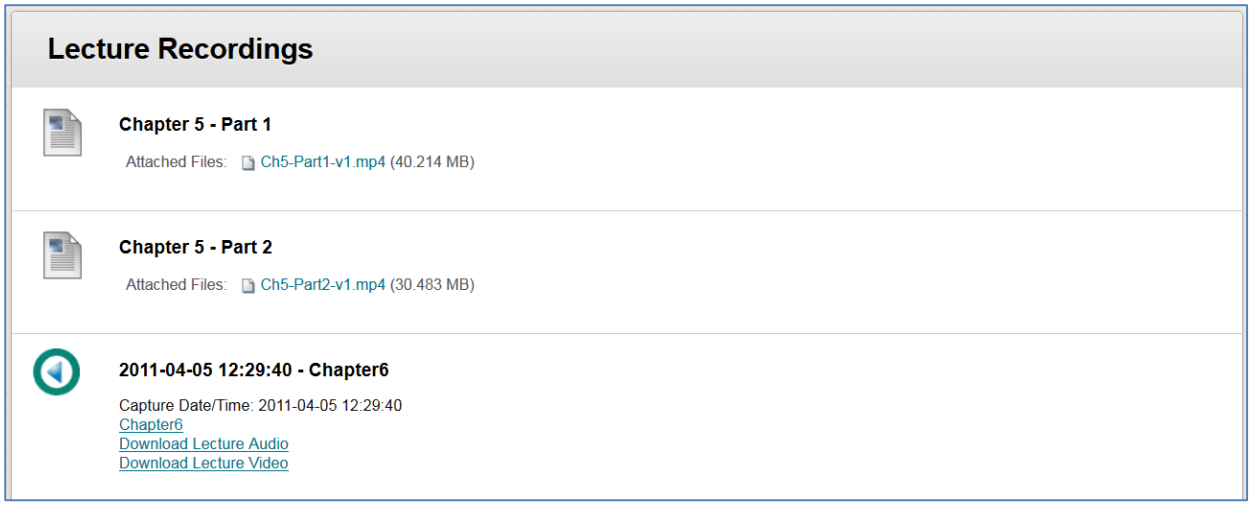

Figure 3: Week 3 video links from online course offered in Fall 2012

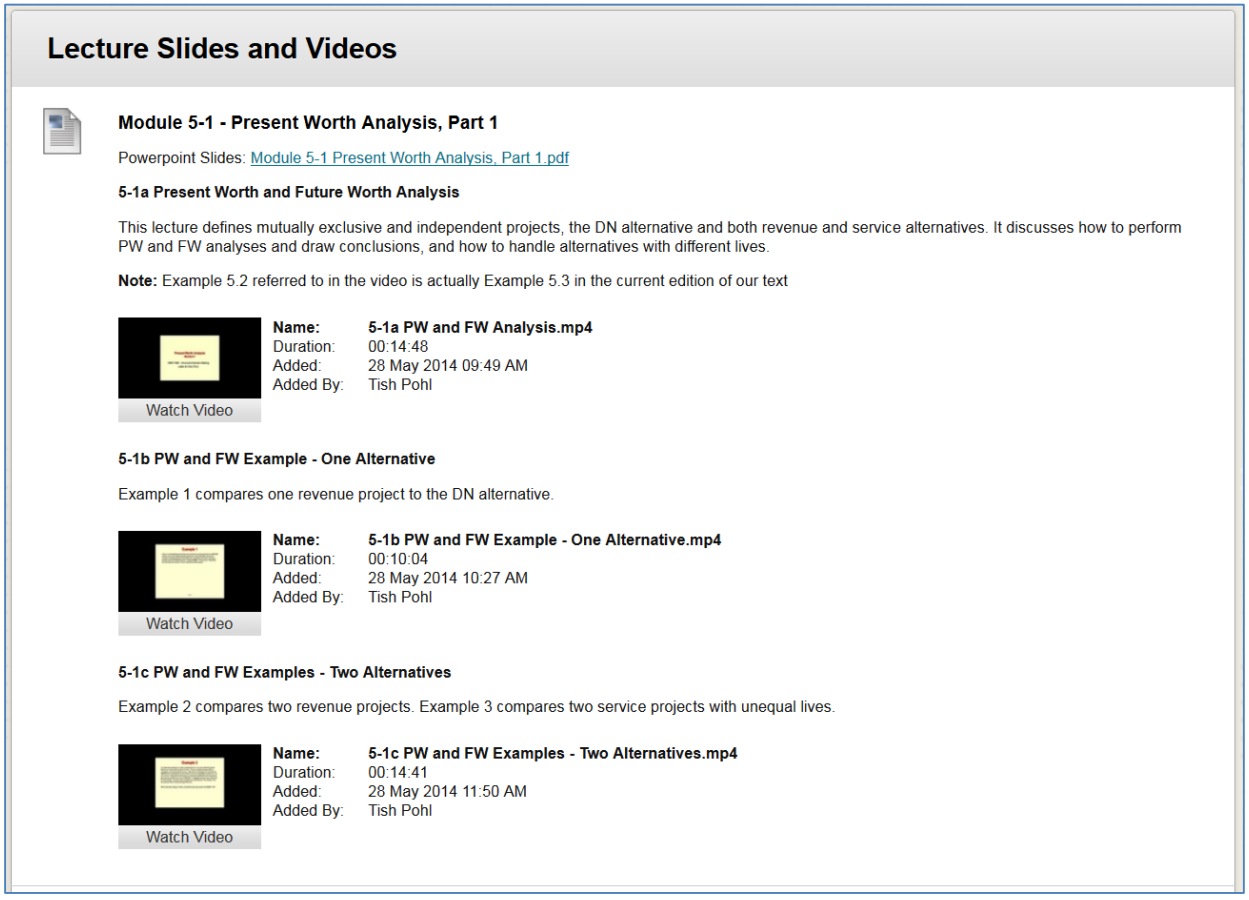

Figure 4: Week 3 lecture slides and videos from online course offered in Summer 2014

Include Both Video and Audio of the Instructor

When producing an instructional video that includes a visual display, such as presentation slides or tablet/paper that is being written on, and the accompanying audio, the instructor has several

options. They can display only the presentation materials, alternate between the presentation and a video of the instructor, or provide a view of both the instructor and the presentation at the same time. In the development of our instructional videos, we chose to show only the slides and did not include our "talking head" on screen. There is somewhat conflicting information from the literature on this point. In his earlier work, Mayer states that people do not necessarily learn better from a multimedia lesson when the speaker's image is added to the screen. He also suggests that if the material being covered is detailed or complex, an inset frame of the instructor's face could be distracting.[7]

On the other hand, there is evidence that indicates that students are more engaged, i.e., they watch for longer, when the instructor can be seen, at least in some shots. Guo et al. suggest displaying the instructor's head at "opportune" times in the video to create a more personal feel and connection to the instructor.[5] Day also suggests that videos are more effective when they include audio, the instructor's video and presentation slides.[9] He recommends that the presenter's video be shot from the lower torso up (rather than a talking head) so that gestures can be captured.

It is our opinion that whether or not to include a video shot of the instructor should be based on instructor preference and the complexity of information being presented. It is however, recommended that online students see at least one video of the instructor to personalize their experience, but this could be accomplished with an introduction video that is viewed at the beginning of the course. Quality Matters™ Standard 1.8 states that "the self-introduction by the instructor is appropriate and is available online," The annotations on the rubric encourage instructors to use a photo, audio, or video to meet this standard.[6]

Practical Suggestions

Create videos around a topic, not a chapter in a textbook. Creating videos is time-intensive. While instruction needs to be refreshed periodically and contemporary examples added, instructional videos will remain relevant longer if you avoid tying the video content to a particular textbook. This was unanticipated at the beginning of our course development, and therefore the lectures referred to specific chapters, textbook examples, and even page numbers in the textbook. When the textbook was revised the next year, the videos, which had taken considerable effort to develop and record, were now outdated. Note in Figure 4 that although the material pertains to Chapter 5 of the textbook, in the new version of the course we refer to "Module 5." This is further illustrated by the note in Figure 4 that states that Example 5.2 in the textbook is now Example 5.3 in the current edition. Information that ties the video to a particular part of the textbook may be useful and can be provided in text that accompanies the video link and is easily updated (e.g., This video shows the solution for Problem 2.34 at the end of Chapter 2).

Do not speak through slide transitions. This makes editing later more complex, because if you want to omit a slide, but need to keep the audio transition, you must separate the audio from the video for proper editing, or re-record that segment. Another advantage is that if the video has a navigable table of contents, then clicking on a particular slide will not catch the speaker in mid-sentence.

Give your students easy access to the videos. Technology changes rapidly, and the technology that was used to manage the media content on our LMS changed twice between the initial development of the course in 2011 and the latest delivery of the course in 2014. Ensure that your students have the ability to playback and navigate through the instructional videos, and even download them so that they can watch them without internet access. Students in the most recent version of our course complained about the inability to download videos and it required involvement of the instructional designers to set the video delivery system up to allow that functionality.

Expect the total length of the instructional videos in your online class to be much less than the contact hours in an equivalent live class. In our example class, the number of class time hours if it had been offered face-to-face would have been about 40 hours (minus the midterm and final exams). Our instructional videos totaled approximately 13 hours, or 32.5% of the live class time. This is due in large part to the lack of announcements and administrative information, questions and answers, and "detours" the instructor may be prone to take in a live class. Online students are much more likely to receive course administrative information in written form rather than from the instructor orally, e.g., syllabus information, announcements and instructions for exams, homework due dates, bad weather policies, etc. Our experience differs somewhat from Day, who states that a studio-recorded lecture will be about 60% the length of the same lecture given live.[9]

Student Response to Videos

As shown in Table 3, the course contained 63 videos, with an average length of 11.6 minutes and total of 719.4 minutes. A list of the videos, their titles, their style (lecture, tutorial or both), and their durations can be found in the Appendix. Videos were included in lessons over seven weeks. There were 22 students in the course; 18 completed the course and 4 dropped the course at various points during the semester.

Table 3: Video Information

Course Offering in Summer 2014	
Videos	63
Total Running Time	11:59:24
Number of Plays (some portion played)	657
Number of 100% play (play until end)	517
Total Time Viewed	126:48:06
Number of Students	22

In each of the four course offerings, the last discussion board of the class was devoted to feedback on the course. Participation was almost 100%, but not anonymous. Each time the course was taught there were positive comments about the videos, both in the discussion board and in the anonymous online course evaluations. However during the last offering of the class in Summer 2014, the number of times the videos were mentioned in student feedback was significantly greater. Over 50% of the students responding in the discussion board commented on the helpfulness of the videos, compared to no more than 10% of students from earlier classes. Table 4 contains the video-related comments from the students in the Summer 2014 course, where they are each identified by a student number (1-18). We attribute this difference between

student response to two factors. First, the videos were essentially the same as earlier, but had been edited to segment, or "chunk" them (average length of 11.6 minutes versus 33.4 minutes). Second, in the most recent course offering, there were descriptive titles and video content descriptions added. It was clear when the video was a walk-through of an example problem and therefore potentially helpful in working homework problems.

Table 4: Video-Related Comments from the Last Class Discussion Board

Student	Comments
1	Slides and videos were great in how they presented the material. I wished I could have downloaded the videos - like I did the slides. The slides are great but the videos added so much more. I was actually unable to view some of them due to my travel schedule and I think that set me back a little.
2	The videos were clear and easy to understand. They were of great help while solving the homework problems.
3	The videos were very helpful.
4	I also like the videos. I actually felt like I was sitting in a classroom. That hasn't been the case in the courses I've taken and I've found the video lectures to be stale and not much help. This was the first one for me where I relied on the videos more than the textbook.
6	I really enjoyed the video walk through examples and learned a lot from them.
10	I really liked the videos, they were great!!! And together with the assignments, they prepared me well for the exam. I opened the book only 2 times, that's how good the videos were. However I did not like how the videos were embedded into the browser. I could not download them and review them without having to be online.
12	Your lectures were great compared to most other professor's lectures. I can't say how important it is to be taught rather than have a slide read to me.
14	The lectures helped comprehension and breaking them up into shorter, focused sections was of great benefit to me as I could watch one or two, walk away, refocus and come back without having to remember where I left off. I also appreciated that the example problems were broken out from the other material so I could re-review them when accomplishing the homework.
15	The videos and PPT were clear, good and well designed. I could easily understand the lectures.

As mentioned earlier and is apparent in the comments above, these students really wanted the convenience of downloading the videos and watching them off-line. This was the instructor's first use of Kaltura as a platform to upload the videos. There is a way to present the videos using Kaltura that allows them to be downloaded, and this will be accomplished the next time the class is offered.

Video Viewing Data

Kaltura is an open-source video platform that allows instructors to upload media, record screencasts or webcam videos, or create clips from existing content. The integration with the

learning management system (Blackboard) allows for detailed analytics. Instructors are able to see which students are watching videos, how long they are watching the video, and if they are skipping to certain points of the video or playing the video from beginning to end.

Video analytics are updated nightly and available for instructors to view in Blackboard or download. Instructors can use video analytics to refine the video offerings in a course. When the instructor sees that most students stop viewing the video halfway through or skip right to a certain point in the video, she can edit the video into smaller chunks of information. Instructors can also use the viewing data to determine whether or not a student has watched the video when he has a question and provide an appropriate response.

The video data were not examined during the course, but have been analyzed since course completion. Figure 5 shows the number of video plays (when they were played 100%) for each of the 63 videos. Lectures are shown in red, while tutorials and videos that contain both lecture and tutorial components are shown in blue. We can assume that the videos were most likely played in sequence, or close to it, and therefore represent a timeline of the 7 weeks of class. Figure 5 shows that the video views tended to increase throughout the course, indicating that the students found them valuable and continued to watch them. When instructional videos are watched initially and not deemed useful, we would expect to see significant drop off in the viewing and we do not see that here.

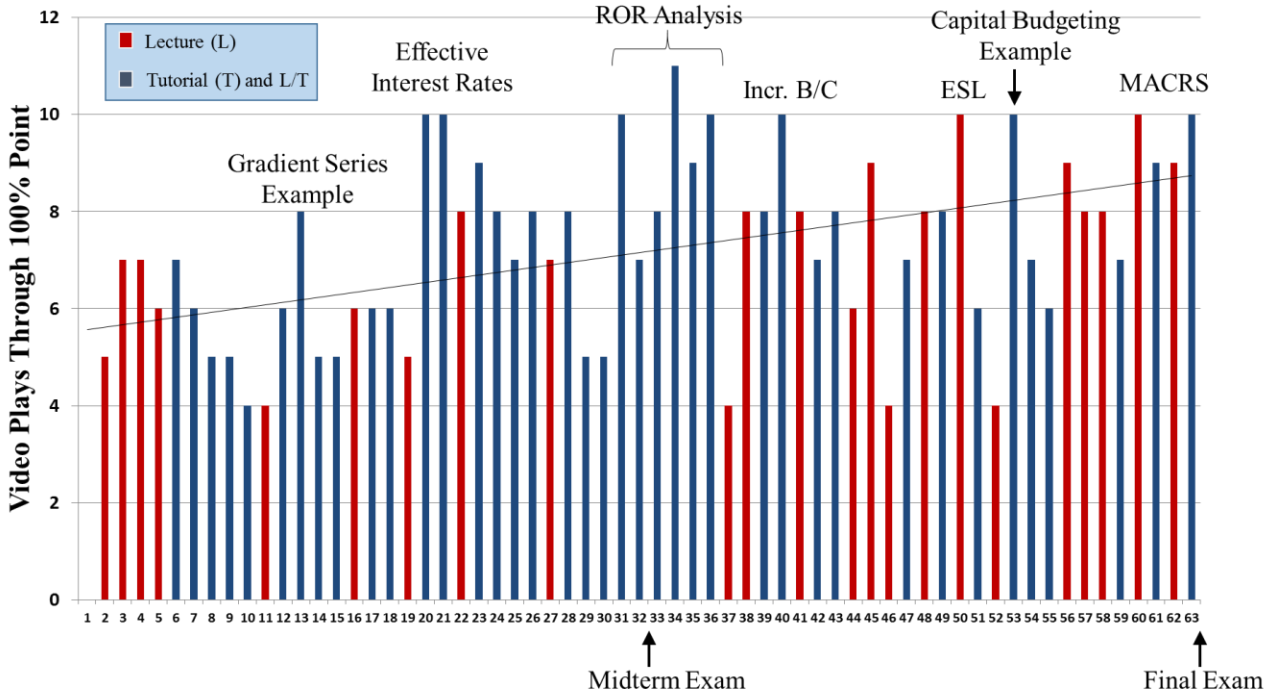

Figure 5: Video Plays Throughout the Course

Also noted in Figure 5 are the topics of videos that seem to have received "peak" views. We have not yet examined these peaks in detail, but it could be that they are a result of a few students re-watching the videos several times, or of single views by a greater number of students.

In either case, we do feel that some of these topics are subjects that often give engineering economics students trouble, e.g., gradient series, effective interest rates, rate of return analysis.

We expected to see that the tutorials were viewed more often than the lectures, which would be consistent with the findings of Guo et al.,[5] however, the data do not support this hypothesis. The percentage of views is consistent with the percentage of videos in each category, as shown in Table 5. In future work we will examine the number of times the videos were replayed by individual students to see if the tutorials were more likely to be re-watched.

Table 5: Videos by Category and Number of Student Plays

Video Category	Total Videos	% of Total	Views (in entirety)	% of Views
Lecture	24	38	202	39
Tutorial	29	46	233	45
Combination	10	16	82	16
Total	63		517	

Table 6 shows the video viewing data by student and their class rank, where each of the 18 students who completed the course are numbered 1-18, and the four students who dropped the course are indicated separately.

Table 6: Student Viewing Data

Student	Class Rank	Viewed entire video	Skipped	Minutes Viewed
Student1	6	26	2	346.93
Student2	2	51	7	813.88
Student3	17	51	14	793.38
Student4	11	16	3	248.64
Student5	14	43	13	558.36
Student6	9	5	4	88.61
Student7	16	1	1	5.5
Student8	4	2	2	19.03
Student9	8	0	1	6.6
Student10	7	60	3	651.21
Student11	18	5	1	54.88
Student12	12	62	11	1441.38
Student13	3	32	3	96.96
Student14	10	5	3	389.08
Student15	15	31	10	442.84
Student16	5	58	22	721.87
Student17	1	9	0	82.71
Student18	13	3	1	40.97
Drop1	-	3	4	34.24
Drop2	-	18	1	280.04
Drop3	-	14	2	179.82
Drop4	-	22	4	311.14

The variability between students is readily apparent, where Student 9 viewed a portion of only one video for a total viewing time of 6.6 minutes, and Student 12 viewed 62 of the 63 videos in their entirety, for a total of 1,441.38 viewing minutes. So how do these viewing habits relate to student performance?

Numerous studies have shown that students who attend class are more likely to perform well. We would like to think that in an online class, the students who watch the videos are also more likely to perform well. However, considering just this one instance, there is no strong correlation between the number of video plays and student grades, due to a number of confounding factors. Figure 6 shows a plot of minutes of video viewed, versus the corresponding student's class rank, where the student with class rank "1" had the highest grade in the class. Something that should be noted is that these students are graduate students, working professionals and tend to be dedicated students. This is a core class in their degree program and if they do not earn at least a C, they have to retake the course. The four students who dropped the course would have been in danger of earning a C or lower. All students remaining in the class received As and Bs, except for the bottom student (rank 18), who failed the course.

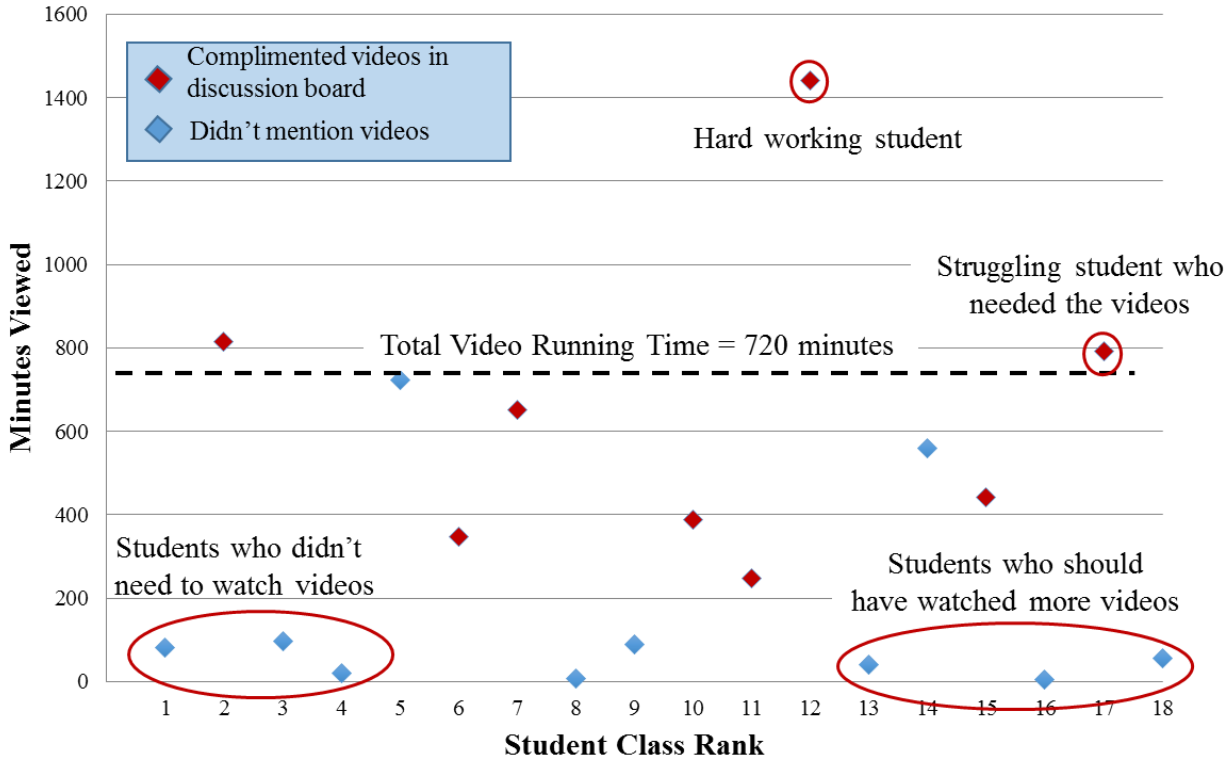

Figure 6: Correlation between Minutes Viewed and Student Class Rank

Students ranked 2nd, 5th and 7th all watched most of the videos and performed in the top third of the class. Whereas students ranked 13th, 16th and 18th did not spend time watching videos and were near the bottom of the class. This is the trend we would expect. However, there are students who did not watch the videos and still performed quite well (1st, 3rd and 4th in rank). These students may have had prior experience with the subject matter (based on their undergraduate degrees) or learned primarily through reading the text and lecture slides.

One very hard working student, Student 12 with class rank 12, who watched for 1,441.38 minutes, was below average in class performance. This student had a terrific attitude and seemed to want to learn for the sake of gaining the knowledge, not just for the grade. Our struggling Student 3 (class rank 17) had the third highest number of views and finished almost at the bottom of the class (barely earning a B). Students 3 and 12 would likely not have been as successful without the videos. Out of curiosity, we noted the students who mentioned the videos as being helpful to their learning in the discussion board. They are shown in red in Figure 6.

While this is just one class of 18 students, the analysis of the viewing data, coupled with the written feedback on the class, revealed some interesting information on videos views and performance. If we were to remove the hard working student, the struggling student and the three who didn't need the video from the data, we would see a positive correlation between minutes viewed and class rank. However, it does not see possible to predict student performance by simply examining their viewing habits.

Conclusions

This paper reviews the literature that includes cognitive research and evidence-based findings on what makes instructional videos effective. We summarize the best practices from that research, using our experience with one online engineering economics class as an illustration. We then examine the student responses to our videos, discuss why we think the videos were useful to many students and look at video viewing data obtained from our learning management system. We attempt to draw parallels between student video viewing and academic performance, but the relationship is complex.

References

1. R.E. Mayer, *The Cambridge Handbook of Multimedia Learning*, Cambridge University Press, New York, 2005.
2. R.E. Mayer, "Applying the science of learning: Evidence-based principles for the design of multimedia instruction," *American Psychologist*, vol. 63, no.8, Nov 2008.
3. M. Alley and K.A. Neeley, "Rethinking the design of presentation slides: A case for sentence headlines and visual evidence," *Technical Communication*, vol. 52, no .4, Nov 2005
4. M. Marshall. "TED Talk: Talk Nerdy to Me" http://www.ted.com/talks/melissa_marshall_talk_nerdy_to_me , Jun 2012, (accessed Jan 2015).
5. P.J. Guo, J. Kim, and R. Rubin, "How video production affects student engagement: An empirical study of MOOC videos," in *Proceedings of the first ACM Conference on Learning at Scale*, Atlanta, GA, March 2014.
6. Maryland Online, Inc., "Quality Matters Rubric Standards, Fifth Edition, 2014," Maryland Online, Inc, Annapolis, MD, 2014.
7. R.E. Mayer, *Multimedia Learning*, Cambridge University Press, New York, 2001.
8. S. Veronikas, and M.F. Shaughnessy, "An interview with Richard Mayer," *Educational Psychology Review*. vol. 17, no. 2, Jun 2005.
9. J.A. Day, "Investigating Learning with Web Lectures," Ph.D. Dissertation, Georgia Institute of Technology, May 2008.

Appendix

Table: 63 Instructional Videos

Video	Title	Week	Category	Length
1	01-1 Economic Decision Making.mp4	1	Lecture	0:12:42
2	01-2 Time Value of Money.mp4	1	Lecture	0:11:22
3	01-3 Cash Flow Analysis.mp4	1	Lecture	0:11:22
4	01-4 Simple and Compound Interest.mp4	1	Lecture	0:07:26
5	02-1a Discounted Cash Flows.mp4	1	Lecture	0:10:51
6	02-1b Single Payment Examples.mp4	1	Tutorial	0:19:36
7	02-1c More Single Payment Examples.mp4	1	Tutorial	0:22:51
8	02-2a Irregular Series.mp4	1	Tutorial	0:12:26
9	02-2b Uniform Series Part 1.mp4	1	L/T	0:20:22
10	02-2c Uniform Series Part 2.mp4	1	Tutorial	0:21:46
11	02-3a Gradient Series.mp4	2	Lecture	0:05:56
12	02-3b Gradient Series Example 1.mp4	2	Tutorial	0:13:58
13	02-3c Gradient Series Example 2.mp4	2	Tutorial	0:11:28
14	02-3d Geometric Series.mp4	2	L/T	0:17:42
15	02-3e Geometric Series Example 2.mp4	2	Tutorial	0:11:05
16	03-1 Combining Factors.mp4	2	Lecture	0:08:53
17	03-2 Combining Factors Part 2.mp4	2	Tutorial	0:06:58
18	03-3 Combining Factors Part 3.mp4	2	Tutorial	0:09:05
19	04-1 Nominal and Effective Interest Part 1.mp4	2	Lecture	0:10:45
20	04-2 Nominal and Effective Interest Part 2.mp4	2	Tutorial	0:13:58
21	04-3 Nominal and Effective Interest Part 3.mp4	2	Tutorial	0:09:35
22	05-1a PW and FW Analysis.mp4	3	Lecture	0:14:48
23	05-1b PW and FW Example - One Alternative.mp4	3	Tutorial	0:10:04
24	05-1c PW and FW Examples - Two Alternatives.mp4	3	Tutorial	0:14:41
25	05-2a Capitalized Cost.mp4	3	L/T	0:17:33
26	05-2b PW of Bonds v1.mp4	3	L/T	0:13:30
27	06-1 Annual Worth Analysis.mp4	3	Lecture	0:14:16
28	06-2 AW Examples 1 and 2.mp4	3	Tutorial	0:14:11
29	06-3 AW Example 3 and Summary.mp4	3	Tutorial	0:07:03
30	07-1 Rate of Return Analysis Part 1.mp4	4	L/T	0:15:09
31	07-2 Rate of Return Analysis Part 2.mp4	4	L/T	0:10:49
32	07-3 Rate of Return Analysis Part 3.mp4	4	L/T	0:09:26
33	08-1 Introduction to Incremental Analysis.mp4	5	L/T	0:10:34
34	08-2 Example 2.mp4	5	Tutorial	0:12:21
35	08-3 Example 3 - ROR analysis for four alternatives.mp4	5	Tutorial	0:13:13

36	08-4 ROR Analysis for Service Projects.mp4	5	Tutorial	0:03:18
37	09-1 Introduction to Public Sector Economics.mp4	5	Lecture	0:11:22
38	09-2 Benefit-Cost Analysis.mp4	5	Lecture	0:09:01
39	09-3 Examples 1 and 2.mp4	5	Tutorial	0:12:19
40	09-4 Example 3 and Summary.mp4	5	L/T	0:08:09
41	10-1 Introduction to Cost of Capital.mp4	6	Lecture	0:12:25
42	10-2a Cost of Debt Capital - Bond Example.mp4	6	Tutorial	0:05:12
43	10-2b Cost of Debt Capital - Loan and Bond Example.mp4	6	Tutorial	0:20:50
44	10-3 Cost of Equity and Debt-Equity Mix.mp4	6	Lecture	0:09:54
45	10-4 Multi-Attribute Analysis and Chapter Summary.mp4	6	Lecture	0:07:14
46	11-1 Introduction to Replacement Decisions.mp4	6	Lecture	0:05:45
47	11-2 Replacement Analysis Example.mp4	6	Tutorial	0:11:04
48	11-3 Economic Service Life.mp4	6	Lecture	0:07:39
49	11-4 ESL Example.mp4	6	Tutorial	0:09:43
50	11-5 Using ESL in a Replacement Study.mp4	6	Lecture	0:08:17
51	11-6 Break-Even Example Other Considerations and Summary.mp4	6	L/T	0:08:04
52	12-1 Introduction to Capital Budgeting.mp4	7	Lecture	0:08:13
53	12-2 Solving the Capital Budgeting Problem Manually.mp4	7	Tutorial	0:07:20
54	12-3 Solving the Capital Budgeting Problem Using an LP.mp4	7	Tutorial	0:06:42
55	12-4 Capital Budgeting Example.mp4	7	Tutorial	0:21:54
56	16-1 Introduction to Accounting Depreciation.mp4	7	Lecture	0:11:56
57	16-2 New Terminology and Straight Line Depreciation.mp4	7	Lecture	0:06:25
58	16-3 Declining Balance Depreciation.mp4	7	Lecture	0:10:12
59	16-4 Example Using SLN and DDB.mp4	7	Tutorial	0:18:15
60	16-5 Introduction to MACRS.mp4	7	Lecture	0:11:16
61	16-6 MACRS Example and Chapter Summary.mp4	7	Tutorial	0:08:14
62	17-1 Corporate Taxes and Asset Disposal.mp4	7	Lecture	0:10:56
63	17-2 After-Tax Example Using MACRS and SLN Depreciation.mp4	7	Tutorial	0:13:19
			Total Time	**11:59:24**