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A Makeover for the Captured Lecture: Applying Multimedia Learning Principles to Lecture Video

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by

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We hereby certify that this dissertation, submitted by Richard Lamb, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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Making video recordings of large classroom lectures and putting them online is increasingly common in distance and blended learning courses. However, the best way to use lecture video is not well understood. Using long streams of one-way communication is not consistent with best practices in online learning. During lectures, students assume a largely passive role. They think faster than instructors speak, so boredom and daydreaming are common. Yet, when complex or novel ideas are presented, students may have inadequate time to encode, organize, and integrate the input with prior experience. Especially for students with low prior knowledge of the subject being discussed, the lecture is a cognitive and affective roller coaster ride that works at cross purposes with learning. Viewing a lecture that was recorded at an earlier time adds the element of temporal distance from the learning event, and changes the student's role from participant to spectator. The present study investigated whether learning could be increased and perceptions of difficulty reduced when a captured lecture received a "makeover" before being put online. The makeover consisted of 1) editing the lecture video in accordance with the cognitive theory of multimedia learning; 2) processing the video using best practices for audio/video production; and 3) increasing the video playback speed. The research design for the study was quasi-experimental. The independent variable was captured lecture form (edited or unedited). The dependent variables were learning results for recognition and recall, and perceptions of difficulty. Data analysis employed independent-samples *t*-tests, multivariate analysis of variance (MANOVA), and repeated-measures MANOVA. Conclusions were that the editing protocol made no significant difference in learning gains for recognition or recall, and did not significantly affect perceptions of difficulty. However, editing did result in a 39% reduction in the length of the lecture, raising the possibility that such a makeover might allow for faster learning when lecture video is used.

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Introduction

Introduction

The human cognitive system – the mechanism by which humans learn – can be seen as an active, limited-capacity, information-processing system with sensory memory, short-term or working memory, and long-term memory (Moreno, 2007; Sweller, 2010). How quickly and easily a human being learns is affected by the capacity of the individual's working memory, the complexity of what is to be learned, the individual's prior knowledge, and how the learning experience unfolds. All of these factors affect the cognitive load, or mental effort in a learning experience. The implications for instructional design are profound and comprise the central concern of *cognitive load theory* (Moreno & Park, 2010; Sweller, 1988, 2010).

The application of cognitive load theory (CLT) to the design of animations, hypermedia, and video that use words and pictures to facilitate learning has resulted in the *cognitive theory of multimedia learning* (CTML), a set of principles and guidelines that help designers of new multimedia instruction to optimize the processing of cognitive load (Mayer, 2009). CTML has also guided the editing of existing instructional videos, making them more effective for learning through retroactive application of cognitive load theory (Ibrahim, Antonenko, Greenwood, & Wheeler, 2012).

The captured lecture is one type of instructional video that has *not* been subjected to such an editing protocol. The reasons are unclear. Perhaps editing lecture video seems impractical or disrespectful of the instructor. It is also possible that lecture video is not recognized as a form of multimedia content. The research that has been done on lecture capture has focused largely on how viewing online the verbatim recording of a lecture compares to attending the lecture in the classroom (e.g., Euzent, Martin, Moskal & Moskal, 2011; Burns, Mitch, & Gomez, 2012; Owston, Lupshenyuk, & Wideman, 2011) or how teachers and students feel about lecture capture (e.g., Toppin, 2011; Hashash & Gunn, 2013; Newton, Tucker, Dawson, & Currie, 2014; Reed, 2014). In these studies, lecture capture rates high for student satisfaction and generates interest among instructors. The effectiveness of the captured lecture at promoting learning is less clear. At best, students learn as well from watching a lecture online as they do from experiencing it sitting in class.

That lecture capture as a pedagogic tool is no worse than live lecture is hardly a ringing endorsement. Lecture-based courses are typically instructivist in orientation and teacher-centered, and are often simply “shoveled into an online format” (Simonson, Smaldino, Albright, & Zvacek, 2009, p. 235). Most lectures offer students little opportunity to actively engage with concepts and construct meaning (Porcaro, 2011) Recorded lectures, however, can be treated as multimedia, and can benefit from theory and practice that have a decidedly more learner-centered and constructivist orientation. Instructional design based on constructivist principles seeks to make learning an active process of sense making in which the student engages with ideas, solves problems, and integrates new ideas with prior experience, rather than passively receiving information (Pang, 2009; Moreno & Park, 2010). Constructing knowledge is believed to lead to deeper levels of understanding, better retention of factual knowledge, and more useful critical thinking skills that allow what is learned to be transferred to other contexts.

Treating lecture video as multimedia requires but a small shift in thinking and the recognition that live performances and recordings of live performances are fundamentally different from existential, legal, and practical viewpoints. Editing of live recordings is commonplace in the arts. Indeed, skillful editing is an art unto itself. Editing of a lecture holds the promise of making it shorter, quicker in pacing, easier to see and hear, devoid of extraneous content, and embedded with on-screen signals that identify what is most important to remember. Instead of a long stream of continuous instruction, an edited lecture could be divided into multiple short segments like chapters in a book. Most importantly, the edited lecture would respect how humans actually learn. The present study produced a “makeover” for the captured lecture. Because the makeover protocol was based on cognitive load theory, empirical research, and best practices in professional audio and video production, predictions of improved recognition and recall of what had been learned were possible.

Statement of the Problem

Although streaming raw lecture recordings is an increasingly popular practice, the best way to utilize captured lecture video is not fully understood. Students viewing captured lectures are spectators to an earlier learning event. They have no influence on the pace or depth of presentation, and no opportunity to ask questions. Students think at a faster rate than instructors speak, so boredom is likely. Yet when novel or complex ideas are presented, students may have inadequate time to encode, process, and integrate new information with prior knowledge. High levels of extraneous cognitive load are thus likely to be present when captured lectures are used, especially for students with low prior knowledge of the lecture topic. More research is needed to determine how the aspects of lecture capture that are at odds with learning can be mitigated.

Discussion of the Problem

Students enjoy the flexibility, convenience, and sense of control that they have when given the option to watch lectures online, but attainment of learning outcomes related to using lecture capture is far from certain (Euzent et al., 2011; Ford et al., 2012; Owston et al., 2011).

Lectures often bore students and boredom undermines academic achievement (Mann & Robinson, 2009; Moreno, 2007). Putting lectures online in verbatim form does nothing to make the lectures more engaging and is seen by some critics as an attempt to "produce educational content on the fly" (Gutbrod, Werner, & Fischer, 2006, p. 197). The expanding use of lecture capture in higher education is driven more by the desire to improve student satisfaction than to improve student achievement (Johnston, Massa, & Burne, 2013).

One avenue that might be taken in addressing this problem begins with the recognition that lectures are multimedia instruction, "presentations involving words and pictures that are intended to foster learning" (Mayer, 2009, p. 5). It follows that the principles embodied in CTML apply to lecture video. CTML predicts that people will learn better from lecture video when 12 instructional design principles are followed (Mayer, 2009). A way of testing this prediction is to edit lecture recordings (captured lectures) to bring them into alignment with CTML principles.

It has already been shown that this sort of makeover can produce improved learning when applied to another form of instructional video, a professionally-produced educational program called "Insect" (Ibrahim et al., 2012). The "Insect" video, produced by the British Broadcasting Corporation, was re-edited to apply three CTML principles: segmenting, coherence, and signaling. Segmenting instruction into five- to nine-minute chunks has been shown to place less demands on working memory and to allow learners to catch up with their essential processing before accepting new input (Lusk et al., 2008; Smith, 2008; Sung & Mayer, 2013). Making instruction coherent by eliminating content that is extraneous to specific learning objectives – even when that content is interesting and non-redundant – reduces extraneous processing and promotes better learning (Ibrahim et al., 2012; Park, Moreno, Seufert, & Brünken, 2011). Adding signaling text to the screen to introduce, clarify, and summarize important information has been shown to increase understanding without increasing extraneous processing the way displaying every spoken word does (Ibrahim et al., 2012; Smith, 2008).

Another editing possibility with the practical advantage of making instruction shorter is time compression. Researchers have shown repeatedly that electronically speeding up narration by 25% or more can be done without affecting the intelligibility of the narrator, compromising learning outcomes, or increasing perceptions of effort (e.g., Orr & Friedman, 1965; Ritzhaupt, Barron & Healey, 2011; Pastore, 2012). Taken together, segmenting, coherence, signaling, and time-compressing, combined with standard practices used by audio/video professionals to improve the quality of picture and sound, comprise an original editing protocol that may imbue captured lectures with the pedagogic advantage they currently lack when compared to their live counterparts. Such a makeover protocol was investigated in the present study. The conceptual basis of this problem was found in the domains of learning theory, cognitive load theory, instructional design theory, and instructional media theory.

Dissertation Goal

The goal of this study was to determine, through quasi-experimental research, whether attainment of learning outcomes could be improved when a captured lecture was subjected to a cognitive-based editing protocol. The theoretical framework for this study was cognitive load theory and instructional design theory. The study had a realistic chance of addressing the problem because lecture video is, by definition, multimedia instruction, which is precisely the domain of CTML (Mayer, 2009). Furthermore, a similar solution (retroactive cognitive-based editing) was employed to solve the same problem with "Insect," a 32-minute instructional video produced in 1994 by the British Broadcasting Company (Ibrahim et al., 2012). Even though

"Insect" had been conceived and produced from the start to be instructional media, it became a better learning tool as a result of being re-edited according to CTML guidelines. Predictions of similar learning improvements with lecture video were thus possible. Time-compression research predicted that the edited modules of a captured lecture could be sped up by as much as 25% with no ill effects. Thus, a captured lecture subjected to the proposed editing protocol might not only produce better learning but do so more quickly than viewing the original lecture, with less likelihood of boring students.

Research Questions

In this experiment, subjects in the control group viewed the lecture in its original, unedited form while subjects in the experimental group viewed the lecture after it had been subjected to cognitive-based editing. A pre-test measured what participants already knew about the subject of the lecture. A post-test measured what they knew after viewing the lecture. Two types of learning – recognition and recall – were measured. Recognition is a lower-level form of learning demonstrated when the subject picks the correct answer out of a group of possible answers. Recall is a higher-level form of learning demonstrated when the subject retrieves the correct answer from memory without seeing a list of possibilities. The overarching multivariate research question (Q) and three contingent univariate research questions for this experiment (Q1, Q2, and Q3) are presented below, followed by their corresponding hypotheses:

Q: How will student success, as measured by recognition learning, recall learning, and perceptions of difficulty, differ between subjects in the experimental group and subjects in the control group?

Q1: How will learning gains as measured by recognition of correct answers differ between subjects in the experimental group and subjects in the control group?

Q2: How will learning gains as measured by recall of correct answers differ between subjects in the experimental group and subjects in the control group?

Q3: How will perceptions of difficulty of the lecture video differ between subjects in the experimental group and subjects in the control group?

Hypotheses

H: Members of the experimental group will achieve significantly greater success, as measured by recognition of correct answers, recall of correct answers, and perceptions of difficulty, than will members of the control group.

H1: Members of the experimental group will perform significantly better in recognition of correct answers after watching the lecture video than will members of the control group.

H2: Members of the experimental group will perform significantly better in recall of correct answers after watching the lecture video than will members of the control group.

H3: Members of the experimental group will rate the lecture video significantly less difficult than will members of the control group.

Scope of the Problem

In the United States, 6.7 million college students – 32% of all those enrolled – now take at least one online course. The number increases by half a million each year, making online learning critical to the long-term strategies of more than two-thirds of the country's academic institutions (Allen & Seaman, 2013). Recording lectures and making them available for on-demand streaming is a relatively quick, easy, and inexpensive way to meet the need for online course content. With research showing that student satisfaction is enhanced by the lecture capture practice (Euzent et al., 2011; Ford et al., 2012; Owston et al., 2011), it is almost certain that the practice will continue to grow (Johnston et al., 2013; Toppin, 2011).

Relevance and Significance

Lecture capture is a technology-centered practice that increases access to teacher-centered instruction (Mayer, 2009; Porcaro, 2011). Lecture capture does not align well with best practices in online learning, which are learner-centered and grounded in an understanding of how the human mind works (Simonson et al., 2009; Smith, 2008). Gutbrod et al. (2006) opine that learning from a linear stream of unedited lecture video is ineffective and "absolutely unacceptable" (p. 197). Yet the lecture capture practice continues and with it comes the same sort of extraneous cognitive load imposed by poorly designed multimedia instruction, especially for learners with low prior knowledge in the subject domain (Mayer, 2009). The possibility that captured lectures can be made into better learning tools made the present research relevant. The research was significant because 1) it added to the general body of knowledge about using technology to further learning, and 2) it offered specific empirical evidence about learning in blended and online courses using lecture capture.

Generalizability and Potential for Original Work

The literature currently focuses on the use of captured lectures in their original, unedited form. Thus, the present study – which investigated the effects of changing the format of the captured lecture through editing in accordance with a proven instructional design theory – qualifies as original, and adds to the knowledge bases in CLT, CTML, and instructional media. Although it followed the basic format of Ibrahim et al. (2012), the present study was different in important ways. Instead of starting with a polished educational video created by one of the world's most respected media producers, the British Broadcasting Corporation, the study started with raw lecture video recorded by an amateur videographer. The editing procedures used by Ibrahim et al. (2012), were expanded, first by optimizing the audio and video using professional production techniques and second, by adding the element of time compression. Time compression, along with the elimination of extraneous material to achieve coherence, introduces the possibility that an edited lecture might be shorter than the original lecture, which would almost certainly appeal to busy students and students prone to boredom.

The generalizability of the work derived from the fact that this editing protocol could be used to improve any multimedia instructional production by:

1. Removing content extraneous to the learning objectives;
2. Segmenting the content into subtopic modules of approximately five minutes each;
3. Giving learners control of the timing between modules;
4. Using time compression to speed up the pace of instruction;
5. Processing narration for maximum intelligibility using audio compression/limiting, normalization, and equalization/filtering;
6. Processing video for comfortable viewing using color correction, reframing for variety, and editing to avoid overuse of the instructor's image; and
7. Adding on-screen text to introduce, clarify, and summarize segment content so that the learner will know what is most important to remember.

Barriers and Issues

The study was sound from a theoretical standpoint. The welfare of participants was not compromised in any way so there were no issues raised when the Institutional Review Board (IRB) for Nova Southeastern University considered the study. The editing protocol was well within the capabilities of the researcher to perform. The methods and data analysis were rigorous but straightforward and were similar to those of the "Insect" study.

The barriers and issues that remained were as follows:

1. Finding an appropriate captured lecture to use in the experiment. This barrier was overcome by first considering what population of online learners was available to the researcher and then finding a recording of a live lecture that had been targeted to that audience. Horse owners were chosen as the general population because the researcher has access to large opt-in email lists for this audience. A lecture on hoof dynamics in sport horses, given by farrier and researcher, Gene Ovnicek, at the 2013 International Lameness Prevention Conference, in Las Vegas, Nevada, was selected because the topic would be of interest to the horse owners on the email lists, because the lecture had been given in a setting similar to a classroom or corporate training theater, because a non-professional recording of the lecture had been made, and because both Mr. Ovnicek and his son, Cody, were supportive of the study and willing to serve as subject matter experts (SMEs).
2. Editing the captured lecture. This was more of an issue than a barrier. The researcher had extensive professional experience in editing audio and video programs. It was important that the editing protocol be kept simple and straightforward so that it could be used by instructors who did not have prior experience in production. This rule was kept in mind as the editing was done, particularly with regard to the application of time compression.
3. Use of the speaker's image during the lecture was also an issue to be resolved. The image principle in CTML states that seeing the speaker's image onscreen *does not necessarily aid in learning* (Mayer, 2009), due largely to the demand placed upon the visual channel when processing moving images (e.g., dynamic visualizations) as compared to still images. This cognitive consideration must be balanced by the affective value of seeing a supporting instructor during learning. For the present study, the following rule of thumb

was developed: A different full-screen image, such as the current PowerPoint slide or signaling text, would be substituted for the instructor's image when doing so could be expected to help learners better process the information. Finally, substitution was also permitted to cover "jump cuts;" i.e., video edits that resulted in a visible jerk in the image.

4. Conducting the experiment. The experiment required pre-testing, presentation of two different versions of the lecture video, conducting a survey, and post-testing. The test needed to separately track multiple-choice (recognition) and fill-in-the-blank (recall) questions, and separately track the control and experimental groups. The initial approach considered was to build a web site for this purpose. The researcher's lack of experience in html coding led to investigating other options. An online testing service, ProProfs.com, had features that seemed to align well with the study requirements. A pilot test was conducted to confirm this and establish the reliability of the test instrument.
5. More work for instructors. The final issue considered was how this research might be seen by working instructors. If editing captured lectures was shown to improve learning outcomes, a new paradigm might emerge in which instructors were expected to edit their lecture videos before putting them online, much the way they would edit their academic articles before publishing them. Serious pushback could result from instructors who could see no benefit, didn't want to learn new skills or didn't want to do additional work. It was decided that the research was still important and that some very real benefits for instructors might emerge. For example, an edited lecture video could be useful in multiple iterations of a course (i.e., have significant "shelf life") and could actually free instructors for other activities.

Assumptions, Limitations, and Delimitations

Assumptions are the unprovable factors that are accepted as true within the context of a study. Assumptions in this research were as follows: 1) The captured lecture used for the study was representative of a meaningful population of captured lectures; 2) The participants in the study were representative of a meaningful population of students; 3) The participants made a sincere effort to complete their assigned tasks in the manner prescribed; and 4) Technical problems did not interfere with viewing the videos or completing the tests and survey.

Limitations are factors that are beyond the researcher's control and have the potential to impact internal validity; i.e., whether the conclusions follow from the results obtained in the experiment. Limitations in this research were as follows: 1) Participants were taken from a pre-existing group (i.e., horse enthusiasts) rather than the general population; 2) Participation was voluntary and participants could withdraw at any time, which meant that those who completed the study were less representative still of all learners; and 3) The study used one lecture on one subject from one instructor, and the lecture might not have been representative of a meaningful population of such lectures.

Delimitations are factors that are intentionally imposed by the researcher to constrain the scope of the study in order to make it manageable. Delimitations impact the generalizability of the results of the study. Delimitations in this research were as follows: 1) The study was concerned only with captured lecture, not captured lecture and discussion; 2) The study looked only at learning among adults in a particular continuing education setting, and the findings may therefore not be generalizable to other learning contexts with learners of other ages; 3) The study did not test the separate impacts of the CTML principles utilized in the editing protocol; and 4) the possibility that prior knowledge of the lecture topic and perceptions of lecture difficulty might interact was not considered.

Definitions of Terms

The definitions presented below are for terms as they were used in this study. Familiar terms are included if they have special meaning in this context. Where academic sources are not cited, the author's expertise as an audio/video and technology professional may be assumed. Additional comments are offered if they are useful to understanding the study.

Best practices for audio and video production are common techniques and principles used by production professionals to make educational media more effective (Purdue University, 2014). In the pesent study, the editing protocol called for optimizing and normalizing the volume level and tone of the speaker's voice, adjusting the color, lightening or darkening the image, varying the framing, and inserting high-resolution slide images or video clips where feasible. Content extraneous to the purpose of the production was also removed. In keeping with common usage, *video* may refer to either an entire audio/visual recording or the visual component alone, depending on context.

Lecture capture (or video lecture capture) is the practice of recording a lecture in front of a live audience of students (Newton et al., 2014). In some cases lecture capture has been extended to mean lectures prepared outside of the classroom. In all cases, the purpose is to allow the student to view lectures online at a time and place of the student's choosing.

Segmenting is applying the segmenting principle in CTML to break long streams of instruction into multiple short segments, typically five to nine minutes in length, playback of which is controlled by users (Mayer, 2009). Segmenting has been shown to be most effective with learners who have low prior knowledge of the subject matter. Learners with higher prior knowledge have more cognitive resources available to process long streams and may prefer them to shorter segments.

Signaling is applying the signaling principle in CTML to help learners identify what is most important to remember in multimedia instruction (Mayer, 2009). Signaling can be used to prepare learners in advance of instruction, to highlight or clarify key points and terms while instruction is being presented, and to summarize the "takeaways" after instruction.

Time compression is speeding up playback of a lecture so that the instructor's rate of speech is closer to the mental processing rate of the average human (Pastore, 2012). The compression process does this without changing the pitch of the instructor's voice. Time compression when the instructor's image is visible on screen must be used with discretion since a sped-up visual may be appear unnatural and distracting to the learner, even when the voice pitch is normal.

Weeding is applying the coherence principle in CTML to remove lecture content that is not essential to the learning objectives (Ibrahim et al., 2012). Judgment must be exercised to not render instruction dull and lifeless through weeding. Some lecture content may be extraneous from a cognitive standpoint (i.e., it "wastes" working memory capacity) but useful from an affective standpoint (i.e., it adds to enjoyment, interest, and motivation) thus having a net positive influence on learning. The learner's prior knowledge of the subject is a relevant factor in weeding; greater prior knowledge makes weeding of extraneous content less important.

Summary

The motivation for the study was the widespread use of lecture capture in distance and hybrid learning contexts without a full understanding of the best way to use lecture video. As a mere spectator to a past learning event, with no power to change the pace or depth of instruction or to ask questions, a student viewing a captured lecture is likely to be both under challenged and over challenged. Boredom and extraneous cognitive load are likely to be high, especially for students with low prior knowledge of the lecture topic, and these factors are known to work against learning.

The goal of the study was to determine, through quasi-experimental research, whether attainment of learning outcomes could be improved when a captured lecture was edited in accordance with established instructional design principles used in the field of multimedia learning. Testing for recognition of correct answers and recall of correct answers was employed before and after presentation of instruction in order to isolate the effect of the experimental treatment. In addition to learning outcomes, perceptions of difficulty were investigated. The hypothesis was that subjects viewing the experimental version of the lecture would demonstrate significantly greater learning gains, both on questions measuring recognition of correct answers and on questions measuring recall of correct answers, and would rate the lecture as significantly less difficult than would subjects viewing the control version of the lecture.

In chapter two of this report, a literature review will be presented. Attention will be focused on lecture capture, multimedia learning, and personal factors in learning. In chapter three, the research approach that was taken will be explored in detail. In chapter four, the results of data collection and analysis will be presented. In chapter five, the conclusions, implications, recommendations for future research, and study summary will be presented.

Chapter 2

Review of the Literature

Introduction

In this chapter a review of the literature will be presented. The research conducted in the present study charted new territory. There was no evidence in the literature that captured lecture video had been subjected to editing in accordance with multimedia learning principles. In order to establish the necessary and sufficient literature foundation for the study, this review will therefore address three main subject areas: video lecture capture, multimedia learning, and personal factors in learning.

Video Lecture Capture

Video lecture capture (or simply *lecture capture*) is the practice of recording an instructor's live presentation and making it available for viewing via the Internet at a time and place of the student's choosing. The captured lecture is a verbatim representation of what happened in class. Many major U.S. and international institutions of higher education have already adopted lecture capture and many more have plans to do so, owing primarily to the popularity of the practice among students. Three intertwined themes are present in the literature relating to lecture capture: the impact of lecture capture on academic performance, student and instructor perceptions of lecture capture, and cognitive engagement when lectures are used.

The impact of lecture capture on academic performance.

A legitimate concern among educators is the effect that lecture capture has on learning. Thus, many studies measure how well students perform when lecture capture is used. For example, Euzent et al. (2011) conducted a quasi-experimental study to investigate the impact of lecture type on grades. The participants were 673 students spread across four sections of an undergraduate course in macroeconomics at the University of Central Florida. Students in two sections received the course with live face-to-face lectures (control group, designated FF) while students in the other two sections received the course with captured lectures (experimental group, designated LC). Students could choose which version of the course they took. LC students also had the option of attending the live lectures on a first-come, first-served basis, but only about 10% of those students regularly did so. There was no significant difference in high school GPA, total SAT score, or total ACT score between the two groups. FF students had a slightly higher university GPA. LC students were more likely to be older, employed full-time, and female.

Lectures were captured in a 280-seat multimedia classroom via two broadcast-quality cameras and a standard document camera. Eight microphones were placed throughout the lecture hall to capture instructor and student audio. The lecture format was “chalk and talk” with PowerPoint and whiteboard. The audio and video were fed to a booth at the back of the room where they were routed to appropriate workstations for recording, editing, backup and delivery. Presumably at least one technician was involved to operate the equipment, although that was not stated. A live feed was sent out without editing within 30 seconds. A second version was edited and archived for on-demand viewing. The nature or extent of editing was not described. New lectures were given each semester. Questionnaires were used to gather data on student perceptions, including instructor evaluation. Performance data came from the final exam and overall course grades. Multivariate analysis of variance was performed between grades and lecture type.

The authors reported that there was no significant difference in final exam or overall course grade between students receiving face-to-face lectures and students receiving captured lectures. However, there was a higher withdrawal rate among students in the lecture capture group. The authors concluded that achievement is neither helped nor hindered by using lecture capture and that students generally approve of the practice. A limitation in this study was the lack of random assignment to control and experimental groups, which may have resulted in the groups being populated by two different types of students. Additionally, the number of videos watched and how often they were watched was not tracked.

Ford et al. (2012) conducted a quasi-experimental study of captured lectures with students in four sections of a General Psychology undergraduate course. Two sections occurred prior to the availability of classroom capture technology (CCT). Students in these sections served as the control group (called the non-CCT group). Two sections took place after CCT became available and students in these sections served as the experimental (CCT) group. In order to measure the effectiveness of CCT as a supplement to in-class lectures rather than a replacement, only selected lectures were recorded and offered online. Each student's prior GPA was collected, along with the final grade for the course. This comprised the objective data for the study. The remaining data were self-reported via a questionnaire at the conclusion of the course and addressed average weekly study time, perceived effectiveness of the debate activity, how effectively learning outcomes were addressed by the course, to what extent the course challenged the students to do their best work, and the frequency of the students' class attendance.

The authors reported that 83% of non-CCT students and 87% of CCT students completed the questionnaires. Correlational analysis showed that there was no correlation between prior GPA and the assignment to one or the other groups (CCT or non-CCT). Compared to the non-CCT group, students in the CCT group (i.e., students who had access to captured lectures) were significantly more likely to report more hours per week studying. However, there was no significant difference between the groups on final course grade or reported class attendance, leading the authors to conclude that there is no evidence that using captured lectures affects learning outcomes.

Johnston et al. (2013) conducted quasi-experimental research using a convenience sample of 499 nursing students taking an introductory anatomy and physiology course at two campuses of an Australian university. Campus A students received live lectures only and campus B students received live lectures and access to recordings of those lectures. The campuses and instructors were comparable. All other aspects of the two courses were identical. All data were collected retrospectively rather than during the semester. Quantitative data took the form of formative and summative test results and patterns of usage collected by the lecture playback software. Qualitative data consisted of verbal and written feedback from students, grouped by theme to enhance and give context to the quantitative results.

The authors reported that 96% of campus B students used the lecture recordings and that the way students used the lecture video varied widely. Some students viewed each lecture in its entirety multiple times. Others fast-forwarded through selected lectures to view certain parts. Still others did not view the lectures at all. Some students may have viewed the lectures instead of attending class, as the average attendance at campus B lectures dropped by approximately 30% when compared to previous years. Lecture attendance at campus A did not vary from previous years.

Academic outcomes at campus A were unchanged from previous years and were significantly better than outcomes at campus B. However, campus B students who frequently used the captured lectures performed marginally better than their campus B classmates who did not. The authors concluded that open questions remain about the impact that student decisions have on academic performance, and questioned an underlying research assumption that students are capable of deciding what learning activities best support their learning. In short, the effort to examine the pedagogic value of lecture capture may have been confounded in this study by the choices students made. The authors summed up by stating that where lecture capture is concerned, “it is very difficult to control for the plethora of factors which contribute to academic outcomes by students” (Johnston, 2013, p. 45).

Owston et al. (2011) explored the relationship between the use of captured lectures and academic achievement by conducting a quantitative study using students in six large freshman classes in health studies at a major university in Canada. Videos of class lectures were made available online and a survey was used for students to report on how they utilized the videos. Participation in the survey was optional. Viewing patterns, in-class behavior, and subjective feelings about using lecture video were correlated with final grades. Sixty-five percent of the students reported attending class less as a result of having the lecture videos available but there was no evidence that grades suffered as a result. Ten percent of the students stopped attending classes entirely, and this group had the highest mean grades, although the difference was not statistically significant. Students who viewed the videos one to three times per month scored significantly higher than students viewing videos four to six times per week. Students who fast-forwarded to sections of the videos and watched the sections once scored significantly higher than students who watched each video in its entirety once and sections multiple times. Students who watched each video once in its entirety scored significantly higher than students who watched the videos multiple times. Seventy-four percent of the students reported that having lecture videos available did not change their in-class note-taking behavior. Students were evenly divided on whether they followed discussions more closely or focused more on the lecture and less on taking notes. Ninety-five percent indicated that having the videos available did not cause them to pay less attention in class. Sixty-five percent indicated that seeing the instructor in the video would be useful or essential in future courses, but no significant correlation between instructor image and grades was seen across the response categories.

The authors speculated that the higher-achieving students may have had the confidence and self-discipline to master the content by viewing the captured lectures and other online materials only when they needed to and felt that attending class or viewing the videos more often would be redundant. Lower-achieving students may have felt the need for more viewings and class attendance. Higher achievers may have used the videos only to clarify or review specific topics, not to review the entire lecture. Lower achievers tended to watch whole videos multiple times and may have created some confusion by over-interpreting the instructor's remarks. Freeing students from the distraction of note-taking was not supported in this study as a justification for capturing lectures. Seeing the instructor in a captured lecture had no effect on achievement. This study suggested that captured lectures may be most helpful and of greatest interest to lower-achieving students.

Limitations to the study were the heavy reliance on self-reporting by the students and the relatively low participation rate; although 37% of eligible students responded to the questionnaire, only 19% provided their student IDs, which was necessary in order to obtain the students' grades. Thus, the study attracted a particular type of student, which limited conclusions that could be drawn about the population as a whole. Also, in this study, students could both attend the live lecture *and* watch the capture if they chose. Other scenarios without that option – e.g., fully online courses or a particular lecture no longer offered live – might produce different usage patterns.

Pierce and Fox (2012) explored the effects of using lecture capture as part of the “flipped classroom” instructional model, which allows shifting of the time and space of teaching and learning. The research type was a design experiment, a type of experiment that is done in a real-world or “messy” setting in order to avoid the distortions of laboratory experiments. Participants were 71 pharmacy students (57% female and 42% male) in an eight-week pharmacy integrated therapeutics course that met twice weekly for two hours. Educational background of the participants ranged from one year of undergraduate courses to a master’s degree. A pre-test was used to establish prior knowledge in the subject domain.

Most of the course was taught in a conventional way. One module on renal pharmacotheraphy featured the “flipped classroom” instructional model, where students view lectures at home and do “homework” in class. For this one module, four hours were recorded as video podcasts for students to view in preparation for a special in-class activity, a process-guided inquiry learning (POGIL) activity. The video podcasts took the form of slide shows with voiceover that were recorded live in the previous year’s course. The same instructor taught both courses in an identical fashion other than using the podcasts. The prior year course served as a benchmark for comparing learning outcomes. Objective data collected took the form of final exam scores and final exam scores from the same course taught the year before. A 10-question survey with Likert-scale questions was used to collect subjective data on student perceptions of the POGIL activity and the flipped classroom instructional model. The survey was administered online using Survey Monkey.

Final exam grades were significantly improved over the prior year, which was identical except for the flipped format/captured lecture component. More research is needed to determine if this was an anomaly. Limitations to this study were that the range of prior education among the participants was substantial and the authors did not make clear whether this fact had any bearing on outcomes or was also true of the previous year's class. Additionally, the amount of instruction used in the study was small: a single module with four hours of captured lecture content.

Captured lectures were one type of instructor-generated video used by Draus, Curran, and Trempus (2014) to measure the impact of increasing instructor presence in an online, upper-level management course. Other instructor-generated video included announcements, explanation of assignments, answering of questions posted on the discussion board, and miscellaneous messages, all of which were recorded by the instructor in his office or home. The study took the form of an experiment wherein one section of the course had instructor-generated video and three past sections of the same course did not. All other aspects of the experimental and control groups were unchanged; i.e., the video did not replace any course materials. Data came from a campus-wide Student Opinion Poll (SOP) completed at the end of the course, final grades, and analytics from the learning management system and YouTube, which hosted the video.

Captured lectures accounted for 76% of the instructor-generated video used. Students in the experimental group spent an average of 8.2 hours viewing the instructor-generated video during the course, which, according to university guidelines, was 12.4% of the time usually spent on an online course. Student performance was measured with final grades and persistence. The results were that there was no significant difference between the two groups in persistence, but a 3.2% increase in grades for the experimental group. Student engagement, as measured by the number and length of student discussion board postings, also increased in the experimental group. The authors concluded that increasing instructor presence with video can have a moderate positive influence on learning outcomes. However, this could not be credited to the use of captured lectures alone.

Student and instructor perceptions of lecture capture.

Online learning is a two-edged sword for universities. They can now enroll students who are geographically distant from campus but they must also actively compete with other institutions for the students in their own backyards. Thus, what learners as customers want out of their learning experiences is important to understand.

In addition to how well lecture capture promotes learning, many research studies have also investigated how students and instructors feel about the process. For example, in the Johnson et al. (2013) study with nursing students, feedback from students indicated a belief that the lecture recordings were a valuable resource, especially as a supplement to attending live lectures. In the Euzent et al. (2011) study with macroeconomics undergraduates, students felt that lecture capture gave them more control over learning (72%), enhanced their interest (38%), enhanced their performance (43%), and was as good as or better than face-to-face learning (81%). The vast majority of these students (73%) indicated that they would take another class that used lecture capture. The general positive feeling extended to the instructor, who was rated notably higher by the lecture capture students than by the face-to-face students in the same course.

The Ford et al. (2012) study with psychology undergraduates compared the perceptions of students using captured lectures with the perceptions of students who didn’t. The lecture capture students were marginally more likely to report that learning outcomes were effectively addressed and significantly more likely to report that the course challenged them to do their best work. The authors concluded that lecture capture is positively correlated with improved study strategies and student satisfaction with a course.

The Pierce and Fox (2012) study of a flipped pharmacotherapy module resulted in overwhelmingly positive perceptions. Students felt that viewing the lectures before the associated class activity was important (96%), that the instructor made meaningful connections between the lecture and class activities (90%), and that viewing the lectures was essential to successfully completing the class activity (76%). Of the flipped classroom model overall, students felt that the model improved their self-efficacy to address the topics on the final exam (80%). The authors concluded that students in this study recognized the convenience and learning benefits of the flipped classroom instructional model and had a consistently high preference for it over more traditional formats.

Some researchers focus exclusively on student and instructor perceptions. For example, Toppin (2011) investigated the implementation of a lecture capture system at a university in the southeastern United States and conducted survey-based research on the use of the system with at-risk science students. The system selected was Panopto by Coursecast, which was synchronized to the university's Blackboard Learning Management System to provide access to the lecture videos. Nine faculty members teaching 16 sections of science courses with high rates of drop, fail, or withdrawal (DFW) were recruited to participate, along with 316 students (238 female and 78 male) in those sections. Student participants were predominantly African American, 60% underclassmen, and 40% upperclassmen or second degree students. A majority of the participants reported their GPAs to be between 2.6 and 3.0, and were repeating the course in the study because they had received a "D" or had failed the course previously. Of the students who began the study, 49% dropped out, leaving a student population of 162. Two faculty members also dropped out, leaving seven faculty and 13 course sections to be used in the study. The pre-instruction survey gathered demographic data on the student participants, while the post-instruction survey gathered information on how the participants used lecture videos during the course and their subjective feelings about the experience. A post-instruction survey was also completed by each faculty member in order to compare student and teacher perceptions.

Survey results indicated that the majority of student participants considered the lecture videos to be highly beneficial to understanding the concepts taught in their courses (77%), to be valuable (80%), to be very beneficial to student learning (68%), and to have no effect on class attendance (86%). Student feelings about using lecture videos to prepare for tests were mostly positive. However, there were many neutral answers about how well the videos prepared the students for class discussions. The author speculated that variations in the use of class discussions from course to course may have accounted for this result.

The faculty survey revealed that six of the seven teachers recorded their lectures “live” in the classroom for students to watch later. One teacher pre-recorded lectures so that students could watch them in advance of the corresponding class meeting. Three teachers offered incentives to get their students to watch the videos. Most of the teachers (83%) agreed that the lecture videos did not reduce class attendance, while 67% noted an apparent performance difference between students who viewed certain topics and those who didn’t. In comparing results of the student and faculty surveys, the authors noted that both groups felt captured lectures were highly beneficial and did not hurt class attendance. However, students had a more exaggerated opinion of how lecture video improved their academic performance than did faculty. This fact underscores the difference between student performance and student perceptions related to their performance.

Nashas and Gunn (2013) investigated lecture capture in an engineering course at the American University of Sharjah in The United Arab Emirates. The goals of this study were to learn how students perceived the benefits and drawbacks of lecture capture, and how often students actually viewed the recorded lectures. Qualitative and quantitative data were collected via a survey, focus group interviews, and video usage statistics from the Blackboard course management system. Participants were a convenience sample of 40 electrical or computer engineering majors (27 males and 13 females) in two sections of the same introductory electronics course.

The evolution of the technology used at this university is an example of how lecture capture implementations can vary. In phase I, a desktop computer, overhead projector, wireless microphone, video recorder, and camera with dynamic tracking of the instructor's movement were permanently installed in the engineering auditorium. A standard whiteboard was also used extensively for working problems to one side of the projection screen. Advantages were that the entire classroom experience was recorded, including the instructor's image. Drawbacks of this system were that it was not portable; it required an IT tech to initiate capture of a lecture and burn a DVD afterward; the video files were so large that they had to be edited and compressed before being stored on a special server by the library; a steep learning curve resulted in poor audio quality for several lectures; ambient lighting issues made both the PowerPoint slides and the worked examples on the whiteboard difficult to see on the video, the camera was not stable while tracking the instructor; there was no zoom function; and there was a two-day delay before the video was available for viewing.

In phase II, an eBeam Edge system was adopted to replace the original configuration. This system consisted of a standard whiteboard, a projector, a Windows-based laptop computer running the eBeam and PowerPoint software, an eBeam transceiver and stylus, and a wireless microphone. With this system, the instructor used the stylus to interact with the projected images, moving elements about, adding hand-written notations, and navigating through the software. Advantages of this system were that audio and video quality were improved; system setup and calibration could be done in five minutes without an IT tech; the lecture was captured directly to the computer's hard disk and required no further processing; the video file size was reduced by a factor of 12; the instructor could upload the file to the course web site without assistance from the library; and the lecture was available for viewing within two hours. Drawbacks were that the system captured the instructor's stylus manipulations but not the instructor's image.

The study conducted by the authors was with the phase II system utilizing the eBeam Edge solution. The survey was completed by 38 students. The majority of participants felt the lecture videos were helpful for understanding the course material (97%), would help raise the student's grade (89%), did not prompt the student to skip class (73%), should be adopted by other professors in other classes (100%), were easily accessible (92%), and were viewed without downloading problems (87%). Blackboard statistics were available for all students. Visits to the course's content area, which consisted almost entirely of the lecture videos, accounted for 73% of the students' use of Blackboard in the course. The visits occurred on a regular basis with peak usage just prior to the midterm exam.

To supplement this quantitative data, qualitative data was collected with open-ended survey questions and focus group questions. The following themes emerged regarding the benefits of lecture capture: more efficient studying possible, less need to ask the professor for clarification, convenience of viewing anytime and anywhere, less concern about missing something in class due to distractions or daydreaming, and less pressure to take notes. Themes related to drawbacks of lecture capture were technical glitches during the lecture (e.g., microphone problems) or playback (e.g., playback freezing, requiring a system restart) and the displeasure of experiencing a bad lecture twice (i.e., in the classroom and online). In their discussion of the study results, Nashas and Gunn (2013) raised excellent points about the usefulness of lecture capture in promoting both formal and informal learning, and its influence on affective factors such as learner autonomy. The authors noted that students viewing a captured lecture have the option of multitasking in ways they can't do in the classroom, allowing more efficient use of their mental processing capabilities. The fact that the instructor's image was not present in the captures did not appear to be an issue with the students in this study.

Watt et al. (2014) conducted a mixed-methods study of student perceptions to evaluate the effectiveness of lecture capture as a tool for universal instructional design (UID). UID has at its heart the belief that instruction that accommodates students with special needs can benefit all students, much the way that universal design applied to fixtures, machines, and spaces can benefit all users. Lecture capture provides students with disabilities alternate access to instruction and also has value for students without disabilities.

The lecture capture platform used in the study was echo360. Participants were recruited from a social sciences course on Canadian children at McMasters University in Ontario, Canada. Quantitative data was collected with an online questionnaire completed by 175 of the students. The questionnaire consisted of 40 multiple-choice and Likert Scale questions. Of the 175 participants, eight students also agreed to face-to-face interviews, which provided the qualitative data. Questions used in the study reflected the nine core principles of UID: equitable use, flexibility in use, simple and intuitive, perceptible information, tolerance for error, low physical effort, size and space for approach and use, a community of learners, and instructional climate.

All respondents were satisfied with the ease of use and quality of the captured lectures. Some students viewed the recordings when they missed a lecture (41%) and some used the recordings in lieu of attending class (21%). Most students (78%) felt that lecture capture improved their understanding of course material and helped them retain what they learned in the course. An even greater percentage (89%) felt that lecture capture provided all students, regardless of learning abilities, an equitable learning experience. Based on these results, the authors concluded that lecture capture consistently aligns with the UID principles.

Reed (2014) conducted survey research at a Russell Group University in the United Kingdom to learn how instructors felt about technology-enhanced learning in three areas: creating minimum standards for the virtual learning environment; enabling online submission, marking, and feedback for assignments; and using lecture capture. Employing an online questionnaire, the author constructed a snapshot case study that identified the experience and attitudes of 100 instructors. For the section on lecture capture, respondents chose from a list of drivers and a list of barriers to express their views. Drivers supporting lecture capture included increasing the flexibility of learning (54%), supporting students with learning difficulties (50%), developing independent learning (47%), creating a blend of face-to-face and online sessions (45%), supporting assessment preparation (38%), improving communication of complex information (38%), overcoming language barriers (29%), overcoming note-taking challenges (29%), overcoming sustained concentration challenges (28%), and overcoming available space challenges (14%). Free-text comments related to drivers for lecture capture were that the practice could save the instructor time and release him/her for other roles, increase consistency for distance learners, provide lecture preview or give a lecture when the instructor wasn't available, increase challenge for learners, and reduce spoon feeding of course content.

Barriers to lecture capture included lack of time (49%), reduced class attendance (33%), reduced attention in class (26%), and disagreement with the lecture capture concept (10%). Free-text comments related to barriers for lecture capture indicated concerns about lack of feedback to instructors, lack of technology skills and support, the need for training in systems and software, the possibility that students most needing to be in class might stop coming, the possibility that students would only watch the lectures and not do assigned reading, the possibility that recorded lectures might be distributed beyond enrolled students, having lecture mistakes recorded and distributed, cross-platform compatibility issues with recordings, and the possibility that having recordings available might inhibit development of note-taking skills.

General free-text comments revealed that some instructors did have experience with various lecture capture methods, that instructors were not in agreement on the likely impact of lecture capture on class attendance, that some instructors felt that using recordings actively undermined the development of deep-thinking skills, that automation or simple workflows were important to making lecture capture feasible, and that recording specific content rather than entire lectures might be preferable. When asked what system features and workflows would be expected in a lecture capture recording system, the overwhelming response was ease of use. The Reed (2014) study concluded that although lecture capture faced more resistance than the other uses of technology, it was still supported by the vast majority (70%) of the instructors in the study, and that the dominant concern was the demand on their time.

Clearly, instructors are not of one mind with regard to lecture capture. Accordingly, it may take different forms at the same time within the same institution. Newton et al. (2014)

investigated how lecture capture is being used at the University of Guelph in Guelph, Ontario, Canada. Four implementations were examined using a case study methodology. The case studies were dubbed The Technologically Challenged Professor, The Technologically Creative Professor, The Professor with a Budget, and The Technology Wizard Professor.

The Technologically Challenged Professor had no prior experience with lecture capture but knew he wanted only his voice and PowerPoint presentation to be captured. With help from more experienced instructors, a very basic and inexpensive capture system was created. Videos were stored in compressed form on the university's server and students gained access through links in the course management system. Numerous courses in undergraduate biological sciences were taught using this system. Class sizes ranged from 34 to 600 students, and the system was moved easily between large and small lecture halls. Approximately $300 was spent on a wireless microphone, capture software, and video compression software.

The Technologically Creative Professor felt that capturing all aspects of the classroom experience was desirable, that the technology used should be simple and portable, and that software and storage should be free. The resulting system recorded the instructor's voice and image, the PowerPoint presentation, and all classroom activity. Videos were streamed by YouTube and links were provided to students through the course management system. The system was used with biological science courses taught in both small classrooms and large lecture halls, and with from nine to 600 students. Approximately $600 was spent on the camera and wireless microphone. The free software used was Apple QuickTime and the free storage was YouTube, which also provided useful closed captioning and translating options, and allowed high definition video to be used.

The Professor with a Budget was involved in launching a new program in accounting and dramatically expanding a second-year management accounting course from class sizes of 55 to more than 600 students. The university gave the professor a five-year budget for classroom technology to assist in this expansion. The capture system that resulted was based around a Lenova tablet/notebook computer with maximum power and memory to allow multiple programs to run at once. The professor used the computer for his in-class presentation, to work problems on the tablet, and to access the Internet, while Camtasia ran in the background and captured everything that was displayed in the classroom. In addition to the computer, a wireless microphone and the Camtasia capture software were purchased for a total one-time cost of approximately $2,000. An additional $1,500 per term was spent for a teaching assistant to do minor editing, and to render, compress, and upload the modified files to the university's server, where the files were streamed via links provided in the course management system. Videos were typically 60-70 minutes in length but were indexed to allow viewing of selected sections.

The Technology Wizard Professor began capturing lectures without any out-of-pocket expenditure by recording an audio feed from the classroom's PA system using GarageBand, an audio recording application standard on MacBook Pro laptop computers. The resulting mp3 audio files were posted along with the professor's PowerPoint presentations, and students were required to synchronize the two files. Wanting to take in-class lecture capture to another level, and to be able to create tutorials in his office, the professor invested in separate components optimized for each: a wireless microphone and portable tablet for in-class use, and a desktop microphone and large tablet for use in the office. The same MacBook Pro running Camtasia was used with both setups. Both YouTube and the university's servers were used for video storage, with links provided through the course management system. Total cost for these two setups was approximately $3,000. The resulting videos were lecture “snippets” rather than complete lectures, and featured the instructor’s voice, the PowerPoint presentation, and tablet images. The instructor’s image was not captured.

Using the lessons learned in these four case studies, Newton et al. (2014) offered technical and pedagogical suggestions for the use of lecture capture. Technical issues to be considered are correct settings while using hardware and software, avoiding infringement of copyright, complying with any applicable disability requirements (e.g., closed captioning), making certain students can access the videos even during periods of high Internet traffic, arranging for long-term storage of the videos, and determining ownership of the videos. Pedagogical issues are avoiding teaching to the technology (i.e., compromising the in-class experience), discerning what subject, teaching styles, and learning environments are conducive to lecture capture, deciding whether the voices and images of students in the classroom should be included, considering the impact of lecture capture on students for whom English is a second language, and making sure all students understand how to use the technology. An important omission was a discussion of whether the instructor’s image should be part of the video.

Student engagement when lectures are used.

Whether it is important for lecture capture students to see their instructors on screen is one question of many that relate to student engagement. For all the interest in academic equivalence and student satisfaction with lecture capture, precious little research has gone inside the student’s mind to study the cognitive and affective processes at work when lecture capture is used. The underlying assumption appears to be that these processes are not so different from what happens during a classroom lecture, a subject that has been explored in the literature on classroom boredom. For example, Mann and Robinson (2009) studied the traditional lecture in their survey research of students at a university in the northwest of England. A convenience sample of 66 male and 145 female participants was formed by recruiting from common areas of the university. Survey questions addressed general proneness to boredom (an adaptation of the Boredom Proneness Scale), how often the students felt bored during lectures, how often they skipped class, how they rated various teaching methods with regard to boredom, and how they coped with boredom during lectures. Data analysis was quantitative and yielded descriptive and inferential statistics.

The authors reported that participants who were more prone to boredom generally (i.e., had high scores on the BPS) were bored more often during lectures and missed more lectures than participants with low BPS scores. The more lectures that students had already missed, the more lectures they were likely to miss in the future. The more lectures missed overall, the more grade point averages decreased. Students prone to boredom were significantly more likely during boring lectures to employ coping strategies such as playing games on their mobile phones, sending text messages, talking or writing notes, doodling, daydreaming, leaving at break time, and deciding not to attend the next lecture, as compared to students not so prone to boredom.

The study results were that 59% of students found at least half of their lectures boring and 30% found most or all of their lectures boring. Limitations in this research arose from the fact that students were asked to recall past lectures, that specific lectures or classes were not identified, and that finding lectures boring might be considered a fashionable response among some students due to what the authors called *social desirability bias*.

The types of classroom lectures that students considered most boring were laboratory work and computer sessions. Although these hands-on activities might be expected to be highly engaging, the authors noted that prior research had already established that such work can be dull and tedious when experiments are too controlled and results are too predictable. Online lecture notes, copying overheads in lectures, and PowerPoint lectures without handouts followed in the rating of most boring teaching methods. Least boring were seminars, practical sessions and group discussions, all of which involved interaction and active learning. The authors concluded that boredom in the lecture theater has significant negative impact on academic achievement and that the two most important factors are boredom proneness in the student and the level of engagement produced by the teaching methods.

Acee et al. (2010) explored student perceptions of academic boredom by conducting two survey-based studies of students in applied courses in learning and cognition at a large public university in the south central United States. In the first study, 170 students (52% female and 48% male) completed a 36-item survey based on the Academic Boredom Scale (ABS). In the survey, students were asked to reflect upon and answer questions about an under-challenging situation (i.e., academic activities too easy and not challenging, easy to understand, and not much work) and an over-challenging situation (i.e., academic activities too difficult and too challenging, hard to understand, and too much work). In the second study, 178 students (58% female and 42% male) replicated the first study's use of the ABS but also completed the Academic Emotions Questionnaire (AEQ) for the same under-challenging and over-challenging situations. The AEQ was modified to measure only class-related emotions such as enjoyment, hope, pride, anger, shame, hopelessness, and boredom. In the second study, demographic data were also collected and participants were asked two open-ended questions that allowed them to describe the under-challenging and over-challenging situations on which they had based their survey answers. Qualitative methods were used to categorize and code the types of situations students remembered.

Exploratory factor analysis and confirmatory factor analysis were used in both studies. In the first study, the authors identified two types of boredom. *Task-focused boredom* centers on features of the task, such as tediousness and meaningless. *Self-focused boredom* centers on negative feelings such as frustration, impatience, and apathy, that the student experiences performing the task. The authors concluded that in under-challenging situations, students did not distinguish between task-focused boredom and self-focused boredom. In over-challenging situations, the students did make this distinction; i.e., under-challenging situations led to one-dimensional boredom and over-challenging situations led to two-dimensional boredom. These conclusions were supported in the second study. The second study also found correlations between boredom and emotions. The more boredom experienced, the more negative emotions and fewer positive emotions were felt. However, the type of situation mattered. In under-challenging situations, the negative emotions were not related to anxiety, while in over-challenging situations, negative anxiety-related emotions such as anger, hopelessness, and shame were experienced. In summary, the authors concluded that academic boredom is multidimensional and context dependent, and is more complicated in situations perceived as over-challenging than in situations perceived as under-challenging. Teachers should thus bear in mind that when students complain of boredom, they may not be talking about the same thing.

Conclusion.

It is clear from reviewing the literature on video lecture capture that the practice is likely to continue because students want the convenience and institutions need to please students. It is also clear that lecture capture is implemented in various ways and for various purposes, even within the same institution, with instructors often making the decisions. What remains unclear is whether viewing a verbatim recording of a classroom lecture is the best way for students to learn from lecture video. Cognitive and affective engagement, which has been explored with traditional lectures, has been largely ignored with captured lectures. If traditional lectures bore students, online lectures are likely to do the same and may result in different coping behaviors.

Multimedia Learning

A lecture consists of an instructor's speech and whatever visual aids – e.g., text, graphics, or video – go along with the speech. In a literal sense, a live lecture qualifies as multimedia instruction because it uses words and pictures to foster learning. Once a lecture is captured, it also fits the more common sense of multimedia instruction, that of a fixed recording or production. Recognizing that captured lectures are a form of multimedia instruction is key to the present research because doing so allows the instructional design principles set forth in CTML to be applied. The literature on multimedia learning is vast but can divided thematically into development and testing of the CTML principles, effects and interactions among CTML principles, and time compression of multimedia instruction.

Development and testing of the CTML principles.

The theoretical basis of CTML is CLT, introduced by Australian educational psychologist, John Sweller, in 1988. Moreno and Park (2010) provided an extensive analysis of CLT and how it developed. *Cognitive load* was a variation on the broader concept of mental effort found in human factors psychology in the 1980s. CLT went through three stages of growth, corresponding to Sweller's identification of three sources of cognitive load during a learning event. *Extraneous* cognitive load is imposed by the design of instruction. In theory, extraneous cognitive load could be eliminated entirely if instruction were perfectly designed. *Intrinsic* cognitive load is caused by the inherent difficulty of the material to be learned, and especially the number of simultaneously-interacting elements. Theoretically, intrinsic cognitive load cannot be reduced, although individual differences in learners can change its impact. Extraneous and intrinsic cognitive load are negative forces in learning. *Germane* cognitive load is the acquiring and automating of schemata in working memory, which is how Sweller conceptualizes learning. Germane cognitive load is thus a positive force in learning (Moreno & Park, 2010).

CLT focuses on the objective characteristics of a task; a student's prior knowledge is the only individual characteristic considered. Other predictors of learning, such as cognitive abilities, learning styles, motivation, and self-regulation are not part of the theoretical framework of CLT (Moreno & Park, 2010). These predictors fall under the general heading of affective factors, and are part of the personal factors in learning that are examined later.

While Sweller focused on cognitive load during learning, Richard E. Mayer focused on the mental processing learners devote to dealing with load, and how instruction with multimedia could optimize this processing. Mayer's work is embodied in CTML. Mayer (2009) is the second edition of the most comprehensive resource available to date on the theory and the research that supports it. Mayer began by noting that multimedia is the latest in a line of technology-based teaching tools, most of which have not fulfilled their promise owing to misplaced focus on the tool rather than how humans learn. With CTML, the focus is on cognition rather than technology (Mayer, 2009).

Cognitive load is a central concern in multimedia instruction because of the amount of transient sensory input that is produced with dynamic visualizations such as animations and video. This input can overload working memory capacity, especially for novice learners. CTML has three instructional design goals:

1. Reduce extraneous cognitive processing; i.e., processing directed to extraneous cognitive load caused by instruction that does not support learning the essential material;
2. Manage essential processing; i.e., processing directed to intrinsic cognitive load caused by the inherent complexity of the material to be learned; and
3. Foster generative processing; i.e., processing directed to germane cognitive load caused by organizing the representation and integrating it with existing knowledge (Mayer, 2009).

Twelve instructional design principles for multimedia have been developed through empirical research conducted by Mayer, often with Roxana Moreno. People learn better from multimedia instruction when these design principles are observed. According to Mayer (2009), the principles intended to *reduce extraneous processing* are:

1. Coherence: Extraneous words, pictures, and sounds are excluded rather than included;
2. Signaling: Cues that highlight the organization of the essential material are added;
3. Redundancy: Graphics and narration are used rather than graphics, narration, and on-screen text;
4. Spatial contiguity: Corresponding words and pictures are presented near rather than far from each other on the page or screen;
5. Temporal contiguity: Corresponding words and pictures are presented simultaneously rather than successively.

Principles intended to *manage essential processing* are:

6. Segmenting: Instruction is presented in user-paced segments rather than in a continuous stream;

7. Pre-training: Names and characteristics of the main concepts are presented before starting the instruction;
8. Modality: Graphics and narration are used rather than animation and on-screen text;

Principles intended to *foster generative processing* are:

9. Multimedia: Words and pictures are used rather than words alone:
10. Personalization: Words are used in a conversational style rather than a formal style;
11. Voice: A friendly human voice is used for narration rather than a machine voice;
12. Image: The speaker's image onscreen does not necessarily aid in learning (Mayer, 2009).

The empirical research underlying CTML, as summarized in Mayer (2009), used multimedia productions about lightning, brakes, ocean waves, electrical engineering, environmental science, airplanes, teaching, tire pumps, lungs, electric motors, geology, and math. Studies were quasi-experimental in design, used convenience samples of university students, relied on pre-tests to measure prior knowledge and post-tests to measure retention and transfer of learning, and utilized mostly quantitative methods for data analysis.

Effects and interactions among CTML principles.

Some CTML principles have evolved over time as interactions between the principles were discovered. For example, Moreno and Mayer (2000) established that narrations with a more conversational style (i.e., that used first and second person and directed extra comments at the learner) fostered generative processing and resulted in deeper learning. This was dubbed the personalization principle. However, directing extra comments at the learner increased extraneous processing, thus violating the coherence principle. Mayer, Fennell, Farmer, and Campbell (2004) repeated the research without the extra comments, effectively untangling the personalization and coherence principles. A 60-second multimedia module on human respiration was used with a convenience sample of university students. Participants in the control group experienced the instruction without personalization (e.g., "the" lungs), while participants in the experimental group experienced the instruction with twelve occurrences of "the" changed to "your" (e.g., "your" lungs, "your" heart, your "breathing," and so on). In a second experiment students were also asked to rate how interesting and how difficult they found the personalized and non-personalized instruction. In both experiments, personalization led to significantly higher scores for transfer, but not for retention. It was theorized that personalization did not improve retention because both groups of students had adequate cognitive resources for the basic processing needed to encode and store ideas in long-term memory. However, personalized instruction led to more generative processing, the organizing and integrating of the encoded ideas with prior knowledge, a deeper form of learning that was evidenced by higher scores for transfer among the experimental group. Perceptions of interest were slightly higher and perceptions of difficulty slightly lower with the personalized instruction, but not at levels of statistical significance.

Park et al. (2011) investigated how the modality and coherence principles interact when multimedia instruction contains seductive details – i.e., interesting but unimportant information. The modality principle states that graphics and narration should be used rather than animation and on-screen text, while the coherence principle states that extraneous words, pictures, and sounds should be excluded rather than included. This quasi-experimental study used a convenience sample of 100 high school students and a self-paced biology module with 11 screens. Students were randomly assigned to one of four groups: on-screen text without seductive details, on-screen text with seductive details, narration without seductive details, and narration with seductive details. Pre-tests were given to measure prior knowledge and spatial ability. Self-reports of perceived mental effort during and after the test served as measures of total cognitive load. Post-tests measured retention and transfer of knowledge. Results showed that students in the narration with seductive details group had the most learning success, and that this group reported less cognitive load than the on-screen text group when seductive details were present. The authors concluded that seductive details might result in increased cognitive engagement and better learning if there are enough cognitive resources available to handle the added processing. Using narration is one way of conserving cognitive resources for such use.

The application of CLT and CTML in empirical research has yielded a number of so-called *effects*. Leahy and Sweller (2005) examined the interactions between three such effects. The imagination effect occurs when students who are asked to imagine a procedure or concept after studying it are able to outperform those who use the additional time to continuing studying. The expertise reversal effect occurs when instruction that helps a novice learn is less helpful or even counterproductive to learning for a more experienced student. The element interactivity effect occurs when material to be learned is uncomplicated enough that the cognitive resources normally applied to processing intrinsic cognitive load can be diverted to processing extraneous cognitive load, i.e., the challenges imposed by the instructional design.

The authors first conducted quasi-experimental research with a convenience sample of 60 fourth-graders in Sydney, Australia. A 2 x 2 x 2 factorial design was developed: imagination vs. study, novice learner vs. expert learner, and high vs. low element interactivity. Learners who were novices in the first phase of the experiment served as experts when the second, identical phase took place two weeks later. The materials used in the experiment were five different bus timetables, each on a separate sheet of paper, and each with text boxes containing instructions on how to solve one kind of problem. During the instruction, the imagination group was asked to look at the timetables and instructions, then turn the sheet over and imagine going through the steps that had been described. The study group spent the entire time looking at the sheet. The time allowed for studying/imagining varied from 120 to 225 seconds, depending upon the complexity of the information on the sheet. Sixteen test questions were then presented. Four of these questions were low in element interactivity (e.g., "What time does the route 101 bus arrive at Main Street?"). The twelve remaining questions were higher in element interactivity (e.g., "What route number should I take from Alt Street to get to Brown Street at 10:55 p.m.?"). Each student was tested individually immediately after instruction. Only first attempts within 90 seconds qualified to be counted as correct answers. The authors conducted a second experiment with 60 fifth-graders using instruction in interpreting temperature graphs. Methods were identical to the first experiment.

Both experiments demonstrated an interaction between the imagination and expertise reversal effects. In phase 1, students were unfamiliar with the content and studying it was more productive than imagining it. In phase 2, students were familiar with the content (i.e., "experts") and imagining was more productive than studying alone. In the first experiment, element interactivity did not interact significantly with the other effects, perhaps due to there being relatively little difference between low- and high-element-interactivity materials. In the second experiment, higher element interactivity materials were used, and a three-way interaction between imagination, expertise, and element interactivity was found. The authors theorized that high element interactivity put greater demand on working memory and made it more likely that effects related to working memory capacity would manifest.

The authors noted that, at this sample size, there was only a 25%-30% chance of detecting interactions between effects. A sample size of 160 participants would have increased to

60% the likelihood of detecting these interactions if they were present. Practical conclusions drawn from this study were that when complex material is to be learned, there is no benefit to studying beyond a certain point; at that point, an imagination strategy may be useful to continue the learning for those learners with enough experience to imagine effectively.

Even though this study did not utilize multimedia materials and focused on children instead of adults, it has a place in this literature review because of its importance to understanding schema construction and automation, a key consideration in multimedia learning theory. The limitations of working memory demand that instruction utilize as much as possible what the student already knows, the existing complex schemata that can be retrieved from long-term memory and treated as single chunks when making sense of new input and integrating it with past knowledge.

Novices may experience the illusion that they understand instruction and “coast” through a lesson – while experts receiving the same instruction have no such illusion and remain cognitively engaged. This illusion of understanding metacognitive effect was investigated by Paik and Schraw (2013) in quasi-experimental research of multimedia instruction with representational animations (i.e., where a dynamic process is illustrated with a series of static images) and directive animations (i.e., where highlighting, signaling, and cueing are incorporated to direct attention to relevant parts of an image). The study used a randomized, double-blind, 2 x 2 between-subjects factorial design. The treatment groups were no animation, representational animation only, directive animation only, and both types of animation. Participants were a convenience sample of undergraduate psychology students (49 females and 16 males) at a university in the southwestern United States. The instruction explained the workings of a flush toilet, replicating one of Mayer’s early studies.

A pre-test measured prior knowledge of flush toilets and gathered demographic information. Post-test questions addressed the participants' subjective perceptions of the difficulty of the instruction and their understanding of it, as well as objective learning outcomes for knowledge retention and transfer. Data analysis of the results supported a conclusion that directive animation produces deeper learning than representative animation, and that both types of animation result in an optimistic illusion of understanding for low-proficiency learners and a pessimistic illusion of understanding in high-proficiency learners, i.e., experts. Since they don't suffer an inflated sense of their own understanding, experts stand to learn more in such cases.

Much CTML research has focused on animations and hypermedia. Ibrahim et al. (2012) expanded this research by retroactively applying three CTML principles to guide the editing of "Insect," a 32-minute instructional video professionally produced in 1994 by the British Broadcasting Company. The research type was quasi-experimental with a between-subjects design intended to measure the effect of applying the CTML principles of segmenting, signaling, and coherence (called "weeding" in the study). The independent variable was video (SSW and non-SSW) and the dependent variables were perceived learning difficulty, knowledge retention, transfer of knowledge, and structural knowledge acquisition. The participants were 226 undergraduate students with non-science majors (42% female and 58% male with a mean age of 20) in an introductory entomology course at a large Midwestern university. Students were given extra credit for participation in the study. The SSW group contained 110 students and the non-SSW group contained 116 students. Each group was an intact section of the entomology course.

The segmenting principle was employed by dividing the "Insect" video into five conceptual segments of six minutes each: basic facts, insect body parts, insect evolution, visual system and communication, and defense techniques. The signaling principle was employed by adding an introduction and summary screen for each segment and adding labels to identify and clarify visual elements. The weeding/coherence principle was employed by having the instructor identify entertaining but non-essential sections (e.g., insect morphing into car, folklore of European insects), which were then removed from the video. Weeded segments totaled 3.3 minutes, or 9.7 % of the original video. The time lost through weeding was offset by the time added through signaling. The segmented video was thus the same length as the original video. Learners had no control over playback in either the control or experimental groups.

Data were derived from a demographic survey, a pre-test and a post-test. The pre-test consisted of an assessment of metacognitive awareness and self-regulated use of learning strategies, and a 10-item test of prior knowledge on entomology. The post-test had one question on perceived difficulty, 20 multiple-choice questions to test knowledge retention, five multiple-choice questions to test knowledge transfer, and a 20-item sorting task with main concepts to test structural knowledge.

The authors reported that the SSW group scored higher than the non-SSW group on overall knowledge gain (3.1%), knowledge retention (3.2%), knowledge transfer (8%), and structural knowledge (6.2%). The differences between groups were statistically significant in each case. It was theorized that the CTML-guided editing resulted in the SSW students having more cognitive resources available to devote to the essential processing of the lesson, which led to more effective organization and integration of new concepts with prior knowledge, deeper learning, and better test scores. The non-SSW students used more cognitive resources sorting relevant from irrelevant material, had no breaks to catch up on this extraneous processing, and were thus less able to perform the essential processing needed for learning.

To be a legitimate alternative to traditional face-to-face education, online multimedia instruction must prove itself equally good or better at facilitating learning. Pang (2009) conducted quasi-experimental research to assess the pedagogical equivalence and effectiveness of video-driven, web-based multimedia in corporate training. The study used 38 participants with ages from 21 to 51, educational backgrounds from high school diploma to doctorate, and jobs from administration and sales to management and business ownership. The control and experimental groups were populated through self-selection and selection by a supervisor. The control group received instruction on organizational leadership in a traditional, instructor-led classroom setting. The experimental group received the same instruction for the same amount of time via an online video program. The independent variable in the experiment was form of instruction and the dependent variables were performance on an objective post-test to measure learning (pedagogical equivalence) and a subjective post-test to measure participants' perceptions of the quality of the learning experience (pedagogical effectiveness).

The author hypothesized that a video-driven, multimedia, online learning environment would be pedagogically equivalent, in terms of knowledge gains, to traditional face-to-face instruction in a competency-based program of professional development. The author also hypothesized that certain components in a web-based environment (e.g., instructor, materials, interactivity) would be more effective for learning based on the perceptions of the learners. Both hypotheses were supported by the study results. The author noted that knowledge gains were actually slightly higher with the experimental group. The cost-effectiveness of web-based video multimedia instruction, coupled with evidence that it is at least as good as classroom instruction at facilitating learning, suggests that it is a worthy option for corporate training applications.

Time compression in multimedia instruction.

Multimedia instruction takes time, considerably more time than reading the same material. A narrator's speech ranges between 120 and 180 words per minute, but the average human reads with comprehension at 270 wpm (Pastore, 2012) and can listen with comprehension at even great rates (Ritzhaupt, Barron, & Kealy, 2011). Ignoring for a moment the value of a student's time, the slow pace of multimedia may constitute the sort of "under-challenging situation" that Acee et al. (2010) found leads to academic boredom.

Long before the modern era of multimedia learning, Orr and Friedman (1965) investigated the educational possibilities of speeded speech. Expanding upon a study they had published the year before with male students, the authors conducted quasi-experimental research using a convenience sample of female college students to determine 1) whether there were differences between the genders in the ability to learn from speeded speech; and 2) whether practice sessions with embedded rest periods produced different results than uninterrupted listening for longer periods. The independent variable in the study was practice with compressed speech and the dependent variables were performance on the STEP Listening Test for college freshmen and the Nelson-Denny Reading Test. Participants were tested before and after training (practice) in speed listening. The reading test was used to investigate the authors' ancillary hypothesis that speed listening training would also improve reading comprehension.

To practice speed listening, the experimental group received approximately ten hours of training with the speed of speech gradually increasing. Practice materials were four full-length novels from the Talking Book library of the American Printing House for the Blind: *Cheaper by the Dozen*, *The "Miracle" New York Yankees, The Man-Eaters of Kumaon*, *and Run Silent, Run*

Deep. The novels were used in the order stated, and were time-compressed to rates of 325, 375, 425, and 475 words per minute, respectively.

Testing was done using six benchmark passages of 3,300 to 4,000 words, which were edited to remove highly unfamiliar words and some proper nouns. The excerpts were then recorded by the Talking Book studio. Each excerpt was compressed to rates of 325, 375, 425, and 475 words per minute. A debriefing questionnaire was also used at the end of the experiment to gather subjective perceptions of the participants.

The authors found that there were no significant differences between the genders in the ability to learn from speeded speech and that rest periods did not significantly improve speed listening ability. Combining the results of their two studies, the authors concluded that with no special training humans can listen effectively at up to double the normal rate of speech, with a maximum loss in comprehension of 20%. The authors also produced evidence that speed listening is a learned skill, and that after just ten hours of training, listening speeds can reach 425 words per minute, about three times the normal rate of speech. This study also confirmed the authors' hypotheses that training to increase the speed of listening also improves comprehension of normal speech and of reading. Orr and Friedman (1965) set the stage for future exploration of how multimedia – speech with visual images – might also be delivered at a rapid pace, and how such manipulation affects complex learning. This research was made possible by a then-new device called the Tempo-Regulator, which allowed audio tapes to be sped up without significantly changing the pitch of the speaker's voice (i.e., introducing a "chipmunk" effect) and the attendant loss of intelligibility.

Ritzhaupt et al. (2011) investigated the effects of time compression using a multimedia module titled *Discovering Australia*, which was composed of a narration and ten pictures alternately related or unrelated to the accompanying sections of narration. The module was uncomplicated and easy to understand (i.e., produced minimal intrinsic cognitive load), making it appropriate for isolating the effects of the treatment. A quasi-experimental research method was employed using a convenience sample of 153 students recruited from a public university in the southeastern United States. Genders were approximately equal. Most participants were upperclassmen and native speakers of English. The experiment had a 4 x 2 factorial design with audio speed serving as a between-subject condition and type of information serving as a repeated measure. Audio speeds were 100% (normal), 150%, 200%, and 250%. Type of information was pictorially related or pictorially unrelated, meaning that in alternating paragraphs of the module, the narrator's words did not relate to the picture displayed. Multiple-choice test questions were used to measure recognition of learned material, an easier task, and short-answer questions were used to measure recall of learned material, a more difficult task.

Results indicated that performance was significantly higher on recognition than on recall. Audio speed significantly affected recognition but type of information did not. Both audio speed and type of information significantly affected recall but they did so independently, without interaction. In summary, displaying pictures related to the narration aided in recall but not in recognition, regardless of the speed of the narration. Consistent with prior research, the authors found that the learner's ability to retain information begins to decline at approximately 275 words per minute, which is about twice normal speed. At 375 wpm, significant losses were found. The authors noted that the digital compression algorithms in use today are far superior to older analog methods, which may account for the intelligibility of speeded speech in this and other studies.

This study extended earlier work in which the authors had investigated the impact on learning of including a related image with sections of normal-speed narration in a multimedia module. The purpose of introducing the audio speed variable was to determine whether processing pictures in the visual sensory channel when the verbal sensory channel was heavily taxed would aid in learning, what the authors called the Conjoint Retention Hypothesis. In simple terms, the authors were interested in whether time-compressed narration would be more effective if a picture related to that narration were presented at the same time. The dual-coding or dual-channel assumption – that mental processing occurs independently in the visual and verbal sensory channels – allows such a prediction to be made, and is central to CTML.

Pastore (2012) also explored how far time compression could be taken when images accompanied speech, and whether the redundancy principle of CTML – i.e., that comprehension is reduced when the same information is presented simultaneously in text and spoken form – might be reversed when time compression is used. Pastore used a 2 x 3 experimental design. Independent variables were compression (normal pace, 25% compressed, and 50% compressed); and redundancy (narration only or narration with text). The dependent variable was performance as measured by identification (recall/low level) and comprehension (transfer/high level) tests, and cognitive load and review behaviors measures.

Participants were 154 undergraduate students (93 females and 61 males) with majors or minors in communication studies, from a mid-sized university in Pennsylvania. Ninety-three percent were 18-22 years old and 7% were 23-30 years old. The multimedia instruction used was a 2,000-word script on the human heart and its parts, with 19 static line drawings that used color-coding shading to highlight concepts as they were discussed. Images and script were both required to understand the content. A male narration was recorded and compressed by 25% and

50% using Audacity, a free sound editor. Time compression was done without affecting the pitch of the narrator's voice. Students controlled the pace of screen changes in the instruction with next, back, and replay buttons. The instruction was presented on CD in a Mac lab/classroom. Students used headphones to listen, and had 90 minutes to complete the instruction. Test results were delivered via Blackboard.

A pretest measured students' prior knowledge of the subject matter. An identification posttest measured recall of factual knowledge and a comprehension posttest measured transfer of problem-solving knowledge. Measures of cognitive load were obtained by administering a Likert-scale questionnaire after the test. Review behaviors (clicks on back or replay buttons) were counted, presumably through the software delivering the instruction.

Data were analyzed using quantitative methods and yielded descriptive and inferential statistics. The author discovered that the recall and comprehension test scores of students receiving normal-paced narration did not differ significantly from the scores of students receiving 25% compressed narration. However the scores for both groups were significantly higher than the scores of students receiving 50% compressed narration. Similarly, students receiving normal-paced or 25% compressed narration did not differ significantly from one another in their perceptions of cognitive load but reported less load than students receiving 50% compressed narration. Neither compression speed nor redundancy produced a significant effect on review behaviors. Pastore concluded that:

1. multimedia instruction can be compressed by up to 25% without sacrificing low-level or high-level learning;
2. Learning at both levels decreases slowly between 0% and 25% compression, and dramatically at some point between 25% and 50% compression;

3. There is no reversal effect of the redundancy principle when using compressed narration. Thus, time-compressed narration should not be accompanied with redundant text on the screen.

Conclusion.

The literature on multimedia learning explains how CLT has been applied to the design of instructional multimedia and the resulting impact on performance. The twelve design principles that make up CTML have evolved as research has uncovered interactions and reversals under boundary conditions. What remains certain is that our understanding of human cognitive function is far from complete, and that the mental effort that accompanies a learning experience – i.e., cognitive load – is sometimes productive and sometimes wasted depending upon where it is directed. Finally, it is entirely possible that learning is compromised when too little is asked of the learner, resulting in a sort of *cognitive underload*. Speeding up the pace of instruction may not be possible in classroom lectures, but it is possible when applying an editing protocol to captured lectures.

Personal Factors in Learning

One of the most interesting research streams in current literature is the role that differences among learners play in academic performance. The implications for instructional design are significant because a design that helps one student to learn may hinder the student sitting beside him. Literature on personal factors in learning can be divided thematically into studies focusing primarily on the cognitive domain (e.g., general intelligence, prior knowledge and memory) and studies focusing primarily on the affective domain (e.g., motivation, interest, and self-regulation).

Personal factors arising from cognitive differences.

Lusk et al. (2008) conducted quasi-experimental research to investigate how the benefits of segmenting multimedia instruction are affected by the working memory capacities of learners, a cognitive differences study. Independent variables in this 2 x 2 design were multimedia instruction (segmented and non-segmented) and working memory capacity (low and high). The dependent variables were learner performance on tests for recall and application. The participants were 133 undergraduate students (59 male, 74 female with a mean age of 20.1 years) who were first randomly assigned to either the control group (designated NS for non-segmented instruction) or the experimental group (designated SI for segmented instruction). Participants were then tested for working memory capacity using the Operation Span (OSPAN) test and those participants in the lowest and highest quartiles remained in the study. The multimedia lesson used was the strategy explanation section of the Summarizing, Contextualizing, Inferring, and Monitoring (SCIM) Historical Inquiry Tutorial. This lesson consisted of 14 narrated multimedia segments of 45-60 seconds in length, for a total running length of 11 minutes. SI students controlled playback of the segments and NS students watched them straight through from beginning to end. Data were collected via two tests given after the lesson. Participants had five minutes to complete a recall test for basic learning and twenty minutes to complete an application test for deeper learning and transfer.

High-WMC students demonstrated better recall and application (basic and deep learning/transfer) than did low-WMC students. SI students demonstrated better recall and application (basic and deep learning/transfer) than did NS students. The authors concluded that learners with low working memory capacity will find basic and deeper learning difficult in complex multimedia tutorials, and that the difficulty can be mediated through segmenting the multimedia content. Both low- and high-WMC learners experience learning benefits from segmentation.

Austin (2009) also explored cognitive differences with quasi-experimental research on working memory capacity, multimedia comprehension skill, and fluid intelligence affect learning outcomes with multimedia instruction. In the first of four experiments using undergraduate students at Texas Tech University, 75 students (39 females and 36 males) enrolled in a General Psychology course were used to replicate one of Mayer's early experiments using multimedia instruction on lightning. Quantitative analysis of the data produced descriptive and inferential statistics. Austin's results supported Mayer's conclusions about modality (i.e., people learn more deeply from pictures and spoken words than from pictures and printed words) and redundancy (i.e., people learn better from graphics and narration than from graphics, narration, and on-screen text.)

In the second experiment, Austin used 132 students (75 females and 57 males) enrolled in Human Sciences, Chemistry, Political Science, Mass Communications, and Education courses. In this experiment, Austin sought to discover whether the modality and redundancy principles confirmed in the first experiment persisted when key cognitive differences in the participants were taken into account. Three instruments were used to quantify cognitive ability: the operating span (OSPAN) test for working memory capacity, the Multimedia Comprehension Battery (MMCB) for multimedia comprehension skill, and the short form of Raven's Progressive Mattrices (RMI) for fluid intelligence. College entrance exam (Scholastic Aptitude Test) scores were also used as measures of fluid intelligence. The procedures of the first experiment were then repeated, but with the variance attributable to differences in cognitive ability extracted in the data analysis. Austin reported that the modality and redundancy effects were still present even after the impact of individual cognitive differences was taken into account.

Austin's third and fourth experiments examined the effects of text positioning and distracting motion in the design of screen displays for multimedia instruction. These experiments supported prior research related to CTML and human factors engineering. However, the experiments added nothing to the present review of research related to personal factors in learning.

A key limitation in Austin (2009) is the failure to measure prior domain knowledge before beginning instruction. Prior knowledge (i.e., expertise) can reverse instructional design principles, a fact established more than a decade earlier (Kalyuga, Chandler, & Sweller,1998). What a learner already knows may be the most relevant of all personal factors from the cognitive domain.

Personal factors arising from affective differences.

Motivation, confidence, self-efficacy, interest, self-discipline, expectations, and other affective differences among learners have proven to be just as important as cognitive differences in influencing academic achievement. The boredom studies of Acee et al. (2010) and Mann and Robinson (2009) underscored that students have different levels of boredom proneness and that being bored by instruction undermines academic achievement. Euzent et al. (2011) found that students choosing the lecture capture version of a course were much more likely to drop out than students taking the face-to-face version, suggesting to the authors that the lecture capture students did not have the self-discipline or motivation to persevere when the course proved to be harder than they expected.

Artino (2010) studied affective differences with descriptive, correlational research that examined the relationship between personal factors and choice of instructional format. Participants in the study were 564 undergraduates (129 females and 435 males) at a United States service academy. Participation was voluntary and no volunteers were excluded. Data were collected after completion of the first part of a required training course in aviation physiology and survival training. The instruction consisted of four 40-minute online lessons incorporating text, graphics, and video, and was accessed through a learning management system. Each lesson ended with a quiz consisting of 12-15 multiple-choice questions to test declarative knowledge. If students scored less than 80% on a lesson quiz, they were required to retake the lesson and face a slightly different group of quiz questions. The second part of the training was traditional instruction at a local training site.

The data collection instrument was a 56-item Likert-scale survey that assessed motivational beliefs (with subscales for task value and self-efficacy), achievement emotions (with subscales for enjoyment, boredom, and frustration), and satisfaction. The survey also collected demographic data and the participant's preference for receiving this sort of instruction in a traditional, face-to-face classroom, or online. Quantitative analysis produced descriptive and inferential statistics, and developed a logistic regression model to show how nine independent variables (personal factors) predicted preference for face-to-face or online instruction.

Results were that instructional choice was closely related to self-efficacy beliefs and overall satisfaction with a recent online course. In other words, students who had good experiences in the online course and felt they had the ability to learn successfully online were more likely to choose the online option in the future. Second, choice of online instruction correlated with lower task value beliefs; that is, students who found the course content interesting, important, and useful preferred to get the instruction in a traditional classroom rather than online. However, those same students performed at a higher level in the online course than classmates with lower task value beliefs. Artino considered this a somewhat paradoxical result that warranted further study. Artino also noted that the study was limited by the homogenous nature of the population used (high-ability students, mostly male, no physical disabilities) and the study's cross-sectional design. Results might have been different with a more heterogeneous group of participants that could be tracked over a longer period of time.

Moreno built upon CTML by proposing in 2005 a *cognitive-affective theory of learning with media*, or CATLM. Moreno (2007) is an early journal article in which the theory was discussed and research presented. Moreno stated three key assumptions in CATLM. First, humans have a limited working memory capacity. Second, long-term memory is a dynamic, evolving structure that holds memories of past experiences and general domain knowledge. Third, motivational factors affect learning by increasing or decreasing cognitive engagement.

The study described in Moreno (2007) was quasi-experimental research consisting of two experiments using convenience samples of pre-service teachers enrolled in introductory educational psychology courses at a university in the southwestern United States. The first experiment tested the effects on learning arising from segmenting and signaling in instructional video and the second did the same for instructional animation. The experiments were identical in all other respects. In the first experiment, 151 students (111 females and 40 males) took part. In the second experiment 143 students (104 females and 39 males) took part. In each experiment, approximately equal numbers of students were randomly assigned to each of five groups: a control group that received no multimedia instruction (C), a group that received multimedia instruction with signaling but without segmenting (SI/no-SE), a group that received the multimedia instruction without signaling but with segmenting (no-SI/SE), a group that received the multimedia instruction with neither signaling nor segmenting (no-SI/no-SE), and a group that received the multimedia instruction with both signaling and segmenting (SI/SE). The testing measured retention based on the theory presented, retention based on the examples presented, transfer (application) to other situations, how the students felt about the instruction (affect), and how much effort the instruction required (cognitive load).

The test results for retention were higher for the control group (no multimedia) than for any of the multimedia groups. The test results for transfer were not significantly different between the control group and the multimedia groups with neither segmenting nor signaling. However, the multimedia groups with segmenting and/or signaling were superior to the control group on transfer. The multimedia groups with just segmenting outperformed the multimedia groups without segmenting in the test of retention. The multimedia groups with just signaling did not outperform the multimedia groups without signaling in the test of retention. The multimedia groups gave higher affective ratings for the instruction than did the control groups. The multimedia groups that received segmenting and/or signaling gave lower cognitive-load ratings than the multimedia groups that received neither segmenting nor signaling.

In these experiments, multimedia was not the better instructional format for attaining the low-level learning outcome of retention. Neither was multimedia a better choice for attaining the higher-level outcome of transfer *unless the multimedia was modified with segmenting and/or signaling.* Within the multimedia groups, segmenting outperformed non-segmenting for retention but signaling did not outperform non-signaling for retention. In general, students liked using multimedia and felt the instruction took less effort when segmenting and/or signaling was used.

A surprising result was that students gave higher affective ratings for the non-segmented animations than for the segmented ones. Moreno speculated that this may have been due to the fact that the animations were very novel and students may have been frustrated by being forced to watch only small segments at a time. Thus, even though segmenting the animations had a positive impact on learning, segmenting had a negative impact on mental state, or affect. Moreno suggested that the affective consequences to using longer animations were worthy of additional study, with additional affective factors such as learner choice and persistence mixed in.

A possible confound mentioned by the author was the fact that while students in the experimental groups were viewing multimedia, students in the control group were reviewing the theoretical instruction already received, which may have given those students an edge on the retention tests. Limitations noted were the specific instructional purpose of the videos and animations (to present models of teaching), the specific audience (teaching students), and the specific content domain (educational psychology).

Ozel, Caglak, and Erdogan (2013) conducted descriptive research to investigate how personal affective factors such as attitude and motivation contributed to science achievement. Data came from the PISA 2006 dataset, a collection of data for 4,942 fifteen-year-old students (2,290 females and 2,652 males) selected from 160 schools in Turkey using stratified random sampling procedures. PISA 2006 included tests in math and science, and questionnaires for the students, their teachers, and their principals. The science scores and 38 questions related to affective tendencies of the students were extracted for analysis in this research. Affective factors fell into six categories: motivation to learn science, interest in science, enjoyment of science, science self-concept, value of science, and usefulness of science. Factor analysis, structural equation modeling, and confirmatory factor analysis were employed.

The authors explained that prior studies addressing the influence of affective factors on science achievement (and the effect of science achievement on affective factors) had produced diverse results, due in part to using different data collection instruments and assessing key variables through different sub-dimensions. The PISA 2006 dataset measured how students had developed the knowledge and skills needed for full participation in society, which made the dataset appropriate for the author's study. However, the dataset was created at a time when Turkey's centrally-managed education system had just begun a move toward more learner-centered, constructivist-influenced design. Thus, while affective factors could be extracted from the data, these factors were not specifically addressed in the testing.

The authors found that affective factors were significantly related to science achievement in positive and negative ways:

1. Motivation to learn science was significantly related and negative;
2. Interest in science was significantly related and positive;
3. Enjoyment of science was significantly related and positive (largest effect);
4. Science self-concept was significantly related and negative;
5. Value of science was significantly related and positive;
6. Usefulness of science was significantly related and negative;

The largest effect was produced by enjoyment of science and the authors recommended that science curricula focus on making science enjoyable for students as a way of improving science achievement. The authors also noted that the negative correlations found could be due in part to the testing methods themselves (still standards-based in PISA 2006) and test anxiety.

At Maastricht University in the Netherlands, Aalbers et al. (2014) explored the motivation of first, second, and third-year medical students to prepare or not prepare for their clinical skills training. Taking a mixed-methods approach, the authors first conducted 24 group interviews (n=209) to identify themes related to motivation to prepare. The themes fell into two categories: personal factors (personal learning style, attitudes and beliefs, and planning and organization), and external factors (preparatory advice; pressure, consequence, and checking of preparation; teacher-related motivations; and contents and schedule of the training sessions). Using these themes, the authors constructed a questionnaire to collect quantitative data from all members of the three classes (n=847). The questionnaire revealed that the two factors that most motivated the students to prepare for their clinical skills training were the objective structured clinical examination, and facilitation of both understanding and memorizing the learning material. The two factors that most demotivated the students to prepare were other students saying that preparation was not useful and indistinct preparatory advices. Three scales were used: urge to learn and expected difficulties (motivators), and lack of motivation (a demotivator). The scales were developed with exploratory factor analysis, reliability analysis, and content analysis. Between-class differences in the scale scores were analyzed with ANOVA.

The authors found that urge to learn was more of a motivator to prepare for first- and second-year students than for third-year students, while expected difficulties was more of a motivator for second- and third-year students than for first-year students. There were no significant differences between the classes with regard to the sole demotivator, lack of motivation. Maastricht University uses problem-based, self-directed learning as its primary educational approach and the authors interpreted the results of their study within the framework of self-determination theory. The motivation to prepare was viewed as existing on a continuum with intrinsic factors (such as the urge to learn) on one end and extrinsic factors (such as difficulties expected) on the other. The fact that there were differences between classes suggested that the phenomenon of learning to learn was at work. Additionally, while first- and second-year students were busy acquiring knowledge and skills, third-year students spent more time applying them, suggesting that differences in the learning tasks were relevant. The authors concluded that preparing or not preparing was an active and deliberate choice made by students, that the choice was motivated in complex ways, and that those motivations evolved over time.

Woo (2014) investigated the empirical relationships between motivation, cognition, and performance in digital game-based learning (DGBL), a form of multimedia learning. Game characteristics are appealing to learners, which can enhance the motivation to learn. However, complex games require significant cognitive investment, which can result in overload that diminishes performance. This research had its theoretical foundations in motivation, volition, and performance (MVP) theory, the information-processing model of human cognition as found in CLT and CTML, and the attention, relevance, confidence, and satisfaction (ARCS) model of human motivation. By investigating DGBL through these lenses, the author hoped to identify canonical relationships between motivation, cognition, and performance upon which design guidelines for DGML materials could be based.

The study used an online game titled, "Operating a Small Factory in Computer-Aided Manufacturing," or OSF-CAM. OSF-CAM had both a multimedia module to teach the basic concepts of CAM and a game module. The multimedia module was designed using CTML-derived strategies such as pretraining, signaling, segmenting, aligning, synchronizing, and weeding. The game module was designed using ARCS-derived strategies such as story-based processes and goals, role-playing, learning task design, score accumulation design, real-time display design, time-limited game design, online updating design, humorous dialogue, exaggerated design, and real contexts and scenarios.

Participants in the study were 63 second-year students in the Department of Art and Design at National Taipei University of Education in Taiwan. Instruction lasted for eight weeks and incorporated both lecture and the OSF-CAM game training. All data was collected at the end the eight weeks of instruction. Motivation was measured with an instructional materials motivation survey (IMMS). Cognitive load was measured with a subjective mental effort survey. Performance was measured with a multiple-choice cognition test to determine learning at multiple levels (i.e., knowledge, comprehension, application, analysis, synthesis, and evaluation), and a two-part skills test to determine planning and machining abilities.

From the results of this study, the author concluded that the design approach of the game did promote learning and skill acquisition while cultivating motivation. Further, two canonical relationships were suggested: 1. Motivation and germane (productive) cognitive load are proportional to cognitive performance and skills performance; and 2. Intrinsic (irreducible) cognitive load is inversely proportional to cognitive skills and performance. The study therefore met the author's goal of proposing a systematic design method for DGML that was supported by empirical research and well-grounded in established learning theory.

Affective factors often play a role in attrition from college programs, and have traditionally been studied with quantitative methods. Mayer and Marx (2014) took a qualitative approach in their study with four former engineering students at Utah State University. In addition to giving voice to the lived experiences of these individuals, the authors cited the need to go beyond general research to examine the attrition issue in a particular program at a particular university, and to target specific areas for improvement. The research questions were (paraphrased): What factors contributed most to the decision to leave? What might increase a future student's chances of persisting in the program? What should the engineering department do to increase retention? Interviews and a journey-mapping exercise were used to gather data about the students' experiences and motivations, and to answer these questions.

Analysis of the data revealed that the decision to leave traced to individual and institutional factors. Individual factors included failure to integrate into the engineering culture, being disappointed, and being overwhelmed. Institutional factors included inadequate high school preparation, loss of motivation to study due to program rigor, poor teaching and mentoring, inadequate advising, an unwelcoming culture within the engineering department, financial pressures, poor academic performance, and disinterest. These findings aligned with prior research on attrition in engineering programs. However, the authors found that individual and institutional factors were not easily isolated from one another. Furthermore, there were additional themes related to the consequences of dropping out, such as a sense of loss and failure, a sense of relief, and the easy transition to other fields of study, where all of the participants had more success and greater enjoyment than they had in the engineering program. Conclusions from this study were that the reasons for dropping out were complex and not easily separated into categories, and that cognitive factors such as inadequate high school preparation, test performance, and study skills interacted with affective factors such as a sense of not belonging, which was exacerbated by the engineering department's own club-like mentality. Specific suggestions were that an introduction to engineering be a mandatory class for all engineering students, and that earlier and more empathetic advising be provided to minimize the toll taken in time, money, and self-confidence when the program was not a good fit for the student. By better addressing student needs, retention rates in engineering programs might be improved.

Learning flow can be conceptualized as a state of complete absorption in learning (Csikszentmihalyi, 1997). Learning flow is an ideal state somewhere between frustration and boredom in which the learner is fully engaged and learning is natural. Learning flow is dependent upon affective factors at work in the individual, as well as the way instruction is presented. Joo, Lim, and Kim (2012) tested a model for predicting learning flow and achievement in e-learning at a large Korean corporation. Survey research was used with 248 participants, which were largely male (87%) and in their 30s or 40s (78%).

In their review of prior research, the authors found that learning flow and achievement had been examined separately but not together. Learning flow was found to be directly affected by motivational factors such as self-efficacy (belief in one’s ability to complete a task) and intrinsic value (enjoyment of the learning process for its own sake), and a contextual factor comprised of perceived usefulness of the instruction and ease of use of the e-learning program. Achievement was found to be directly affected by these same factors plus test anxiety (another motivational factor) and learning flow. The authors put forth three hypotheses. The first two hypotheses echoed what prior research had already established about the factors directly influencing learning flow and achievement. The third hypothesis was that learning flow functioned as a mediator variable between the other factors and achievement.

To test their hypotheses, the authors developed two different surveys. The first survey was administered in the first week of a multi-week corporate e-learning program and measured self-efficacy, intrinsic value, and test anxiety using instruments adopted from the Motivated Strategies for Learning Questionnaire (Pintrich & DeGroot, 1990). The second survey was administered during the last week of the program and measured perceived usefulness and ease of use of the courseware, using instruments adopted from the Technology Acceptance Model (Davis, 1989). The instrument for measuring flow was the Flow State Scale (Jackson & Marsh, 1996). Achievement was measured using final exam scores, which were retrieved form the data base of the learning management system for the course.

Results indicated that self-efficacy, intrinsic value, and perceived value/ease of use had statistically-significant direct effects on learning flow, and that intrinsic value, test anxiety, and perceived usefulness/ease of use had statistically-significant direct effects on achievement. These results were in alignment with prior research. However, the results also showed that neither self-efficacy nor learning flow predicted achievement, which did not align with prior research. The authors offered several possible reasons for this outcome. Differences in learning context (academic learning vs. corporate learning) may have been relevant. Participants in this study had to continue performing their jobs and could not focus exclusively on the learning. The country and culture may also have affected the outcome of the experiment. Finally, self-reporting was the only data collection method used; observation or interviews might have produced different results. The authors suggested that the limitations of their study be addressed in future research.

Conclusion.

The literature on personal factors in learning emphasizes the danger of generalizing about how people learn or how they should be taught. Each student is an evolving individual with a unique combination of prior experiences, abilities, interests, and character traits, all of which come to bear during learning from instructional materials. It is also clear from the literature that human behavior is an extremely complex subject and even when personal factors can be identified, they are not always reliable predictors of what students will actually do in various learning contexts. The challenge this presents for designing instruction and assessing performance is significant.

Summary

The approval of lecture capture by students is a fact that universities cannot ignore if they wish to successfully compete for students. According to Johnston et al. (2013), “given student demand for recorded lectures it is unlikely that university policy will allow the deliberate withholding of recorded lectures from students, irrespective of the potential impact for less experienced learners or the strengths and potential weakness of the technology” (p. 45). The exact format that captured lectures will take may change as student preferences are weighed against pedagogic and economic considerations. It is also possible that improvements in technology, such as better software for lecture capture, lower storage costs, and ever-increasing connection speeds, will render some current concerns about overhead associated with lecture capture less important.

Boredom during lectures is a complex topic that merited special attention in the present study. Using multimedia learning principles helps to reduce extraneous processing, manage essential processing, and foster generative processing, which promises to optimize cognitive load and avoid over-challenging the learner. Time compressing the captured lecture segments helps avoid under-challenging the learner with instruction that is too slow and does not take advantage of the speed at which the learner can process ideas in working memory. Ideally, these strategies maximize the moments of flow in which learning is natural and fulfilling. However, these strategies cannot completely eliminate the confounding effects of individual differences, especially with regard to affective factors such as motivation and self-regulation. The great challenge for instructional design remains finding balance between the cognitive and affective factors at work in the learning experience.

Chapter 3

Methodology

Introduction

In this chapter, the methodology of the study will be presented. As discussed in Chapter One, the purpose of this quasi-experimental study was to determine whether editing a captured lecture allowed greater learning gains to be achieved as compared to using the lecture video in its original, unedited form. Subjects in the experimental group viewed a lecture after it had been treated using a cognitive-based editing protocol while subjects in the control group viewed the same captured lecture in its original form. Subjects were tested before and after viewing their lectures so that learning gains attributable to lecture form could be determined. Subjects were also surveyed to learn how they rated the difficulty of the lecture video.

The pre- and post-tests were identical and consisted of ten multiple-choice questions to measure recognition of correct answers from a list, a lower-level cognitive process, and ten fill-in-the-blank questions to measure recall of correct answers from memory, a higher-level cognitive process (Ritzhaupt et al., 2011). The survey consisted of a single item in which subjects were asked to rate the difficulty of the lecture video on a symmetrical scale from 1 (very easy) to 7 (very difficult). Lecture form served as the independent variable with two levels: edited and unedited. Recognition learning, recall learning, and perceptions of difficulty served as the dependent variables.

The study was driven by one overarching multivariate research question, designated Q, and three contingent univariate research questions, designated Q1, Q2, and Q3. Each research question was answered by testing a corresponding hypothesis. Hypotheses were tested by observing how the experimental treatment (i.e., editing the lecture) affected the dependent variables. This information came from the data collected in the tests and survey. MANOVA and repeated-measures MANOVA were used in analyzing the data collected. In the sections that follow, the methodology used to answer each research question will be explained in detail.

Q: How will student success, as measured by recognition learning, recall learning, and perceptions of difficulty, differ between subjects in the experimental group and subjects in the control group?

This question was answered by testing the multivariate hypothesis, H:

> Members of the experimental group will achieve significantly greater success, as measured by recognition of correct answers, recall of correct answers, and perceptions of difficulty, than will members of the control group.

H was tested by examining the impact of the independent variable, lecture form, on the combination of dependent variables for recognition, recall, and perceptions of difficulty. Relevant data were the number of correct answers to the multiple-choice questions, the number of correct answers to the fill-in-the-blank questions, and the survey response. An independent-samples *t*-test was performed on the pre-test recognition and recall scores to confirm that the two groups had equivalent levels of prior knowledge of the lecture topic at the recognition and recall levels. MANOVA and repeated-measures MANOVA were then performed on the post-test scores and survey response to compare student success in the experimental and control groups. In the event that H proved to be true, contingent research questions were provided to address univariate results.

Q1: How will learning gains as measured by recognition of correct answers differ between subjects in the experimental group and subjects in the control group?

This contingent question was to be answered by testing the univariate hypothesis H1:

> Members of the experimental group will perform significantly better in recognition of correct answers after watching the lecture video than will members of the control group.

H1 was to be tested by examining the impact of the independent variable lecture form on the dependent variable recognition. Relevant data were to have been the number of correct answers to the multiple-choice questions. The univariate results from the MANOVA were to have provided the data analysis needed to compare the learning gains in the experimental and control groups.

Q2: How will learning gains as measured by recall of correct answers differ between subjects in the experimental group and subjects in the control group?

This contingent question was to be answered by testing the univariate hypothesis H2:

> Members of the experimental group will perform significantly better in recall of correct answers after viewing the lecture video than will members of the control group.

H2 was to be tested by examining the impact of the independent variable lecture form on the dependent variable recall. Relevant data were to be the number of correct answers to the fill-in-the-blank questions. The univariate results from the MANOVA were to have provided the data analysis needed to compare the learning gains in the experimental and control groups.

Q3: How will perceptions of difficulty of the lecture video differ between subjects in the experimental group and subjects in the control group?

This contingent question was to be answered by testing the univariate hypothesis, H3:

Members of the experimental group will rate the lecture video significantly less difficult than will members of the control group.

H3 was to be tested by examining the impact of the independent variable lecture form on the dependent variable perceptions of difficulty. Relevant data were to be ratings of difficulty given in the survey taken immediately after viewing the lecture video. The univariate results from the MANOVA were to have provided the data analysis needed to compare perceptions of difficulty in the experimental and control groups.

Data collection instruments

In experimental research, data collection instruments measure dependent variables for the purpose of determining to what extent changes in those variables are caused by manipulation of independent variables. Reliability is the degree to which an instrument is stable and consistent in the results it produces over the course of many testings with many respondents (Gay, Mills, & Airasian, 2012). Temporal (test/retest) reliability of the test questions was investigated by conducting a pilot test with friends, family, and colleagues of the researcher. Eleven subjects took the same test twice, a few days apart. Test and retest scores were strongly correlated, $r(9) = .963$, $p < .01$, which was evidence of good temporal reliability.

Validity is the degree to which an instrument accurately measures what it purports to measure and allows appropriate interpretation of the results (Gay et al., 2012). In the present study, learning gains for recognition were measured with multiple choice questions and learning gains for recall were measured with fill-in-the-blank questions. The validity of these question types for measuring lower-level and higher-level learning, respectively, was established by Ritzhaupt et al. (2011). Construct validity of the questions was addressed by having the subject matter expert and lecturer, Gene Ovnicek, review the questions. Mr. Ovnicek approved the questions.

The survey item measured perceptions of difficulty by asking subjects to rate the lecture video immediately after watching it using a symmetrical scale where 1 = very easy, 2 = easy, 3 = fairly easy, 4 = neither easy nor difficult, 5 = fairly difficult, 6 = difficult, and 7 = very difficult. This rating scale was used verbatim in Marcus, Cooper, and Sweller (1996), and a similar scale with just a slight change in wording ("extremely" replaced "very") was used in the parent study, Ibrahim et al. (2012). These prior research uses gave the survey instrument the reliability and validity required.

The tests and survey used in this study were administered on the platform offered by ProProfs.com, an online knowledge management service. ProProfs uses a hierarchical structure wherein groups are assigned to classrooms, classrooms contain courses, courses contain chapters, chapters contain pages, and pages contain materials. The materials in this study consisted of a text file (the informed consent pdf), two quizzes (the recognition and recall tests), a survey, and two versions of a lecture video. Prospective members of the experimental and control groups received email invitations that allowed them to self-register and go through the study as part of Classroom E or Classroom C, respectively. Each classroom took one course. The courses were identical except for the video versions embedded. After the two-week data collection period, the study was closed. Reports from ProProfs contained the test and survey results broken down by classroom. The ProProfs reports were downloaded in Excel format, allowing the data to be imported into SPSS for analysis. Building the study on the ProProfs.com platform allowed modularity of components, collection of the data needed, and protection of identities. It also gave subjects the option of completing the study in more than one session.

Study materials

For this study, the lecture used was, “Hoofcare Today: A Closer Look at Dynamic Mechanics in Sport Horses.” The lecture was given by farrier and researcher, Gene Ovnicek, RMF, CLS, at the International Lameness Prevention Conference in Las Vegas, Nevada on October 25, 2013. The lecture was selected for the following reasons.

1. The format was consistent with that used in many large college classes: an instructor speaking with a PowerPoint presentation of less than an hour in length;
2. The subject matter was sufficiently complex (i.e., high enough in the intrinsic cognitive load produced) to allow meaningful conclusions to be reached about the experimental treatment;
3. The subject matter was likely to appeal to both horse owners and professional farriers, which made it more likely that the participants recruited for the study would have varied prior knowledge in the domain of the lecture topic.
4. Although the speaker is a highly-respected expert in his field, he is an average public speaker, which is also true of the typical college instructor;
5. The recording of the lecture was typical in that the sound came from a lavaliere microphone worn by the speaker and the video came from a camera that captured both the speaker and the PowerPoint screen beside him, both of which were difficult to see because of the ambient lighting in the room;
6. The original PowerPoint file was available, allowing high-resolution versions of the slides and video clips used in the lecture to be inserted as dictated by the editing protocol.

The experimental treatment

Editing the captured lecture was the experimental treatment at the heart of this study. Conceptually, the editing protocol can be viewed as having three primary tasks: application of CTML principles, optimization of video and audio, and time compression. These tasks were not completed in strict succession. Much like the phases in instructional design, this editing protocol had an iterative and non-linear quality in application. All of the tasks in the protocol were performed using Final Cut Pro (FCP) for video and audio editing, and Pro Tools (PT) for audio processing. However, other full-featured editing software would also have worked. The edited lecture was reviewed and validated by SME, Cody Ovnicek. The original lecture video may be viewed on YouTube at this URL: http://youtu.be/7gCICmciXKw. The edited lecture may be viewed on YouTube at this URL: http://youtu.be/w1etY_233qs.

Application of CTML principles.

Three CTML principles actively guided the editing of the lecture. The coherence principle was applied by weeding out material extraneous to the learning objectives. Extraneous material included time spent attaching and testing the microphone, an opening joke, off-topic comments, unnecessary repetition, misspeaking, and lengthy pauses. The segmenting principle was applied by breaking the lecture into five subtopics of three to five minutes in length. The signaling principle was applied by bookending each segment with a preview/review screen that gave the segment a title and identified its three key points, and by displaying text clouds (cloud-shaped graphics with text inside) as needed during the segments to clarify the speaker's comments. Of the remaining nine CTML principles, the multimedia principle was foundational to the entire study. The redundancy, spatial contiguity, temporal contiguity, modality, pre-training, and personalization principles were taken into account when signaling was done. The image principle was kept in mind in deciding how often the instructor's image should be on screen. The final principle, voice, was not relevant to the study because the principle cannot be applied retroactively to change the instructor's choice of words or style of delivery. Appendix A contains a list of the subtasks in the main task, Application of CTML Principles. Appendix B contains a visual aid for the process. Appendix C contains screen shots showing how signaling was applied with preview/review screens and text "clouds" to clarify, summarize, and connect ideas.

Optimization of video and audio.

Optimizing video and audio was guided entirely by best practices in the field of video and audio production. Most original recordings in the entertainment, advertising, and corporate training fields are enhanced through post-production processes. Indeed, "fixing it in post" is a common expression for manipulating less-than-perfect recordings using sophisticated hardware and software tools in the controlled environment of an editing suite. The editing protocol for lecture recordings was a simplified version of what professionals do every day.

The majority of the subtasks in the editing protocol were performed using FCP, with video and audio locked together. However, the protocol allowed for exporting the audio track to PT for three audio processes: maximizing audio volume, enhancing intelligibility of the voice, and shifting frequencies to restore the normal pitch of the voice after time compressing. For this particular lecture recording, processing for volume and intelligibility were not needed due to the high quality of the original lecture audio. Thus only pitch shifting was performed in PT. The processed audio track was then synchronized and locked to the video once again in FCP. Video processing included color correction (to make the speaker more visible in the darkened auditorium) and reframing (zooming in at edit points to avoid jump cuts.). Inserting high-resolution versions of the PowerPoint slides or video clips at key points in the lecture completed the editing task. A different lecture recording might have required more or less manipulation of its look or sound than did the one used in this study. Appendix A contains a list of the subtasks in the main task, Optimization of Video and Audio. Appendix D contains screen shots showing how video optimization was performed.

Time compression.

Adjusting the playback speed of the lecture, also known as time compression, came after other editing decisions that affected pacing had been made. Prior research into time compression in multimedia had addressed speeding up the voice of the speaker but not the image of the speaker. Speeding up a voice recording causes the voice to rise in pitch, but techniques for restoring the natural pitch of the voice have been available for decades. PT has such an algorithm in its set of processing tools. Time compression when the person speaking can be seen poses a different challenge as there is no way to compensate for the faster movement of the visual. Thus, this step required some experimentation to be certain that the speaker's movement did not seem unnatural. The 25% time compression used by Pastore (2012), while acceptable for audio, produced slight jerkiness in the video. Thus, a more conservative time compression factor of 10% was used for the entire lecture. The edited lecture, after all processing was performed, was 20:09 in length. The original lecture was 33:14 in length. Thus, the editing protocol produced a 39% reduction in lecture length. Both FCP and PT were used in the time compression task. Appendix A contains a list of the subtasks in the main task, Time Compression.

Recruiting participants for the study

Three opt-in email lists of horse enthusiasts and equine professionals were used to recruit participants: TheHorseShow.com, the Equine Lameness Prevention Organization, and the

American Competitive Trail Horse Association. To achieve random assignment to the experimental and control groups, the three lists were merged in Excel and put into random order using the RAND function. The randomized list was then cut in half. One half was used to recruit subjects for the experimental group and the other half was used to recruit subjects for the control group. The goal was to have a minimum of 60 participants complete the study.

Initial email invitations were sent to both groups via Constant Contact on December 10, 2014. Statistics from Constant Contact indicated that 4,631invitations were delivered successfully to members of the control group and 4,732 invitations were delivered successfully to members of the experimental group. Follow-up invitations with clarification of how to navigate the study were sent a week later in the same manner, with approximately 1% fewer successful deliveries due to opt-outs generated by the first mailing. Each email invitation contained a link to allow the recipient to self-register into his/her assigned group (E or C) and take the course assigned to that group. Appendices E and F contain the initial and follow-up invitations to participate, respectively.

Informed consent and protection of identities

An informed consent document was presented to subjects in the first module of the study (a.k.a. the first chapter of the course). Obtaining informed consent followed IRB online study guidelines, which waive the requirement for a paper form, original institution letterhead, and physical signature. Continuing past the first chapter stipulated agreement with the provisions of the informed consent document. Identities of study participants were protected by the security features built into ProProfs.com. All study participants created their own usernames and passwords as part of the self-registering process. Appendix G contains the informed consent document.

Data collection

Data collection employed the test and survey tools available with a premium subscription to ProProfs.com. ProProfs.com allows creation of groups, classrooms, courses, chapters, and pages so that content modules (e.g., instructional materials, media, quizzes, or surveys) can exist independently of the control structure presenting them. This guarantees the correct sequencing of course elements and makes updates to courses more efficient.

Appendix H contains a graphic representation of the data collection flow through one of the courses. Flow was identical for the experimental and control groups. Two quiz modules were used. The recognition quiz consisted of 10 multiple-choice questions. The recall quiz consisted of 10 fill-in-the-blank questions. The survey consisted of a single question in which the participant was asked to rate the difficulty of the lecture. The questions and survey item were identical for the two groups. Appendices J and K show the test questions and survey item, respectively.

Data analysis, presentation of results, conclusions, and future directions

Data collection spanned a two-week period, from December 10, 2014 to December 24, 2014, after which time all quiz and survey results were downloaded from ProProfs.com in separate Excel files. The data was then merged into a master Excel file. Only participants for whom a complete, valid data set existed were represented in the master Excel file. A complete data set consisted of pre- and post-test scores for recognition and recall, and a survey response. A data set was considered invalid if the time stamps on the pre- and post-test scores were too close together for the participant to have viewed the video. After the cleaning and merging process, the experimental group contained 40 subjects and the control group contained 43 subjects. The master Excel file was then input to the Statistical Package for the Social Sciences (SPSS), where data analysis was performed.

Resource requirements

Two computer systems were used in this study. To process audio and video, a MacBook Pro laptop with a fast outboard disk drive (LaCie Rugged, 500 GB, 7,200 mbps) was used. Final Cut Pro version 7 and Pro Tools version 8 were used to edit video and audio, respectively. To create the modules in ProProfs.com, an ASUS PC laptop was used. The Chrome browser was used for accessing ProProfs.com.

Internet resources included a high-speed connection through a cable modem. The experimental and control versions of the lecture were converted from their native HDV 1080i60 format to mp4 format in order to meet the file size limitations for video embedded in ProProfs pages. Embedding the videos in ProProfs rather than streaming them from YouTube was done to keep participants within the ProProfs environment. SPSS version 20 was used for data analysis. Human resources used included the subject matter experts, Gene and Cody Ovnicek, the study participants, the researcher, and the researcher's dissertation committee.

Summary

By applying an editing protocol to lecture video, the current study extended prior work done by Ibrahim et al. (2012). In this parent study, the authors investigated the effects of editing an instructional video so that it complied with three CTML principles: segmenting, signaling, and weeding (or coherence). "Insect," a 32-minute instructional program professionally produced by the British Broadcasting Corporation, was the video used in the study. The authors had two research questions (paraphrased): 1) Will the treatment affect the perceived difficulty of learning for novice learners? 2) Will the treatment affect how well the novice learners retain, organize, and transfer knowledge? The authors used the MANCOVA data analysis model. The independent variable was the editing protocol (used or not used) with covariates of prior knowledge and metacognitive awareness. The dependent variables were perceived learning difficulty, knowledge retention, transfer of knowledge, and structural knowledge acquisition. The study took place in a college classroom with 226 undergraduate participants.

The current study was similar to Ibrahim et al. (2012) in overall approach, focus of the research questions, basic editing parameters, and basic data analysis model. However, the proposed research extended the parent study in important ways. First and most important, the editing protocol was applied to raw lecture video, a verbatim recording of a live event, rather than a carefully scripted and produced instructional video. These were significantly different starting points. Second, the editing protocol included steps to process the video and audio in order to make the lecture easier to see and hear. These steps were missing in the parent study because the video had already been professionally produced. Third, the current study included increasing the playback speed of the instruction to better match the mental processing rate of the average human. This step was not included in the parent study. Fourth, learners were given control of playback in the proposed research. In the parent study, the videos were watched straight through in a classroom environment. The control group saw the video in one continuous stream while the experimental group saw the video in edited segments which played back to back. Participants had no control of the media.

Because the current study was conducted entirely online, the option of doing it outside of the university context was exploited. The researcher’s status as an author, educator, and broadcaster in the horse industry provided access to thousands of potential study participants. Opt-in email lists were obtained from the researcher’s web site, thehorseshow.com; the membership of a professional farrier's association, the Equine Lameness Prevention Organization; and an association of recreational trail riders, the American Competitive Trail Horse Association. More than 13,000 prospective participants were randomly assigned to experimental and control groups and were invited to take part in the study. Ultimately, 40 subjects comprised the experimental group and viewed the edited version of the captured lecture, and 43 comprised the control group and viewed the original, unedited lecture. A pre-test was conducted to confirm that there was no significant difference in prior knowledge between the two groups. A post-test was conducted to measure knowledge gained from watching the video. The pre- and post-tests were identical. In addition to learning gains, perceptions of lecture difficulty were also measured for both groups. All data collected in the study were quantitative in nature, allowing statistical analysis methods to be used to test the hypotheses and answer the research questions. Appendix L contains a think-aloud journal kept by the researcher during the process of developing the methodology, and collecting and analyzing the data in this study.

Chapter 4

Results

Introduction

The data collection period of two weeks ended on December 24, 2014. At that time, 359 of the invited individuals had self-registered in either the experimental group (181) or the control group (178). Test and survey results were downloaded, merged into a master Excel data base, and examined for completeness. A complete data set for a study participant consisted of four test scores (pre- and post-test scores for recognition and recall) and a survey response. Complete data sets were obtained for 83 study participants (40 in the experimental group and 43 in the control group), which exceeded the minimum of 60 participants needed for the study. Table 2 below presents the descriptive statistics from the study. A between-groups analysis of post-test scores was then performed using MANOVA after confirming with independent-samples *t*-tests that the two groups began with comparable prior knowledge. A within-groups and between-groups analysis was also performed with repeated-measures MANOVA to provide another view of how learning gains compared between the two groups.

Table 2

Descriptive Statistics

	Pre-Test		Post-Test		
	Recognition	Recall	Recognition	Recall	Difficulty
Group (*N*)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
E (40)	83.0 (15.392)	40.75 (15.589)	90.0 (11.323)	61.75 (19.597)	3.73 (1.198)
C (43)	81.16 (16.214)	44.19 (16.509)	86.98 (11.241)	67.67 (14.612)	3.79 (1.013)

Analysis of pre-test scores with *t*-tests

The first analysis approach assumed that the two groups were well matched in their prior knowledge of the lecture topic. To validate this assumption, pre-test scores were considered. Pre-test scores for recognition in the experimental group ($N = 40$, $M = 83.0$, $SD = 15.392$) differed numerically from pre-test scores for recognition in the control group ($N = 43$, $M = 81.16$, $SD = 16.214$). To determine whether the differences were statistically significant or due to chance, an independent-samples *t*-test was performed. The requirements for using an independent-samples *t*-test were met: The groups were independent of one another, the data collected were quantitative and normally distributed, and the variances in the two sets of data were sufficiently homogenous ($F(81) = .14$, $p = .713$). The independent-samples *t*-test indicated that there was no significant difference between the two groups on pre-test recognition scores ($t(81) = -.53$, $p = .599$). Thus, the two groups had statistically-equivalent (and relatively high) prior knowledge at the recognition level.

Similarly, pre-test scores for recall in the experimental group ($N = 40$, $M = 40.75$, $SD = 15.589$) differed numerically from pre-test scores for recall in the control group ($N = 43$, $M = 44.19$, $SD = 16.509$). Independent-samples *t*-tests were performed on those scores to determine whether the differences were statistically significant or due to chance. The requirements for using an independent-samples *t*-test were met, including homogeneity of variances ($F(81) = .14$, $p = .711$). The independent-samples *t*-test indicated that there was no significant difference between the two groups on pre-test recall scores ($t(81) = .97$, $p = .333$). Thus, the two groups had statistically-equivalent (and relatively low) prior knowledge at the recall level. The assumption that the two groups were well matched in their prior domain knowledge was supported and post-test scores could be further examined with MANOVA.

Analysis of post-test scores and survey responses with MANOVA

MANOVA revealed that there were no significant differences between groups with regard to the impact of the independent variable, lecture form, on the combination of dependent variables (post-test scores for recognition and recall, and perceptions of difficulty), Wilks' Λ = .936, $F(3,79) = 1.79$, $p = .156$, partial $\eta^2 = .064$. On the basis of this analysis, the overarching multivariate hypotheses, H, was rejected. As a matter of interest, it can be seen in Table 3 (Appendix M) that the greatest difference between groups was in post-test recall scores. However, the difference was not statistically significant ($p = .121$).

Analysis of post-test scores with Repeated-Measures MANOVA

To verify the results of the between-groups analysis of test scores conducted using independent-samples *t*-tests and MANOVA, a combination within-groups/between-groups analysis was conducted with repeated-measures MANOVA. This approach effectively treated time as a covariate to the independent variable, lecture form, allowing the learning gains of the individuals within each group and the performances of the two groups to be compared together. Repeated-measures MANOVA revealed that: 1.There was no significant difference between groups with regard to the impact of the independent variable, lecture form, on the dependent variables (post-test scores for recognition and recall), V = .061, $F(2,80) = 2.61$, $p = .080$, partial $\eta^2 = .061$; 2. There were significant differences in pre- and post-test scores within both groups attributable to the time covariate, V = .722, $F(2,80) = 103.849$, $p = .000$, partial $\eta^2 = .722$; and 3. There was no significant difference between groups with regard to the impact of the independent variable interacting with the covariate (i.e., lecture form interacting with time) on the dependent variables (post-test scores for recognition and recall), V = .012, $F(2,80) = .479$, $p = .621$, partial $\eta^2 = .012$. H was again rejected. Thus, the contingent research questions were moot.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Conclusions

In the present study, an audio/video recording of a live lecture presented in a lecture hall with a PowerPoint presentation was used to test an experimental intervention in which the lecture recording was subjected to an editing protocol before being presented to learners. Learning outcomes and perceptions of difficulty were measured with tests and a survey. Analysis of the data collected allowed the hypothesis to be tested and the research question that prompted the experiment to be answered.

The overarching multivariate research question was, "How will student success, as measured by recognition learning, recall learning, and perceptions of difficulty, differ between subjects in the experimental group and subjects in the control group?" The results of the experiment led to the conclusion that there was no significant difference in student success based on these three measures in combination. In other words, editing the lecture didn't help participants recognize correct answers when they appeared in a list, recall correct answers from memory, and make the lecture seem any easier. The answer to the overarching multivariate research question rendered the contingent univariate research questions moot, and testing of the univariate hypotheses unnecessary.

Implications

This study was a first attempt to investigate an editing protocol for captured lectures. There were significant limitations to the study, all of which can be addressed in future research, as discussed below. However, practical and theoretical implications can still be drawn from the study as it was conducted. From a practical standpoint, the study contributed an editing protocol that is grounded in literature and professional practice, and can be used by interested instructors to bring their lecture recordings into alignment with multimedia instructional theory and the cognitive/constructivist foundation underlying online learning. At present, there are no guarantees that using the protocol will lead to measurable improvements in learning outcomes and make the lectures seem easier to students. However, future research with better control over the sampling may change that and shed light on whether editing correlates with faster learning.

From a theoretical standpoint, the study suggests that, under some conditions, learning with captured lectures may be different than learning with other types of multimedia instruction, where CTML principles have been proven to be helpful (e.g., Ibrahim, Antonenko, Greenwood, & Wheeler, 2012; Mayer, 2009; Park, Moreno, Seufert, & Brünken, 2011). This implication might be easier to understand if the captured lecture used in the study were dramatically different from a typical multimedia module; e.g., if it relied more heavily on words than it did on pictures. Many PowerPoint-supported lectures consist almost entirely of words, either those coming out of the instructor's mouth or those projected on the screen. The only "pictures" present when that sort of lecture is recorded are the instructor's image and visual representations of words on the slides. In the present study, however, PowerPoint was used almost exclusively to display photographs and video clips that supported and illustrated what the instructor was saying, very much like a conventional multimedia module, as can be seen in the screen shots contained in Appendices C and D. In other words, the captured lecture used in this study satisfied the literal definition of multimedia instruction and was consistent with the form it most commonly takes. In spite of this fact, employing the CTML principles via retroactive editing failed to produce a measurable effect on learning and perceptions of difficulty in this study, as occurred when a similar protocol was applied to traditional multimedia instruction by Ibrahim et al. (2012).

Recommendations for future research

A major limitation of the present study was that it used email marketing to recruit participants. According to the Direct Marketing Association (as cited in Chapman, 2012), the average response for email campaigns to existing customers is .12%. The 83 subjects who completed the study comprised .89% of the 9,363 horse owners or professional farriers who received email invitations. Thus, response to the email invitations was seven times the typical email response. However, the fact remains that 99.1% of the group targeted for the study either opted not to participate or dropped out after starting the study. Why the 83 remained in the study is open to conjecture. Given the relatively high pre-test recognition scores, it could be that the subjects had higher-than-average levels of interest and/or experience in the lecture topic. Affective factors such as interest are known to interact with cognitive factors in multimedia learning (e.g., Moreno, 2007; Ozel, Caglak, & Erdogan, 2013). Similarly, the expertise reversal effect is known to affect learning from multimedia (e.g., Leahy & Sweller, 2005). If it inadvertently used only highly motivated or knowledgeable learners, the study may have investigated a boundary condition, committed a type II error (failed to detect a legitimate effect), and diminished the study's internal validity. It is recommended that future research repeat the experiment with better control of the participants. An online or hybrid college course in which use of the lecture is required might be a good place to start. It is worth pointing out that the parent study, Ibrahim et al. (2012), exercised absolute control over the sample by conducting the study in a university classroom. Captured lectures are not used in classrooms, so future research would need to achieve the control needed and be suitable for use with online learners.

Another limitation of the study derived from the learning platform used, ProProfs.com. Extensive research went into the selection and testing of the learning platform, as detailed in the Researcher's Journal (Appendix L). Approximately $500 was spent in subscription fees. The hierarchical structure of the ProProfs system (e.g., groups, classrooms, courses, chapters, pages, and instructional materials) was well-suited to the study, as was the tracking of scores and survey responses. Technical support was adequate during development. However, operational problems during data collection may have contributed to a high attrition rate among subjects who attempted to participate in the study. Of the 9,363 invitees, 359 self-registered into either the experimental group or the control group. Yet only 83 (24% of the experimental group and 22% of the control group) went on to complete the study. Put another way, 77% of the people who came to the study with the intent of participating dropped out before completing it.

Three operational problems were identified. 1. After successfully registering into the E or C group, an indeterminate number of people were taken to a classroom page that informed them that no courses were yet assigned to their classroom. This bug in the ProProfs software resulted in a dead end for those would-be participants. By the time this problem manifested, the data collection period was nearly over. 2. Blank screens with only a "next" button at the upper right were presented between the pages of the course. Technical support at ProProfs could not explain or replicate this problem prior to data collection. The only option was to instruct participants to "click the next button when you encounter a blank screen." Judging from emails received, many people were not reading instructions carefully, and may have been confounded by the blank screens, resulting in more attrition. 3. During the course, screens sometimes took several seconds to load and video playback sometimes buffered, even during testing on the researcher's high-speed Internet connection. No pattern could be seen and no solution could be offered by

ProProfs.com. Email comments received during data collection suggested that some people gave up as a result of poor response from the ProProfs.com system, possibly exacerbated by poor local Internet speeds. The follow-up email invitation (Appendix F) advised participants to be patient if they experienced poor system response. Recommendations for future research would be to replicate the study with a platform other than ProProfs.com.

A self-imposed limitation in this study was the use of a safe time compression rate of 10%. As noted earlier, this rate was chosen for two reasons. First, the pacing of the lecture had already been increased significantly by weeding extraneous content and tightening long pauses. Second, higher compression rates made the speaker's movement jerky, which might have distracted viewers from the lecture content. Using multiple compression rates (i.e., a lower rate for when the instructor could be seen and a higher rate for when the instructor was not seen) would make the editing protocol too complex to be practical and was rejected early on. Future research might investigate whether any detrimental effect would be encountered with higher compression rates, as high as the 25% suggested by Pastore (2012). It is entirely possible that students would habituate to a sped-up visual and the distraction would diminish or disappear entirely within an acceptable period of time. Research of this type could follow that of Pastore (2012) using a captured lecture with a visible speaker instead of the narrated multimedia module used in the Pastore study.

Perhaps the most intriguing subject for future investigation is whether learning can be faster with an edited lecture. In the parent study, Ibrahim et al. (2012), the edited multimedia program was the same length as the original. The editing protocol in the present study reduced the length of the lecture, organized it into subtopics, highlighted what was important to remember, and made the lecture easier to see and hear. The resulting video was 39% shorter and more densely packed with information than the original lecture. The question to be answered is whether these changes allowed users to complete their learning more quickly. To answer this question, time spent watching the edited and unedited lectures would need to be tracked and compared, in addition to testing what was learned. While the present study found no significant differences in the amount or perceived difficulty of learning after a lecture makeover, it left open the question of whether the same outcomes could be achieved more quickly with such a makeover.

Future research could also replicate the study with a different lecture topic, or a different presentation mode, such as the whiteboard or "chalk and talk" method wherein visual lecture content is added on the fly (e.g., Euzent, Martin, Moskal, & Moskal, 2011; Nashas & Gunn, 2013). Finally, future research could focus on the impact of seeing the instructor's image on screen, which would shed light on the image principle, the vaguest of the twelve instructional design principles put forth in CTML (Mayer, 2009). To fully investigate this principle, personal qualities of the instructor (e.g., whether he/she was engaging, supportive, and likable, or boring, distant, and unlikable) would have to be considered in addition to the amount of time the instructor appeared on screen.

Summary

Video lecture capture is the practice of recording a live classroom lecture and making it available to students for viewing at a later time via the Internet. College students approve of the practice because it gives them more control over the time and place of their learning and reduces unproductive time spent traveling to campus. Difficult sections of a lecture can be repeated to master the material and to prepare for tests. Learning can be more conveniently integrated with other dimensions of the student's life, such as job, family, and recreation. Institutions support the lecture capture practice, largely because student satisfaction is critical to competing effectively for enrollments in an increasingly-global education marketplace. Increased competition for online students results in increased demand for instructional content that can be accessed online. Recording a live lecture is a quick and easy way to generate such content. Thus, video lecture capture is well entrenched in higher education and is likely to remain so (e.g., Johnston, Massa, & Burne, 2013; Toppin, 2011).

A problem exists, however. The best way to use lecture video is not fully understood. Even though the student has control over the playback of the lecture, the student is an observer of an earlier learning event, with no opportunity to interact with the teacher and classmates or to ask questions. As a consequence, new or complex ideas presented in raw lecture video may overload working memory, making it difficult to create new schema and integrate them with existing schema (i.e., prior learning) retrieved from long-term memory. At other times, the pace of raw lecture video may be too slow to keep learners engaged, given the fact that humans can listen with comprehension at a much faster rate than instructors can speak. Philosophically, long streams of one-way communication do not align well with the cognitivist/constructivist perspective underlying online learning.

The present study investigated the contention that captured lectures can be improved as learning tools if time and effort are put into editing them before presenting them to learners. The theoretical basis of this contention lies in the fact that captured lectures are a form of multimedia instruction; i.e., "presentations involving words and pictures that are intended to foster learning" (Mayer, 2009, p. 5) and should therefore behave similarly to other forms of multimedia instruction. Instructional design considerations for multimedia have been explored extensively in the literature on CTML (e.g., Austin, 2009; Lusk, Evans, Jeffery, Palmer, Wikstrom, & Doolittle, 2008; Ibrahim, Antonenko, Greenwood, & Wheeler, 2012; Mayer, 2009; Moreno, 2007), which provided a basic framework for the editing protocol. The protocol was intended to reduce extraneous cognitive load, increase germane cognitive load, and manage intrinsic cognitive load, all of which are known to support learning (e.g., Moreno & Park, 2010).

Three primary CTML principles were applied, similar to the Ibrahim et al. (2012) study. The coherence principle was applied by weeding (deleting) any lecture content that was extraneous to the learning objectives of the lecture, even if the content was interesting and non-redundant. The segmenting principle was applied by dividing the long stream of video into segments on subtopic boundaries, like chapters in a book. The signaling principle was applied by adding descriptive text to preview important points at the beginning of each segment; emphasize, clarify, and connect ideas during the segment; and review what was important to remember at the end of the segment.

The editing protocol was expanded beyond CTML principles in two ways: first, by speeding up playback of the edited lecture, which was supported by literature on boredom in the classroom (e.g., Acee, Kim, Kim, Chu, Kim, Cho, & Wicker, 2010; Mann & Robinson, 2009) and time compression in multimedia instruction (e.g., Pastore, 2012; Ritzhaupt, Barron, & Kealy, 2011); and second, by incorporating best practices in video and audio production, which was supported by the researcher's professional experience in media production. The editing protocol was kept relatively simple to ensure than it could be quickly learned by instructors wishing to edit their own lectures. It was predicted that the transformation of a captured lecture using this editing protocol would result in increased learning and decreased perceptions of lecture difficulty in an experimental setting.

The captured lecture used for the experiment was a talk given by farrier and researcher, Gene Ovnicek, RMF, CLS, at the International Lameness Prevention Conference in Las Vegas, Nevada, on October 25, 2013. The setting was consistent with that of many college lectures: a hall with a podium and projection screen, an instructor wearing a lavaliere microphone and giving a PowerPoint presentation with visuals projected on the screen beside him. As is often the case with PowerPoint presentations, the lighting in the hall was too dim to see the speaker clearly and too bright to see the projected visuals clearly. A stationary, consumer-grade video camera was used to record the video and audio of the lecture.

Subjects in the experimental group viewed the edited lecture video and subjects in the control group viewed the unedited lecture video. Pre- and post-tests and a survey allowed learning gains and perceptions of difficulty to be measured. Subjects were horse owners and professional farriers who participated voluntarily in response to an email invitation. Of the 9,363 individuals invited, 359 attempted to take part, and 83 completed the entire study, randomly assigned to either the experimental group (40) or the control group (43). The study was conducted online during a two-week data collection period in December 2014 using the ProProfs.com training and testing platform. Data analysis was conducted in SPSS with *t*-tests to confirm equal levels of prior knowledge, and MANOVA to examine the impact of the independent variable, lecture form, on the dependent variables recognition test scores, recall test scores, and perceptions of lecture difficulty. A repeated-measures MANOVA was also used to provide an alternate analysis of the study data.

Conclusions drawn from the analysis were that editing the captured lecture resulted in no significant differences between the experimental and control groups with regard to learning at the recognition and recall level, and perceptions of lecture difficulty. Although the study did not support the original prediction that editing a captured lecture would lead to greater and easier learning, it did raise the possibility that editing might permit faster learning, as the edited lecture was 39% shorter than the unedited lecture. This possibility would need to be fully examined in future research that tracked viewing times before any claims could be made regarding time savings or efficiency of learning resulting from editing.

Future research could also address a limitation of the study arising from the sampling technique. In the present study, participation was optional, with no incentive of any kind offered. Participation required up to an hour of the subject's time and required dealing with testing software that was counterintuitive at times. The 83 individuals who persevered to the end of the study comprised less than one percent of the population of 9,363 horse owners or farriers who received email invitations. Why these few people completed the study when the vast majority did not is unknown. One explanation would be that the 83 participants had exceptionally high levels of interest in the lecture subject, the presenter's work, or the researcher's work. If this is true, the study investigated a boundary condition, which would compromise the internal validity of the study. Repeating the study with the required participation of an entire group, such as a college class, with a different lecture topic, with an unfamiliar presenter and researcher, and a more reliable testing platform might produce different results.

Another area suggested for future research concerns the impact of seeing the instructor on screen. From an affective standpoint, seeing a supportive instructor may increase interest, motivation, or confidence among learners. From a cognitive standpoint, processing a moving image produces high levels of load on the visual channel of working memory. In the present study, the time compression rate applied to the lecture video was kept low to be certain it didn't cause the instructor to move in an unnatural way and distract learners. How often the instructor needs to be seen in a lecture video and to what extent viewers can habituate to faster-than-normal movement when the instructor is seen are questions that remain to be answered and would affect choices made in the editing protocol. Research in this area would also shed light on the image principle of CTML, which states simply that the speaker's image onscreen does not necessarily aid in learning (Mayer, 2009).

The present study examined an ongoing practice in higher education, that of using video recordings of in-class lectures to supplement or replace attending the lectures. By noting that lecture video is a form of multimedia instruction, the study allowed a rich body of existing knowledge to be applied in an attempt to improve learning outcomes when lecture video is used. The editing protocol that was devised and tested in the study did not lead to the predicted increase in learning and decrease in perceptions of difficulty with the particular learner sample, subject matter, and testing platform used. However, its use did uncover the possibility that learning can occur more quickly when lecture video is edited. By exploring the impact of applying an editing protocol retroactively to captured lecture video, the present study took an important first step in this research domain and added to the body of knowledge underlying the use of computing technology in education.

Appendix A

Table 1 Editing protocol

Task	Subtask	Step
Application of CTML Principles	Weed	1. Cut out any video prior to the start of the lecture. This might include class administration matters, equipment manipulation, and social chat. 2. Cut out any off-topic stories or seductive (interesting but unimportant) details in the lecture. 3. Cut out pauses that are awkward or excessive. 4. Cut out false starts or misspeaking where it can be done cleanly. 5. Cut out all video after the lecture ends. NOTE: Use edit mode wherein the gap is closed when a section is cut out.
	Segment	1. After weeding has been completed, look for natural breaks in the lecture topic. 2. Separate the lecture into sub-topics of no more than nine minutes in length; 3. Fade in and out of each segment.
	Signal	1. For each segment, assign a meaningful title; 2. Identify the segment's three key points; 3. Build a simple graphic displaying the title and the key points for the segment. 4. Display the graphic for 15 seconds at the beginning and end of the segment, with the labels "preview" and "review," respectively; 5. During the segment, overlay cloud text (a cloud shape with text inside) to emphasize, clarify, or connect ideas presented in the segment; 6. Position cloud text so that it does not obscure relevant screen content, including the instructor's image; 7. Use an appropriate dark fill color with some transparency to it and white text to give cloud text the appearance of being layered on top of existing screen content.

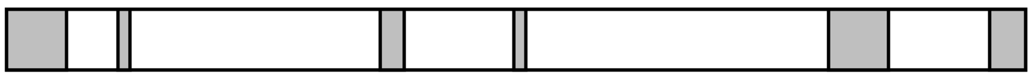
Table 1 (Cont.)

Task	Subtask	Step
Optimization of Video and Audio	Optimize Video	1. Use color correction as needed to lighten, darken, increase color intensity or decrease color intensity of original video image. 2. Adjust framing as needed to enlarge or straighten original video image. 3. Insert full-screen still images or video clips from PowerPoint presentation as needed to make the lecture more effective or to cover edits in the original video. 4. Use fades from/to black at beginning and end of segments.
	Optimize Audio	1. In FCP, export the audio track of the edited lecture as a single, contiguous file. 2. In PT, use normalization to bring the entire audio track to its maximum safe volume relative to its original peaks. 3. Use gentle compression/limiting to reduce the dynamic range of the normalized track; i.e., make the loudest parts softer and the softest parts louder. 4. Renormalize the compressed track to the new peaks. 5. Use filtering and equalization as needed to reduce ambient noise and to brighten the instructor's voice. 6. Bounce (rewrite) the processed audio track to create a new file. 7. Import the new audio track into FCP. 8. Mute original audio track and use new audio track.
Time Compression	Adjust Speed	1. In FCP, experiment with "change speed" process to find pace that can still be understood and does not look unnatural when the instructor moves, typically 110-125% of the original speed; 2. Export sped-up audio to PT and use "pitch shifting" to lower instructor's voice to its original pitch; 3. Export pitch-shifted audio track from PT and resynchronize it with the video in FCP.

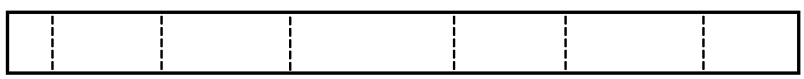
Appendix B

Editing Protocol – Visual Aid

Original video is one continuous stream.

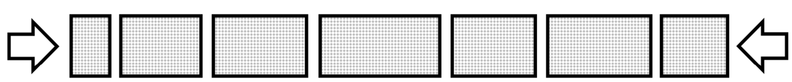


Extraneous content is first identified for weeding.



After weeding, topical breaks are identified for segmenting.

After segmenting, signaling text is added before, during, and after each segment.



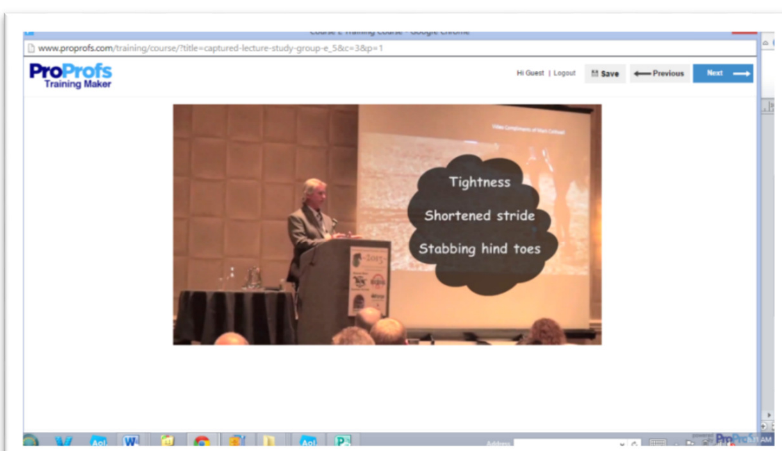
After signaling, video and audio are optimized and time compression is applied.

Appendix C

Signaling - Screen Shots

The Preview screen names the segment and prepares viewers for key points to come.

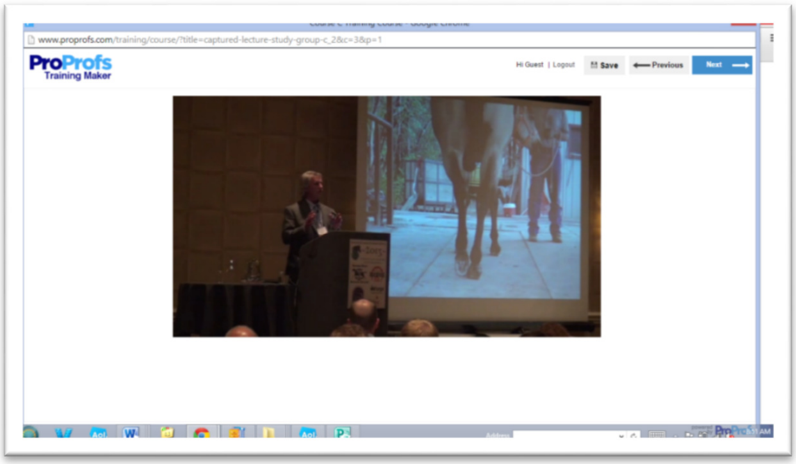
The Review screen reinforces what is important to remember from the segment.



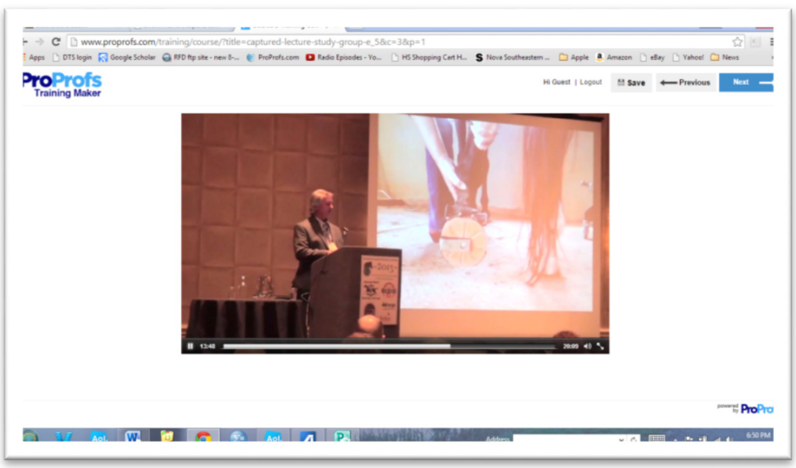
Text “clouds” emphasize, clarify, and connect ideas during the segment.

Appendix D

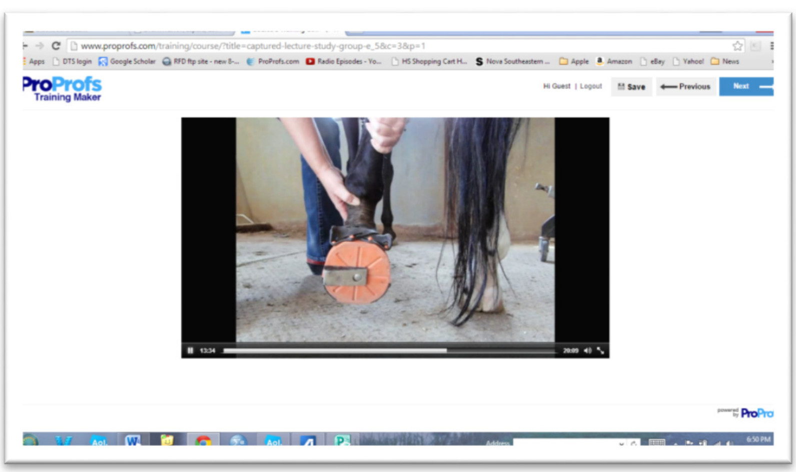
Video Optimization - Screen Shots



In original lecture video, instructor cannot be seen clearly.



After color correction, instructor can be seen more clearly, but slide is washed out.



Full-screen, high-resolution images replace washed-out slides as needed.

Appendix E

Initial Invitation to Participate

Subject line: Invitation from Rick Lamb – group C

Hi. Rick Lamb here.

I'm writing to invite you to be part of an online study I'm conducting as part of my graduate work in educational technology at Nova Southeastern University. You were included in this invitation because you have expressed an interest in horses by becoming a member of TheHorseShow.com, the Equine Lameness Prevention Organization, or the American Competitive Trail Horse Association.

In this study, you will take a pre-test, watch a lecture by Gene Ovnicek about equine lameness, rate the difficulty of the lecture, and take a post-test. It should take between 45 and 60 minutes of your time.

Please consider taking part. You may quit at any time if you change your mind. Click the link below to start. You'll first need to register by choosing a username and password. Use **join code C (capital "c").**

http://www.proprofs.com/classroom/?ID=1722753

Thank you!

Rick Lamb

rl905@nova.edu

602-677-8841

Appendix F

Follow-up Invitation to Participate

Subject line: Clarification from Rick Lamb – group C

Hi. Rick Lamb here again.

I just wanted to answer some questions people have asked about my dissertation study. First, yes, I will be happy to share the answers after the study closes on December 24th. Just email me to request the answers. The remaining questions are about navigating the study.

Log in screen: click "Sign up" to get the User Registration screen. Enter the username and password you want to use, and the group you want to join (C). If you have trouble registering, just pick a different username and try again. A message will announce that you've registered successfully. Click "Log in" below that message to start the study.

Your Classroom is the next screen. You have one course, which is pending because you haven't taken it yet. Click on Open and you will be taken into the study.

General advice: Give the pages time to load. If the video buffers at first, just be patient. If you get a page with nothing but the Next button in the upper right, just click that Next button. As before, please don't hesitate to email me or call me if you have trouble. I really appreciate your participation in my study! Here's your link to get started:

http://www.proprofs.com/classroom/?ID=1722753

Thank you!

Rick Lamb

rl905@nova.edu

602-677-8841

Appendix G

Consent Form for Participation in the Research Study Entitled
"A Makeover for the Captured Lecture: Applying Multimedia Learning Principles to Lecture Video"

Funding Source: None

IRB Protocol #:

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For questions/concerns about your research rights, contact:
Human Research Oversight Board (Institutional Review Board or IRB)
Nova Southeastern University
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Site Information
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What is the study about?
This study is an experiment concerning how people learn from watching lecture video. People in the control group will view a lecture about equine lameness while people in the experimental group will view the same lecture in a modified form. Tests and a survey will be used to compare the learning gains and perceptions of people in the two groups. You may direct any questions about the study to me, to my co-researcher, Dr. Ellis, or to the IRB at Nova. Contact information is above.

Why are you asking me?
I'm asking you to take part because you have expressed an interest in horses by becoming a member of TheHorseShow.com, the Equine Lameness Prevention Organization, or the American Competitive Trail Horse Association. I need 60 – 200 participants having a wide range of prior experience with horses. You can help me add to the body of knowledge about online learning regardless of how much or little you know about equine lameness.

What will I be doing if I agree to be in the study?
You will take a pre-test, watch a video, take a survey and take a post-test. The pre-test and post-test are identical. There are 10 multiple-choice questions and ten fill-in-the-blank questions. The

survey has just one item in which you rate the difficulty of the video. My best estimate is that the study will take less 45 – 60 minutes of your time. There is no time limit and you may complete the study in multiple sessions if that is more convenient for you. Since you'll be watching online video, you'll need a high-speed Internet connection.

Is there any audio or video recording?
No audio or video recording will take place during the study.

What are the dangers to me?
Risks to you are minimal, meaning that I believe the risks to be no greater than other risks you experience every day.

Are there any benefits to me for taking part in this research study?
I believe that you will find the information presented in the lecture to be interesting and useful in caring for your horse or the horses of your customers.

Will I get paid for being in the study? Will it cost me anything?
You will not be paid and there will be no cost to participate.

How will you keep my information private?
I am using a professional test and survey service, ProProfs.com. This service has state-of-the-art security to protect the identities of study participants. You will create a username and password for the study. All data collected in the study will be destroyed 36 months after the study ends.

What if I do not want to participate or I want to leave the study?
You may decline to participate or leave the study at any time with no penalty whatsoever.

Other considerations
If Dr. Ellis or I learn anything that might change your mind about being involved, I will pass on that information to you.

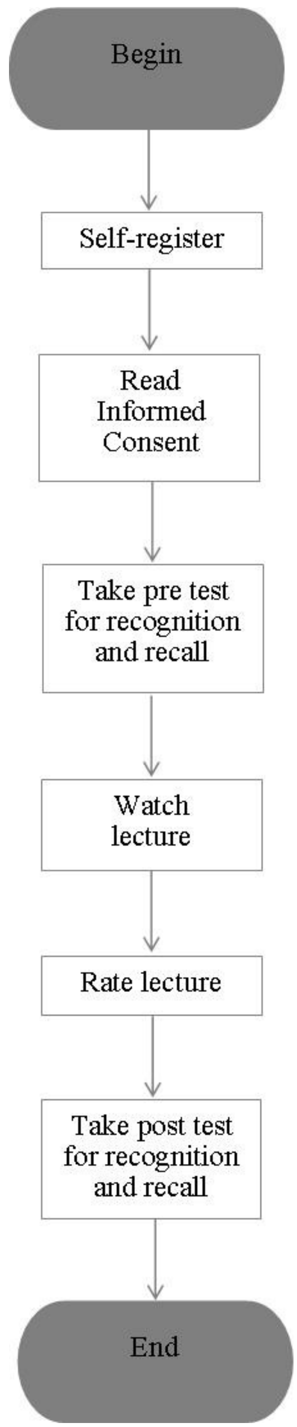
Voluntary Consent by Participant
By continuing into the study, you indicate that

- This study has been explained to you
- You have read this document or it has been read to you
- Your questions about this research study have been answered
- You have been told that you may ask the researchers any study related questions in the future or contact them in the event of a research-related injury
- You have been told that you may ask Institutional Review Board (IRB) personnel questions about your study rights
- You are entitled to print out a copy of this form
- You voluntarily agree to participate in the study entitled *A Makeover for the Captured Lecture: Applying Multimedia Learning Principles to Lecture Video.*

Please close this document when you are finished with it. You will be returned to the study, where you may exit or continue.

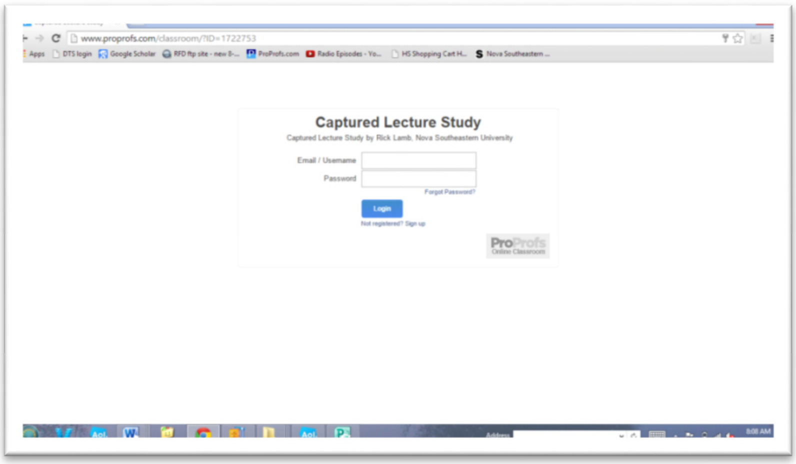
Appendix H

Data Collection Flow

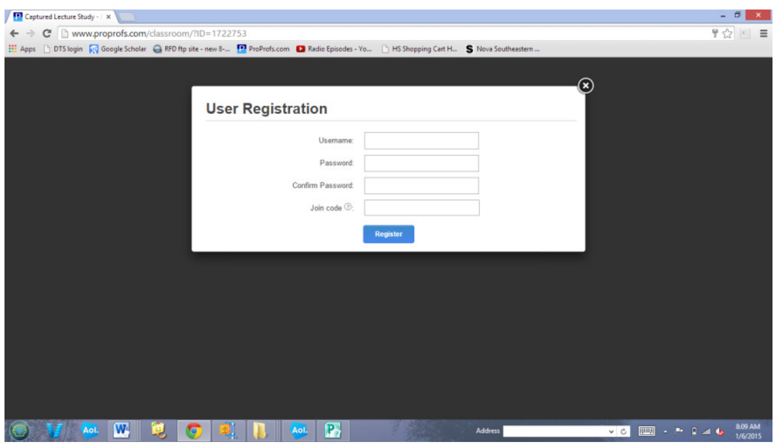


Appendix I

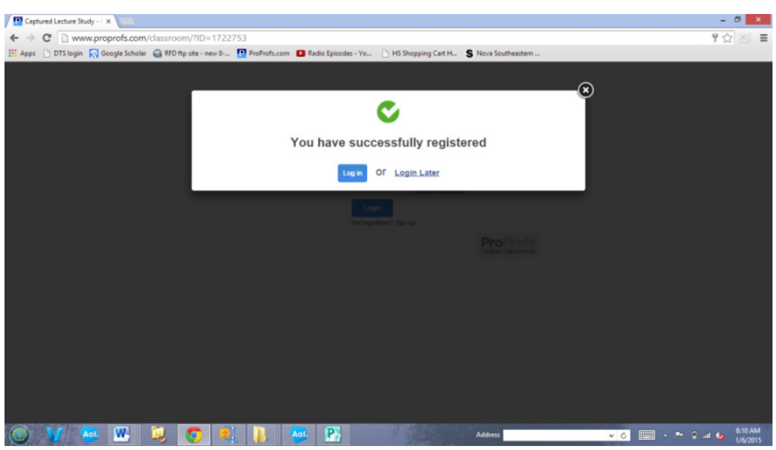
Data Collection - Screen Shots



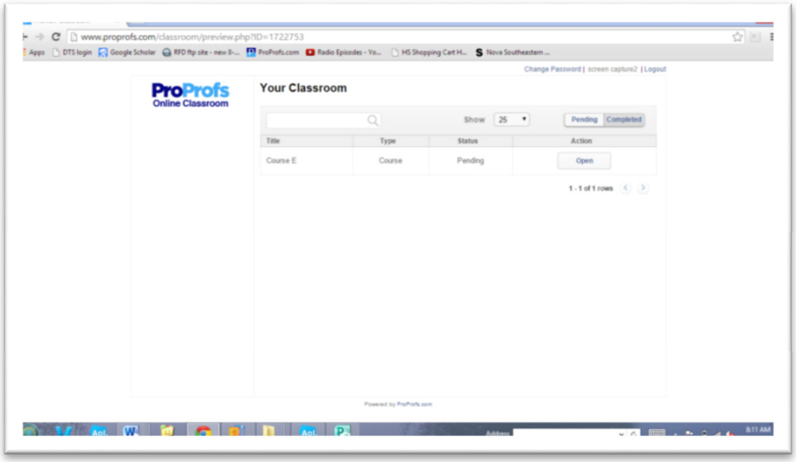
Subjects are taken to a landing page when they click on the link in the invitation email.



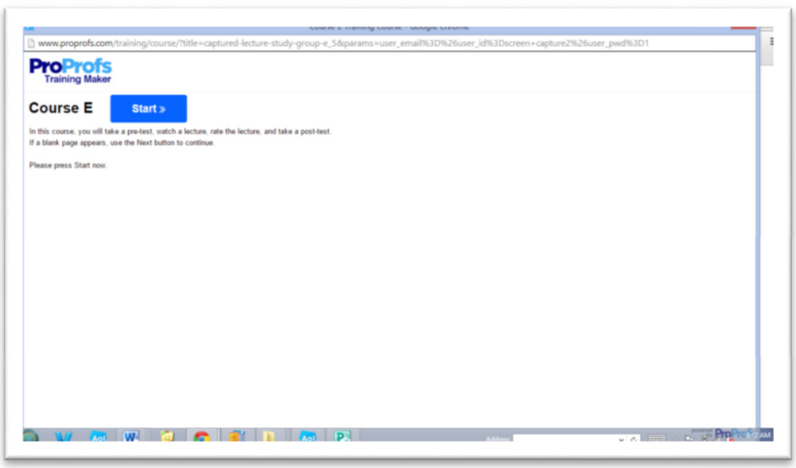
Subjects self-register and join the E or C group, as instructed in their email invitations.



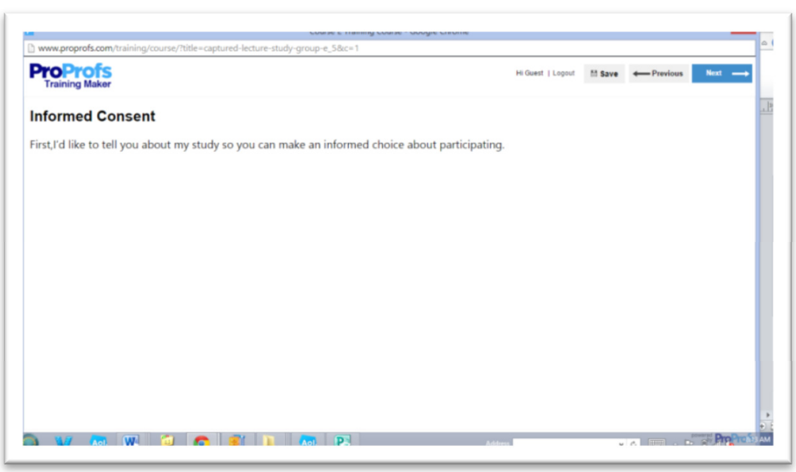
After successfully registering, subjects may begin the study.



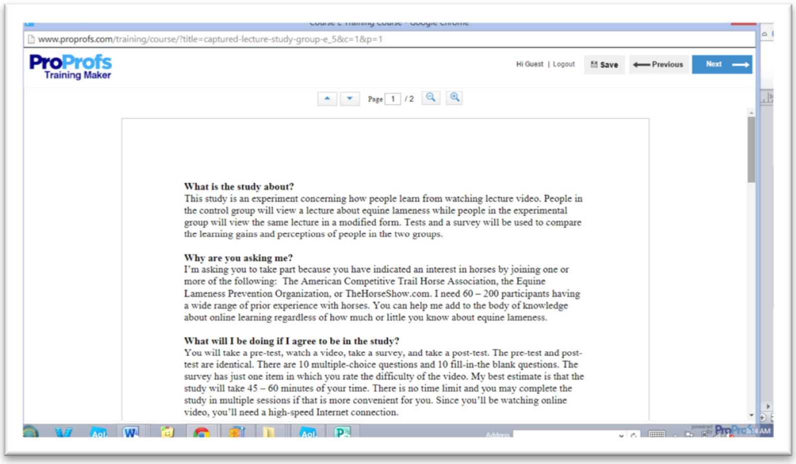
Subjects open the course assigned to their classroom.



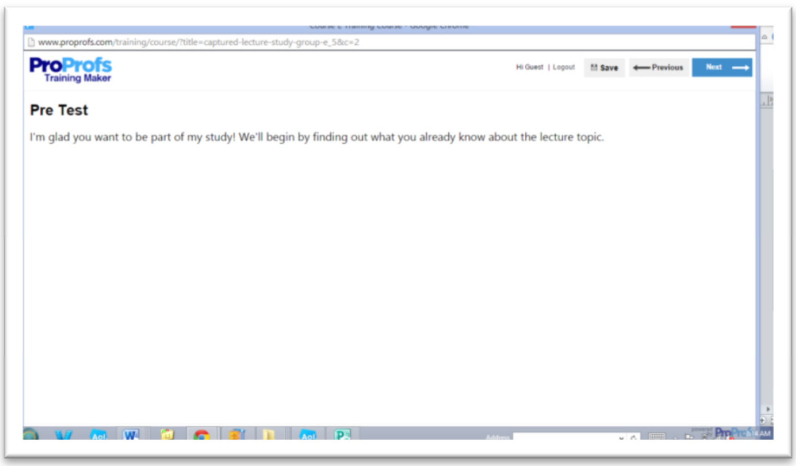
The landing page for the selected course provides an overview of the course chapters.



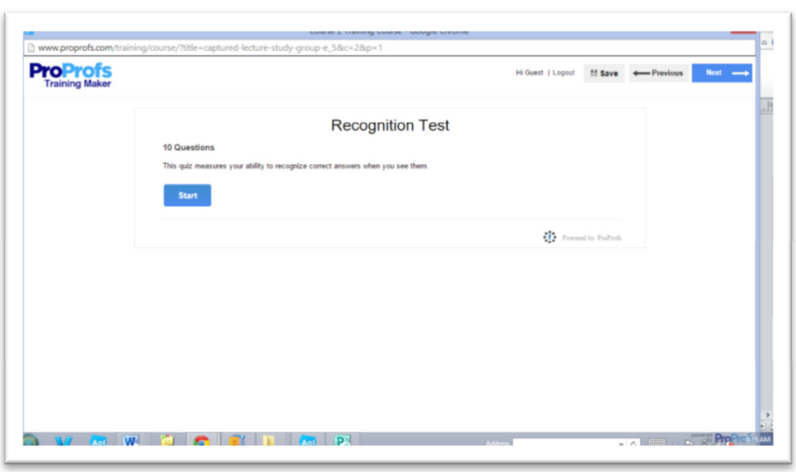
Informed consent is the first chapter in the course.



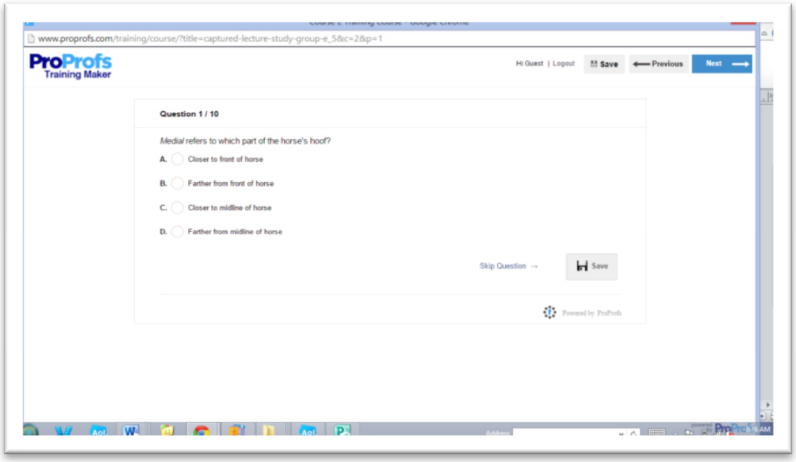
The informed consent document is the only page in the first chapter.



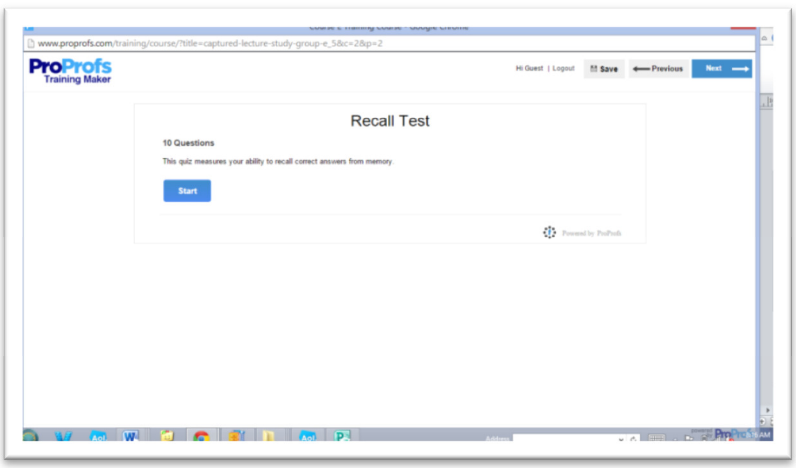
The Pre-Test is the second chapter in the course.



The Recognition Test is the first page in the Pre-Test chapter.

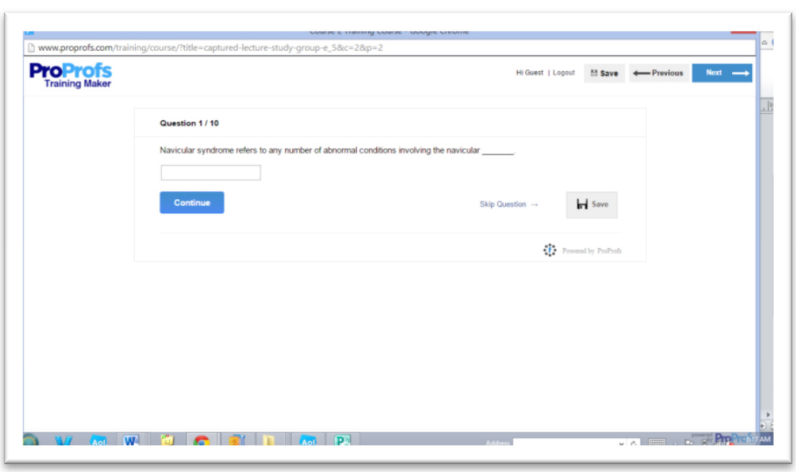


The Recognition Test consists of 10 multiple-choice questions.

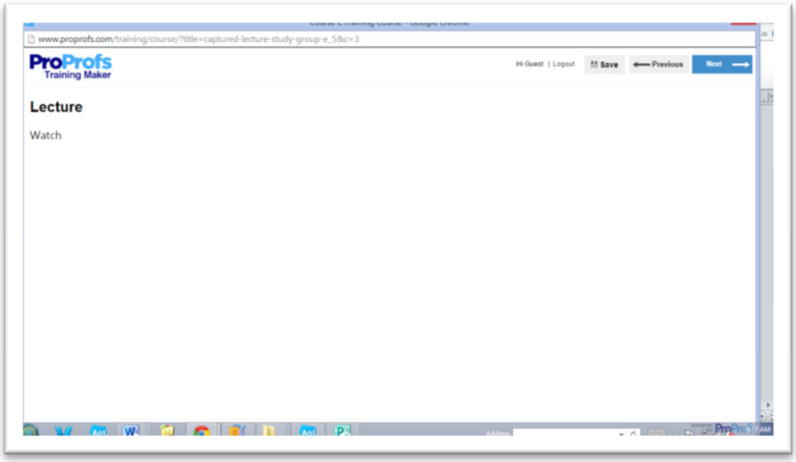


The Recall Test is the second page in the Pre-Test chapter.

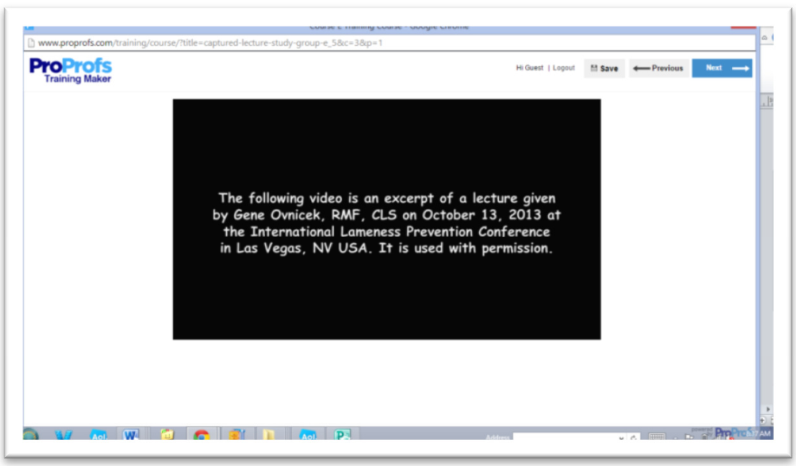
i



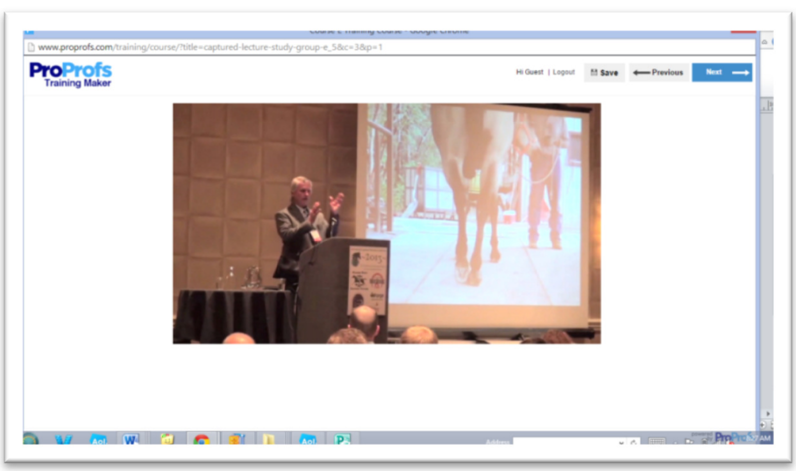
The Recall Test consists of 10 fill-in-the-blank questions.



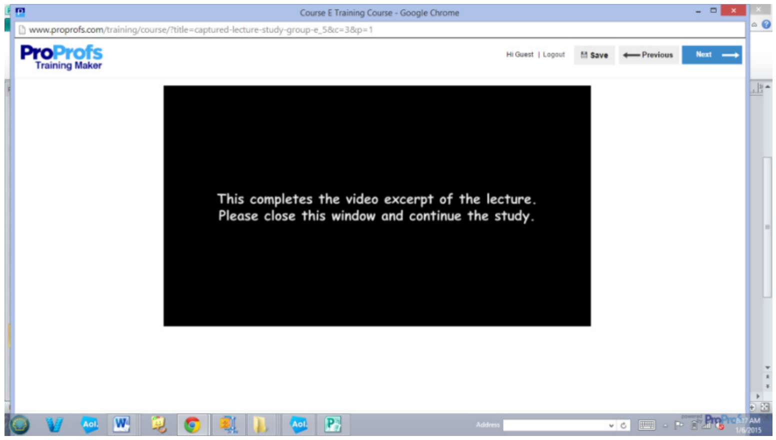
Watching the lecture is the third chapter in the course.



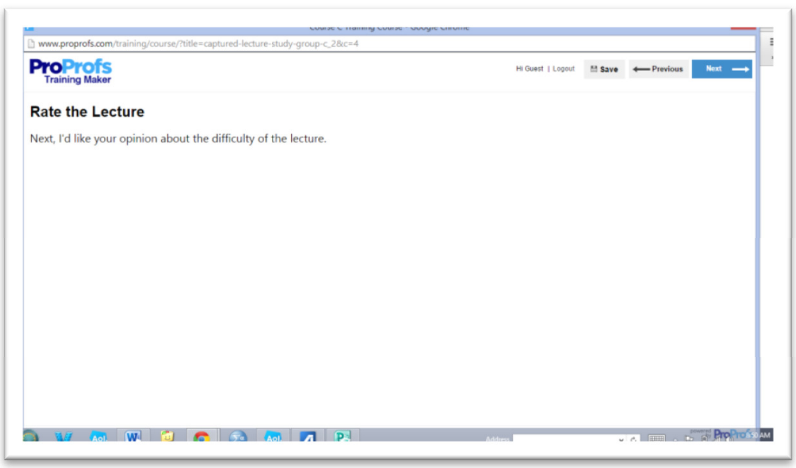
The lecture video is the only page in the third chapter.



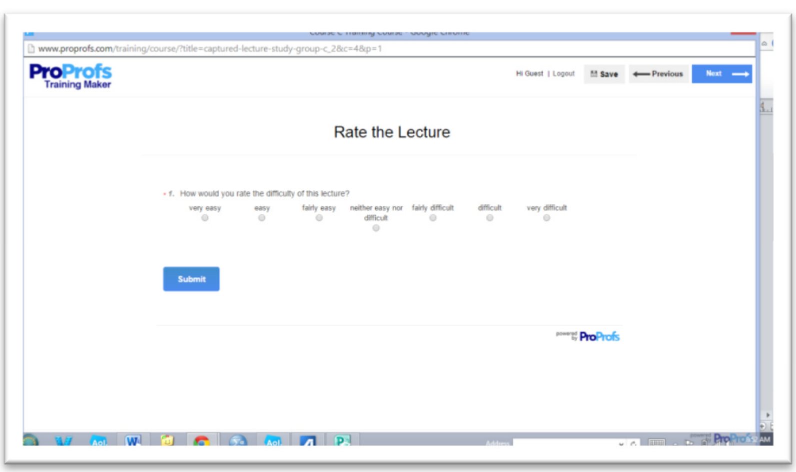
Course E uses the edited video (shown) and Course C uses the unedited video.



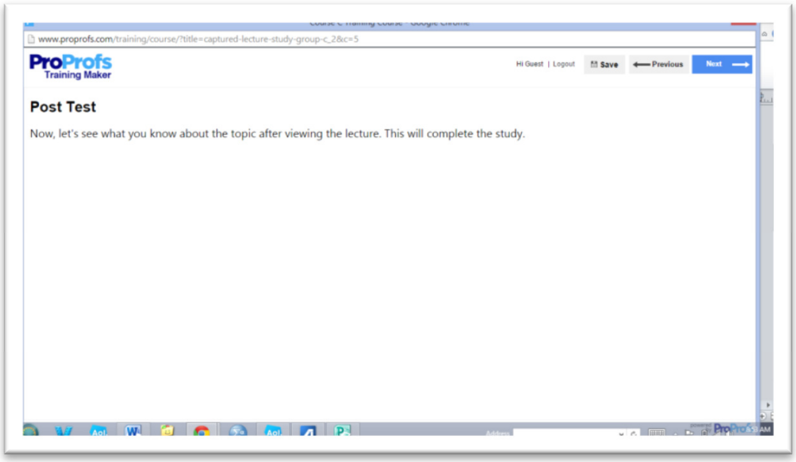
Both versions of the video inform viewers that the lecture excerpt has ended.



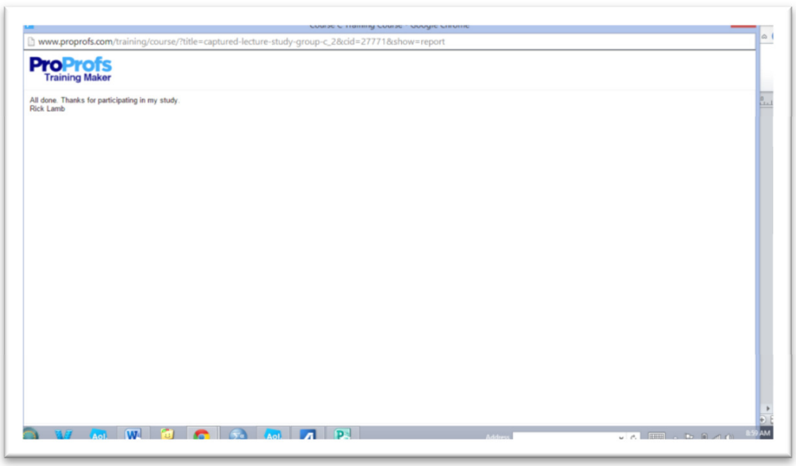
Rating the difficulty of the lecture is the fourth chapter in the course.



The Likert Scale survey is the only page in the fourth chapter.



The Post-Test is the fifth chapter in the course. It contains the same pages as the Pre-Test.



The study ends by thanking subjects for participating.

Appendix J

Test Questions

Questions measuring recognition of correct answers

1. *Medial* refers to which part of the horse's hoof?

    a. Closer to front of horse

    b. Farther from front of horse

    c. Closer to midline of horse

    d. Farther from midline of horse

2. To rest while standing, a horse will

    a. take the weight off of a back foot

    b. take the weight off of a front foot

    c. take weight off of each foot in turn

    d. stand evenly balanced on all four feet

3. Hoof balance affects a horse's

    a. posture

    b. comfort

    c. performance

    d. all of the above

4. Medial-lateral imbalance means that a horse's hoof is out of balance

    a. From front to back

    b. From top to bottom

    c. From side to side

d. From one gait to another

5. Abducting a limb means

   a. Moving the limb away from its natural position

   b. Moving the limb toward its natural position

   c. Tensing the muscle controlling the limb

   d. Relaxing the muscle controlling the limb

6. Hoof mapping is

   a. Plotting the locations of certified farriers in an area

   b. Marking a hoof before trimming it

   c. Selecting the proper size shoe or appliance for a horse

   d. Taking radiographs of a horse's hoof

7. Which of these is a sign that a horse may be sore in the hindquarters?

   a. Resistance to extending hind leg during hoof care

   b. Shorter stride than normal

   c. Toes of hind feet stabbing ground

   d. All of the above

8. What type of movement is most stressful for a horse's lower limbs?

   a. Circle

   b. Straight line

   c. Backing

   d. Collection

9. What is the best description of *loading* in hoof care?

   a. Adding weight to a shoe

b. **Putting a structure under stress**

c. Increasing carbohydrates in diet

d. Covering hoof wall with protective sealant

10. Asking a horse to move about at the end of a short rope does what?

a. Allows subtle changes in movement to be felt

b. Allows resistance to be felt

c. Provides a way of testing before and after treatment

d. **All of the above**

Questions measuring recall of correct answers

1. Navicular syndrome refers to any number of abnormal conditions involving the navicular bone.
2. What is the name of the largest bone in the horse's hoof? P3, pIII, third phalanx, distal phalanx, pedal, pedal bone, coffin, coffin bone
3. In the balanced trim, a key reference is the widest part of the foot.
4. Founder is an advanced form of what abnormal condition? Laminitis, laminitus
5. The v-shaped structure seen when viewing the bottom of a horse's foot is called the frog.
6. The Krosschek System utilizes a strap-on boot with a movable wedge that allows the horse's hoof to be put in different orientations relative to the ground. What is the word used to describe this sort of testing? Leverage, leverage testing.
7. Many lame horses are relieved of their discomfort with a treatment that elevates the medial side of the hoof.
8. When significant hoof discomfort has been relieved, it is common for the horse to immediately lower his head and do what? Sleep, fall asleep, doze.

9. Performance horses often receive injections to give them relief from pain in which part of the hindquarters? Hock, hocks, the hock, the hocks.
10. A horse that is experiencing hoof discomfort cannot get the rest he needs to function at his best.

Appendix K

Survey Item

How would you rate the difficulty of this lecture?

1 = very easy

2 = easy

3 = fairly easy

4 = neither easy nor difficult

5 = fairly difficult

6 = difficult

7 = very difficult

Appendix L

Researcher's Journal

8/27/14 Received PPT of Gene's lecture from Cody Ovnicek, along with raw lecture video from three cameras in three file formats (avi, mpeg,mp4). Converted all video files to QuickTime HD (.mov) format via Wondershare Video Converter Ultimate Video using default settings. Cam 1 shows Gene and the screen, which is the picture I need. However, the audio on the Cam 1 file is from the on-camera mic, which I can't use. Cam 2 shows Gene alone at podium, which I can't use, but the audio is from his lavalier mic, which is the audio I need. I will need to use cam 1 video with cam 2 audio. Only problem is that the good audio on cam 2 ends at 33:25, probably due to the battery in the wireless receiver dying. Cam 3 is the screen alone – I probably won't need this since the protocol calls for replacing video of the screen with high-res images or clips from the PPT file.

NOTES: Video conversions are very time consuming. A single format should be used for shooting and editing, making conversions unnecessary. I am converting everything to the format I already use on my TV show (HDV 1080i60) for my own convenience.

8/28/14 A possible solution to the lav audio ending early is to cut to on-cam audio and EQ to match the two sources as best I can. The audio purist in me cringes at this. Viewers will notice the change in sound but should adjust quickly since the speaker can still be understood.

NOTES: Synchronizing audio and video from two different sources would normally not be necessary since they would have come from the same camera in a typical lecture capture situation.

10/1/14 May want to end video at 33:25 to avoid problem with audio change. It's not an ideal place to end but I could put up a graphic on both versions to explain why it ended. Not much to gain by going longer than this anyway as Gene gets into Q&A, which would need to be cut out anyway.

10/10/14 Thoughts about how to use Gene's image. First, his image on video is not great since light is subdued to allow PPT presentation to be seen. This is a Catch 22! Need light up to see instructor; need light down to see screen! Also, he's a friendly guy but he looks pretty severe in the video, partly because of the lighting and partly because he's very focused on what he's doing. Video of him speaking definitely needs to be seen part of the time. What about when I insert a high-res jpg of the PPT slide? Could shrink and crop the video of him speaking and insert in upper corner, like picture in picture. Maybe better option is to put a nice smiley still shot of him in the corner, one in which he looks friendly and supportive. Taking CLT view, a still would use less working memory capacity than a video (dynamic visualization), which would leave more

WMC for processing the instruction. The nice still might also increase “instructor presence.” Look for a good still of Gene.

10/22/14 Got ACTHA list of email addresses of people who responded to hoof care mailing. About 10,000 in list per Tom Scrima, ACTHA GM. Told Tom I needed a more general list. Maybe use this list as backup? ACTHA member list of 9,311 email addresses received. This will be my primary list.

10/26/14 Received text from Gene that the test questions were fine with him. This gives construct validity to the test instrument. Now I can conduct the pilot test.

10/29/14 Talked to Cody Ovnicek about using ELPO email list to get subjects with higher levels of prior knowledge. Total should be 180 email addresses. Exported the opt-in email list from my web site,TheHorseShow.com. Total 4,244. Total of all primary sources 13,735 before removing dupes, if any.

10/30/14 Received ELPO email list. Final count of study prospects, after removing dupes, is 13,215. Sorted all email addresses into random order using Excel’s RAND function. Used procedure demonstrated here: https://www.youtube.com/watch?v=lajWM28JCHE.After randomizing entire group, I cut in half, assigning first half to the experimental group and second half to the control group. Experimental group: 6,608 prospects. Control group:6,607 prospects

10/31/14 Sent pilot test to 17 friends, family, and colleagues.

11/1/14 Began building modules in ProProfs.com.

11/3/14 Thoughts on analyzing pilot test. One way would be to consider a ratio between the scores on the two attempts (lower score over higher score). This could be a problem because a small difference in scores gives a very different ratio when both scores are low than when both scores are high. Consider a difference of one correct answer (five points). 20/25=.8. 90/95=.95. What’s really important here is the difference between scores, not the scores themselves. In the example above, both subjects had the same difference between their test and retest scores. Good test-retest (temporal) reliability is indicated by low differences. I could average the differences, then subtract from 100 to give an overall indication of reliability. If it were just the two subjects in the example, my degree of confidence would be 95%.

11/19/14 More on pilot test. Eleven of 17 subjects took the test twice with about a week between testings. The mean difference between test and retest scores was 3.18 points out of 100. Dr. Ellis requested that I compute Pearson’s r to determine whether the test/retest scores were correlated. I did that with SPSS, using both 1-tailed and 2-tailed options. The value of r in both cases was .963. A value of 1 is a perfect correlation so this is very high. The conclusion from SPSS was “Correlation is significant at the .01 level.” I reported this to Dr. Ellis and he agreed that this data suggested that my test instrument had temporal reliability. He asked that I use APA style guidelines to describe the results of the pilot test in my report and gave me a link to help.

11/20/14 Continued work on lecture video. Decided to use only first 33 minutes of the lecture to avoid dealing with the audio problem that follows. This is adequate for the purposes of the study. I created a standard opening and closing graphic (billboard) to use on both versions. The open identifies the speaker and the event, and states that the video is used with permission. It also refers to this as an excerpt of a lecture so subjects will not be surprised by the abrupt ending. The closing graphic states that the lecture excerpt has ended and asks the viewer to close the window to return to the study. Both graphics are 15 seconds in length with a one-second fade in and fade out. Other than the early end, no changes were made to the control version of the lecture. It is now complete so I exported it in standard HDV format and uploaded it to YouTube with a "private" setting so the general public would not have access to it. Length of control version, with graphic open and close, is 33:30. REMEMBER: I need to use a YouTube link that embeds the player in the current window so I retain control of what the subject sees. With a regular YouTube link the player window would be surrounded by thumbnails of other suggested videos. I would lose complete control of the flow!

Raw video is both too dark and too light. Too dark to see Gene's face clearly and too light to see the PPT slides clearly. I expected this but I was going to save color correction until later. Decided to work on it now and found that I could increase the mids by about 60% to lighten the video enough to see Gene's face. This took out a lot of the color, leaving the image washed out. To compensate, I increased the saturation control by about 65%, which had the effect of adding color back in. It actually looks surprisingly good, especially when compared to the original. Of course, the slide displayed beside Gene is extremely light now. Not a problem because any time the slide content is important, I'm substituting a high res image of the slide.

First subtopic ends about 3.5 minutes in, which is short but might still work.

PPT slide images were 4:3 aspect ratio but video is 16:9. Thus slides were stretched horizontally when put in the timeline. Experimented with distortion parameter and got the correct proportion with a distortion value of 33.

11/21/14 I'm finding a down side to doing the color correction early in the editing protocol. The color correction is done with a filter. I haven't wanted to permanently alter the original video file, in case I want to adjust it later, so I've been using the filter as a real-time effect. However, any time I layer something on top of the filtered video, the display has to be rendered again. This is causing a lot of extra rendering time, too much to be practical.

There are several solutions: 1) wait until the very end of all editing and apply the color correction, render overnight, and export the final video. The advantage of this is that it preserves all of the original files in the timeline, allowing any editing to be undone. The big drawback is I have to look at the dark video the whole time I'm editing; 2) Do the color correction as a pre-processing step and export a new file for all further editing. The advantage here is that there is much less rendering required and as long as I save the original video in its original timeline, I could go back to it if need be. As a practical matter, going back is unlikely and I make this kind of permanent change all the time in my TV and radio work.

At this point I can't think of any other edits that would require this much rendering. All of the video clips have been converted to the proper video form (HDV 1080i60). The stills (PPT slides) have some processing (distortion to create the right aspect ratio and or expanding to fill the frame) but no movement, so the stills don't require a lot of rendering.

I've decided to go with the second option. It looks like it will take about an hour to render the timeline so I can export it and continue editing. Since I'm already about 1/3 of the way through with the editing of the lecture content, I'll effectively locking in those early edits. It will be difficult but not impossible to change them.

NOTE: I thought I might keep track of my editing time and include it in the report, thinking this would be representative of the time it would take an instructor to edit a typical captured lecture. However, my editing time is irrelevant, as I'm creating the protocol as I go. The color correction issue took hours to resolve. Fixing the color first would dramatically cut down render time. Also, just knowing what distortion value to use to get a 4:3 still to display correctly in a 16:9 timeline would eliminate all of the experimentation I did.

NOTE: It appears that PPT was handling video clips of different formats with no problem. I'm finding that I need to convert every video source (camera video and clips used in the PPT) to the same format. In FCP, that is done by dragging the original clip into a timeline with the desired settings, rendering it and then exporting in HDV 1080i60 format. Doing this once saves excessive rendering time, just as it did with the color correction.

Noticed that the original lighting changed several times during the lecture. Possibly someone was turning lights in the room on or off. This could distract the viewer. I will try to cover the change with a PPT slide or instant zoom.

11/24/14 Thoughts about speeding up playback: The process of weeding out extraneous content and cleaning up the speaker's performance results in a quickening of the pace to begin with. This lessens the need for time compression. Also, some of Gene's content is pretty dense, meaning the learner needs time to digest it, especially when Gene uses technical terms (e.g., medial abduction of the hock). I may not do as much time compression as I thought I would. Either use it less or make the percentage smaller, e.g., 10% rather than 25%.

11/25/14 More thoughts on speeding up playback: YouTube player has option to play at 1.25 times normal speed. I tried this and could hardly tell. I'm thinking that the entire edited lecture could be sped up without regard to Gene's time on screen. This is the last step anyway. Whatever time compression I use, I need to explain this in chapter 3.

Regarding test modules, I have been worried about how I would connect each subject's pre-test scores to his/her post-scores. This may not be necessary. My research questions can be answered by looking at the composite scores of each group. This way, the average of all scores in the experimental group can be compared to the average of all scores in the experimental group. Two comparisons are of interest. When I compare the pre-test scores, I should find them statistically the same. When I compare the post-test scores I should find them statistically different (per my hypothesis). I can treat the two sections of the test (recognition and recall) as separate tests. Need to run this by Dr. Ellis.

Per phone call with Dr. Ellis, I need to collect as much data as possible. He agreed that the pre-test confirms that the two groups start at the same place, statistically, and the post-test is where the hypotheses are tested. My research questions can be answered with the results of the groups as a whole but it would be good to have the data to compare the learning gains of individual subjects, rather than just the groups. He felt ProProfs should be able to correlate the pre- and post-test scores of individual students.

11/26/14 Continuing to work on editing the lecture. Gene wanders a bit and even though I know his work well, it's not always clear what he means. I've found a few cases where he actually misspoke and said the opposite of what he meant to say. So far I've been able to correct all of those. His discussion of abduction of the hock on ground engagement is particularly hard to follow. I may need to put us some clarifying text on the screen and even use arrows to show where the viewer should look. It's clear he's talking to peers (professional farriers) in this lecture but I still think I can make it clear for the lay person (horse owner).

Still working out where the video will actually live. I first thought YouTube but the problem is that, even when the player is embedded, a link displays that allows the video to be viewed on YouTube, where subjects would be tempted with all kinds of other videos to watch. If they go out to YouTube they might not come back and finish the study.

ProProfs allows video to be inserted in the modules and claims to use a proprietary player that works on all devices. I tried to load the control version of the lecture with no luck. No error message, etc. I tried in a different part of PP and got a message that the limit was 500MB. After several conversion attempts, I got the video below 500 MB and it uploaded okay.

11/27/14 I think I finally have the modules refined and the basic flow worked out. It's actually simpler than I thought it would be. Separate classrooms for control and experimental groups, self-registration when a member of the class first arrives, separate courses for each classroom. Within each course are chapters for Informed Consent, Pre Test, Watch the Lecture, Rate the Lecture (survey), and Post Test. Treating these as chapters forces the sequence I needed. The two courses contain the same chapters EXCEPT for Watch the Lecture.

Multi-sectional exams: Just as classrooms have courses, and courses have chapters, chapters can have pages. Since a page can be virtually anything, I can have my two quizzes (recognition and recall) as pages in the chapter named "Pre-Test" and then the same quizzes as pages in the later chapter named "Post-Test." Thus, I only need one version of each test and the survey.

Hierarchy (each "contains" what is below it)

Classrooms (Group E or C)

Courses (Version E or C)

Chapters (Informed Consent, Pre, Watch, Rate, Post)

Pages (Informed Consent pdf, Recognition Quiz, Recall Quiz, Video, Survey)

Questions for PP: can we get rid of the blank page that displays after a module ends? What about the tendency of the video to buffer? Confirm that when student self-registers, the username is checked for uniqueness. I can test this.

12/3/14 Back to work on editing lecture. Now I'm using "Preview" and "Review" as the labels for the signaling text (list of key points) before and after each lecture segment. Preview prepares the student (like an advance organizer in schema theory). Review reinforces what the student should remember like a summary at the end of a chapter. I'll also add captions during the segment the way I do in the ADM nutrition segments on my TV show.

Talked to Gene three days ago. He has a very busy schedule for the next couple weeks. I'll ask Cody to review the edited lecture. He and Steve Foxworth (president of ELPO) know Gene's work well enough to confirm that the message is still correct.

Decided on a "thought cloud" as the background for my captions during the segments. I tried the standard thought bubble graphic with the little bubbles trailing off of the big bubble but I decided it would look like that was what Gene was thinking instead of what he was saying. So I cropped off the little bubbles and am using the cloud shape alone. Nice thing is that I can distort it as needed to accommodate the text. I'm reducing its opacity a bit so it the bubble has a slightly translucent quality to it. I've also picked comic sans MS bold as the font. It's less formal and easier to read than the arial narrow font I was using for the preview/review text.

I'm making some editing choices that I believe present a more effective slide than Gene chose for that moment. They are still slides in his presentation, but sometimes he gets off on a tangent and the slide still on the screen is not the most relevant. I think this is a valid part of the protocol because instructors would probably do the same thing if they were editing their own lectures. The editing is meant to make the lecture BETTER.

Sometimes Gene pointed to things on the screen with the mouse. I used yellow arrows to draw attention (another type of signaling).

12/5/14 I need to be careful about adding new ideas via signaling. In practice, an instructor might do this to expand the content of the lecture. My test questions include some general knowledge (e.g., hocks being injected) that Gene does not explicitly mention in the lecture. I should not add this via signaling as it gives the experimental group an unfair edge over the control group when answering that question.

Finalized the edit, uploaded to YouTube and sent link to Cody Ovnicek, Gene's son and also a subject matter expert. Cody shot the original video and runs Gene's company, EDSS, Inc.

12/6/14 Cody gave the edit his approval as an SME (Gene was not available). Cody commented that he learned things he didn't know from the way I drew out Gene's points via signaling. Good news!

Before sending out the invitations, I need to talk to ProProfs to learn how the self-registration works, about eliminating the empty screens between some of my sections, about the video buffering, and about the problem I've had with spaces being dropped between words in the chapter descriptions (new development).

12/10/14 Performed the time compression. Used 10% instead of 25% since material was at times pretty dense. First increased speed to 110% in FCP. This raised pitch of Gene's voice noticeably. I then exported the audio track to PT and used pitch correction to drop pitch back to normal range for Gene. I tried lowering by 10% and that did seem to restore his normal sound. I normalized volume of the processed track and took the new file back into FCP. I was surprised that it didn't sync up perfectly to the original. It should have. I went through and made minor edits as needed to get it back perfectly in sync. As the final step, I output the experimental (edited) version of the lecture. It's length was 20:09, which made it 60% the length of the original. Nearly 40% time savings! This is major. Even if learning gains were unchanged by the protocol, the time savings alone would make the protocol worth using.

Called Dan at PP about several issues. He could not reproduce the blank screens I kept getting between pages and chapters in the course. I decided I couldn't wait any longer to resolve that and added an instruction at the beginning of study to click Next to get past blank screens.

Sent email invitations. I have tested this thing so many times but I'm still nervous about it, since I only get one shot. Emails appear to have gone out okay. Constant Contact did not stop them, which had been a worry. Got lots of auto responses. Almost immediately started getting reports that people couldn't get in. It was clear that some people hadn't read the instructions and tried to log in before registering. Responded to each email and tried to make suggestions.

Looked at reports for each course to monitor progress. Couldn't see any reporting of survey results or separate quiz results from the pre and post-tests. I'm trying not to freak out about this. So far, PP has thought of everything. I can't believe this is really a problem.

12/12/14 Looked around some more on the PP site. Quiz reporting and survey reporting were found in those sections of the site. Again, it's a matter of getting my head around how PP thinks. Everything is modular, compartmentalized. Looks like I have the data I need.

Still getting emails from people who can't get into the course. From their emails, I can't tell if they made a mistake or there is a glitch I didn't uncover in testing. I will respond to each as a courtesy but I cannot troubleshoot with each of them.

12/24/14 Data collection period of two weeks is now over. Downloaded all data today. Although I can look at test results by group, it doesn't appear that I can download them by group. However, I can get a list of usernames by group and use that to separate the data by group since username is included with the scores. It took some time, but I was able to build a master data base with a row (record) for each subject in my study. Columns (fields) were group, pre-test recognition score, pre-test recall score, post-test recognition score, post-test recall score, and survey response. This is all I need. I deliberately did not include any sort of identifier for the subjects (IP address or username) in my final data base in order to be extra sure that anonymity was preserved.

In building the data base, I had to eliminate from the study any subject for whom I did not have a complete set of data. In the end, I had 40 subjects in my experimental group and 43 subjects in my control group. I was disappointed at first since I had sent out so many invitations. However, since 83 total subjects are significantly more than my minimum of 60, I met my goal and that's what counts.

1/1/15 I've been thinking about the number of invitations I sent out compared to the number of complete data sets I acquired. I thought I had more than 13,000 in my original email list of prospects but what I didn't realize was that a lot of the ACHTA members had been on the member list at my web site at one time and for whatever reason had opted out. Thus, Constant Contact would not send to them. Here are how the numbers went:

Experimental Group

4,954 emails sent

222 bounces (4.5%)

2,414 opens (51%)

181 self-registered into Group E

40 completed the study successfully.

Control Group

4,886 email invitations sent

255 bounces (5.2%)

2,341 opens (50.6%)

178 self-registered into Group C

43 completed the study successfully.

With both groups, there were a few more usernames created than there were clicks of the link in the invitation email. This suggests that some people created more than one username, probably because they were having trouble registering. When I went through all the data and compiled the 83 complete data sets, I discarded any obvious dupes.

My 51% open rate on the email invitation was very good and probably due to my name being recognized. Interestingly, 3.8% of the original prospects in each group registered to be in the study. This is closer to the response rate of direct mail marketing (4.4%) than to email marketing (.12%), according to the Direct Marketing Association. So even though the response seemed poor at first, it was actually quite good for email marketing.

Also of interest was the number of users who completed the study compared to the number who registered successfully. This was 24% for the experimental group and 22% for the control group. Looked at another way, I had an attrition rate of 76% and 78%, respectively. When I cleaned and merged the data, it did seem like most participants who registered took at least the first pre-test. Why they dropped out after that is not certain. It could be that the blank pages between modules confused some people, even though I specifically addressed that in my instructions. Some modules were slow to load and the video did buffer a bit, even with my fast Internet connection at home. It's possible that people got frustrated over these technical issues and gave up. I specifically addressed this in the follow-up invitation (e.g., be patient, give it time). It's also possible that the topic of the video didn't interest some people once the video started. Finally, I can't ignore the fact that several people said they registered successfully into their group only to get a screen informing them that there were no courses assigned to the group. A couple people sent screen shots to prove this to me. By that time, data collection was nearly complete so I did not spend any time on solving the problem. If I had to explain the attrition rate, I would say that there were some legitimate bugs in the ProProfs system that I did not uncover during testing and that my instructions were not being read carefully. If I had it to do again, I would further simplify the data collection process.

1/4/15 I've been watching some YouTube videos on analysis with MANOVA. Followed instructions and am looking at output. Not clear at this moment what it's telling me. Need to clear an entire day and immerse myself in this.

1/21/15 Went through entire study on ProProfs and collected screen shots to include in a new appendix. I can now walk the reader through the entire data collection process with screen shots. I also collected screen shots from the edited version of the video to show signaling (preview/review screens and text clouds), color correction (dark shot of Gene compared to same shot after lightening and adjusting color), and substituting high-res images and clips. It's actually pretty impressive to see the editing protocol applied to real lecture video.

Another thing I noticed that might have confused subjects and thus affected attrition (in addition to the blank screens between pages in a chapter) is that, for the fill-in-the-blank questions, the cursor is not positioned to begin typing; i.e., you must move the cursor to the box and click before you can start entering your answer. This is bad design from ProProfs, in my opinion. Some subjects may have not have known what to do at this point and just given up.

1/22/15 I'm determined today to dig into MANOVA. My procrastination about data analysis has been an incentive to get everything else done (my "positive procrastination" theory at work!).

1/24/15 As Dr. Ellis said, there are many YouTube videos on MANOVA and SPSS. It didn't take long to get comfortable with SPSS again but it took several videos and rereading Dr. Terrell's book to start getting comfortable again with the tests. I'm glad I bought the finished Terrell book; we used a loose-leaf draft when I took my first stat course at Nova three years ago. I'm struck again by how much is packed into that book. MANOVA is a special case of ANOVA, which is a special case of *t*-tests so it all comes down to understanding *t*-tests. In watching the videos, I found that the style of the instructor made a big difference in how well I understood the material. I think a nice mix of precision and common language works best. Some instructors seem to be trying to impress rather than share knowledge! It would be interesting to see if increasing instructor presence in a captured video helped or hindered in those cases. Another study for another time …

I'm using my parent study (Ibrahim, 2012) as an example of how to report my results. I need to cross-reference this with the source Dr. Ellis gave me earlier and with APA. Important: the eta squared value is the magnitude of the effect of the experimental treatment. In my narrative I can use it as a percentage: "Editing the lecture resulted in a xx% increase in recognition (low level) learning."

Wow. If I'm interpreting the MANOVA correctly, there is no significant difference between my two groups on any of the dependent measures. That means none of my three hypotheses is supported and the answers to my research questions are all "no significant differences." Interestingly, the "no significant differences" also tells me that reducing the lecture length by 39% did not reduce the learning effects or make the lecture seem more difficult. Hmmm.

Appendix M

Table 3 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Recog Post	189.409[a]	1	189.409	1.489	.226	.018
	Recall Post	727.347[b]	1	727.347	2.460	.121	.029
	Survey	.089[c]	1	.089	.073	.788	.001
Intercept	Recog Post	649056.879	1	649056.879	5100.779	.000	.984
	Recall Post	347122.528	1	347122.528	1174.232	.000	.935
	Survey	1170.547	1	1170.547	956.838	.000	.922
Group	Recog Post	189.409	1	189.409	1.489	.226	.018
	Recall Post	727.347	1	727.347	2.460	.121	.029
	Survey	.089	1	.089	.073	.788	.001
Error	Recog Post	10306.977	81	127.247			
	Recall Post	23944.942	81	295.617			
	Survey	99.091	81	1.223			
Total	Recog Post	659600.000	83				
	Recall Post	373400.000	83				
	Survey	1272.000	83				
Corrected Total	Recog Post	10496.386	82				
	Recall Post	24672.289	82				
	Survey	99.181	82				

a. R Squared = .018 (Adjusted R Squared = .006)
b. R Squared = .029 (Adjusted R Squared = .017)
c. R Squared = .001 (Adjusted R Squared = -.011)

References

Acee, T. W., Kim, H., Kim, H. J., Kim, J., Chu, H. R., Kim, M., Cho, Y., & Wicker, F. W. (2010). Academic boredom in under- and over-challenging situations. *Contemporary Educational Psychology, 35,* 17-27. doi: 10.1016/j.cedpsych.2009.08.002.

Aalbers, M. W., Hommes, J., Rethans, J.-J., Imbos, T., Muijtjens, A. M., & Verwijnen, M. G. M. (2013). Why should I prepare? A mixed method study exploring the motives of medical undergraduate students to prepare for clinical skills training sessions. *BMC Medical Education, 13*(27), 1-9.

Allen, I.E. & Seaman, J. (2013) Changing course: Ten years of tracking online education in the United States. Babson Survey Research Group and Quahog Research Group, LLC.

Artino, A. R. (2010). Online or face-to-face learning? Exploring the personal factors that predict students' choice of instructional format. *Internet and Higher Education, 13,* 272-276. doi:10.1016/j.iheduc.2010.07.005.

Chapman, L. (2012). 2012 Response rate report. Retrieved from http://managementhelp.org/blogs/marketing/2012/07/2012-response-rate-report/.

Csikszentmihalyi, M. (1997). *Finding flow: the psychology of engagement with everyday life*. New York: Basic Books.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340.

Draus, P. J., Curran, M. J., & Trempus, M. S. (2014). The influence of instructor-generated video content on student satisfaction with and engagement in asynchronous online classes. *Journal of Online Learning and Teaching, 10*(2), 240-254.

Euzent, P., Martin, T., Moskal, P., & Moskal, P. (2011). Assessing student performance and perceptions in lecture capture vs. face-to-face course delivery. *Journal of Information Technology Education, 10,* 295-307.

Ford, M. B., Burns, C. E., Mitch, N., & Gomez, M. M. (2012). The effectiveness of classroom capture technology. *Active Learning in Higher Education, 13*(3), 191-201.

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational research: Competencies for analysis and applications*. Upper Saddle River, NJ: Pearson Education, Inc.

Gutbrod, M., Werner, C., & Fischer, S. (2006). Platform-independent authoring and production of rapid e-learning content. *Interactive Technology & Smart Education, 3*(3), 197-206.

Ibrahim, M., Antonenko, P. D., Greenwood, C. M., & Wheeler, D. (2012). Effects of segmenting, signalling, and weeding on learning from educational video. *Learning, Media and Technology, 37*(3), 220-235. doi: 10.1080/17439884.2011.585993.

Jackson, S. A. & Marsh, H. (1996). Development and validation of a scale to measure optimal experience: The Flow State Scale. *Journal of Sport and Exercise Psychology, 18,* 17-35.

Johnston, A. N. B., Massa, H., & Burne, T. (2013). Digital lecture recording: A cautionary tale. *Nurse Education in Practice, 13*, 40-47. doi:10.1016/j.nepr.2012.07.004.

Joo, Y. J., Lim, K. Y., & Kim, S. M. (2012). A model for predicting learning flow and achievement in corporate e-learning. *Educational Technology & Society, 15*(1), 313-325.

Kalyuga, S., Chandler, P., & Sweller, J. (1998). Levels of expertise and instructional design. *Human Factors, 40*(1), 1-17.

Leahy, W., & Sweller, J. (2005). Interactions among the imagination, expertise reversal, and element interactivity effects. *Journal of Experimental Psychology, 11*(4), 266-276.

Lusk, D. L., Evans, A. D., Jeffery, T. R., Palmer, K. R., Wikstrom, C. S., & Doolittle, P. E. (2008). Multimedia learning and individual differences: Mediating the effects of working memory capacity with segmentation. *British Journal of Educational Technology,* doi:10.1111/j.1467-8535.2008.00848.x.

Mann, S., & Robinson, A. (2009). Boredom in the lecture theatre: an investigation into the contributors, moderators and outcomes of boredom among university students. *British Educational Research Journal, (35)*2. 243-258. doi:10.1080/01411920802042911.

Marcus, N., Cooper, M., & Sweller, J. (1996). Understanding instructions. *Journal of Educational Psychology, 88*(1), 49-63.

Mayer, R. E. (2009). *Multimedia learning.* New York, NY: Cambridge University Press.

Mayer, R. E., Fennell, S., Farmer, L., & Campbell, J. (2004). A personalization effect in multimedia learning: Student learn better when word are in conversational style rather than formal style. *Journal of Educational Psychology, 96*(2), 389-395. doi:1037/0022-0663.96.2.389.

Meyer, M., & Marx, S. (2014). Engineering dropouts: A qualitative examination of why undergraduates leave engineering. *Journal of Engineering Education, 103*(4), 525-548.

Moreno, R., & Mayer, R. E. (2000). Engaging students in active learning: The case for personalized multimedia messages. *Journal of Educational Psychology, 92*, 724-733.

Moreno, R. (2007). Optimising learning from animations by minimising cognitive load: Cognitive and affective consequences of signalling and segmentation methods. *Applied Cognitive Psychology, 21,* 765-781. doi: 10.1002/acp.1348.

Moreno, R., & Park, B. (2010). Cognitive load theory: Historical development and relation to other theories. In J. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive load theory* (pp. 9-28). New York, NY: Cambridge University Press.

Nashash, H. A., & Gunn, C. (2013). Lecture capture in engineering classes: Bridging gaps and enhancing learning. *Educational Technology & Society, 16*(1), 69-78.

Newton, G., Tucker, T, Dawson, J., & Currie, E. (2014). Use of lecture capture in higher education – lessons from the trenches. *TechTrends, 58*(2), 32-45.

Orr, D. B. & Friedman, H. L. (1965). Research on speeded speech as an educational medium – project report. American Institutes for Research.

Owston, R., Lupshenyuk, D., & Wideman, H. (2011). Lecture capture in large undergraduate classes: Student perceptions and academic performance. *Internet in Higher Education, 14,* 262-268. doi: 10.1016/j.iheduc.2011.05.006.

Ozel, M., Caglak, S., & Erdogan, M. (2013). Are affective factors a good predictor of science achievement? Examining the role of affective factors based on PISA 2006. *Learning and Individual Differences, 24,* 73-82. doi:10.1016/j.lindif.2012..09.006.

Paik, E. S., & Schraw, G. (2013). Learning with animation and illusions of understanding. *Journal of Educational Psychology, 105*(2), 278-289. doi:http://dx.doi.org/10.1037/a0030281.

Pang, K. (2009). Video-driven multimedia, web-based training in the corporate sector: Pedagogical equivalence and component effectiveness. *International Review of Research in Open and Distance Learning, 10*(3), 1-14.

Park, B., Moreno, R., Seufert, T., & Brünken, R. (2011). Does cognitive load moderate the seductive details effect? A multimedia study. *Computers in Human Behavior, 27,* 5-10.

Pastore, R. (2012). The effects of time-compressed instruction and redundancy on learning and learners' perceptions of cognitive load. *Computers & Education, 58*(1), 641–651. doi:10.1016/j.compedu.2011.09.018.

Pierce, R. & Fox, J. (2012). Vodcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education, 76*(10), 1-5.

Pintrich, P. R., & DeGroot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33-40.

Porcaro, D. (2011). Applying constructivism in instructivist learning cultures. *Multicultural education & Technology Journal, 5*(1), 39-54.

Purdue University (2014). Educational video best practices: Guidelines for creating and using engaging educational videos. Retrieved from http://www.itap.purdue.edu/learning/innovate/hdiseries/VideoBestPractices/Educational%20Video%20Best%20Practices.pdf

Reed, P. (2014). Staff experience and attitudes towards technology-enhanced learning initiatives in one faculty of health and life sciences. *Research in Learning Technology, 22*. doi:10.3402/rlt.v22.22770

Ritzhaupt, A. D., Barron, A. E., & Kealy, W. A. (2011). Conjoint processing of time-compressed narration in multimedia instruction: The effects on recall, but not recognition. *Journal of Educational Computing Research, 44*(2), 203-217.

Simonson, M., Smaldino, S., Albright, M., & Zvacek, S. (2009). *Teaching and learning at a distance: Foundations of distance education*. Boston, MA: Pearson/Allyn and Bacon.

Smith, R. M. (2008). *Conquering the content: A step-by-step guide to online course design*. San Francisco, CA: Jossey-Bass.

Sung, E., & Mayer, R. E. (2013). Online multimedia learning with mobile devices and desktop computers: An experimental test of Cark's methods-not-media hypothesis. *Computers in Human Behavior, 29*(3), 639-647. doi: http://dx.doi.org/10.1016/j.chb.2012.10.022.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285. doi: 10.1207/s15516709cog1202_4.

Sweller, J. (2010). Cognitive load theory: Recent theoretical advances. In J. Plass, R. Moreno, & R. Brünken (Eds.), *Cognitive load theory* (pp. 29-47). New York, NY: Cambridge University Press.

Toppin, I. N. (2011). Video lecture capture (VLC) system: A comparison of student versus faculty perceptions. *Educational Information Technology, 16*, 383-393. doi: 10.1007/s10639-010-9140-x.

Watt, S., Vajoczki, S., Voros, G., Vine, M., Fenton, N., & Tarkowski, J. (2014). Lecture capture: An effective tool for universal instructional design? *Canadian Journal of Higher Education, 44*(2), 1-29

Woo, J.-C. (2014). Digital game-based learning supports student motivation, cognitive success, and performance outcomes. *Educational Technology & Society, 17*(3), 291-307.