

# What Effect? Studying Technological Changes (Specifically Distance Learning) in the Classroom

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**Abstract** – Tennessee Technological University's (TTU) Department of Civil and Environmental Engineering is developing and testing a distance learning approach to Engineering Mechanics (statics). Camtasia Studio, PowerPoint, and a tablet PC have been used to develop the DVD or Web based course work. The concept is much like an engineering e-book where, students learn the theoretical principles of structural mechanics with step-by-step graphics, text and voice narration. However, learning is improved by use of the tablet PC to demonstrate the process of accurately working and checking statics problems by hand. The concept has been used progressively for two semesters in engineering mechanics classes at TTU. This paper describes the development approach for creating the distance learning class as well as qualitative findings based on student evaluations.

*Keywords:* Distance Learning, pedagogy, Engineering Mechanics

## INTRODUCTION

Podcasting, wikis, blogs, paperless classrooms, wireless tablet computers, WebCT, BlackBoard, Video Conferencing.

Security, on-line cheating, copyright issues, dissemination techniques, platform compatibility, pedagogical effectiveness.

The options and attributes, as well as the challenges of classroom technology are changing and expanding rapidly. Apparently these technologies have, as yet, had a limited affect on the traditional constructs of teaching (that is, teaching methods are essentially the same, just with more gadgets) [Nguyen, 9], and little research in engineering has been conducted as to the affects of technological changes on the learner.

Studies indicate that challenges exist in both synchronous and asynchronous learning environments that may deter the successful implementation of technology in the classroom [Beldarrain, 1]. However, there's no doubt that technology will proliferate, and its use in the classroom will, ultimately, affect both students and instructors. The question is: What effect? Even mobile phones and PDAs are now considered viable teaching instruments. One author says that PDAs (i.e., "mobile learning" devices) offer the "delivery of audio material, automated multiple-choice quizzes, one-on-one and group discussion in real time using voice or text messaging, e-mail interactions, the delivery of text and image files and computer files as attachments, and the display of text and small still and moving pictures" [Clyde, 3].

Some studies that have been conducted shed light on (and may generate some more questions regarding) the above mentioned attributes and challenges of teaching technology. For example, Nguyen and Paschal [9] found that

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teaching efficiency improved dramatically with the use of certain types of online techniques. However, Tomei [11] studied the teaching demands of an online course and the effect on faculty teaching loads. He concluded that online teaching required 14% more faculty time than traditional approaches while traditional instruction was more stable as far as surges in instructor time required.

Research by Wallace et al. [12] and Henderson et al [7] are two studies that attempted quantitative statistical assessments of student achievement for technological or distance learning approaches. Quantitative assessments are rare when compared to the sheer volume of technological change in the classroom; however, they are important as they provide insight into response to innovation. For example, quantitative studies have shown that students learn differently (e.g., visual vs. auditory learners), and techniques that address diverse learning preferences are the most effective. Recently, educators have made use of this studied fact in the implementation and design of technology for students [Bonk, 2]. Likewise, student expectations about levels of service and support related to distance education have been found to affect student perceptions and, indirectly, success [Stevenson, 10]. Also, face-to-face interaction between students and professors, as well as peer interaction, apparently plays a major role in successful learning [Kearsley, 8].

The above articles and associated literature review point to two baseline conclusions that one may draw regarding technological and distance learning: 1) simply keeping up with technology-based teaching strategies (much less effectively implementing such strategies) is difficult for most engineering professors and 2) understanding the effects of such strategies on student learning is even more difficult. Nonetheless, colleges and universities are embracing teaching technologies and moving rapidly toward distance-learning approaches in the classroom [Henderson, 6].

What then is the strategy for delineating best practices in such a complicated educational environment? Well, hopefully, educators will agree that abandoning evaluation techniques (despite their difficulty) is not the answer. Quantitative assessment of pedagogical affects on student learning is essential. When complexities exist in the realm of experimental physics or engineering research, the best approach is to clearly delineate the problem and isolate the objective to be studied by removing less important variables [Henderson, 5]. This approach is suggested for studying educational processes as well and has been attempted and described herein for the design and evaluation of a particular distance learning instrument for Engineering Mechanics. This paper describes the details of the learning instrument and the method for evaluating its effectiveness.

## TECHNICAL DEVELOPMENT

The following specific conclusions related to the design and testing of a learning instrument seem to be evident from the review of pertinent literature:

1. Educational technologies, particularly related to distance learning, are proliferating;
2. Accurate analysis of educational technologies is a complicated venture often leading to nebulous or contradictory results;
3. New educational technologies to be analyzed should be clearly defined and designed so as to have the highest likelihood of student benefit, preferably with decreases (or minimized increases) in instructor load; and
4. New educational technologies should be objectively scrutinized as to effectiveness by a quantitative (e.g., comparison of student test scores in an experimental and control type of testing environment) and qualitative (e.g., comparison of student perceptions) comparison to baseline traditional approaches.

Conclusions 3 and 4 form the framework (i.e., goals) for the development and testing of the distance learning instrument described herein. With these foundational conclusions in mind, a distance learning strategy was devised

and a test plan for assessing the strategy has begun to be implemented for Engineering Mechanics at Tennessee Tech University.

### **Distance Learning – What is Beneficial? At What Distance?**

If one of the design goals is student benefit, one must ask: What's beneficial? Simply using an existing technology is not sufficient. Meeting a currently unmet student need must be a central part of the rationale. For this project, the design objective was to produce a learning instrument that rivals or surpasses the traditional in-class approach in terms of student learning and acceptance, while providing the student with significantly greater autonomy in the study of the course material. This autonomy would entail less dependence on the physical presence of the instructor and the increased flexibility of "having class" outside the normal constraints of scheduled class time.

A second consideration for a distance learning project is, "At what distance?" This question is related to the student's distance from campus. Can the student be expected to attend on-campus activities or will greater distance make this impractical or impossible? Student proximity is especially important in that it will influence issues of providing various types of support, often out-of-class support, to the student. When considering the design of the course addressed here, the concept of "short distance" and "long distance" evolved. "Short distance" (which was adopted as the model to be tested) was taken to mean that it was reasonable to expect that the student could attend campus for activities such as lab participation, test administration, special meetings with the instructor, etc., however, the bulk of the learning process would occur outside of traditional class meetings.

[Note: The concept identified as "long distance" learning was not addressed as part of this study; however, it is felt that the learning instrument (as designed) is adequate for both short- and long-distance learning. Special planning, and often software delivery and testing, may well be required in long-distance situations. For example use of e-mail, chat sessions, blogs, or other communications services may be appropriate. In some cases the use of web-based conferencing software such as Microsoft NetMeeting may provide a support product for answering student questions, personal response to several students, or demonstration of a solution on the student's computer. Often support, both class related and institution-oriented support, may be provided through course management systems such as WebCT or Blackboard. However, as mentioned in the introduction, the favored approach to studying a learning technology is to study student response based on the gradual introduction of technology and the removal of extraneous complexity. The complexities of long-distance learning, though probably achievable by this learning instrument, would likely cloud the results of the study of effectiveness. Thus, the applicability of long-distance learning is postponed as future work based on the results of this first phase.]

### **Specific Design Elements**

Though the enjoinder to "begin with the end in mind", was not limited to educational activities, this principle was used as a guideline for development of this educational technology product [Covey, 4]. Recall that the first goal of the distance learning instrument was to be well-designed and clearly defined so as to have the highest likelihood of student benefit. In this way, a fair evaluation may be made between live and distance teaching approaches (second goal). The following specific design elements were felt to be crucial to producing a quality distance learning instrument that would be competitive with traditional in-class methods.

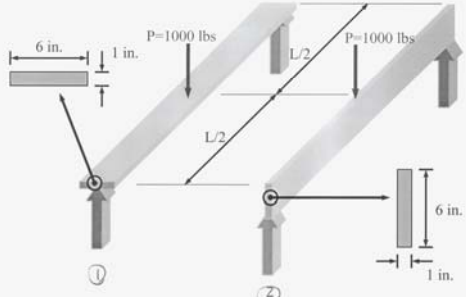
Student Notes: A key element of the classroom for any student is the quality of the notes that are derived from the instruction process. Furthermore, the actual process of taking notes is instructive and develops in the student a sense of ownership in the subject matter. Disorganized or poorly implemented lectures result in poor quality notes for the student. As a result, a carefully planned notes package was delivered to the student at the start of the semester. These notes were approximately 30% complete and provided a framework which was to result in a neat, complete, and useful set of notes at the end of the semester. (See Figure 1)

Content Vehicle: Ultimately, the subject matter content, in this case engineering mechanics, must be presented to the student in an engaging and challenging way. The vehicle for this presentation was chosen to be videos in WMV format created using PowerPoint, Camtasia Studio, and a tablet computer. Access to the content was possible via 1) a campus network download, 2) the internet, or 3) DVD. Figure 2 shows the WMV video presentation. Because of

the importance of engineering students understanding the appropriate methods for taking notes, the videos were not completed in the typical PowerPoint presentation format. Instead, actual notes were modeled using the tablet computer along with accompanying voice explanations and intermittent video explanations. Notice the relationship between the student notes on moment of inertia in Figure 1 and the presentation of Figure 2.

11.3 Centroidal Moment of Inertia (Example 2)
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**2. Given:**  
Two identical beams resist a vertical load,  $P = 1000 \text{ lb}$  at the beam center line as shown. The beams are both made of steel with length,  $L = 10 \text{ ft}$ , and cross-sectional dimensions of  $1 \text{ in.}$  by  $6 \text{ in.}$



**Required:**  
Determine the maximum deflection for each beam.

**Solution:**

**Beam ①**

$$I = \frac{6(1)^3}{12} = 0.5 \text{ in}^4$$

$$\Delta = \frac{1000 \text{ lb} (10 \text{ ft})^3 (1728 \frac{\text{in}^3}{\text{ft}^3})}{48 (29,000,000 \frac{\text{lb}}{\text{in}^2}) (0.5 \text{ in}^4)}$$

$\Delta = 2.48 \text{ in}$

**Beam ②**

$$I = \frac{1(6)^3}{12} = 18 \text{ in}^4$$

$$\Delta = \frac{1000 \text{ lb} (10 \text{ ft})^3 (1728 \frac{\text{in}^3}{\text{ft}^3})}{48 (29,000,000 \frac{\text{lb}}{\text{in}^2}) (18 \text{ in}^4)}$$

$\Delta = 0.07 \text{ in}$

$\Delta = 2.48 \text{ in}$   $\Delta = 0.07 \text{ in}$   
 $\frac{36 \text{ TIMES}}{\text{STIFFER}}$

**Figure 1: Student Notes on Centroidal Moment of Inertia**

**Practice:** The practice of thinking through the application of classroom content is essential to student learning either in the traditional classroom or by distance education. As such an accompanying third-party text is used for homework assignments associated with various subject areas within Engineering Mechanics.

**Learning Styles:** As various research studies have suggested, students begin to learn and assimilate information in different ways. For example, site learners assimilate data primarily by seeing the process, whereas hearing learners understand the material quicker and more thoroughly by listening to a voice explanation. Each of the various learning styles is most effective when accompanied by practice of the concept [Bonk, 2; Henderson, 7]. The inclusion of voice and visual input in conjunction with the requirement of completing notes and homework as a part of the learning instrument is an attempt at addressing the various learning styles.

**Learning Curve:** As Engineering Mechanics is a challenging and time-consuming subject for students, minimizing the learning curve is essential. As such, there are 100 pages of engineering mechanics notes and 100 WMV files (each approximately 15 to 25 minutes in length) were developed so as to be separately accessed by a simple navigational manager. The student need only click on the appropriate video (linked to each page of the notes) and it begins to play and may be paused or replayed as necessary.

**Instructor Load:** The Engineering Mechanics classes associated with this distance learning experiment meet once each week for a quiz and to answer (in person) questions that the students may have. The instructor is available throughout the week by e-mail and during office hours. This schedule results in no significant addition to the typical instructor load and may result in a reduction after development of the learning instrument.

Introductory material matches student notes

**STATICS Classroom**
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### 11.3 Centroidal Moment of Inertia (Example 2)

**Given:**  
Two identical steel beams resist a vertical load at the beam center line as shown.  $L = 10$  ft.

**Required:**  
Determine the maximum deflection for each beam.

**Solution:**

$$\Delta = \frac{PL^3}{48EI}$$

$E = 29,000,000 \text{ psi}$

BEAM ①

$$I = \frac{6 \cdot (1)^3}{12} = 0.5 \text{ in}^4$$

$$\Delta = \frac{1000 \text{ lb} (10 \cdot 12 \text{ in})^3}{48 (29,000,000 \text{ psi}) (0.5 \text{ in}^4)}$$

Example presented using Tablet Computer and audio explanation

Intermittent Video Assistance

**Figure 2: WMV Presentation of Centroidal Moment of Inertia**

### Development Approach

Once the specific design elements of a learning technology have been decided upon (that are anticipated to achieve the desired goals), it is necessary to choose the software and hardware that can best create the desired design. As

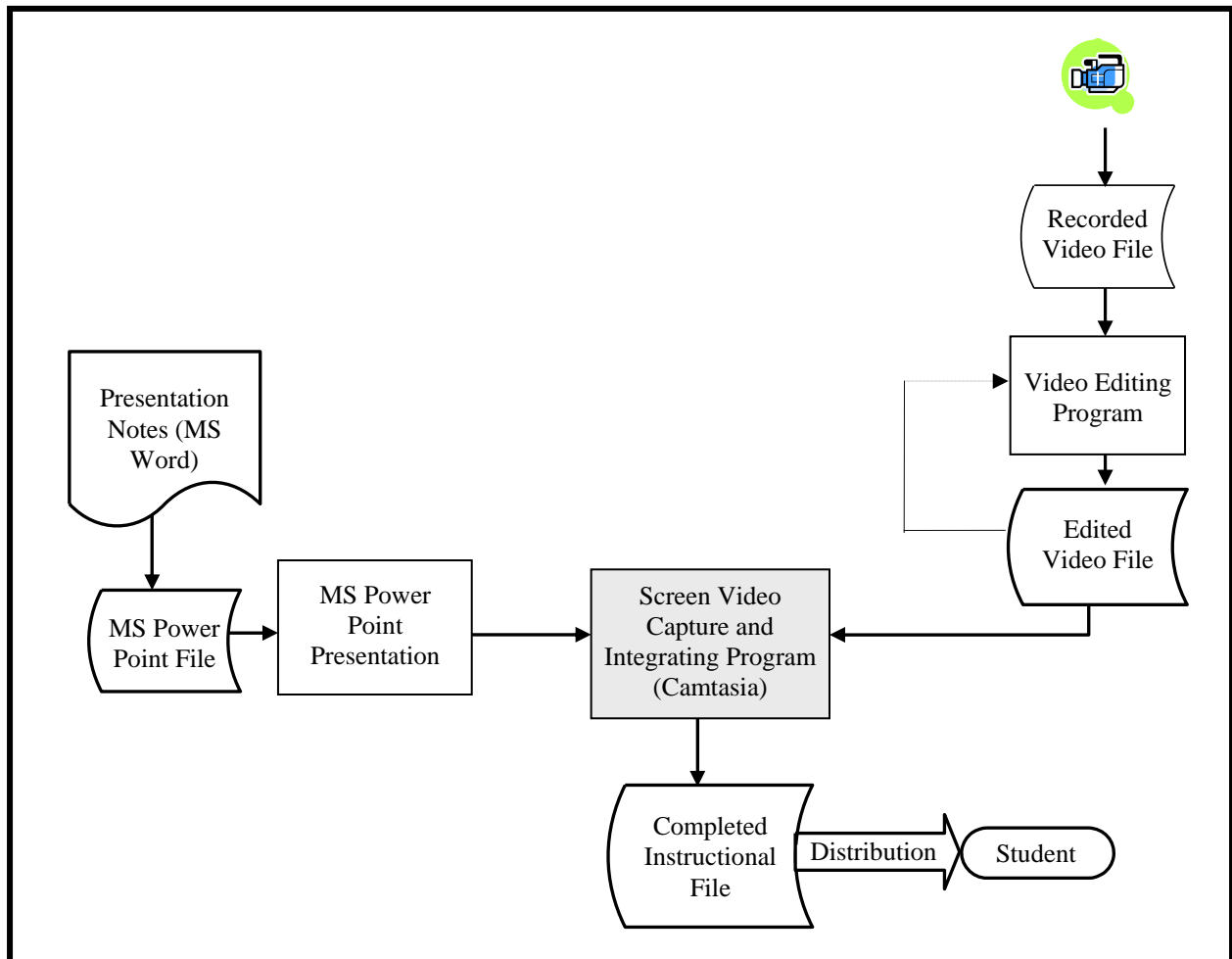
with learning technologies, a wide array of choices exists. Choosing wrongly may result in less than adequate functionality or increase the possibility of design delays.

Software: During development of the instructional software, two primary guidelines for choice of software development tools were established:

1. The product must support appropriate functionality.
2. The learning curve for the product should be limited.

Closely associated with the second objective was the goal of using a rather small number of development tools. As much as possible, products were chosen that appropriately accomplished the function and made use of the project team's existing expertise.

The methodology for creation of the distance learning tool is shown in Figure 3. The process began with formulation of the appropriate notes for engineering mechanics in MS Word (see Figure 1) and the transfer of the subject content to MS PowerPoint. The similarity between these two Microsoft products makes the transfer fairly straight-forward.



**Figure 3: Distance Learning Design Methodology**

Each page of the course notes is ultimately stored as a separate Windows meta-video (WMV) file containing the PowerPoint presentation and possibly an embedded video of the instructor emphasizing an important point (see Figure 2). Usually the embedded videos are short (30 to 60 seconds) and are included to simulate the classroom environment. So, if there are 100 pages of notes there are 100 WMV files (accessed via a simple navigational program) with a length of 20± minutes. As can be seen from Figure 3, the embedded video production is managed separately from the screen video capture, but both come together in some type of integrating program. Here, Camtasia Studio was chosen for this purpose due to its seamless interaction with PowerPoint and its ability to resolve issues related to 1) the multi-media player and 2) compression / decompression software.

Microsoft Windows Media Player was chosen as the default multi-media player. This product offered appropriate capability, was available for free download by students from a Microsoft web site, and was widely used in educational settings. Since the completed instructional material was prepared for delivery with files in widely used formats, students could use a number of other multimedia player software products but no effort was made to test the deliverables and insure compliance with them.

The second major software product of concern was the codec (coder-decoder or compressor-decompressor) software. This component typically works behind the scenes in concert with the multimedia player to compress and decompress the video and audio signals of the multimedia presentation. Particular codecs may be chosen to achieve attributes such as either higher resolution, or quality, of image or sound, of smaller file size. The critical factor is that the same codex must be used to present the product that was used to develop the product. Use of a number of software development tools may introduce complexities of codec selection that may not be obvious at the time of development. Since the codex must be present on the delivery or target machine, the use of multiple codec software tools may require the installation of a number of products whose requirements may not be obvious. Even if additional software development products are added to the development process, the preparation of the final product to be delivered to the student with an “integrating” type of product at the end of the development process should continue to support this objective.

The specific products listed in Table 1 were used to accomplish the functional purpose shown.

Functional Software Requirement	Software Product
Course Notes	MS Word (Microsoft, Inc.)
Presentation Program	MS Power Point (Microsoft, Inc.)
Video File Transfer	Pinnacle Studio Plus (Pinnacle Systems, Inc.)
Video Editing Program	Pinnacle Studio Plus (Pinnacle Systems, Inc.)
Screen Capture and Integrating Program	Camtasia (TechSmith Corporation)
<b>Table 1: Functional Software Requirement and Associated Software Products</b>	

Hardware: Creation of the final product is both software and hardware intensive. Hardware items upon which the successful completion of the project depends include: 1) CPU with sufficient video-editing memory; 2) tablet computer for writing lecture notes; and 3) video camera with sufficient low-light and microphone-enabled capability.

**Practical Concerns:** Based on previous software development projects [Henderson, 6], limiting required supporting software tools was considered a priority. Though various tools might be, and were, used for development, use of the learning instrument should not require a wide variety of supporting software. Where supporting software is required, it may be possible to intervene with a student, in a lab-based delivery setting, by means of lab monitors if the need for additional delivery support was identified. However, since the current product was to be used in a distance learning mode, intervention with the student during the delivery of a lesson was less than practical and would have served as a distraction from the learning process.

Video assistance clips were recorded with a digital video camera and then transferred to the development computer under control of a video editing program. Generally, each introductory clip was supported by a written script, was recorded three times, and from within the video editing program, the best of the three recordings was selected after some additional editing was performed. Normally the original video clip was shot with a solid green background, and then “green screen” or chroma key techniques were added within the editing program to provide a selected background. Since the final video would only occupy a relatively small area of the display unit a fairly simple background, with limited detail, was selected. For this project, Pinnacle Studio Plus (ver. 10.0) was judged to provide a reasonable balance between functionality and ease of use for video editing.

Somewhat related to the issue of codex selection was the issue of multimedia file format selection. Multimedia file formats vary widely in terms of resolution supported and size of the file that is created. A general rule for this project is that all material was originally recorded in a format that supported a high level of resolution and then, when appropriate, recorded in a format that supported a smaller file size. For example, the video clips were generally recorded and uploaded from the video camera to the computer in an AVI format. However, after editing of the file and application of the special effects, the file was recorded in a WMV format. Each of these formats are multimedia file formats defined by Microsoft, Inc. Table II indicates the difference of file size with one short clip in AVI and WMV format.

Multimedia File Format	File Format Description	Screen Size (Pixels)	File Size
AVI	Audio Video Interleave	720x480	197,183 KB
WMV	Windows Media Video	320x240	2,769 KB
<b>Table 2: File Format and File Size Example *</b>			

\* Each multimedia file is 53 seconds long when presented

From the above table, we note both the dramatically smaller file size and the smaller screen size, as expressed in pixels. The smaller screen size was determined to be appropriate for this project based on the use of these video clips.

## **PRELIMINARY RESULTS AND FUTURE IMPLEMENTATION**

The summer and fall semesters of 2006 have been trial runs of the software (with associated modifications) in two Engineering Mechanics courses at TTU. Approximately 40 students have used the approach and qualitatively compared it to traditional in-class methods for limited sections of the course content. The following survey questions were responded to after using the approach.

1. Please describe your overall impression of the distance approach as compared to the traditional in-class method. Be specific and complete.



2. Which approach would you prefer? To what degree would you prefer it (i.e., is it a close race or is one a good bit better than the other)? Why do you prefer the method you chose? Be specific and complete.
3. If you think the in class method was better, is it possible to change the distance approach enough for you to favor it? If so, how?
4. Did the use of the tablet (i.e., my actual writing and voice) for example problems improve your opinion of the approach? If so, would you suggest that this technique be used for both theory and examples? Explain your rationale.
5. Would you use this as a supplement if it were offered in addition to the standard lectures? Why or why not?

At this point, virtually all students seem to think that the distance approach has merit in some form, if nothing else as an effective supplement to traditional lectures. No consensus exists as to its strict use as a distance learning tool, however, it would appear that a majority (probably 2/3 of the students surveyed) prefer meeting with a teacher in class. The following two student opinions (responses to Question 2, above) are instructive as to the perception of this pedagogical instrument.

I have to say that I was very impressed with this method of teaching, however I would personally prefer face to face lectures because if you see you have a problem while in class, you can ask about it right there. I went through the first two videos on the CD. I feel that you have done a very good job thinking of everything to put on here to help the student learn. One thing that I liked was that when I listened to it I filled in the notes and then I went back and listened to it a second time, I think this aspect of it is very helpful to the student. I also really liked how you could fill in the information as you went. It was as close as you could get to being in class with out being there. **(Student A)**

I would prefer the distance method because it allows me to complete the lecture on my schedule. Sometimes during lectures, I feel like I could have understood the material in 15 minutes as opposed to the hour that was spent explaining it. Other times, I would like more time to digest the information. Learning styles and rates are different with different people, and I think that the distance method caters to that. You are not only seeing and hearing the lecture, but you also have the option of repetition if you so desire. Convenience is a huge factor, too, because I could set up my personal schedule to have online classes and take care of those in the morning and have my afternoons and evenings to work or hang out with friends. **(Student B)**

Because of the preliminary nature of the assessment thus far, firm conclusions as to student opinion or performance are premature.

In order to analyze the effectiveness of this distance learning approach both qualitatively and quantitatively, the following implementation strategy will be administered. Starting in Spring 2007, an instructor will teach two Engineering Mechanics classes, one using the distance learning method described herein and one using traditional approaches. Each class will have approximately the same number of randomly-assigned students. Under the traditional approach (i.e., the control group), the instructor will meet with and teach the students three times each week for 55 minutes. Homework, quizzes, and four tests (including the comprehensive final) will be given throughout the semester. For the distance class (the experimental group), the instructor will meet with the students on the first day of class and explain the process. Then, he will meet with the students once per week henceforth which will consist of a short quiz followed by a Q/A time. The two classes have back to back timeslots. Similar tests and identical comprehensive finals will be given and compared.

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