2006-841: EDUCATIONAL TECHNOLOGIES: WHAT WORKS, WHAT DOESN'T WORK, AND WHY

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Educational Technologies: What Works, What Doesn't Work, and Why

Introduction

Educational technologies have been heralded as a mechanism for engaging greater numbers of students, whether traditional students, non-traditional, or working professionals. Educators have come to realize that far too often course content is presented in a manner that appeals to a limited group of learners. As a result, many students perform poorly and lose interest in the content areas. While trade publications and some professional journals glorify examples of successful use of technology, we are all aware of spectacular failures.

Through several grant programs extending over the past five years, the College of Engineering at the University of Cincinnati, has prepared, presented, and evaluated content using various educational technologies. The technologies include: streaming media, video conferencing, animations, interactive exercises, and other web-based applications. The College has collaborated with the College of Education and the College of Applied Science (engineering technology) to develop and evaluate content.

In working to provide courses and programs to working professionals, the College has developed and presented courses using a variety of distance learning technologies that enabled students to take these courses at their convenience. Technologies include interactive video, web pages, streaming media presentations, and blended courses.

Brief Description of Technologies

While most are familiar with the educational / distance learning technologies described, it is useful to provide a brief discussion to facilitate a consistent understanding of the technology and pedagogy.

Two-Way Interactive Video

A classroom equipped with video transmission/receive equipment is connected to one or more other remote classrooms similarly equipped. Typically, a presentation originates from one site and is transmitted to the other site(s). The students in remote classrooms can both see and hear the instructor real-time, and the instructor can see and hear students from the remote sites. Remote sites have the image of the instructor and presentation materials either on a television monitor or as a projected image. The instructor can lecture and present materials using the same media as in a traditional classroom (chalk, overheads, video tapes, computer generated images, demonstrations). To be effective, however, these presentation materials must be formatted in such a manner that they are appropriate for display by a television monitor. Attention must be given to layout, font size, colors, clarity of graphics, etc. Interaction between the instructor and the students at the remote sites must be planned for if it is to be effective.

Streaming Video

Streaming is a technique whereby information is provided by a web server in a "just in time" format to a user requesting a large file. Rather than downloading an entire audio or video file then playing the file, streaming sends a portion of the file, begins playing the file, while

continuing to send successive portions of the file. As a method for delivery of instruction, the process that incorporates streaming video includes:

- Presentation of material via lecture and visual presentation materials
- "Capturing" the presentation (both audio and video) typically on videotape
- Converting the audio and video to digital formats that are capable of being streamed
- Storing these files on an appropriate server
- Files are streamed to a student when requested by a web browser

The instructor can lecture and present materials using the same media as in a traditional classroom (chalk, overheads, video tapes, computer generated images, demonstrations). All aspects of the presentation are captured on video and audio. In one sense, providing instruction via streaming video is a recreation of the classroom experience in an on-line delivery format. Interaction between students and the instructor, however, is significantly different than in a synchronous delivery mode (e.g., traditional classroom or two-way interactive video). Students do not have real-time interaction opportunities with the instructor. Interaction happens at a later face-to-face meeting, through email, phone calls, or some combination of techniques.

Web-based Instruction

We define web-based instruction as a purposeful design of an educational offering that uses the technology to provide content in a manner that is not possible without the Web. To this end, web-based instruction is not text files saved as html, a PowerPoint presentation placed on a web site, or a video recreation of a traditional lecture provided via streaming audio and video. Web-based instruction is instructional content formatted for efficient delivery over the Worldwide Web that is structured to promote interaction with the content and facilitates exploration and multiple paths through the content.

Interaction with the content includes reading of text, viewing graphic images, following links to related topics, providing responses to prompts that provide "response specific" feedback, submitting analysis / evaluation of data for other students to view, etc. This interaction is facilitated by the computer-mediated delivery with some aspects of the interaction not possible in a traditional classroom.

Content is structured to be delivered efficiently over the web in a manner that is conducive to learning. Lengthy sections of text are broken into modules and linked in a logical sequence. Visual images must be of sufficient quality to add to the learning experience but not occupy so much file space that they are overly time-consuming to download. The formatting of text and visual content is attractive but not glitzy (visually pleasing without being cluttered or overly embellished).

Blended Courses

In this format, content and interaction take place in asynchronous and synchronous fashions. Often, this takes the form of “routine” content provided via asynchronous web-based delivery mechanisms coupled with in-person recitations, problem sessions or lab sessions. This format can minimize the amount of time students may need to spend on-campus while still providing a level of personal interaction that many students appreciate. This format does not enable students to take a course completely at a distance.

What Works and What Doesn't Work

One example of the educational technology development was for engineering science content developed for both engineering and engineering technology students through an NSF Planning Grant (grant # EEC-0341842)[1]. Content was designed to appeal to a variety of student learning styles. The various modes of instruction developed during the project were categorized as:

- **Read It** – text and illustrations to appeal to visual learners / linguistic learners
- **Watch It** – streaming media presentation to appeal to visual learners / auditory learners
- **Visualize It** – animations to appeal to spatial learners / visual learners
- **Try It** – active exercises to appeal to kinesthetic learners / active learners

When comparing student performance in traditional courses with performance in "technology-enabled" courses, we find no significant difference. However we did find differences in student engagement with the various technologies. Table 1 is one measure of the difference between engineering students and engineering technology students (using a modified Liekert scale: 1 – No through 5 – Yes).

Table 1 Student Evaluation of Content

Survey Question	Engineering	Engineering Technology
The Animations Helped Me Learn the Material	3.1	3.4
The Web Pages Helped Me Learn the Material	2.9	3.7
The Streaming Video Helped Me Learn the Material	3.0	4.1
The Interactive Exercises Helped Me Learn the Material	3.0	3.8
The Material for the Course is Interesting and Engaging	3.6	3.9
Given a Choice, I would Enroll In a Technology-Enabled Course	3.2	4.3

Engineering technology students were more positive about the use of technology than were the engineering students. For every category of technology, engineering technology students provided more favorable responses than the engineering students.

In another example of application of technology to teaching, a team from the University of Cincinnati examined the use of educational technologies to optimize the learning process for students with different learning styles and personality types[2]. In order to achieve this goal, we evaluated students in Mechanics I courses taught during the spring quarter 2000 and spring quarter 2001 and students in Basic Strength of Materials courses taught in spring quarter 2001. Three educational technology based courses were being evaluated: 1) Interactive video, distance learning, in partnership with Wright State University or with two classes at University of Cincinnati; 2) web-assisted course; and 3) streaming video course. The control class was the typical lecture class. Students were randomly assigned to one of five classes per course

(interactive video-originating site, interactive video-receiving site, web-assisted, streaming video, or traditional lecture).

Student learning was evaluated in all classes. The standard lecture class was used as a "control" class. The interactive video class was held at both University of Cincinnati and Wright State University during the first year and solely at University of Cincinnati during the second year. There was an instructor at all sites. Students in the interactive video class were able to interact with the instructor during the class sessions. In both the web-assisted and the streaming video course, the students were directed to view the next session's lecture material prior to the actual in-person session. During the scheduled class session, the students met with the instructor and were able to ask questions, clarify theory and discuss problems. The instructors were told to use class time to enhance the learning material.

Students in all sections of the Mechanics I class took common tests and common exams. The tests and exam were all graded by the same individuals regardless of the particular section (instructional format). The number of students participating in each section each year is shown in Table 2 (note that the "format designator" is used in all figures presented). Final course grades for both years are shown in Figure 1.

Table 2 Number of Students in Study

Instructional Format	Format Designator	Number of Students in Mechanics I	
		Year '00	Year '01
Streaming Media	SV	28	22
Web Assisted	Web	34	24
Interactive Video - Originating	IVO	23	27
Interactive Video - Receiving	IVR	15	14
Traditional	Tr	35	18

Using the average of the final course grades for each instructional technology, a least significant difference, post-hoc analysis indicates that the differences in course grades are significant at an alpha level of .05. When the average course grades for both years are combined we found that in each of the sections using technology, students performed better than in the traditional classroom setting.

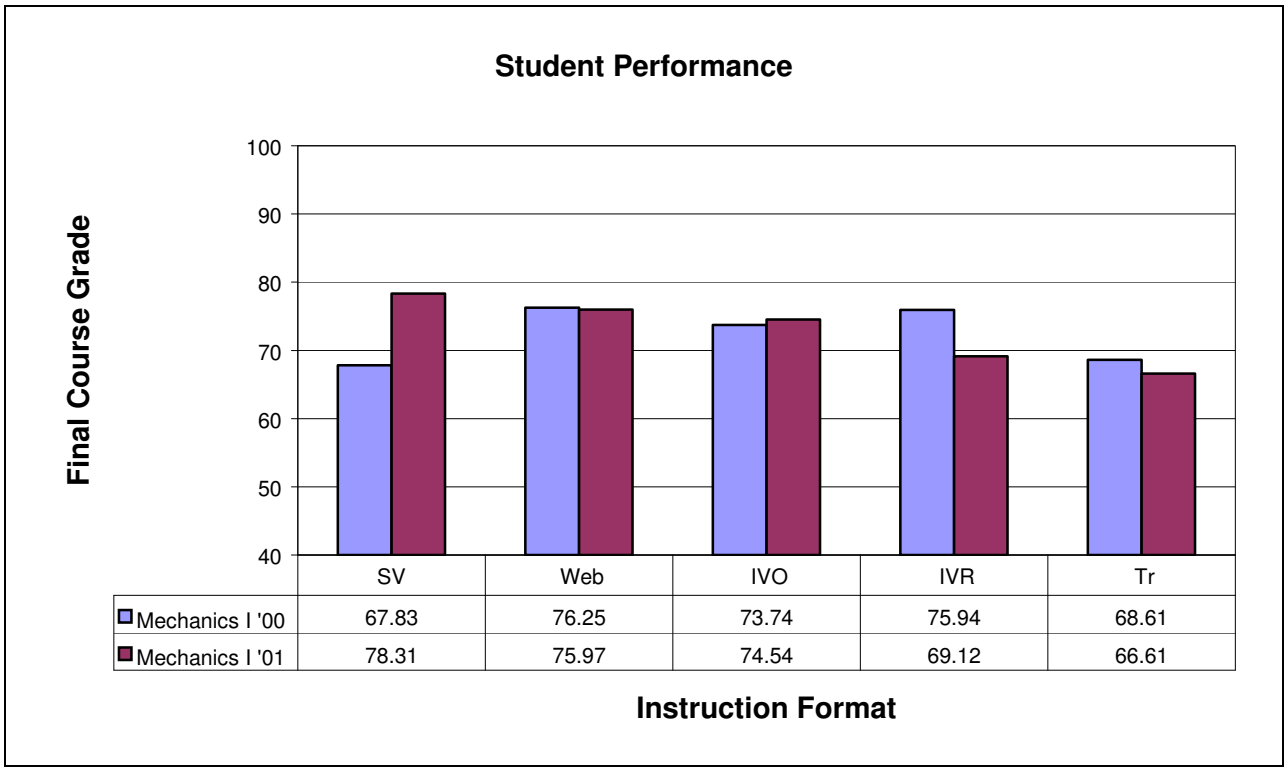


Figure 1 Final Course Grade by Instructional Format

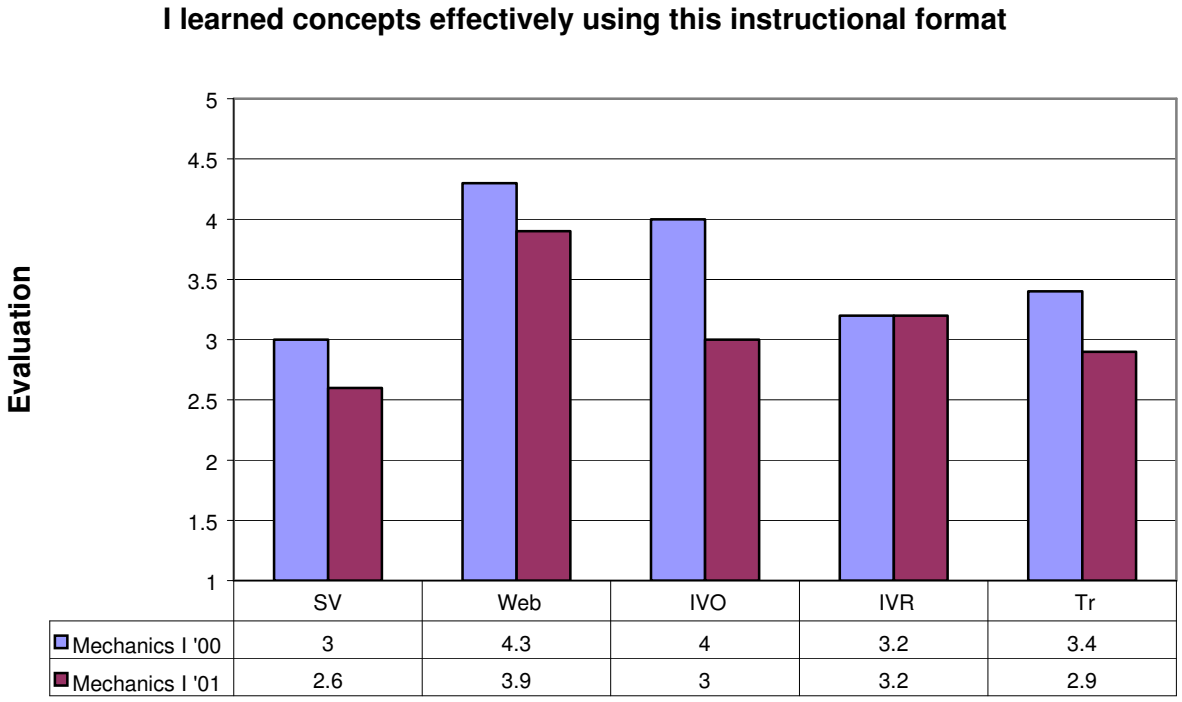
The project sought to measure the impact of instructional technologies on student learning in order to optimize the teaching / learning process, particularly for the basic engineering science courses. One aspect of the teaching / learning process is the students' acceptance of the technologies. Surveys were designed to help quantify student satisfaction and acceptance of the various technologies and to determine if these instructional technologies resonated with a particular student learning style or personality type. The surveys provided information regarding student interest, engagement and satisfaction with the instructional technologies.

The surveys also provided a mechanism to identify potential problems in the implementation and delivery of the course using the instructional technologies. For example, if large numbers of students were having problems finding and navigating web material, the surveys would identify this problem. The project team could then make modifications or improvements so that the problem was eliminated or at least minimized.

Surveys were developed for each section of students, corresponding to each instructional technology. The survey for each section contained questions common to all sections, and questions distinct to the instructional technology being used for that section. The common questions allowed the project team to qualitatively compare the various technologies. The questions specific to each technology allowed us to more accurately quantify student satisfaction with various aspects of the particular technology.

Students used a modified Liekert scale to respond to survey questions. A response of 1 indicated strong disagreement; 3 was neutral; and 5 indicated strong agreement.

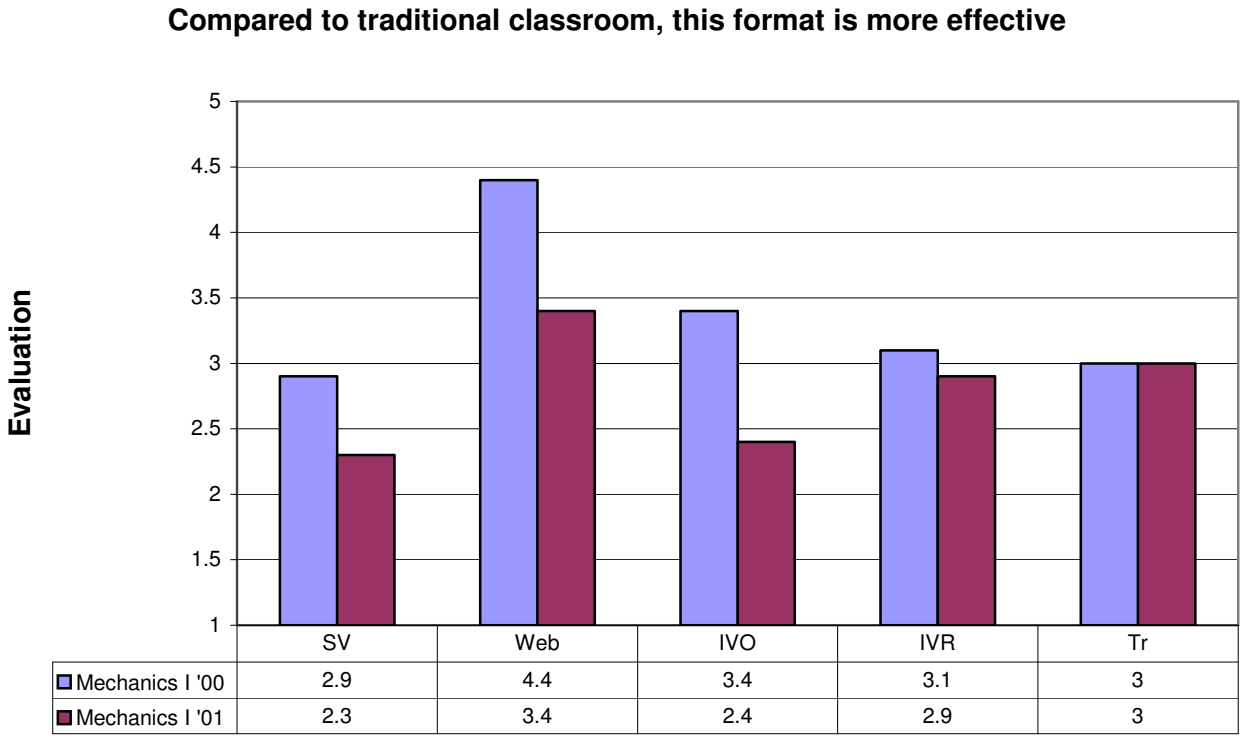
Figure 2 shows student response by instructional technology to the statement "I learned the concepts effectively using this instructional format".



	SV	Web	IVO	IVR	Tr
Mechanics I '00	3	4.3	4	3.2	3.4
Mechanics I '01	2.6	3.9	3	3.2	2.9

Figure 2 Student Response to Learning

Figure 3 shows student response to the statement "Compared to a traditional classroom setting, this format is more effective". A neutral response of 3 is shown for the traditional setting for point of reference.



Why Educational Technologies (Don't) Work

Our experience with seven years of analysis of educational technologies leads us to conclude that any use of technology for education can succeed or fail. Insufficient attention to the needs of the students and the receptivity of the students to the technology will lead to a less than desirable result. Simply stated, effective education is not about technology but the needs of the students. Use of educational technology that is not based on knowledge of and needs of the students will not result in effective education for (many) students. Some typical reasons why educational technologies fail include:

- Ambiguity about what is to be learned from the material either due to lack of clarity of expectations or a delivery format that emphasizes special features over core content
- Delivery of content / navigation through content leads students to focus on secondary material
- Students' expectations for the technology are significantly different than the actual implementation of that technology
- Insufficient or inappropriate opportunity for student interaction with content, instructor and other students

In order to maximize the potential for effectiveness, instructors are encouraged to follow the principles of Instructional Design (see for example Gagné, et al[3]). Instructional design is the systematic development of educational materials using learning and instructional theory to ensure the quality of instruction. As stated by the IEEE[4], it is the process an educator uses to determine the appropriate teaching method to obtain a desired goal for a specified set of students in a specific context. Elements of instructional design that need to be considered include:

Student Analysis – this includes knowledge of what the students need to learn as well as characteristics of the student population. Points to consider regarding content include: the educational preparation of the students, the place of the particular topic in the broader curriculum, the desired learning outcomes, and appropriate measures of achievement. Characteristics that influence students' ability and readiness to learn include maturity, access to resources, and motivation to learn the material.

Develop Learning Objectives - learning objectives are clear, concise, descriptions of what the students will be able to do as a result of the educational experience. Many educators describe the development of appropriate learning objectives as the most significant activity an instructor can perform in order to help students achieve educational goals. As stated, these objectives focus on what students will be able to do after successfully completing the instruction. These should form the basis of how students are evaluated and what is included in the evaluation.

Determine the Instructional Strategy – having knowledge of the students and the desired outcomes of the educational experience, instructors select the tools and methods they will use to enable students to meet the learning objectives. In the traditional classroom, the strategy would often revolve around the types of activities to take place in the classroom. Educators today can now include strategies that utilize various educational technologies. If the needs of the students dictate a specific delivery mechanism (e.g., a course of study for first responders that is not to interfere with the performance of their job duties may dictate an asynchronous delivery mechanism) the instructor still must decide what appropriate and available activities to include.

Develop Materials – once the strategy is selected materials are developed that enable students to accomplish the learning objectives using the instructional strategy. While there are often special considerations when developing materials that utilize educational technologies (MERLOT is one good resoruce[5]), essential considerations are the same as for traditional materials[6].

Evaluation of Educational Experience – an assessment of the instructional unit that has been developed and implemented will benefit the instructor and the students. This evaluation is not the same as assessment of student learning. The evaluation has to do with the efficacy of the educational experience. A peer review is one method of evaluating the effectiveness. An honest assessment of your satisfaction with students' attainment of learning objectives is another method.

Applying the practices of instructional design will significantly increase the potential for a successful use of educational technologies.

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