REDESIGN OF AN INTRODUCTORY MECHANICS COURSE FOR ONLINE DELIVERY

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Introduction

With the burgeoning growth of distributed or distance education, higher education is attempting to bring traditional courses online in record numbers. In the rush to accomplish this many institutions have lost sight of the fact that merely converting existing course material into an electronic format in the belief that that constitutes distributed education only accomplishes adoption of a technology without integrating change. The field of distance education has also grown rapidly incorporating substantial improvements in the use of media, pedagogies, and related technologies.

The advent of new accreditation criteria in EC 2000 provided the stimulus for engineering educators to reevaluate programs and curriculum, an exercise that also led many to reconsider teaching methods and learning styles. Coincident with this movement was the emergence of new technologies offering the potential to permanently alter the traditional classroom experience. The challenge has been to exploit these technologies in a way that enhances the learning experience without overly burdening faculty or compromising their role in the education process.

The primary objective of this project was to bring a college once active in distance education back into the environment of delivering courses remotely after a five-year hiatus from a college-wide distance education initiative. To accomplish this cost-effectively, rapidly and without a large staff or much equipment, new technologies and a systems model approach were adopted and tested in a pilot study discussed in this paper. Rather than taking traditional course material and merely converting it into a new format, the study attempted to redesign one core curriculum course, ENG Mechanics I, in the program and develop new methods for teaching and learning at a distance using a comprehensive systems model approach [1].

A secondary objective was to choose a course from the Boston University Late Accelerated Entry Program (LEAP), a program that prepares students with non-engineering degrees, from any geographic location, for entry into master degree programs in engineering. It was decided that eliminating constraints to the learning environment, such as proximity to campus, would make the program or courses more attractive to potential students outside the Boston area [2].

The goal of the pilot study was to redesign a specific engineering course through a challenging application of distance education technologies and distributed learning pedagogies, with the ultimate purpose of raising the entire LEAP program to a higher level. At a time when it takes considerably more time, expertise, and staff assistance to develop enhanced delivery of instructional material, it still remains the responsibility of the instructor to serve as the main content expert [3]. Using the systems model approach, the course instructor developed course material for this study in unison with a team of content experts in the disciplines of technology, design, web development, and course development [1, 4, 5].

Course Redesign

The redesigned course is usually taken in the fall semester sophomore year. The course is somewhat unusual for an introductory mechanics course, in that coverage includes both statics-- particle and rigid body-- as well as particle dynamics. This structure is dictated by the absence of any additional mechanics course requirements in several of the College's programs and thus, this course serves as the sole exposure to engineering mechanics for students in those programs.

The course also represents the first exposure to the formalization of engineering problem solving methods. As such, a large portion of class time (approximately sixty percent) is devoted to solving example problems. The heavy emphasis on problem solving makes the course an ideal candidate for asynchronous lectures, a major feature of the course redesign, offering students the opportunity to self-pace through the examples, and to review the material as needed for homework and exam preparation [6].

Lower division mechanics courses have been a popular target for early adaptation of web-based delivery. A full on-line statics course was developed using lectures in streaming video format, along with a courseware CD-ROM and on-line quizzes [7]. An early development of an on-line statics course was based on web browsers and standard software [8]. A one-credit web-based statics course was created using text-based material and interactive animations for use as a study guide for the FE exam [9]. Web-based supplementary materials have also been developed for mechanics courses, including multiple-component learningware [10] and java-based applets [11], among others.

Various approaches for asynchronous lecture delivery have been reported for web-based engineering course. Slide shows with synchronized graphics and audio provide a relatively simple approach [10,12]. A comparatively easy method has been reported for adding synchronized, low frame rate video to prepared slides or to a virtual whiteboard [13].

Streaming digital video and audio provide for a presentation more consistent with traditional classroom lectures, but can require significant up front resources for videotaping and encoding. Videotaping traditional lectures at blackboards or whiteboards can also require high-resolution video and careful lighting to assure legibility of information on the board. This problem can be addressed by supplementing the streaming video with synchronized PowerPoint slides providing higher quality copy of the lecture notes [6]. For the present study, a modified form of this approach was adopted.

Use of animation tools, such as Macromedia Flash, either with synchronized audio or video, can provide an added dimension to on-line lectures, one that is unique to the web-based delivery format. In addition, it can be used to alleviate some of the high demands of streaming graphics and video, since only the updated portion of graphical content is streamed. However, it imposed additional development time for first-time users, and as such, was not used given the timeline of the redevelopment project. A further disadvantage stems from the image-based nature of the content, which is not viewable by screen reading equipment used by the visually impaired and cannot have image-associated meta tags, which means that Flash pages cannot be detected by some search engines.

Asynchronous Lecture Format

Normally, the course consists of twenty-five lectures. Seven of those were delivered in an online, asynchronous format. The remaining lectures were traditional, except that the traditional class lecture material was prepared in the same format (PowerPoint slides) as the asynchronous lectures, with the lecture slides available online for students to view at any time through the use of the course tool application CourseInfo.

Although special care is taken in developing all course materials, distance education courses require even greater attention to detail since anticipating the inevitable helps alleviate any problems students may have when separated from the instructor. Significant effort was therefore expended in preparing the slides, to assure legibility, a modest degree of graphical flare, and consistency with the nomenclature and color scheme used in the required textbook-- Vector Mechanics for Engineers, Statics and Dynamics, 6th Edition, by Beer and Johnston.

While a uniform format was used for navigational reasons, it was not meant to be a one-size-fits all design. Rather than assuming that the new course design would work for all students, the course redesign process attempted to incorporate flexibility and different learning environments to provide students with greater choice and the ability to interact with the course material. Current research indicates this as one of the critical components for development of a successful distributed education course [14, 15]. The underlying structure of the redesign integrated a blend of technologies that would appeal to different learning styles. An example of this was the use of multimedia applications that provided information in text based (straight text), graphical format (presentation), auditory/visual (streamed audio and video) and analytical (self-paced problem solving) in an interactive environment (course tools application) [16, 17].

Summary of Course and Video Development

Technology was integrated into the course redesign through brief, modularized and focused encoded and streamed video-based lectures using PowerPoint for presentation slides. Staff from the College of Engineering's Office of Distance Learning, College Network Office, the University Office of Information Technology, and a student staff partnership with the College of Communications Video Department provided technical and video support as well as course and graphic development assistance. CourseInfo was selected for its ease of use and short learning curve. The video-based lectures were recorded using a Sony HandyCam TRV 720 digital camcorder and encoded using Real Networks RealProducer. This product was selected because of its availability through the University's Office of Information Technology where a Real Server, streamed licenses and additional staff support were free to all university departments.

While there was an effort made to not let the technology drive the academics, there were occasions when technology actually offered solutions to pedagogical problems. A typical lecture in the traditional classroom format would last approximately 100 to 110 minutes with periodic breaks. The encoded video files were so large that it would have been prohibitive for students to view the videos with an average computer setup. The distance education office made the suggestion of chunking the course material (fitting a particular learning style). This would translate into a more reasonably sized video-based lecture.

The lectures were then broken into modules that were each associated with their respective slides. Similar approaches have been used by other on-line course developers [7]. Each lecture consisted of five to nine modules, depending on the lecture, with a file size of approximately 10-20 Mb. This was one example of where technology enhanced the ability to provide greater flexibility and work with the potentially different learning styles of the students.

Synchronized Media

Two different pedagogical approaches were tested in the pilot study. The first placed the instructor, the slides and the video lectures together in one package to be streamed on the Web. RealProducer was used for its producer-in-a-box ability to enable integration of informational and instructional graphics, text, video, slides, and links through the code developed by RealNetworks called synchronized multimedia integration language (SMIL) (Figure 1).

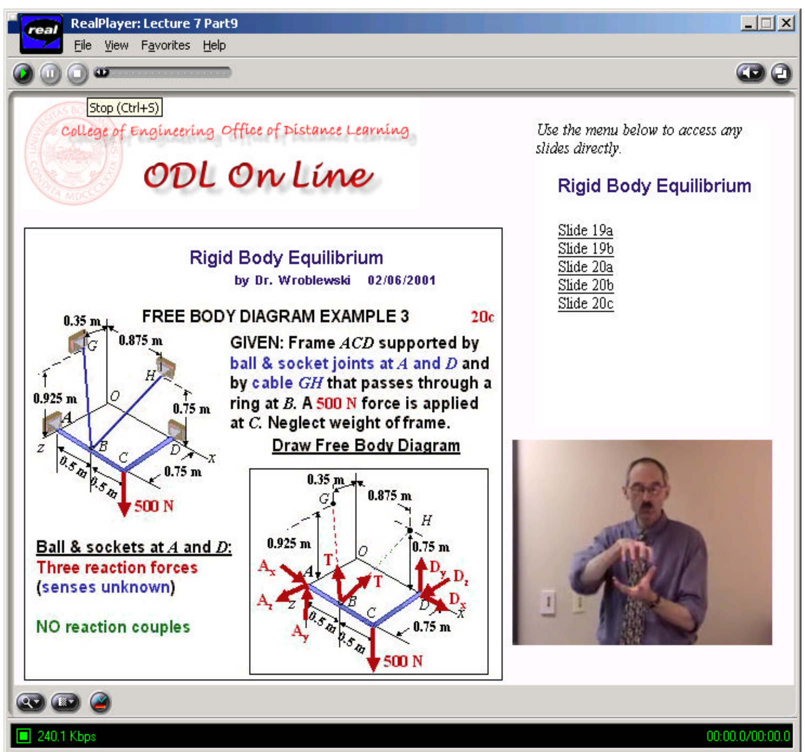

Figure 1: Example of lecture format with synchronized video

This approach was used on the first three of the seven asynchronous lectures. The approach allowed students to view the entire lecture in one package while still enabling them to move freely through different portions of the lecture, replaying it as frequently as necessary. The video

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player could be set to remain “on top” of the student’s computer desktop while working with the CourseInfo course site in the background. This way the students could still move about in the course site while watching the video, which was often resized and placed in a corner of the page. Once the video finished, or was stopped, it would drop below the current active program.

The SMIL code approach was used initially to provide lectures that integrated video and slides, offering students a way to view lectures with minimum nuisance. Synchronizing the slides meant that students could simply watch the lectures without any additional input on their part. This approach also allowed students to easily navigate through slides, reviewing sections that may have been unclear, or skipping sections that were well understood.

However, this method had its disadvantages. The coding effort was extensive requiring significant time commitment to optimize the bandwidth of all the streams. Often, the optimization at this earlier level of the technology led to a sacrifice in the quality and resolution of the slides. However, the main reason for abandoning this approach was that for most of the lectures, the slides were static; streaming video that consisted mainly of static information was not considered an optimum use of the available bandwidth.

The second pedagogical approach took straight encoded video (see Figure 2) and embedded it, along with the PowerPoint slides, into the course application tool CourseInfo (see Figure 3). Figure 4 shows how the two windows are positioned for viewing in this mode, although the student is free to place the windows where it is most comfortable for them. This approach was used on the remaining four video taped lectures.

Figure 2: Example of separate video

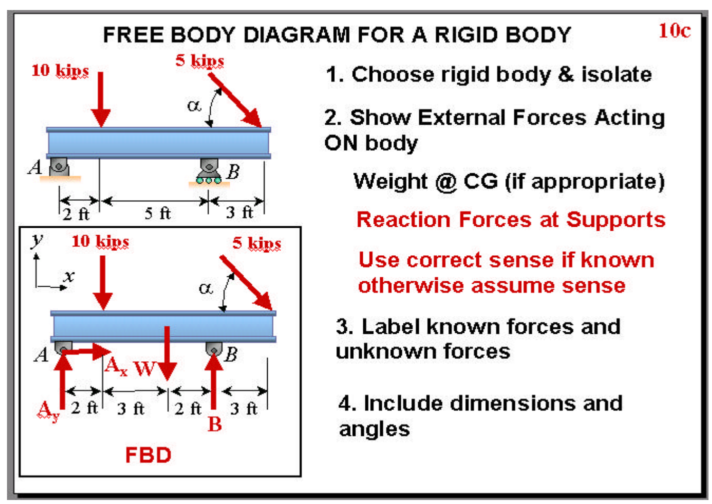

Figure 3: Example of separate slide file

Separating the video and the slides permitted smaller files for the streaming video, reducing the number of segments per lecture from nine to five or six. However, students would be required to provide some input to synchronize the slides and the video. This was accomplished by displaying slides numbers in the video and by combining visual and verbal cues on the video, with the students required to advance the slide show at the appropriate cue. This made it more

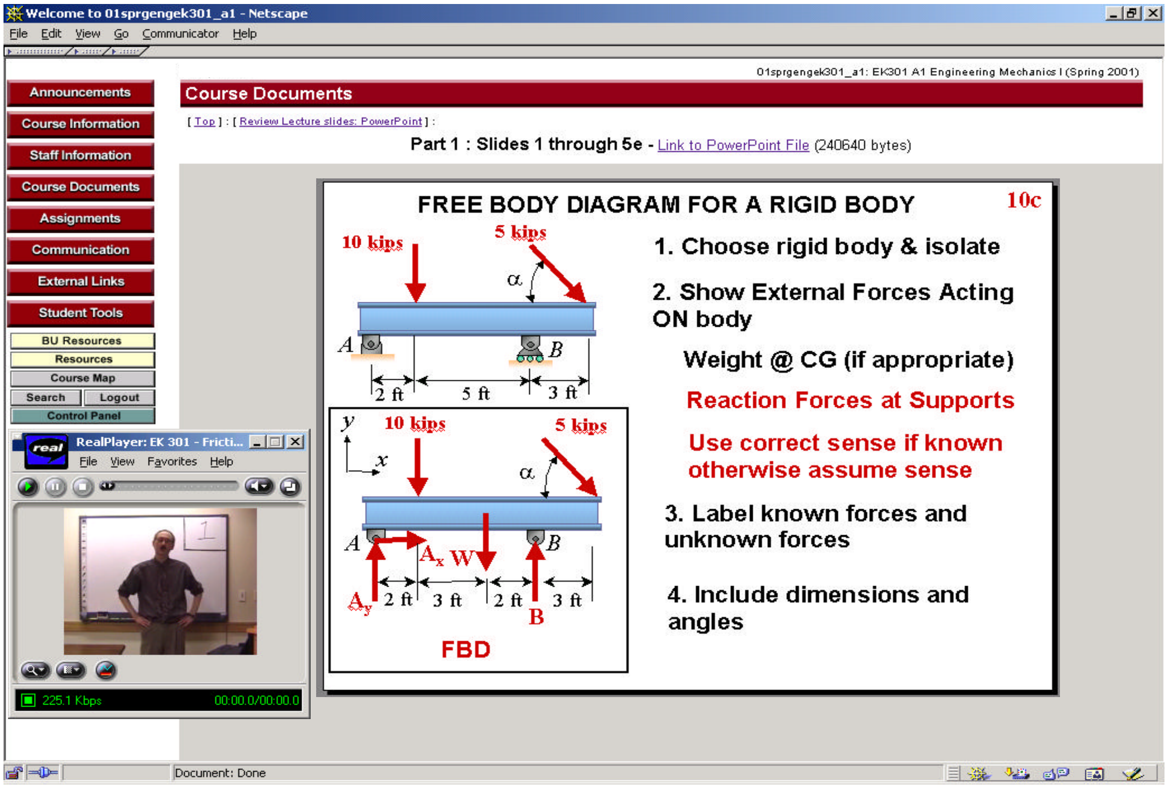

Figure 4: Example of video file positioned within CourseInfo window for simultaneous viewing with slides

difficult to navigate back and forth through the lecture. However, it was easier to subsequently review the lectures slides after viewing the lecture-- for example when doing problem sets or when reviewing for an exam-- since no streaming video was required.

Course Management Software

The online content of the course was coordinated through CourseInfo. The primary use of CourseInfo was to provide access to online lectures and archived lecture slides. However, general course information and policies, updates to syllabus, design project testing results and homework assignments were also provided through the site.

Access to online office hours was offered, through the virtual classroom facility of CourseInfo, during the regular class meeting time for the days when online lectures replaced the live lectures. Students were encouraged to view the lectures during the regular class time, and ask questions in real-time, online. Unfortunately, this method was not widely adopted by the students, as reflected in the survey results, for two reasons. First, the instructor did not offer this option until the third of the taped lectures, and many students had already become comfortable communicating questions or concerns through e-mail. Second, the noon to 2 PM class time coincided with the period of high traffic on CourseInfo, slowing access time and increasing the number of technical problems. The students quickly realized that viewing the lectures at night or on the weekends was not only more convenient, but more trouble-free as well.

Technology Selection, Configuration and Implementation

With computing technology advanced at a rapid pace, the choice of equipment and computer software and hardware was based on the criteria shown in Table 1.

Table 1: Technology Selection Criteria
1. Equipment and development cost-effectiveness
2. Remote student accessibility
3. Availability of campus network infrastructure for optimal course delivery
4. Learning curve for faculty development and student use
5. Development and technical support availability
6. Compatibility with academic course tool applications
7. Development timeline
8. Ongoing technical support sustainability

Equipment selection was investigated thoroughly prior to purchase although the ultimate decision came down to what would work with the available on-campus network (RealNetworks) since there were no funds to purchase servers and operate a streaming service on-site.

Expert advice was therefore sought from those with experience on campus and from other institutions. At the time there was relatively little information available publicly about the combination of proprietary equipment and fewer, reasonably priced software applications to automate the process. Less was available in the form of 'lessons learned'. Rather than rely on information from sales and 'white papers', advice was sought from as many sources as possible through informal partnerships. Professors James Lengel, Boston University's College of Communication and Michel Dupagne at the University of Miami, School of Communication [18], offered experience gained in similar projects where mixing technologies with widely varying proprietary standards were involved.

After troubleshooting too many problems with varying video formats and proprietary standards trying to record using a Sony HandyCam TRV 720 digital camcorder using their iLink IEEE 1394 cable to encode the video to RealProducer's own proprietary encoding algorithms, the incompatibilities and subsequent solutions became apparent. Instead, an already existing Gateway multimedia workstation was upgraded to its capacity of 512 Mb of RAM to serve as both a course development station for faculty and staff and as a video production station. With the installation of an Osprey100 capture card, and a generic IEEE 1394 cable, the video was captured and compressed (encoded) using RealProducer. Ultimately, with professional lighting and installation of a video switching system, videos were recorded using professional quality Beta SP tapes and encoded directly from an analog Betadeck into RealProducer's digital encoded format.

Since the content of the course was delivered through audio as well as video, both were assessed for their quality. It was found that the students placed more emphasis on the video quality when they had only straight video to view, but this also required them to switch between video player, course tool application and presentation slides where the actual content resided. By combining the slides and CourseInfo with the video, in one window, the emphasis was returned to the academic materials as well as making it easier for students to search for, and locate specific content.

Assessment

Assessment took two forms. The course tool application CourseInfo offered an array of course statistics. Chief among these was tracking individual activity in the course, which allowed evaluation of student access of each online lecture by date, time of day, and student.

In the second assessment approach a pre-test, post-test design was proposed. In the absence of a control group a within-subjects evaluation design was used. The initial survey was offered online with a response rate of nineteen out of a total class of thirty-seven students or fifty-one percent. The final survey was administered in class. The improved response rate was sixty-seven percent.

The final survey was designed to assess a variety of attitudes toward learning within the redesigned format for EK301. The survey anticipated the following primary factors:

- Inexperience in distance education
- Problems learning and problem-solving independently
- Difficulties with self-motivation and self-discipline

The survey utilized a structured questionnaire. The questions were organized by:

- General distance education questions
- Technology questions
- Support questions
- Academic questions

The survey results reflected the increased acceptance and awareness of electronic and distance learning. A possible reason for this, in a class of freshmen and sophomores, was the increased technical sophistication and available connectivity found nationwide in secondary education. Although some orientation was provided, students were generally prepared to use the software and technology implemented in the course without further training. Over the entire semester only five students experienced difficulty that was resolved by the Office of Distance Learning staff and the course graduate teaching assistant. While a solution was offered, one of these five students did not respond for some time after their initial request for help.

Results

In the initial survey thirty-six percent felt the distance format was a good form of education. By the end of the semester eighty percent of the students indicated that the distance learning format was satisfactory or exceeded their expectations and did not experience difficulty using PowerPoint. Twenty percent (or three students) were disappointed in the distance learning format. Those same students felt that the format hindered them academically, while approximately sixty percent felt the electronic format helped them academically with the remaining twenty-five percent divided on the issue. The same students who felt the electronic format helped them also felt self-motivated toward learning independently. The majority of those students also felt self-disciplined. One of the three disappointed students experienced difficulty working with PowerPoint and two were uncomfortable with CourseInfo. Seventy-six percent found the subject matter of the course interesting.

In the initial survey seventy-three percent thought the distance format would represent more work. By the end of the semester, of those who felt the distance format exceeded their expectations, about half felt it represented the same amount of work as the traditional class lectures with the remaining students split on whether it represented more or less work. Two of the three disappointed students felt that it represented more work to them.

By the end of the semester ninety-two percent felt that they could learn when separated from the instructor and classroom compared to seventy-eight percent earlier. Looking at the questions on self-motivation and self-discipline alone fifty-six percent felt sufficiently motivated (compared to seventy-three percent earlier) with seventy-two percent feeling they were sufficiently self-disciplined (compared to sixty-eight percent earlier). With a nearly unanimous response that they were comfortable using the computer for instruction (ninety-two percent compared to seventy-eight percent prior to working in this format), only seventy-two percent felt prepared to work in the distance format. Twenty-eight percent said they would choose this format over the traditional delivery after having the experience. The group was almost evenly split on their comfort using electronic office hours.

Sixty-four percent experienced no difficulty setting up the RealPlayer, while thirty-six percent experienced enough difficulty to indicate this on the survey. Eight-eight percent felt the video quality was sufficient to follow the instruction. Of the same three students who were disappointed in the distance format, two felt the video quality was insufficient.

About half of the students connected from their dorm rooms with another third connecting from campus computer labs. Roughly three-quarters connected using a LAN and the other quarter used a dial-up connection.

The group was almost evenly split on the issue of whether the media CDs were helpful. A dismal eight percent participated in the online discussions more than three times, preferring face-to-face communication with the instructor (ninety-two percent) and with students (eighty percent). These numbers did not change from their impression in the initial survey.

Only thirty-six percent felt the online discussions were useful while they are comfortable using electronic mail (ninety-six percent) and a Web browser (ninety-two percent). A full ninety-two percent were pleased with the convenience of the video-based lectures with eighty-four percent finding the video-PowerPoint combination helpful.

Most felt there was sufficient staff support for general technical issues (eighty-four percent said yes) while only seventy-two percent felt that the online technical information was sufficient to help them. These figures were corroborated when the questions were crossed with the questions on self-motivation and self-discipline; those who felt the electronic format helped them also felt there had been sufficient support. This included the Office of Distance Learning web site technical information pages that offered troubleshooting advice in the absence of 24x7 support staff normally provided in full distributed education programs. The same amount, seventy-two percent, felt there was sufficient online instructor support with eighty-eight percent indicating that questions were answered promptly. Of those who worked in campus computer labs only fifty-six percent said there was sufficient staff available to help them with problems associated with the video-based labs and online course content. A full sixty percent of the respondents recommended a brief orientation prior to the start of class to better understand how to use the distance format. By the end of the semester this figure had not changed.

Course Statistics

Using statistics available from CourseInfo, it was determined that the videos were accessed on average 1.7 times per lecture per student, indicating that students were watching the videos more than once. This may have been because they wanted to re-watch some segments, or because they were stopping and restarting segments. In either case, the students were taking advantage of the convenience offered by the asynchronous format.

Table 2 shows the breakdown for each lecture. It is interesting to note that lecture 3, 7 and 13 all show similar access rates near 1.4 accesses per lecture, while lectures 10, 19 and 25 all were near or over 2 accesses per lecture. The higher value for lecture 10 may reflect reviewing of the material in the truss lecture for use in the design project. Lecture 25 was the review for the final exam, covering problems from previous exams, so the higher access rates may not be surprising. In fact, the highest number of accesses in a single day occurred two days before the final exam. Lecture 19 was the most accessed of the lectures, with 2.3 hits per student, possibly due to the difficult nature of the material (Newton's Law in normal and tangential coordinates) compared to other taped lectures.

Table 2: Access statistics for taped lectures

Lecture	Accesses/student
3: Vector Products, Moments	1.4
7: Rigid Body Equilibrium	1.4
10: Trusses	1.9
13: Friction	1.4
16: Kinematics: Normal/Tangential Coord.	1.6
19: Kinetics: Normal/Tangential Coord.	2.3
25: Final Exam Review	2.1

As mentioned previously, although they were encouraged to view the lectures during the regular class-meeting time, students generally watched the lectures at other hours. Only ten percent of the accesses were during the noon to 2 PM class time slot. The most active two-hour block was 7 PM to 9 PM, accounting for over fifteen percent of the accesses. Fifty two percent were between 4 PM and 12 PM, clearly indicating the popularity of the evening-night study period, and demonstrating that the students were taking advantage of the flexibility and convenience of the asynchronous format.

Lessons Learned

Online Course

The online format featuring asynchronous videotaped lectures proved to be a useful tool. The students generally felt that the lectures enhanced their understanding of the material, and they exploited the convenience, by repeated viewing of the videos and by viewing at their leisure. However, it should be remembered that these lectures represented less than one third of the total number of lectures, so the majority of the class experience was traditional. Despite the strong acceptance of the online format (based on the post-class survey), only twenty eight percent of the students indicated that they would choose it over traditional delivery methods.

Although this project was a hybrid distributed education course it was still apparent in the use of electronic office hours that students needed contact for more than just the course content. Human contact in the tradition classroom occurs naturally. In the remote classroom human contact is important for more than continuous academic feedback; it also provides encouragement for students who, despite professing self-motivation and discipline, still benefit from engagement and the knowledge that their efforts are recognized. Even still, participation in online interaction could have been improved by scheduling online office hours to correspond to student's penchant for evening and nighttime viewing of the lectures, and by introducing it earlier in the semester.

In the summer immediately following the pilot study, all of the lectures were videotaped, including re-tapings of several of the original videotaped lectures that did not include cues for slide transitions. The overall format was nearly identical to that of the last four lectures, with three changes. First, all of the lectures were taped and encoded in five separate segments, with each segment running from twelve to eighteen minutes. Second, a more legible, more professional looking slide number cue was employed. Finally, professional theatrical lighting was used to improve the video quality.

One of the goals of the pilot study was to prepare for a complete online offering of the course for out-of-town LEAP students. Currently (at the time of writing), this course is being offered, with four students enrolled, utilizing the lectures taped during the summer. As a means of blending some synchronous content in the predominately asynchronous course, the students will be required to participate in online discussions or online office hours on a regular basis (at least once every other week). The intention is to provide the human contact (albeit virtual) needed to keep students engaged throughout the semester.

Technical

An important fact to remember is that the students in this pilot project all viewed the course material from the same geographic area. They viewed the material in a closed network capacity, or on modems with university-recommended configurations. There were no time zone or cultural differences, no vastly differing computer types or configurations and very little variability in connectivity. This made technical and academic support easier, and should be considered in delivery where distance is a real issue.

Much time and research went into locating the correct capture card which, when housed in the multimedia workstation, allowed the capture of video/images to RealProducer installed on the workstation. The project began with the availability of a Sony Betadeck and camcorder, therefore a capture card was sought that would be compatible. All resources recommended a Margi Capture-To-Go card, but despite hours of painstaking system configuration changes the Margi proved unsuccessful with equipment setups similar to those who had recommended and used the equipment successfully. After many hours of research and painstaking testing, the decision was made to use the Osprey 100 capture card that by that time was sold directly through RealNetworks. This problem will disappear as more applications become available that automate the integration of multimedia.

Assessment

A valuable lesson was learned regarding planning far enough in advance to organize the students in order to administer a pre-test and to make it mandatory. This did not happen. In fact, it was decided in the rush of semester startup that questionnaires would be used and that they could be anonymous, expecting that anonymity would increase the response rate. It didn't. With both the pre-test and post-test as anonymous voluntary surveys, it was eventually impossible to compare reliable pre-test and post-test data.

Another important aspect of the surveys that could be improved was the wording of the questions, which was short-changed somewhat by the time factor and extreme activity of course and technical development. A formal pre-test / post-test design would have taken into consideration more careful wording of the questions so that they were similar between the two tests. More time and careful thought to development and wording of the questions could have improved the assessment in two ways. First, it would have allowed assessment of educational aspects of the course, like learning style, so that the instructor could gauge the best learning approach for students or where they may have been more apt to succeed or have difficulty. Second, it would have allowed more data analysis through in-depth use of statistical procedures such as cross tabulations, to see where patterns and trends might have existed, thus helping to determine areas where the redesign of the course might help future redesigns.

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