AN INTERACTIVE DISTANCE LEARNING COURSE ON DYNAMICS

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Abstract

An interactive distance learning course on Dynamics was developed and offered to groups of on- and off-campus undergraduate engineering students using a multi-media approach and a combination of teaching tools. The course was presented to a live audience on campus in a specially designed class room and transmitted to off-campus sites in real time using modern information transfer equipment. The paper describes a practical method of distance learning that overcomes problems associated with developing and teaching web-based engineering courses on-line.

Introduction

Educators have always been interested in finding ways to improve the economy and effectiveness of classroom delivery, especially at the undergraduate level of higher education. Recent advances in information technology are prompting us to develop cost effective teaching methods and tools that were unthinkable only a few years ago. A number of US universities are now actively engaged in developing and teaching distance learning courses that are available simultaneously to large bodies of students at multiple locations. College education is no longer confined to university campuses but can be made available to every interested person anywhere there is a phone connection. However, contrary to the initial overly optimistic expectations, recent experience of those involved in actual delivery of technical courses shows that there are serious difficulties in teaching technical courses compared to teaching non-technical courses using 'web based' distance learning methods. The present case study confirms that the method of delivery is a critical factor in distance learning for its effectiveness and acceptance by the students. Secondly, from purely economic considerations, it appears that the engineering courses that have the best chance of success as distance learning courses are the basic mechanics courses with traditionally large enrollments such as Statics, Dynamics, Mechanics of Materials, and Fluid Mechanics. This paper presents the results of an experiment in teaching Dynamics, using a multimedia distance learning approach at a small college with student population located at three different campuses.

Multimedia Approach

A baccalaureate level engineering course on Dynamics was taught at West Virginia University Institute of Technology, using a multimedia approach with a multitude of instructional equipment. The equipment included: video cameras (V-TEL^R CamaraMan-Parker Vision), a 'document camera' (ELMO^R Visual Presenter EV 400 AF), a 'smart board' (V-TEL^R) and a 'touch control panel' (V-TEL^R). The video cameras are controlled remotely by the instructor and are programmed to become operational, one at a time in recording the classroom proceedings on a video tape. They are positioned one for the instructor, one for the students in the on-campus classroom and one each at the (remote) off-campus classrooms. TV monitors, strategically located in the classrooms, display the proceedings in real time. The document camera is used to display

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pre-prepared as well as real-time instructor-written notes on the TV monitors. The smart board may be used like a traditional black board by the instructor to write class notes. Controls are located on the touch panel placed within easy reach on the instructor's desk. A video recording system tapes the proceedings on VHS video tapes. Prior to starting the class, a technician activates the equipment, and establishes contacts with off-campus stations using an ATM (Asynchronous Transmission Mode, 512 kb/s) phone system. After the session begins, the technician monitors the equipment to ensure their proper operation. At each of the off-campus stations, another technician or a staff member is responsible for the operation and monitoring of the system.

Special Classroom Features and Facilities

The course was taught in a non-traditional classroom, specially designed for this purpose with several unique features, including a video recording booth and electronic connections for communication equipment. Student seats are arranged in semi-circular rows in a gallery-like layout so that the instructor and the TV monitors are within about 15 feet from any student for convenient viewing of the written material on the TV monitors or the smart board. The cameras record and display the proceedings. The instructor controls his/her camera from the touch panel and it stays focused on the instructor with a 'tracker'. Each student has a control pad near his/her seat, which when pressed, activates a microphone and automatically focuses the student-camera on that student. The instructor may then press a control button to have the student's image appear on the TV monitors. Several large-screen monitors are placed at strategic locations in the classroom. Students at the off-campus locations control their cameras with a 'joy' stick and use a microphone to communicate with the instructor. Their images may be programmed to appear either on separate monitors, one each per group, or all on a single 'split screen' TV monitor. The document camera, with wide-angle and zoom features, is used to display printed or instructor-written class notes on the monitors. The smart board replaces a traditional classroom 'black board' on which the instructor can write using a magic marker. The material written on the smart board appears, as it is written in real time, on the monitors but without the instructor's physical image or features[(1)]. The instructor controls what is displayed on the TV monitors using the touch panel. Live audience for the lectures was provided by the on-campus students who signed up for this course. Initially arrangements were made to send the course material to two remote locations 30 and 75 miles from the main campus using ATM phone lines. Once the main campus equipment is installed and running satisfactorily, adding a new remote station is as simple as activating a phone line.

[(1)] Superposing a live-image ('picture-in-picture-PIP') of the instructor on the TV monitor while he/she is

writing on the smart board should enhance the quality of presentation. This technology currently exists, (as seen on TV news Broadcasts) but was not used in the present case due to time and money constraints.

Student Interaction

From experience, educators know that a healthy interaction between the students and the teacher is a necessary condition for optimal learning experience. Effectiveness of the mode of teaching described in this paper and its eventual success may depend on how satisfied the students are with their interaction with the instructor. The objective, therefore, should be to create, among other things, an interactive environment that is lively and conducive to efficient learning. In the present case, the on-campus students' interaction was similar to what is seen in a traditional classroom. Because there was a live-instructor in front of the class, students interacted with the instructor in the usual manner. In addition, they could also activate the sound system and appear on the TV monitors by touching the control pad in front of them. However, interaction with students at off-campus locations turned out to be far more challenging[(1)] . First, it was the reluctance on the part of the students to raise questions when the teacher is not 'physically' present in front of them. Secondly, the need for pressing the control button to get on the system rather than raise a hand, appears to dampen the enthusiasm to interact with the instructor. Sometimes the problem was the time taken by the instructor to realize that a student has a question, since it involved watching for audio or visual signs on the system rather than recognizing a physical sign such as a raised hand. However with passing time and growing familiarity with the arrangement, these problems became easily manageable.

Preliminary Planning and Preparation

Teaching a course in this mode requires extensive planning and preparation. It has been the author's experience that it takes about four hours of instructor's time for each hour of class presentation, particularly the first time the course is taught. A major part of this time is for the preparation of hand-outs for distribution at the start of each session. On the first day of the semester, a '*Course Policy'* handout was distributed consisting of *Course Description*, *Textbook and References*, *Instructor's Information*, *Course Objectives, Learning Outcomes, Syllabus* (with a course outline, homework assignments and test schedule), *Assessment Procedure* and *Grading Scale*. At the start of each session, a *'welcome'* sheet, showing the course title and the session number of the day was distributed along with a one-page *'summary'* sheet containing the material planned for the day with important definitions, brief derivations of formulas necessary for the day's lecture, and a list of 'class work' and 'home work' problems. A time saving practice that was also very popular with students was to distribute, at the beginning of each session, a set of working papers (containing a printed practice problem at the top of each page - reproduced from the text with publisher's permission, if necessary). In addition, the author prepared and made available to those who wanted, hand written solutions to the class work problems (***not*** *reproduced from the 'solution manual').*

[(1)] Due to economical and logistical reasons, only secretarial assistance was provided to the students at off-campus locations. No teaching assistant or course facilitator was available during the sessions to answer students' technical questions. The primary instructor handled questions from students at remote sites via e-mail, phone and two personal visits. When using this method of distance learning, one of the challenges is providing the off-campus students with sufficient support outside of class.

Prior to starting a session the technician at the main station activates all equipment, checks for their proper operation and establishes communication with all off-campus stations. At the remote stations, the persons-in-charge activate the equipment and make the necessary arrangements to get their system ready for the session. The instructor is ready to start the session when the images of the local and remote classrooms with students appear on their respective TV monitors.

Material Presentation[1]

Before starting a session, the instructor or staff members at the off-campus stations distribute the hand-outs while a welcome sheet is displayed on the TV monitors using the document camera. The welcome sheet is intended to allow some time for students to settle down and get ready for the session. After wearing a microphone and a 'tracker', the instructor activates the appropriate control on the touch panel to have his/her image appear on the TV monitors. Following the usual greetings and pleasantries, the previous session's material is briefly reviewed. The current session's summary sheet is then displayed using the document camera and briefly discussed while the students look over the sheet. It helps them to get oriented for a more effective reception of the lecture material that follows. The instructor then presents the lecture material which may include definitions, descriptions, derivations and explanations. During this phase of the presentation, a judicious use of both the document camera and the smart board was found to be highly effective[2]. In using the document camera, color felt-tipped pens may be used with drafting aids such as a straight edge and a circle template, to write on a standard size paper placed on a glass sheet facing the camera lens. While using this camera, the instructor needs to keep a constant watch on what appears on the TV monitors to insure proper letter size for easy reading and to avoid writing outside the camera field of view. It takes some effort and practice to overcome this problem. (A couple of students were drafted to help the instructor by tapping on their desk when a problem occurred). In using the smart board, the instructor writes on a white smooth electronic board with a magic marker. The material from the document camera or the smart board is transmitted in real time to the monitors at all locations.

[1] **Consent Form:** On the first day of the semester, students should sign a release form consenting to appear on television and be recorded on video tapes while taking the course.

[2] The size and clarity of the written material appearing on the TV monitors depend on the monitor quality and size. With small or medium size monitors the letters may be too small to read. To minimize this problem large 60-inch 'flat-screen' monitors are recommended.

In using the smart board, the author encountered four problems. First, the smart board is much smaller in size than a traditional black board; thus a relatively small amount of written material fills up the board requiring more frequent erasing. Secondly, while the instructor is writing on the smart board, only the written material appears on the TV monitors without the human image. Students, especially those at off-campus locations, may need some time to get used to seeing the instructor's writing appear on their monitors without a human image[(1)]. Thirdly, the written material was somewhat distorted in transmission from the smart board to the TV monitors. This made it necessary for the instructor to continuously watch for the quality of his writing on the smart board. Using large capital letters was found to minimize this problem. Fourth, in order to erase the smart board the instructor needs to follow two steps in sequence: first erase the board using a special eraser and then touch the 'clear' button on the board's control panel to delete the display on the monitors. It may take some time to get used to this sequence of operations.

After completing the discussion of the theory and appropriate derivations, the document camera is used to solve a set of practice problems. Students should have copies of these problems, one problem per page, so that they can work with the instructor. The instructor places the problem page under the document camera which transmits it to the TV monitors, reads out the problem contents, writes on the page 'given' data and 'to be found' unknowns, and then proceeds to solve the problem in steps, drawing figures wherever necessary. Neat sketches drawn with felt tipped color pens and drafting aids will enhance the quality of the material presented. It is the author's experience that students learn better and faster by participating in solving practice problems in class with the instructor. Problems for illustration purposes were selected based on graded difficulty and the available class time for their completion. In order to accommodate slower students hand written copies of the solutions may be made available before the class begins. In the present case a majority of students preferred to work out the solutions with the instructor. The last few minutes of the session may be utilized to summarize the day's work and introduce next topic.

Assessment

Students were assessed using a combination of traditional tools such as home work and quizzes (20% toward the final grade), three class tests (60%) and a final comprehensive examination (20%). At the end of the semester the students evaluated[(2)] the instructor and the course with the following results: Present case: **On-campus:** 4.42 (out of a maximum of 5), **Off-campus**: 3.77, A traditional class: **On-campus**: 4.09 .

[(1)] An alternative to the smart board is to use a (traditional) portable 'black board'. The instructor's camera may be programmed to record and transmit the instructor's image along with what he/she is

writing on the board. However, in the present case, while the quality of the human image was reasonably good, the written material was too small and too light to read on the TV monitors due to the camera being 15-20 feet away from the board. A better camera with appropriately designed lighting may resolve this problem.

[2] The author used an '*End of the Semester Course Evaluation Form'* that was developed for all courses in the M.E. Department consisting of fifteen (15) Learning Outcomes based on the ABET Criterion 3. Six (6) of these (judged to be relevant to the current course) were selected for scoring.

Merits

The multimedia distance learning approach discussed in this paper has several merits. First, it provides a method of offering an engineering course to students who may not be able to take the course in-person at the main campus site. Secondly, it overcomes some of the difficulties (such as creating complicated figures), associated with the web-based methods[1] that have been successfully used for purely descriptive non-technical courses in Business Management, Humanities and Social Sciences. Thirdly, the multimedia approach illustrates an effective way of combining several currently available instructional tools to offer, in the distance learning mode, technical courses that are not easily amenable to web-based on-line teaching. Fourth, it illustrates an economical and effective way of combining traditional classroom teaching facilities with modern information technology to teach courses, engineering or otherwise, to multiple groups of students who are scattered over widely distributed areas. The differential cost factor is highly favorable to increasing the number of off-campus receiving stations. Fifth, once they are fully prepared and ready, recorded video tapes and supplementary material discussed above, can be used to offer basic courses such as Statics, Dynamics, Mechanics of Materials etc., during regular as well as off-seasons to accommodate students who may need to catch up with these courses to maintain satisfactory progress in their academic work. In fact it has been done at the author's institution with success and may be repeated during the forthcoming semesters if the need arises. Sixth, in traditionally large enrollment courses such as those listed above, multimedia courses developed on the lines discussed in this paper may be offered as an alternative mode of accelerated learning or independent study for the academically gifted or highly motivated students. Based on the feed back from his students, the author believes that there will always be some students who would prefer to take at least a few basic courses offered using this method.

Limitations

As with any emerging technology, distance learning is going through teething problems at present. It is very likely, however, that in course of time, experience and technical developments will address and resolve a majority of these problems. A few of the concerns discussed in this paper are being addressed already by the on-going developments in video recording, transmission, and display technologies. However in order to make informed decisions, those of us who are involved in distance learning should be aware of the following limitations. First, it is usually very difficult to estimate in advance, the number of students who will sign up for this type of courses, especially at off-campus locations. A reliable market survey to determine the level of demand supported by an in-depth cost analysis is imperative for its economic success. Secondly, the distance learning method discussed in this paper is not suitable for all students. The author is aware

of a case where some mathematics courses were offered at his college as purely web-based on-line courses with no other alternative classes and at the end of the semester the drop out rate is reported to have reached as high as fifty percent. Among a

(1) Sometime back the author attempted to develop a 'web-based' Dynamics course (with WebCT^R – Web Course Tools)-intended as an on-line course - but was unsuccessful because of the technical difficulties and the enormous amount of time and effort needed to create quality figures, free body diagrams, formulas, and equations that are so essential to teach Dynamics.

typical group of college students there will always be some who will neither accept nor benefit from this mode of teaching due to their personality traits and study habits. It is therefore imperative that they be provided with an option to learn in a traditional classroom environment. Thirdly, substantial financial resources, technical competency and administrative support are essential for the successful and satisfactory operation of the distance learning program discussed in this paper. The electronic equipment should be continuously up-dated to improve the quality of delivery to insure student satisfaction and retention. Fourth, dedication, interest and hard work on the part of the instructor will be crucial for the success of the program. In order to produce a satisfactory program, it is estimated that (first time the course is offered) the instructor needs to devote about four hours for each hour of classroom presentation. Once the system is fully operational, the time could be reduced substantially.

Conclusions

An interactive multimedia distance learning program was developed and used to teach a course on Dynamics to a traditional class and groups of students located at different sites. The method described in this paper is particularly suited for large-enrolment mechanics courses such as Statics, Dynamics, Mechanics of Materials, and Fluid Mechanics, which are normally taught with multiple sections in many colleges and universities. Evidence seems to suggest that a notable fraction of the student population (especially those with high motivation, self discipline and good study habits) will welcome an alternative to the traditional method of classroom instruction. Since access to a course is as simple as providing a phone connection, a TV monitor and a camera, this method offers an effective way to achieve economy of scale in teaching large-enrollment courses once the system is set up and running. Recorded video tapes and the supplementary material produced during the sessions may be utilized (over and over again if necessary), to offer the course to non-traditional students, such as those who may not be able to attend regular classes or those with special needs, at a time and place of their choice. Finally the distance learning mode may be the only financially viable mode of offering some courses to certain students.

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Biographical Information

Dr. Govind Puttaiah is a Professor and the Chair of Mechanical Engineering at West Virginia University Institute of Technology. He received his Ph.D. degree in Engineering Mechanics from Penn State University. His recent scholarly activities include M.E. Laboratory Manuals, Handbooks on Mechanical Engineering & Academic Advising and Workshop on Professional Ethics. He is a member of the ASEE and ASME.
