A CD-ROM Based Laboratory in Fluid Mechanics

Gary R. Crossman
Old Dominion University, Norfolk, Virginia 23529

Abstract

An existing junior level laboratory course, MET 335, Fluid Mechanics Laboratory, was modified to be presented in a digitally videotaped format and subsequently converted to CD-ROM. The additional presentation method was developed to accommodate distance-learning students who have limited or no access to campus facilities. All students enrolled in the course have completed an associate degree in mechanical engineering technology, civil engineering technology, or a closely related area and, therefore, have completed basic courses in their discipline taught in a traditional laboratory environment. Moreover, most of the students are working in industry as engineering technicians and have sufficient maturity to understand the practical aspects of their observations. Students are also required to be concurrently enrolled in or have completed the lecture course MET 330, Fluid Mechanics, or an equivalent course from another institution.

The major educational objectives of this laboratory course are to have students verify the basic engineering principles of fluid mechanics and understand the practical operation of various fluid devices and the measurement of fluid properties. Students are also expected to improve their skills in recording, presenting and discussing observations and overall report writing. All experiments parallel those offered in the more traditional course on campus and include experiments on viscosity measurement, orifice and venturi meters, centrifugal pumps, momentum forces and pipe friction. The CD-ROM shows the instructor setting up the equipment in accordance with diagrams provided to the students. The equipment is then operated by the instructor and a student assistant in a step-by-step fashion with the camera zooming in on each instrument reading and at other appropriate times. The student watching the video records the data in the same fashion as if he or she were the recording member at a group performing the test in the actual laboratory. The student then analyzes the data, prepares performance calculations and curves and submits comprehensive reports to the instructor.

A comprehensive final examination testing the expected outcomes of the course is being developed and implemented. Performance studies thus far indicate that the video-taped laboratory is an effective method of teaching this laboratory course.

I. Introduction

Old Dominion University has been involved in distance education for more than 15 years. The Department of Engineering Technology, through its civil, electrical and mechanical engineering technology programs offers upper level programs to more than 50 remote students in Virginia

and selected out-of-state sites via the university's TELETECHNET (interactive television) system. Lecture courses are offered in synchronous a two-way audio, one-way video format. The University has developed extensive facilities (an entire building is dedicated to off-campus delivery) for the delivery of these courses. Typically the faculty member teaches from a highly mediated classroom with approximately 20 local, on campus students and from one to ten students at at least 20 of the 50 sites. The mediated classroom allows the instructor to use a white board, a writing tablet, a computer (power point) presentation, and audio and video tapes. The University also equips and controls the operation of the down link sites, with a full-time university employee (site director) at each site. The course is taught in exactly the same manner as on-campus-only courses, with the same expectations. The experience of the administration and faculty and feedback from students, including regularly scheduled evaluation of individual courses, indicate that the method of delivery is successful. Old Dominion University is recognized as a national leader in distance education. Details of the TELETECHNET system have been presented in other papers and presentations.[1]

The goal of engineering technology education is to provide a practical, applied approach in the teaching of engineering and technical topics. It has traditionally included substantial "hands on" laboratory experiences to enhance this method of education. At Old Dominion University several laboratory courses are included in the upper level engineering technology curricula and, as its distance education program developed, the ability of remote students to access these components needed to be addressed. Initially, students attended traditional summer laboratory courses on the main campus taught in the laboratory facilities. Rather than doing one laboratory experiment per week for 12 weeks, as scheduled in the regular semester, students attend three or four alternate Saturdays in the summer for eight hours each, doing three or four experiments each session. This method continues and even many on-campus students prefer these laboratory classes to those that are weekly. Because of the remoteness of some students (up to seven hours travel to the main campus), the university developed another laboratory site at a community college in the western part of the state, at which some of the laboratory courses are taught by regular engineering technology faculty in the three to four Saturday format. The College of Engineering and Technology with the help of a National Science Foundation Grant has also developed a mobile laboratory (trailer) which will be activated at remote sites for use in the summer of 2001. This mobile laboratory was completed in 1998 but due to logistical considerations has not been fully utilized until now. Other papers [2, 3] have addressed the development of this mobile laboratory and the general teaching of laboratory courses to remote students.

2. Video-Based Laboratories

Most of the remote students in the engineering technology programs at Old Dominion University reside in Virginia. However, because of work and family constraints, it has been difficult for some to attend laboratory classes in the summer Saturday format, even at the remote laboratory site. That format also restricts the students to taking the laboratory courses in the summer only. In addition, the university is expanding the delivery of its programs outside Virginia to sites as far away as Bremerton, Washington. These logistical situations coupled with the advances in communication capabilities prompted the engineering technology programs to investigate other means of delivering laboratory courses to remote students.[4] At Old Dominion University, two

laboratory courses are currently being taught interactively using the web, one in Electrical Engineering Technology and the other in Mechanical Engineering Technology. Two laboratory courses, one in Electric Engineering Technology and one in Civil Engineering Technology are presented in VHS video-taped format. One of these, the Materials Testing Laboratory was discussed at the 2000 ASEE Annual Conference.[5] In the spring of 2000, a video-based Fluid Mechanics laboratory courses using CD-ROM's was developed and offered. Aspects of the development and presentation of that course are discussed below.

3. Course Development

Fluid Mechanics Laboratory, MET 335, is a required laboratory course in the Mechanical Engineering Technology and Civil Engineering Technology curricula that complements the lecture course Fluid Mechanics, MET 330. It may be taken concurrently with the lecture or in a subsequent semester. Its purpose is to demonstrate the principles learned in the lecture course, acquaint the students with experimental procedures and set-ups, including instrumentation, and teach the student and assess the students' ability to present and discuss experimental data. The laboratory course consists of individual experiments with appropriate student reports required for each. The traditional course consists of ten weekly experiments performed in the laboratory facility with reports due the following week. Students usually work in groups of four. In a typical 14-week semester, the first week is utilized by the instructor to review the goals and objectives of the course and the format and expectations of reports. Instructions for each experiment are given to the students at this time. Individual instructions are reviewed for each experiment just prior to the weekly experiments. The instructor is available in the laboratory for questions and to insure safety procedures.

The format of this video-based laboratory was not originally intended to be on CD-ROM. Experience with the previously developed VHS video-based laboratories required the video tapes to be sent to each student, and then required their return to the instructor at the end of the course. Over 200 individual tapes were used. To overcome this double exchange of video tapes, the original intent for this course was to digitally record each experiment and install them on a course website for downloading by each student. After all laboratory experiments were recorded and installed on the web it was found that because of the variation in students' access to computer hardware and software, the time for a student to download each experiment ranged from one hour to 16 hours, with some students indicating they could not download the experiments at all. To facilitate the students' access to the taped experiments, each was put on a CD-ROM and sent to the Old Dominion University directors at appropriate TELETECHNET sites. Students would then check out the CD-ROM's and download to their computer or disk. Given this scenario, it would appear that VHS video tapes would have been at least an equal choice at this time, but the CD-ROM format may provide the opportunity to again post the experiments on the web for future courses, as student's computer capabilities increase and the formatting of the experiments on the web is improved.

The department recorded the laboratory experiments in the traditional on-campus laboratory. Normally, four students would perform the experiment after receiving initial instructions. However, it was felt that a group of four students might prove unwieldy and block the view of the cameras used to record the experiments. It was decided to utilize the instructor and one

student to perform the experiments according to the written procedures. The experiments were set up to facilitate the video taping, near a blackboard to record data as is done in the traditional class. After an overall introduction to the experiment each procedural step on the laboratory handout instructions was read by the instructor and carried out by the instructor and the student. Significant measurements and other data were recorded on the blackboard as observed, with a final view of all data at the end of the experiment. Because the instructor was involved in the performance of the experiment and would not be available to direct questions when the students were viewing the tape, the instructor tried to anticipate as many questions and clarifications as possible, based on his 30 years of experience with the traditional course. All ten experiments were carried out in this manner.

4. Implementation and Communication

The video-based format of the course was first implemented in the spring of 2000 with 28 registered students. As with other distance learning courses, all students were provided with Old Dominion University email addresses. The email addresses of the class roster was provided to the instructor for communication throughout the course. The course also had its own website for the initial downloading of the experiments before it was decided to present them on CD-ROM. This website was also used by the instructor to provide the course syllabus and updates to the students. An initial email was sent to the students attaching the instructions for report writing and the instructional handout material for the first two experiments. The same instructions for report writing distributed to students in the live on-campus course were sent to the off-campus students. Since this set of instructions is normally discussed with students in the on-campus course with amplification of several points by the instructor, a second set of report writing instructions was also sent with these amplifications highlighted. CD-ROM's for the first two experiments were sent to the appropriate sites for copying by the individual students at about the same time that the instructions were sent. Students were instructed to read the instructions before viewing the video. Instructional material and additional CD-ROM's for two experiments were sent to students at approximately two week intervals until all ten experiments had been delivered. Generally students were given two weeks to complete their reports on the two experiments and submit them to the site directors. A courier service then delivered them to the instructor, who graded them and returned them to the students through the appropriate site in approximately one week. Thus students had appropriate feedback to assist in the writing of subsequent reports. Because several students had some initial problem in getting and copying the CD's from some sites, the instructor maintained a flexible deadline schedule as problems were ironed out. Schedule updates were provided via email and the course website.

Communication between the students and instructor is a particularly important consideration in a course such as this. As with an on-campus laboratory course, students are going to have questions about the course and individual experiments, even more with a video-taped format. As previously mentioned, the instructor communicated with the students via email and the course website. The students communicated with the instructor via email, telephone, and fax. The instructor remained particularly attuned to the students questions and possible need for clarification and tried to respond as quickly as possible.

5. Evaluation and Future Considerations

This laboratory course follows several others in the engineering technology programs which have been made available to remote students in Old Dominion University's distance learning system. Those courses are being continually evaluated to ensure that they accomplish course goals and are comparable to those taught in the traditional mode. Some results of those evaluations have been previously presented[5]. The first offering of this fluid mechanics laboratory course in CD-ROM format was deemed to be successful. No specialized evaluation of this course format was initiated in this first offering, only the traditional student course evaluations that are required in all courses. In addition, the instructor took particular note of student questions and comments during and after completion of the course. Feedback from the initial presentation of this course in the video format indicates that the students in the course were generally pleased with the course. They generally felt that the instructions provided were adequate, particularly with the availability of the instructor to answer questions promptly. They also felt that most of the videos did a reasonably good job at demonstrating the procedure and the process of data collection. One problem that surfaced in two experiments was that two cameras were sometimes used which caused a gap in the audio and video parts of the presentation. They were particularly pleased with the availability of such a course to allow them not to have to travel several hours to the main campus. The most frustrating aspects of taking this course were the timely access to the CD's from the sites that had several students in the class and some difficulty in down loading the CD's into their computers. This feedback has also provided the following considerations for improvement of the course and subsequent laboratory courses that may be presented in a similar format.

(a) Mechanisms to provide for comparison of this delivery method to traditional delivery of the course must be developed. This must include the review and updating of course goals and objectives toward continuous improvement of both delivery methods of the course. The course is again being taught in CD-ROM format in the spring of 2001, alongside a traditionally delivered course. Both classes will be given the same final exam (not usually done in a laboratory course) addressing the experiments performed and not merely knowledge obtained from the lecture course. Also, an additional student course evaluation form addressing the format of the course is being developed for required student input at the completion of the course.

(b) It is still desirable to be able to post the course experiments on the internet for easy downloading by students to replace the CD-ROM distribution, but formatting of the course for downloading from the website needs improvement. Consideration will be given to the minimal capabilities of the hardware and software access available to students.

(c) The video presentation of some of the experiments also need improvement, with particular emphasis on ensuring proper meshing of the audio and video.

(d) The traditionally delivered course utilizes handout instructions that have been developed and regularly updated over a 30 year period. These handout instructions have been adequate for that class because the instructor is going over those instructions face to face and the students can, and do, ask relevant questions about the procedures during this encounter with the

instructor. The instructor is also in the laboratory during the experiments for additional questions. With the video-taped delivery method, students do not have this opportunity; therefore, more questions arise when they are assimilating the data and writing their report. This has prompted the instructor to review the handout instructions and include more information. These improved instructions will be distributed to students in both the traditional course and the video based courses.

It is anticipated that results of these considerations coupled with information obtained from evaluations of the parallel courses being taught in the spring of 2001 will provide significant content to be presented at future ASEE and other professional conferences.

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GARY CROSSMAN

Gary Crossman is an Associate Professor of Engineering Technology at Old Dominion University in Norfolk, Virginia. He also serves as Director of the Mechanical Engineering Technology program. Professor Crossman received his B.S. degree from the U.S. Merchant Marine Academy in 1964 and his M.E. degree in 1970 from Old Dominion University, where he has served on the faculty for over 30 years. Professor Crossman is a Fellow of ASEE and the recipient of the James H. McGraw Award for leadership in engineering technology education.