A CD-ROM BASED LABORATORY IN FLUID MECHANICS
PART II: COURSE ASSESSMENT AND EVALUATION

Gary R. Crossman¹, and Tarek M. Abdel-Salam²

Abstract – This paper evaluates an existing distance learning fluid mechanics laboratory, MET 335 and compares it to the on-campus version of the course. The course was developed at Old Dominion University and offered for the first time in the Spring of 2000 as a video-based laboratory on CD-ROM.

The overall assessment of the distance learning laboratory is based on a detailed analysis of the different components of student evaluation for the course. The analysis of these results is in turn compared with similar analysis of other existing on-campus laboratory courses taught by the same instructor. The assessment of the distance learning laboratory course shows that the video-taped CD-ROM laboratory is an effective way of teaching this laboratory course.

Index Terms – CD-ROM Based Laboratory, Course Evaluation, Distance Learning.

INTRODUCTION

In order to provide college level education to a wider population, particularly those in areas remote to the main campus, distance learning course have become an important and sometimes a crucial way of teaching. Old Dominion University has been involved in distance education for more than 15 years. The Department of Engineering Technology offers upper level programs to more than 50 remote sites in Virginia and selected out-of-state sites via the university’s interactive television system (TELETECHNET). The College of Engineering and Technology also has a mobile (trailer) thermo-fluids laboratory for providing access to distance students at some remote locations [1]-[2].

The method of conducting distance learning courses, especially laboratory courses, is significantly different from on-campus courses. Two major differences between an on-campus and distance learning (pretaped) laboratory course are (1) the inability of distance learning student to gain “hands-on” experience and (2) the lack of an on-site instructor to answer questions during laboratory experiments. For the on-campus course the instructor assists the students during the experiments and answers relevant questions. Distance learning students do not have this opportunity and must rely on pre-taped and long distance communication with the instructor. For this and other reasons, monitoring and evaluating such courses are essential to assess, modify and improve the overall quality in order to help the student understand and evaluate the experiments effectively. To this point, two major parameters have been used to evaluate the distance laboratory learning courses and compare them to on campus versions of the same course. These parameters are student performance on written lab report assignments, and performance on final exams [3]-[5].

BACKGROUND

Previous work describes in detail the development of distance learning at Old Dominion University and the fluid mechanics laboratory course[2]-[5]. In the late 1980’s, ODU began offering the upper level of its TAC of ABET accredited engineering technology programs to one site in Virginia, expanding to three sites by 1992. Old Dominion University is located on the eastern seaboard in Norfolk, Virginia. The first site was in Roanoke, Virginia 250 miles away. At that time students were required to attend the main campus on weekends in the summer to complete required laboratory courses. Faculty and equipment were also transported to the site in Roanoke to teach some laboratory courses there. Utilizing a National Science Foundation grant, the university developed a mobile laboratory to be utilized at the three sites. At the same time, ODU expanded its distance learning delivery which now consists of over 50 sites in Virginia, most located at Virginia community colleges. The method of delivery for lecture courses is interactive satellite video with video-streaming available to out-of-state students.

The large expansion of the TELETECHNET system investigated the development of video based laboratories. These CD-ROM’s (or video tapes) would be produced with the same realism as in the on-campus laboratories. The experiments in the fluid mechanics laboratory were video recorded with the instructor and one student performing the experiments and writing the results on the blackboard, just as in the on campus laboratory course. Of course, there is always a question of whether a non-hands-on experiment could be as effective as actually performing the experiment. It was felt that these courses could be as effective for two primary reasons: (1) all of the distance learning students attained there associate degrees (or equivalent) at their local community college which required hands-on laboratories in physics, chemistry and lower level technical courses, and

¹Gary Crossman, Old Dominion University, Program Director, Mechanical Engineering Technology, Norfolk, VA 23529, gcrossma@odu.edu
²Tarek Abdel-Salam, Old Dominion University, Mechanical Engineering Technology, Norfolk, VA 23529, abdel@mem.odu.edu
(2) almost all of the students were working in an industrial
environment which afforded them opportunities to work
with equipment and in many cases be proficient in its
operation. Also, many students are more mature and have
been working in industry for a substantial period.

**COURSE DESCRIPTION AND DELIVERY**

Fluid Mechanics Laboratory, MET 335, is a required course
in the Mechanical Engineering Technology and Civil
Engineering Technology curricula that complements the
lecture course MET 330, Fluid Mechanics which is a pre-or-
co-requisite. 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 CD-ROM Distance Learning Course

The major educational objectives of this course are to have
students verify the basic engineering principles of fluid
mechanics and understand the practical operation of various
fluid devices and measurement of fluid properties.

CD’s are given to the students during the semester
containing eight different experiments. Each CD-ROM has
sufficient information about the experiment and a video file
showing the instructor and a student conducting the
experiment just as a group of students would do in an on
campus laboratory, and taking data, step-by-step, as shown
in Figure 1. Also, handout sets are emailed to the students,
which include instructions for report writing, data plotting
and analysis and a complete set of instructions for
conducting each experiment. Figure 2 shows the
communication road map between the instructor and the
distance learning students. In the first week, the first set (two
CD’s) of experiments and the instructions for report writing
are sent to the students. These instructions have additional
information that is not given to the on-campus students since
the instructor will not discuss it with them as in the regular
class. The course also has its own website for initial
downloading of the experimental procedures and for course
updates. However, a high level of student-instructor
interaction is maintained. The students communicate with
the instructor via email, telephone and fax. The instructor
remains particularly attuned to the students questions and
possible need for clarification and responds as quickly as
possible. The instructor receives comprehensive reports of
the first two experiments from the students after two weeks
to grade and return with the next set of two experiments
within one week. At this stage the students have appropriate
feedback to assist them in the writing of the subsequent
reports. This process is repeated two more times before
giving the final exam to the students in the last week of the

More information about this course can be found in Ref.[5].
The Traditional On-Campus Course

The method of conducting the traditional on-campus course is described in this section since it will be used in the assessment process of the CD-ROM course. The course consists of eight weekly experiments performed in the laboratory facility with reports due the following week. Students usually work in groups of four, however, each student must submit a separate report for each experiment. Usually reports are graded and returned to the students with written comments at the beginning of the next class. 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. A packet of instructions for each experiment is given to the students at this time along with a laboratory experiment schedule. 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.

Course Assessment Criteria

The overall assessment of the distance learning laboratory is based on a detailed analysis of the different components of student evaluation for the course (various reports submitted during the semester and the final exam). The analysis of these results is in turn compared with a similar analysis of the same existing on-campus laboratory courses taught by the same instructor. For robustness considerations, results are further analyzed for three different semesters for both distance learning and on-campus students.

Students submit eight laboratory reports for the eight experiments. All reports have the same format and structure. The handout material for each laboratory experiment includes the purpose or objectives of the experiment, theoretical considerations, a detailed description of the apparatus and the procedure to follow (on campus) or that was followed (video). Students are required to perform the experiment as a group (on campus) or observe the performance of the experiment (video) and present and discuss results. The presentation of results will generally include tables of recorded and calculated data, sample calculations and computer generated graphs. The discussion will contain the interpretation of the results, usually graphs, and conclusions. The reports are then graded on organization, neatness, accuracy of results, completeness and demonstration of understanding, grammar, and organization of thought in the discussion.

The final exam is a comprehensive closed book exam and is given to the students at the end of the semester. The exam consists of twenty multiple choice questions. Four of these questions concern the mechanics of report writing and data interpretation. The other sixteen questions consist of two questions each about the eight experiments performed. Care is taken to ensure these questions are taken from the lab experiment and are not questions that could readily be answered from knowledge obtained from the pre-or-co-requisite course, MET 330, Fluid Mechanics. Students need to study and review only the laboratory reports and the given handouts and recall their laboratory experiences to answer this exam completely.

RESULTS AND DISCUSSION

In order to address TAC of ABET criteria all courses in the engineering technology programs at Old Dominion University have their own course objectives and measurable outcomes. Courses are assessed on a regular basis to determine if objectives are being met and/or if changes in the courses are necessary. Because the Mechanical Engineering Technology program teaches all of its upper level courses both in the on-campus and distance learning format, and the course objectives for the on campus and distance courses are the same, comparison of these courses is necessary to insure that the distance courses meet course objectives as well as those on campus. This is particularly true for laboratory courses, to ensure that students viewing the laboratory experiments on CD-ROM’s receive a comparable experience to those actually doing the experiment in the laboratory.

The evaluation of the on campus and distance learning Fluid Mechanics Laboratory courses led to several
comparisons of the two courses. First, average grades and distribution of grades on the final examinations for on campus and distance learning courses for three semesters were compared. In addition, comparisons of each final examination question were performed. The standard deviation of exam grades was also calculated for the three semesters in which data has been collected.

Comparison of the first five questions on the final examination are shown in Figure 3. It is clear that more than 80 percent of both classes consistently answered all but question four correctly, and there is generally less than ten percent difference in the two classes for these questions. Question four shows an average of about seventy percent with a range from fifty to eighty percent, and the largest difference of thirty percent for any questions as indicated in the first bar graph. From the bar graph shown, there does not appear to be any trend of difference between the two classes. In fact, for two semesters the on campus students perform better on question one while in the other semester the distance learning students perform better. Just the opposite is true for question two. This was typical, not only for the five questions presented, but for all twenty questions. It was thus concluded that performance on the final exam was primarily dependent on individual students, regardless whether they were on campus or distance learning.

Figure 4 shows a comparison of the mean final examination scores for the on campus and distance learning courses for the three semesters for which data was observed. In Spring, 2001, the averages were essentially the same at 72. In Spring, 2002, distance learning students scored about ten points higher, 82 compared to 72, and in Fall, 2002, on campus students scored five points higher, 80 compared to 75. The three semester average for the on campus students is 74 and that for the distance learning students is 76.5, a small difference. Again, no pattern was concluded. Figure 5 shows the comparison of standard deviation for both courses for the three semesters. In the first two semesters, Spring, 2001, and Spring, 2002, the standard deviation for on campus students is slightly higher than for distance learning students, both in the 12-14 range. However, in Fall, 2002, the standard deviation of the distance learning students was over 15, more than double that of the on campus students. However, the average standard deviation for the on campus students was 13.4 and that for the distance learning students was 13.6, essentially the same. Again it is felt that there is no particular trend, and that performance is mostly dependent on individual students, and not the method by which they receive the class. However, because of the large difference in standard deviation in Fall, 2002, particular attention will be paid to this area on future assessments.

The correlation between student performance on final examinations and their average grades on laboratory reports for Fall, 2002, is demonstrated in Figure 6. Each graph, the first for distance learning students and the second for on campus students, plots final exam scores for individual students starting with the lowest score and ending with the highest. The average of that student’s grades on the eight laboratory reports is also plotted in the same order. The range of grades for the final exams for the distance learning students is 40 to 88 and for on-campus students, 52 to 88. The range of average laboratory report grades for the distance learning students is 56 to 96, and that for the on campus students, 60 to 96. In general, for both graphs the average lab report scores follows the established increasing
trend, but there is significant scattering. In other words, those students with the lower final exam scores do not necessarily have the lower average lab report grades. The scattering was substantially more for the on campus students. In addition, the trend line for average lab report grades for the distance learning students was substantially higher than the trend line for final exam scores, while the trend line for average lab report grades for the on campus students was only slightly higher.

![FIGURE 4](image)

**FIGURE 4**
**MEAN EXAMINATION SCORES OF THE FINAL EXAMS**

![FIGURE 5](image)

**FIGURE 5**
**STANDARD DEVIATION OF THE FINAL EXAMS**

**CONCLUSION**

Based on three semesters of data comparing on campus and distance learning Fluid Mechanics Laboratory courses it is apparent that the performance of distance learning students in these courses is equal to the performance of on campus students, both in the writing of laboratory reports and in scoring on final examinations. The average age of on-campus students is approximately 26, with most students working full or part-time. The average age of distance learning students is closer to 30, with almost all students working full-time. This slightly higher level of maturity may contribute to the comparable performance on video based instruction in laboratories. Further investigation will be made concerning demographics. It is also demonstrated by the results of these assessment methods that course objectives are met by either delivery method.
REFERENCES


