

1997

# Assessment Methods for Virtual Laboratories in Civil Engineering Technology

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## Repository Citation

Considine, Carol L. and Lewis, Vernon W. Jr., "Assessment Methods for Virtual Laboratories in Civil Engineering Technology" (1997). *Engineering Technology Faculty Publications*. 67.

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## Original Publication Citation

Considine, C. L., & Lewis Jr, V. W. (2001). *Assessment methods for virtual laboratories in civil engineering technology*. Paper presented at the 2001 ASEE Annual Conference & Exposition, Albuquerque, New Mexico.

## **Assessment Methods for Virtual Laboratories in Civil Engineering Technology**

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### **Abstract**

Old Dominion University has developed an extensive distance learning system that includes 40 remote sites. A majority of the sites are located at community colleges. There are 30 sites in Virginia, three sites in North Carolina, one site in Washington State and one site in Arizona. In addition, there are four sites at Higher Education Centers in Virginia and one site at a local industrial facility.

The Civil Engineering Technology curriculum requires three laboratory courses, which are a challenge in the distance learning environment because of the lack of laboratory equipment and computers at the broadcast sites. The three courses include a laboratory in materials testing, a laboratory in soils testing and a laboratory using commercially available structural analysis and design software. In an effort to better evaluate the performance of students in the distant classes in comparison to that of the students in the on-site classes, changes have been implemented for these courses. This paper discusses concerns with this process and provides a summary of our efforts to improve assessment for these courses.

### **Introduction**

Old Dominion University is one of the largest degreed distance education programs in the United States. The University is committed to providing distance learning students the same educational opportunities that are available to on-site students. The Civil Engineering Technology (CET) curriculum is one of the degreed programs that are offered through the Old Dominion University Distant Learning (TELETECHNET) system.

Distance-learning students typically earn an associate degree at their local community colleges and then attend Old Dominion University through the TELETECHNET system to earn their baccalaureate degree in CET. The typical lecture courses are delivered in synchronous mode, and the students have great success in this manner. There are, however, three laboratory courses in the CET curriculum: CET 345, Testing & Inspection of Construction Materials, CET 341, Soils Testing and Inspection, and CET 400, Computer Applications in Structures, that do not fit into the synchronous delivery format. CET 341 and CET 345 require laboratory equipment to perform the experiments, and CET 400 requires that students have access to a computer. In most instances, neither the laboratory equipment nor the computers for students are available at the broadcast sites.

In summer 1998, CET 345, Testing and Inspection of Construction Materials, was videotaped in the laboratory with all discussion, measurements and testing recorded. These videotapes were used successfully in fall 1998 and summers 1999 and 2000 for the asynchronous delivery of the laboratory for the distant students. The success of the asynchronous delivery of the CET 345 laboratory class was documented in the paper titled *Experiences With A Virtual Laboratory Class in Materials Testing For Civil Engineering Technology*.<sup>[1]</sup> The results indicated that the average grade for the videotaped classes was higher than the average grade for the on-site classes.

Based upon the success of the CET 345 videotaped laboratory, it was determined that CET 341 and CET 400 laboratory classes could be developed in a similar asynchronous format. CET 400 was first delivered in the asynchronous format spring 2000, and CET 341 was taped in summer 2000 with the first delivery to distant students scheduled for spring 2001.

### **Assessment and Objectives**

The original assessment criterion for CET 345 was the evaluation of students' reports. This evaluation method has been determined to be a meaningful way to assess the students' performance.<sup>[2]</sup> Based upon this assessment method, results for the CET 345 virtual laboratory course indicated that the distant learning students were achieving equivalent or better learning outcomes than on-site students.

However, during a recent TAC of ABET visit, it was suggested that additional assessment data be gathered to verify the equivalency of laboratories delivered in the asynchronous format to those delivered on-site. In response to this suggestion, instructional objectives were added to each laboratory experiment, and a written final examination based on those objectives was added to the course. The results from the exam provide another means of measuring the equivalency of the distant and on-site laboratories.

In addition, although there were course objectives for each laboratory course, a formal assessment process for each of the objectives had not been established. In an effort to address this issue, an assessment process was developed for each of the laboratory course objectives.

### **Hands-on Experience**

While developing the assessment process for the course objectives, it became apparent that some objectives had to be modified. One of the more significant modifications involved the objective of providing "hands on experience" in CET 345 and CET 341. Since the distant students would not be touching the specimens or operating the equipment, it would be impossible for them to meet this objective. Upon further evaluation of the on-site labs, it became clear that some of the on-site students probably did not meet this objective either. Lack of "hands on experience" is not a concern for CET 400 because students are required to purchase a copy of the computer applications software and use it in their laboratory assignments.

In the on-site laboratory sessions, students are divided into groups with approximately four members each. Students take the role of equipment operator, observer, recorder or calculator

with the roles to be rotated weekly so that everyone gets a chance to function in different roles. During the weeks that the students take the roles of observer, recorder and calculator, they do not touch or operate the equipment. However, they are still meeting the requirements of the laboratory class and gaining practical experience about how the materials behave.

In this regard, the distant students have an advantage over the on-site students because they have the opportunity to watch the experiments repeatedly until they understand and document the materials behavior. The on-site students, however, have only one opportunity to record and document the material behavior in their laboratory experiments. The distant students also have an advantage because they have the opportunity to correct data collection errors by repeatedly watching the experiment.

An argument might be made that the purpose of a laboratory experiment is for students to “learn by doing”. In CET 341 and 345, the students are required to participate in the experiments by recording and analyzing data, which is then presented in a technical report format. The report produced is the essence of the laboratory experiment and serves as an indicator of the student’s ability to collect and analyze data and present it in an acceptable engineering report format. In CET 400, students are required to work independently with the software.

Engineering technology programs are frequently promoted as providing students with “hands on experience”. However, even a student who chooses a materials testing career path will probably find that equipment and methods used in the professional laboratory are different from those used in the educational laboratories. Any methods or procedures used previously will have to be modified to the equipment available. In addition, material testing firms are testing volumes of samples, rather than two or three, in a production setting. A better description of the technology programs is that they are applied programs, which prepare students to enter industry with the ability to understand how testing data is obtained, analyze the data and use the results to perform additional engineering analysis. The asynchronous delivery of these CET laboratories to off-campus sites does not impede or detract from students’ ability to perform those tasks.

### **CET Laboratory Courses**

**CET 345 Testing and Inspection of Construction Materials:** a typical engineering materials testing laboratory class, which introduces both destructive and non-destructive testing methods to the students. Destructive tests are performed on steel, wood and concrete material samples.

#### *Distance Education Delivery Method*

Students receive videotapes of each of the experiments. The videotapes are prepared so that the viewer becomes an observer of the actual process. The student records data as it is produced on the tape and generates the appropriate report results as he would had he been in attendance. Students watch one tape weekly and are required to submit lab reports according to the schedule published in the course syllabus.

The course syllabus is posted on the class web page so students can access it easily, and most correspondence between student and professor is via e-mail. Site directors deliver videotapes to

the students at their distant sites, and reports are submitted to the instructor through the TELETECHNET delivery system to verify that they are submitted as required.

*Assessment Criteria*

Tables 1 and 2 below provide the grade assessment criteria for CET 345 offered prior to fall 2000 and fall 2000 and beyond, respectively. As indicated earlier, it was decided that a final exam was necessary to provide an additional assessment tool to determine if both the on-site and distant delivery methods are equivalent. The written final exam is based upon the laboratory instructional objectives provided at the beginning of each lab session for both the on-site and distant delivery methods.

TABLE 1

CET 345 Testing and Inspection of Construction Materials – Grade assessment criteria prior to fall 2000		
Item	On-site delivery	Distant delivery
Preparatory Assignment or Quiz	10%	0%
Lab Reports	90%	100%
Final Exam	0%	0%

TABLE 2

CET 345 Testing and Inspection of Construction Materials – Current grade assessment criteria fall 2000 and beyond		
Item	On-site delivery	Distant delivery
Preparatory Assignment or Quiz	10%	0%
Lab Reports	70%	80%
Final Exam	20%	20%

Upon review of Table 2, it should be noted that the grade determination method for both the on-site and distant students is not identical. The on-site students are required to perform preparatory assignments or take quizzes because they must be prepared to perform the experiments. They are responsible for equipment operation and they only get one chance to perform the experiment correctly. If they do not perform the experiment properly, they may not get satisfactory data to complete their lab reports. The distant students have an advantage in that they can view the videotapes repeatedly to get the data from an experiment that has been performed properly.

It has been the authors' experience that if there is not a grade value applied to the preparatory assignment, the on-site students come to the laboratory session unprepared. This might be a factor in the current performance comparisons between distant and on-site students. Many of the on-site students do not perform the preparatory assignments even with the grade penalty, which would lower the on-site students' average scores. This impact will be evaluated in the future.

### *Laboratory Status*

The on-site version of this laboratory was offered in fall 2000 using the grade determination method outlined above. The virtual laboratory will not be offered again until summer 2001. At that time, data will be compiled and evaluated to verify the equivalency of the assessment outcome for both the on-site and distant laboratory. It is anticipated that the average grade comparison will support previous data indicating that the average grade for the distant students is equivalent to or better than that of the on-site students.

**CET 341 Soil Testing and Inspection:** an introductory soil laboratory class, which includes laboratory procedures that are essential to understanding the properties of soils and their behaviors. The course includes standard methods of inspecting, sampling, testing and evaluating soils.

### *Distance Education Delivery Method*

For each of the experiments students receive CD-ROMs, that are viewed on their personal computers. They watch one experiment weekly and are required to submit lab reports according to the schedule published in the course syllabus.

The CD-ROMs are recorded in the same manner as those of CET 345. Unlike CET 345 where the results are called out for the students to record, the results for the CET 341 experiments are recorded directly from digital displays on the CD-ROM. Recording data from digital displays is representative of what happens in the on-site laboratory classes, with the exception that one student usually records the data and distributes it to the other members of their group.

The course syllabus is posted on the class web page so students can access it easily, and most correspondence between student and professor is via e-mail. Site directors deliver CD-ROMs to the students at their distant sites, and reports are submitted to the instructor through the TELETECHNET delivery system to verify they were submitted as required.

### *Assessment Criteria*

Table 3 provides the grade assessment criteria for CET 341 offered in spring 2001 and beyond. As indicated earlier, based on our experiences with CET 345, it was decided that a final exam was necessary to provide an additional assessment tool to determine if both the on-site and distant delivery methods are equivalent. The written final exam is based upon the laboratory instructional objectives provided at the beginning of each lab session for both the on-site and distant delivery methods.

TABLE 3

CET 341 Soils Testing & Inspection – Current grade assessment criteria spring 2001 and beyond		
Item	On-site delivery	Distant delivery
Lab Report	80%	80%
Final Exam	20%	20%

*Laboratory Status:*

This lab has not previously been offered in the distant learning method. There is a distant learning and on-site section of this laboratory being offered in the current semester, spring 2001, using the grade determination method outlined in Table 3.

**CET 400 Computer Applications in Structures:** a one-hour laboratory course that introduces the use of commercially available structural analysis and design software. The exercises start with relatively simple two-dimensional structures and become progressively more difficult with the introduction of multiple loading conditions, three-dimensional structures and structural design software for steel and concrete.

*Distance Education Delivery Method*

Students receive a tutorial via e-mail for each of the exercises. They perform one exercise each week (most exercises) and submit a solution to each with the answers to a set of questions that evaluate their understanding of the results produced by the analysis. The course syllabus, schedule and other information required for the class are posted on the class web page so students can access it easily. Most correspondence between student and professor is via e-mail. The exercises are submitted to the instructor through the TELETECHNET delivery system in order to verify they were submitted as required.

*Assessment Criteria*

Tables 4 and 5 below provide the grade assessment criteria for CET 400 offered prior to spring 2001 and spring 2001 and beyond, respectively. As indicated earlier, it was decided that a final exam was necessary to provide an additional assessment tool to determine if both the on-site and distant delivery methods are equivalent. The written final exam is based on the laboratory instructional objectives provided at the beginning of each lab session for both the on-site and distant delivery methods. The written exam does not include an analysis experience. It consists of short answer questions designed to test the student's understanding of the operation of the program and evaluation of the results of the analysis.

TABLE 4

CET 400 Computer Applications in Structural Design – Current grade assessment criteria prior to spring 2001		
Item	On-site delivery	Distant delivery
Exercise Submittals	100%	100%
Final Exam	0%	0%

TABLE 5

CET 400 Computer Applications in Structural Design – Current grade assessment criteria spring 2001 and beyond		
Item	On-site delivery	Distant delivery
Exercise Submittals	80%	80%
Final Exam	20%	20%

#### *Laboratory Status:*

The on-site version of this laboratory has been offered in the spring semester for several years. In spring 2000, it was offered on-line for the first time using the grade determination method outlined above. This virtual laboratory is also being offered in the current semester, spring 2001. The class has been divided into on-site and off-campus groups, with the on-site group receiving instruction by lecture. Following this class, data will be compiled and evaluated to verify the equivalency of the assessment outcome for both the on-site and distant laboratory.

#### **Conclusion**

It is critical to the success and continued accreditation of the TELETECHNET degreed programs at Old Dominion University that the distant learning students receive an education that is equivalent to that of the on-site students.

The methods we have outlined in this paper will provide objective data for determining whether the distance-learning students are, in fact, receiving an education equivalent to that of the on-site students. If shortcomings are identified, corrective measures then can be applied.

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