

Interactive Multimedia Labware For Civil Engineering Curricula

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Abstract

A website and CD-ROM based laboratory manual for the Environmental Engineering and Mechanics of Materials Laboratories is being developed as a collaborative NSF-funded project between the Civil Engineering Department and the Interactive Multimedia Program at Southern Illinois University Carbondale. This presentation will be an overview the preliminary development and a summary of the formative assessment during the first semester of the two-year project.

The labware is intended to enhance student learning through the development of and exposure to richer learning tools, resources, and advanced technologies. The pedagogy promoted by our approach is to engage students in active learning. The approach is to develop an interactive multimedia program for the laboratory component of the courses, which in turn strengthens the bridge between application and classroom theory. For laboratories equipped with the appropriate equipment, the labware is designed with the expectation that students review various aspects of the CD at different stages of the learning process. Prior to attending laboratory, students will be expected to review the basic concepts of the theory and to experience a “virtual lab” prior to their hands-on experience. After the experiment, students can use the labware to understand data reduction and data analysis in addition to accessing additional sets of experimental data. This additional data can include data from the same material measured in the laboratory in order to understand statistics or data resulting from varying parameter conditions. In the case of equipment failure or poor experimental controls and/or data collection by the students, the additional data will allow students to complete data reduction and data analysis critical to the link between the theory and the application of the experiments. For laboratories that do not have access to state-of-the-art equipment, the students can still investigate and link the theory, experimental methods, data collection, and data reduction and analysis. In terms of assessment, there is a positive overall response to the use of the labware, even at this preliminary stage.

I. Introduction

The Introduction to Environmental course is a junior level Civil Engineering course required for all civil engineering majors. In addition, students from the environmental studies program may take this course. The laboratory component of the course includes, but is not limited to, measuring biochemical oxygen demand, determining solids content, measuring the temperature, pH, and dissolved oxygen profiles in a lake, and conducting coliform bacteria tests. To date, the main focus of the project has been on the development of the environmental laboratory, due in large part to the time required to purchase new equipment for the mechanics of materials laboratory.

Mechanics of Materials is a second-semester sophomore or first-semester junior level engineering class, and is required for all civil engineering majors, as well as most other engineering majors. The laboratory component of this class includes, but is not limited to experiments measuring bending, buckling, compression, tension and torsion properties of materials.

The labware (laboratory courseware) was designed to present elements of theory, experimental procedure, data collection, data reduction, report writing and statistics. To accomplish this, the labware can combine text, illustrations, photographs, video-clips, sound, simulations, animations, hypertext descriptions, and hot-links to the Internet, making it truly multi-media. The final product will be published on a CD-ROM, with portions of the material available on the World Wide Web. This format provides the opportunity for incorporating many novel aspects into the labware. The long-term goal of the project is to use the style and approach developed on this project as a template for other civil engineering laboratory courses. Common elements to all of these laboratories include modules on laboratory safety, report writing, statistics and unit conversions.

The labware has potential use in a diverse range of university environments. The pedagogy promoted by our approach is to engage students in active learning, and to accommodate various learning styles. By focusing on the development of an interactive multimedia program for the laboratory component of the course, the labware can strengthen the important bridge between application and classroom theory. For laboratories equipped with the appropriate equipment, the labware was designed with the expectation that students review various aspects of the CD at different stages of the learning process. Prior to attending laboratory, students are expected to review the basic concepts of the associated theory and to experience a “virtual laboratory” prior to their actual hands-on experience. For laboratories that do not have access to state-of-the-art equipment, the students can still investigate and link the theory, experimental methods, and data collection.

II. Background

Multimedia applications represent the best application of modern technology to education and

training in all areas. It can be very cost effective and increase retention rates dramatically [1]. Computer technology and multimedia applications are particularly relevant in engineering education [2- 4]. They give students the opportunity for self-paced learning in an interactive environment [5, 6]. The format is nonlinear, allowing the student to review certain parts in a manner that is much easier than with simple videotapes or audiocassettes. The effectiveness of computer-based instruction has been widely documented in numerous studies. These results are summarized in three survey papers [7 - 9]. Web-based classes have been also proven to be effective [10], allowing class time to be spent in other ways [11]. Multimedia instructional modules tend to engage students in active learning [12, 13], which is very important in modern educational theory [14]. Even non-technical topics such as communication skills have been successfully addressed by multimedia instruction [15]. Distance education is another area where multimedia applications are very appropriate [16]. Student acceptance and usage of educational multimedia is high [17].

There has been a significant amount of work done in the area of multimedia and/or web based interactive learning modules in science and engineering. This work ranges from basic courses such as physics [18], statics [19, 20], dynamics [21], thermodynamics [22], strength of materials [23], and engineering economy [24], to advanced topics such as finite element analysis [25]. One area that has received considerable attention is manufacturing with some work done on laboratory applications [26, 27] and other work on using multimedia simulations to teach design [28]. Some work has also been done in the area of environmental engineering [29 - 31].

The topic of trying to supplement or replace basic engineering laboratories has also been studied. The concept of virtual engineering laboratories was introduced for electric circuits at Vanderbilt in a paper by Mosterman et al [32]. Simulations in manufacturing process laboratories and manufacturing design have been presented by Hailey and Hailey [27] and by Riggs et al. [28]. In the Civil Engineering area, Alani and Barnes discussed the development of a multimedia soils mechanics laboratory [33]; and the paper done by Kantz et al. [31] looks at some aspects of an introductory environmental lab.

III. Program Overview

Working with the College of Mass Communication and Media Arts Interactive Multimedia Program provides a unique opportunity. For the College of Engineering, elements of design and state-of-the-art web and CD based technology are integrated into the project without the daunting task of mastering advanced software and hardware. In return, the project provides a client base for graduate students from the Interactive Multimedia Program that is still within the academic environment. The main software used includes Macromedia's Dreamweaver and Flash for web development, and Adobe's Premiere for video editing and Photoshop for still photography. The video has been recorded with digital camcorder using the Mini DV format tapes.

The initial page for the web site is shown in Figure 1. The second page provides links to the two

main laboratories as well as common topics such as report writing and statistics, as shown in Figure 2. The main pages for the two laboratories have similar style and navigation. Figure 3 shows the main page for the Mechanics of Materials laboratory. In the upper right hand side, numerous still photographs showing the use of materials in engineering projects are presented in sequence. As in the previous figures, the URL is shown in the figure.

Figure 4 shows the procedure of the BOD experiment within the Environmental Engineering laboratory. At this stage of the project, video clips are being integrated into these laboratories. Shorter clips of various stages of the experiment are used as opposed to one long clip of the laboratory in order to allow the user to choose segments. The additional advantage to this strategy is shorter download time of the videos. In this laboratory, there is an initial video presenting an overview of a wastewater treatment facility, showing where the samples are collected. Additional clips are used for the preparation of samples, the incubation of samples, and measuring data.

As seen in the menu on Figure 4, there are additional data sets available. This will be a common element in most of the laboratories developed in this project. These data sets can be used to supplement the data collected in the laboratory in numerous ways. In this case, a virtual long-term study can be conducted where the student can monitor wastewater characteristics over an extended period of time. In all the laboratories, this additional data can be used for statistical analysis of the parameters studied. In most curriculums, the typical laboratory experiment does not allow for either of these two studies. In cases where laboratory equipment is not available, student can complete a virtual experiment including observation of the collection, preparation and measurement of the data.

IV. Assessment

At this early stage of the project, the assessment is formative, based on one semester of use in the environmental engineering laboratory and prior to the addition of the video clips, photography or design elements incorporated through our collaboration with the Interactive Multimedia Department. Five experiments used the web site during this first semester, namely, measuring biochemical oxygen demand, determining solids content, measuring the temperature and dissolved oxygen profiles in a lake, evaluating solid waste characteristics and conducting coliform bacteria tests. At this stage, all material was accessed via a web site.

The assessment is based on a questionnaire presented on a six-point scale, where scores of 1, 2 and 3 were used to indicate that the students strongly agreed, agreed, and slightly agreed with the statement. Scores of 4, 5, and 6, indicated that the respondent slightly disagreed, disagreed and strongly disagreed with the statement.

The following questions were used on the survey. The results are shown in Table 1a-b.

1. The information presented on the web site was complete, clear and effective.

2. The web site is more effective than printed lab manuals.
3. The level of detail on the web site for this experiment was appropriate.
4. For this experiment, the web site needs more detail.
5. For this experiment, the web site needs less detail.
6. Video-clips, sound clips and photographs would help me understand this experiment better.
7. Reading the material on the web site prior to conducting the experiment helped me understand and conduct the lab.
8. Reading the material on the web prior to conducting the experiment helped me with data reduction and interpretation of the results.
9. Reading the material on the web site after conducting the experiment helped with data reduction and interpretation of the results.

There were 24 respondents. The results presented are the percentage of respondents that agreed (i.e. answered 1, 2, or 3) or disagreed (i.e. answered 4, 5, or 6) with the statements. The students surveyed did not respond to all questions, however, the total number of students were still used to determine the percentages.

Table 1a: Assessment

Question	BOD lab		Lake Profile		Solids	
	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)
1	73	27	95	5	92	8
2	47	53	89	11	64	36
3	87	13	100	0	92	8
4	40	60	58	42	60	40
5	33	67	47	53	48	52
6	87	13	79	21	84	16
7	80	20	100	0	80	20
8	90	10	100	0	70	30
9	92	8	88	13	83	17

Table 1b: Assessment

Question	Solid Waste		Coliform		Overall	
	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)	Agree (%)	Disagree (%)
1	96	4	100	0	91	9
2	67	33	56	44	65	35
3	96	4	92	8	93	7
4	33	67	44	56	47	53
5	21	79	36	64	37	63
6	63	38	88	12	80	20
7	67	4	90	10	83	10
8	50	8	90	10	80	11
9	79	0	88	12	86	10

Overall, there is a positive response to the use of the labware, even at this preliminary stage. Since video clips, animation and photography were not available to students at this point; the response to question 2 was anticipated. Without these elements, the web site or CD offers little or no advantages to the traditional hardcopy manual students can take to the lab, since the hardcopy manual allows for in-class note-taking, reference and data entry. This conclusion was in part drawn from informal discussions with the lab groups. It will be interesting to see the changes in the response to this question as the project develops. In response to the current assessment, PDF files of the experiments will be available for the students to download and print. As with other elements of this project, this will allow for individual learning styles and preferences.

Questions 4 and 5 were intended to monitor student response by posing a question in reverse. In this case, the students were asked whether the website needs more detail, then whether the website needs less detail. Ideally, the questions should have mirrored responses. However, in this survey, it was not the case. Overall, a majority of students disagreed with both statements (53% and 63%). In fact, these two questions received the highest disagree ratings, with the next highest disagreement being 35% disagreeing with question 2, which compares the web site to printed manuals.

One valuable aspect of this project, which cannot be understated, is the resource it provides to graduate students conducting the laboratory. Although an assessment of this benefit cannot be made at this early stage, informal discussions with graduate students has emphasized the importance of this material for their review, preparation and delivery of the laboratory.

V. Summary

This project represents the two different aspects of civil engineering laboratory curriculum as well as a unique collaborative effort with the College of Mass Communication and Media Arts. Overall,

the project is developing into a beneficial activity for both colleges, supplementing the educational needs of both the undergraduates and graduates.

VI. Acknowledgement

This project is funded in part from the National Science Foundation (DUE CCLI Project Number 9952577), the College of Engineering at Southern Illinois University Carbondale (SIUC), the Department of Civil Engineering at SIUC and the College of Mass Communication and Media Arts at SIUC.



Figure 1: Main page for web site



Figure 2: First page with links to the two main laboratories and common topics.

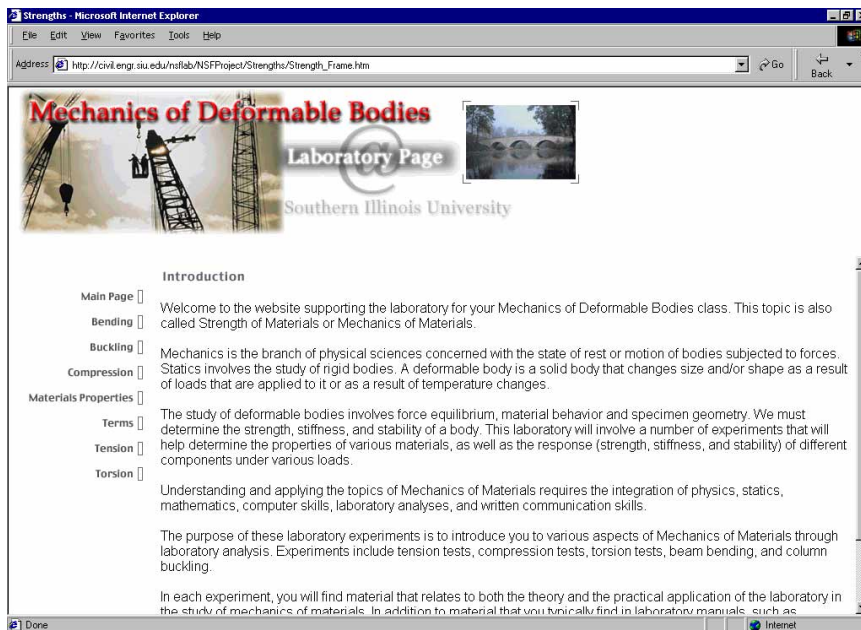


Figure 3: Main page for the Strength of Materials laboratory.

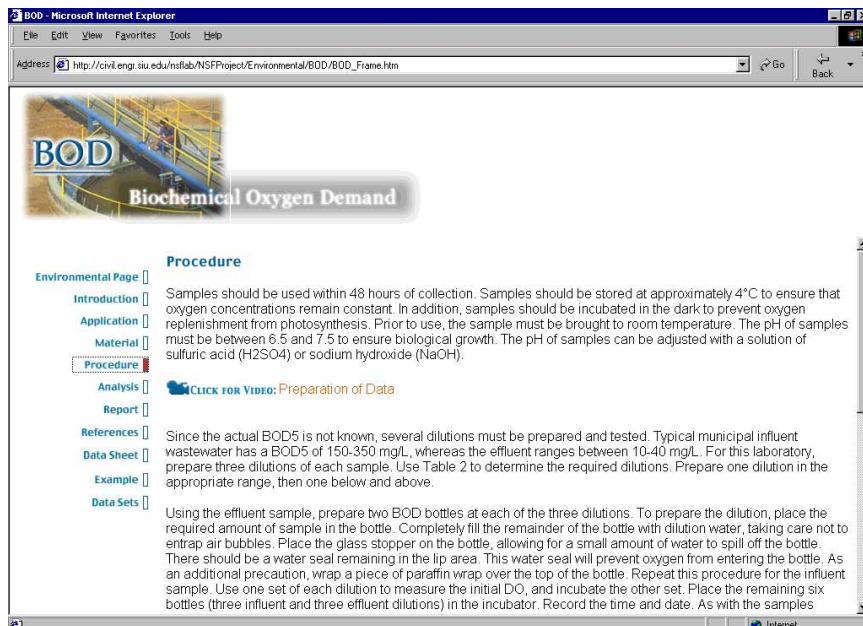


Figure 4: Procedure page for biochemical oxygen demand

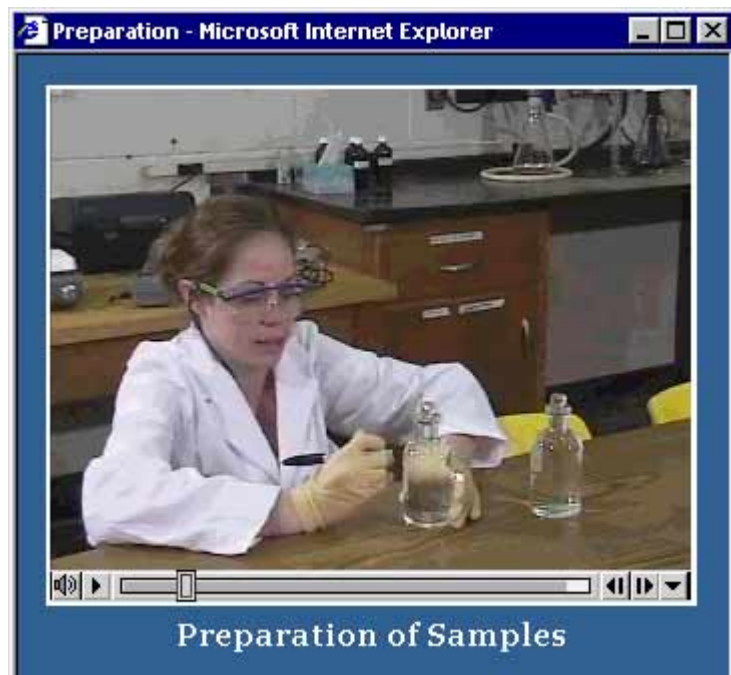


Figure 5. Example of video clips used.

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