EXPERIENCES IN DEVELOPING AND MANAGING A WEB SITE TO ASSIST IN TEACHING CIVIL ENGINEERING UNDERGRADUATE LABORATORY COURSES

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Abstract

Undergraduate laboratory courses have been considered an indispensable part of engineering education. These undergraduate instructional laboratory courses are intended to help students understand basic engineering theories and also allow them to relate these theories to practical situations. It is rather expensive, however, to adequately support a quality undergraduate lab course even with the dramatic increase in the ratio of technology available to its relatively modest cost. In addition to the initial setup cost, the routine maintenance cost has become a burden for many academic units to support lab courses.

Internet technology can alleviate some of the burden and provide additional enhancement to students' learning. The web-assisted teaching method can benefit lab courses in ways different from lecture courses. Lecture courses can effectively use web pages as a display board to show information that benefits the course. Not much student input is typically required for lecture courses aside from email communication between instructors and students. However, lab courses do require students to input collected data on the web so other students can share the data.

The means to support the frequent sending and retrieving of data by users are the major differences between designing lecture and web-assisted lab teaching sites. Although software packages exist to help to efficiently develop websites for lecture course, it is believed by the authors of this paper that such tools have not been made available commercially. To address this situation, the paper describes the initial development of a web-assisted lab teaching web site, the important database and website management issues encountered, lessons learned and later improvements made to the system.

Introduction

For many years, undergraduate laboratory courses have been considered an indispensable part of engineering education. These undergraduate instructional laboratory courses are intended to help students understand basic engineering theories and also allow them to relate these theories to practical situations. The criteria developed by the Accreditation Board for Engineering and Technology (ABET) in EC2000[1] requires each accredited engineering program to exhibit an outcome that students can design and conduct experiments, as well as to analyze and interpret data.

It is rather expensive to adequately support a quality undergraduate lab course even with the dramatic increase in the ratio of technology available to its relatively modest cost. In addition to the initial setup cost, the routine maintenance cost has become a burden for many academic units to support lab courses. One of the alternative methods being used to reduce this burden is the use of computer-simulation programs for creating a distance (or internet) learning environment to completely replace the traditional physical lab activities. As pointed out by Feisel and Rosa[2], these simulation programs are particularly useful for delivering training exercises for various activities. However, the authors indicated that these simulation programs have their limitations in accurately modeling real devices and materials with their inherent complexity. This is particularly true for civil engineering (CE) programs since a majority of CE subjects deal with real-world complexity; thus, the hands-on experience has continued to be essential to student's understanding of various CE subjects.

Although simulation programs cannot replace the hands-on experience students gained from the physical CE laboratory courses, the use of web technology in lab courses can definitely improve students' learning. The authors of this paper have more than 30 years of combined experience in teaching laboratory courses. The lead author has been using the web-assisted teaching method for the past 8 years in teaching CE lab courses. Based on his experience, web-assisted lab instruction can provide the following benefits as compared with the traditional teaching method:

- the ability to share information by the use of a specifically designed web database makes it an excellent tool for students to exchange their information and lab data sets for current semester and earlier experiments through the web site. These earlier data sets can be conveniently redistributed to current student groups that fail the experiments so that they can still perform the needed data analysis and write their reports;
- the web pages stimulate students' interest in and learning from lab courses. The "e" generation of students expects to use internet technology in their educational career. Employers also want to hire incoming engineers who are able to efficiently use all available technology;
- the internet technology provides a common platform to link all undergraduate lab courses together. Students no longer consider each lab course as an independent course;
- the web pages are excellent places to post necessary training information for new Teaching Assistants. This training information provides adequate background for preparing new TAs to set up physical lab experiments; and
- using the web-assisted teaching tools has definitely improved the instructor's organization of the course. All the necessary hand-out materials as well as assignments can be placed on the web sites ready for students to use.

The web-assisted teaching method can benefit lab courses in ways different from lecture courses. Lecture courses can effectively use web pages as a display board to show information that benefits the course. Not much student input is typically required for lecture courses aside from email communication between instructors and students. However, lab courses do require students to input collected data on the web so other students can share the data. There are two methods currently used for data input in our system. One is that students type the data into an online web page form which then sends the data to the web server. The other method is to use a PC-based data acquisition system to collect data which in turn posts the data to the web server. These two methods required the establishment of a web-based database system to store collected data and to then make the data available for retrieval by students using the web system. The means to support the frequent sending and retrieving of data by users are the major differences between designing lecture and web-assisted lab teaching sites.

In recent years, commercial interests have developed many tools to expedite the development of web pages for teaching purposes. Blackboard and WebCT are the two leading software packages for educational web page development. The main focus of these two software packages is to support lecture courses. It is believed by the authors, however, that they have not developed enough of the necessary tools to fully support lab courses. In October 2005, the two companies announced their merger.[5] It is anticipated that the cost for using these software packages in the future would increase significantly due to the dominance of the market share by the company. Therefore, it is necessary to continue to develop a low cost and easy-to-maintain web-assisted education site to help in teaching lab courses.

The Civil Engineering Department at Southern Illinois University Edwardsville (SIUE) developed its web-assisted teaching site in 1998. The main purpose for establishing this web site was to use the new (at that time) technology to help instructors teach lab courses more effectively so students may learn more from the courses. Over the past eight years, a number of additional web site enhancements have been made to further leverage appropriate web technology tools to help teach the lab courses in the CE department at SIUE. These web sites allow users using web browsers to enter and acquire necessary information or for running specially designed programs. Two technical papers were published[3,4] to describe the methods being used in the web sites and the positive results generated from using these sites.

Based on the experience learned over the last eight years, it was found that a well-designed web-assisted teaching site should not only provide a favorable environment for students using it, but also allow instructors to easily perform routine maintenance work. A well-maintained web-assisted teaching site can help students better understand the information on the web site. From the students' point of view, a useful web-assisted teaching site must contain up-to-date information, require student input, enable teachers to give timely feedback and also provide students with tools to conduct their experiments as well as compose their lab reports. From the developer's point of view, the routine maintenance activities, which typically include updating information, adding and deleting user account information, creating and editing content, or writing software programs to store and disseminate necessary information, should be easy to perform. The management tasks, therefore, require not only the necessary programming skills, but also file organization as well as the ability to establish functional relationship database programs. This paper discusses some of things that the authors have learned from developing and managing these sites as well as the methods developed on these sites to alleviate the problems encountered in the traditional style of teaching lab courses.

CE Lab Courses and Tools Used to Establish the Web-Assisted Site

At SIUE, the CE department has four laboratory courses in its current undergraduate curriculum: CE Computer Applications (sophomore course), Geotechnical Laboratory (junior course), Engineering Materials Laboratory (junior course) and Applied Fluid Mechanics Laboratory (senior course). All of these courses are required courses, and both individual and group reports are required for these courses.

Each of these four courses has a web-assisted teaching site to help students conduct their experiments, share data and compose their individual and group reports. The tools that we used to establish these web-assisted sites are all Microsoft products, such as Access, FrontPage, and Active Server Pages (ASP). Currently, there are many software packages that are capable of creating web sites and managing the input data. The reasons that we chose these packages for creating our web sites are:

- there was no additional cost to us for using the Microsoft products since SIUE has an on-going license agreement with the company, and these products are proven products that have been on the market for a number of years;
- the initial development of our web-assisted teaching site for our lab course was in 1998. At that time, very few educational software products were available on the market with a long-established reputation;
- the tools we chose have allowed us to have full control of the development environment, saving significant time for developing or modifying jobs; and
- the tools we chose provide us with the flexibility to design some needed special features, such as collecting students' feedback, computing each student's

contribution toward a group report, performing lab data acquisition, etc.

The Components of the Web-Assisted Teaching Sites for Lab Courses

The central core of the web-assisted teaching sites used in the CE lab courses consists of three Microsoft ACCESS database modules: LADI (Laboratory Database Interface), ActiveData and LM2000. LADI stores individual user's login information, lab enrollment information that keeps track of which section and lab group each student belongs to, and manual user input data for each lab experiment. A flowchart representing the general logic for student interaction with the database is shown in Figure 1. The ActiveData database stores all data files collected from GENTEST, a PC-based data acquisition program developed by the first two authors of this paper. A flowchart showing the general interaction between GENTEST and the ActiveData database is shown in Figure 2. LM2000 stores the setup information for various transducers being used with the GENTEST program as well as sampling criteria and on-screen graphical display parameters. ASP files were created to communicate between web pages and database modules.

Through web connectivity, many improvements in data acquisition and dissemination in the lab course have been achieved. Improvements include software distribution, equipment configuration, data file transfer, and on-line help. Besides allowing students to share the lab-collected data, the web-assisted teaching sites also provide useful tools for grade checking, sharing photos of experiments, downloading stored data files, sharing lab lecture notes, accessing report writing instructions, etc.

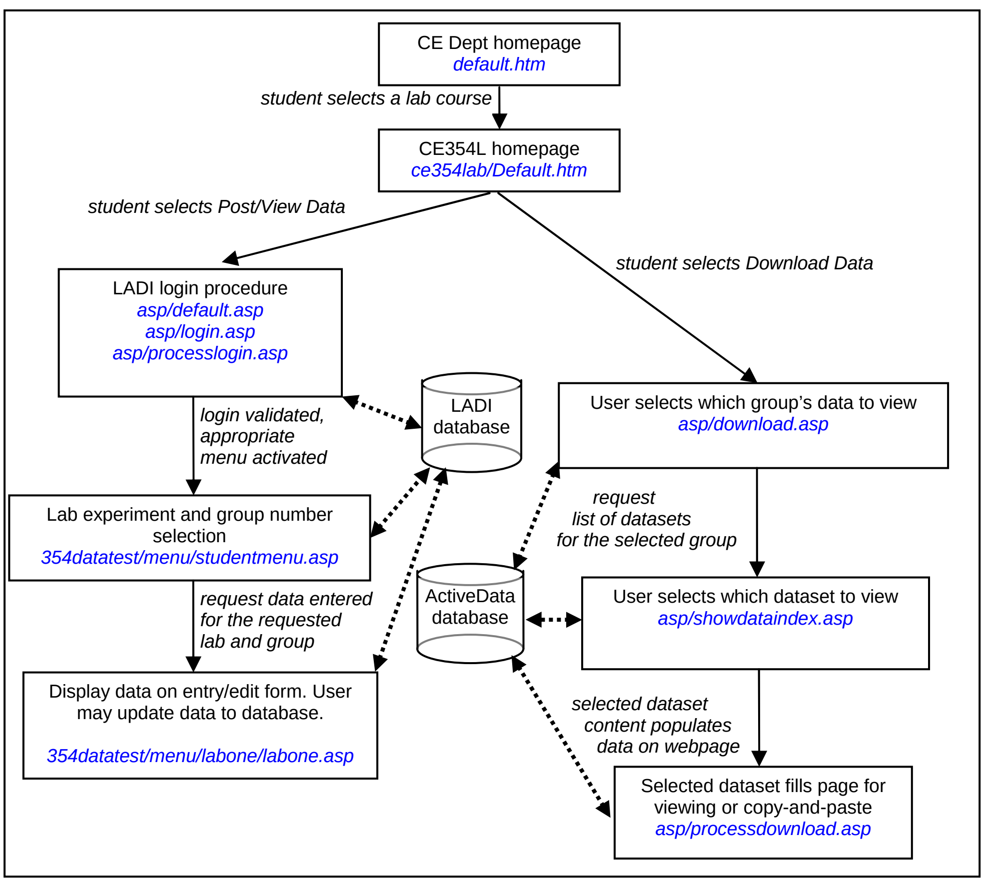


Figure 1: Flowchart for CE lab student data entry and data download web pages.

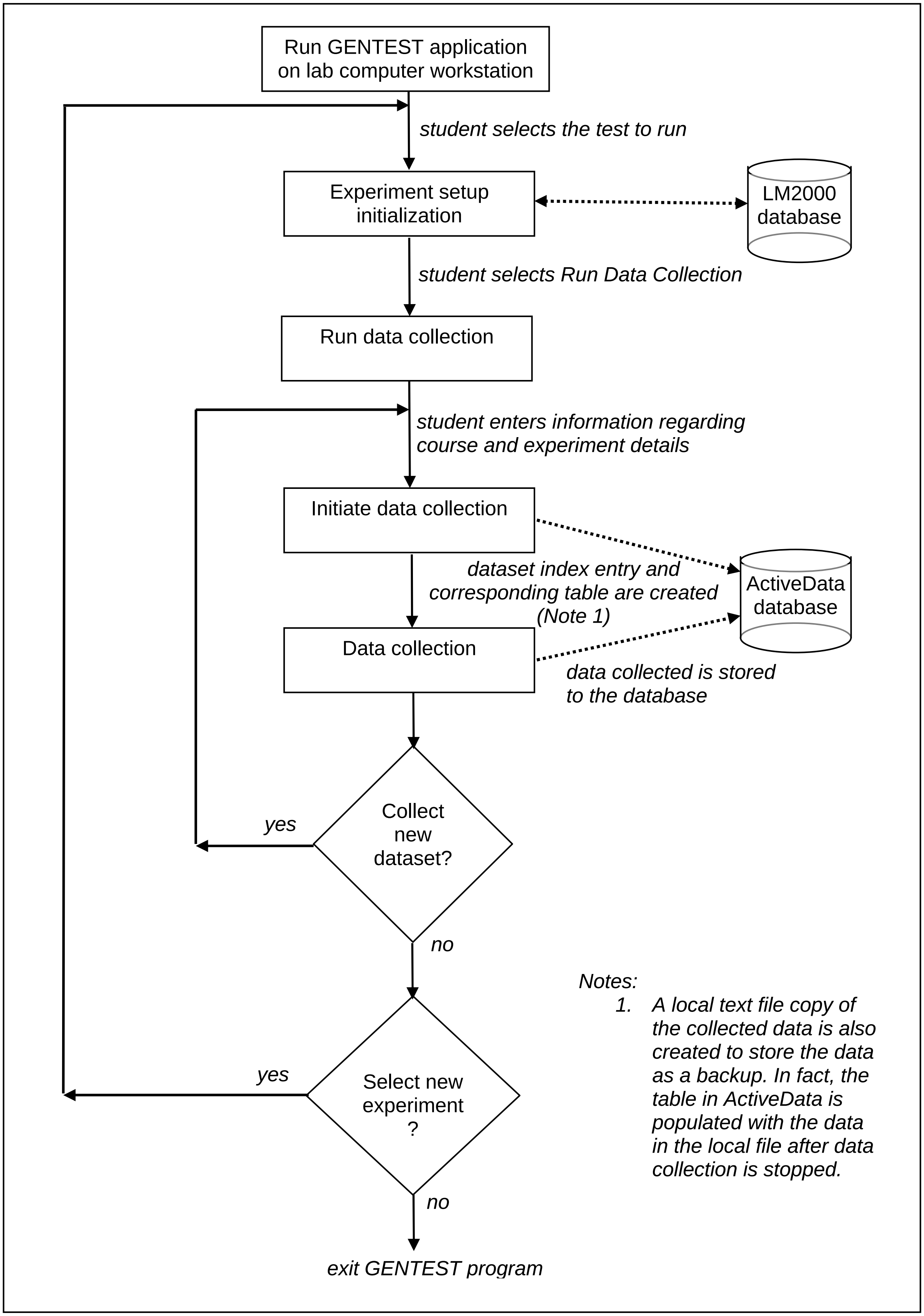


Figure 2: Flowchart for GENTEST interface between student and web databases.

Problems in Managing the Web Sites

The use of these web-assisted teaching sites has reduced many of the deficiencies encountered in the traditional lab teaching as mentioned earlier. However, we also experienced some new problems when we replicated the original web-assisted teaching site to create sites for other lab courses. Most of these problems were related to the LADI database since it is the main database to store students' login information as well as manually input data. These problems included:

- the number of web pages increased when we duplicated the original web site which caused difficulty in finding the right files for inputting updated information specific to each course;
- because of the duplication, redundant data tables in LADI system were created that required repeated inputs from both the system manager and users registered in more than one lab course in the same semester. As a result, parts of the LADI system became redundant and unwieldy, and the system was inefficient to operate and maintain;
- because ASP scripts were used as the interface between LADI and web pages, a separate (and redundant) version had to be created for each new lab class and were added to the LADI system; and
- students still did not have immediate access to their data files because the GENTEST data files had to be manually posted on the web by instructor or system manager.

Solutions

Modifications had to be made in order to make the LADI database more efficient not only in operation but also for routine maintenance. The solution selected for updating GENTEST was to allow it to automatically transmit the data to the web server through an internet connection so that the data would be accessible immediately.

The modification work was started in 2003 and ended in late 2005. The following section describes the detail of this work.

(1) It was decided that a single set of user information tables (*tblUser*, *tblClass* and *tblEnroll*) in the LADI database should be created for all the students enrolled in the lab courses. Examples of manager interface for managing the database is shown in Figures 3 through 5. The relational database was also modified to reduce redundancy and to increase database integrity. These tables also provide information to be used to verify a user's login information. Various forms were created to allow instructors or lab managers to more easily populate and edit the tables.

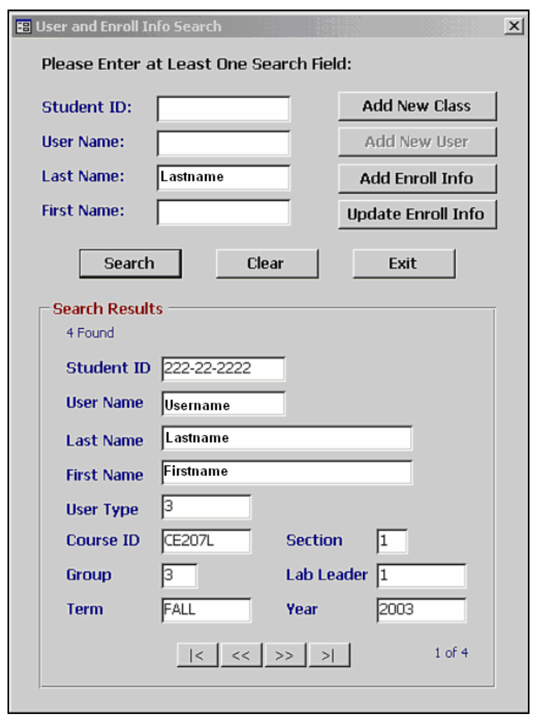


Figure 3: Form for user information lookup and editing.

Figure 4: Form for user account data input.

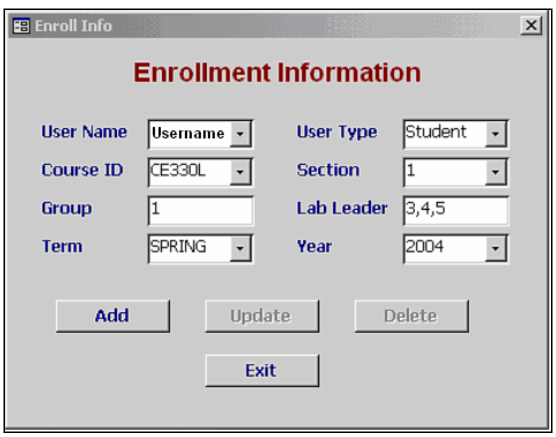


Figure 5: Form used to link student to course and group.

(2) Besides the common users' information, each lab class in the LADI database has unique data tables, such as lab experiment data tables and students' grade tables. To manage these tables more efficiently, a naming convention that includes the class number was added to each table's name, such as *tblCE330LGrade* or *tblCE330Lab Asphalt*.

(3) The web server system responds to user requests for data entry and retrieval by communicating with the LADI database through the use of ASP scripts embedded in the web page coding. This method of server side programming reduces the need for special requirements on a user's computer, thus students should encounter fewer difficulties in accessing the web site.

(4) New ASP files as well as modifications to existing ASP files were needed in order to accommodate the changes being made in the LADI database. A drop-down menu was added to the login page, *login.asp*, to allow students to enter the appropriate lab data viewing and downloading area. The classes listed under the drop-down menu are loaded directly from *tblClass* so that any new information from *tblClass* can be automatically reflected in this drop-down menu. A single ASP script file, *processlogin.asp*, was established to include a new entry, class number, for verifying students' login information. The "class number" information is shared with other ASP files. Therefore, instead of using multiple individual files previously required for individual classes, only one set of ASP functions is now needed to handle all the lab courses. Specially designed pages for each lab experiment must still be designed since the data entry requirements differ significantly for most of the lab experiments. A typical data entry form web page is shown in Figure 6.

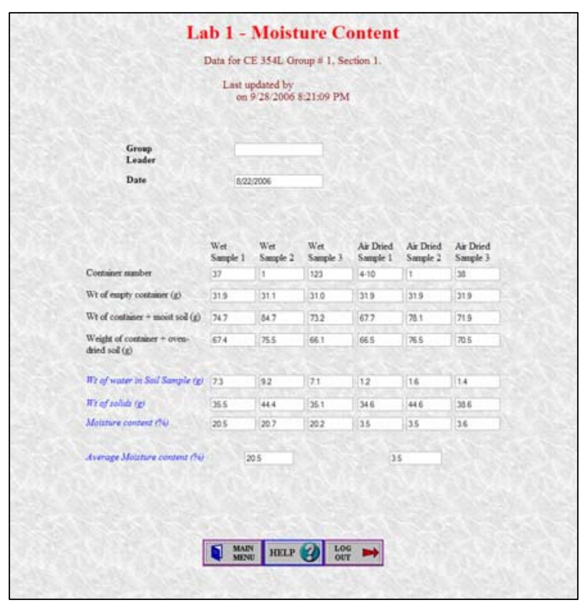


Figure 6: Typical student lab data entry form.

(5) The modification of the GENTEST program consisted of three parts. The first part was to establish a new MS Access database, ActiveData, to which GENTEST would store data collected in the labs. Each lab course using GENTEST will have multiple data tables in ActiveData, one table for each data set. The second part of the modification was to change the naming convention of the data files created by users. A data table in ActiveData is created with the same name as the data file stored on the local computer hard drive as a backup. In the past, users could select file names based on their own preference; however, due to inconsistent results (file name conflicts), we decided to have GENTEST assign the file names according to users' inputs, such as 354L_SEC3_L10 _G8_SES1_SEQ1 (class CE354L, section 3, lab 10, group 8, session 1, sequence 1). An example of this information entry screen is shown in Figure 7. Before assigning a new file name, a verification process automatically ensures the name it chose is unique. The third modification was to create three ASP pages that allow the datasets kept in ActiveData to be viewed or downloaded immediately from the web. These three ASP fileswere designed so that they could share the information stored in the LADI and ActiveData databases regardless of the lab course in which the data sets were collected.

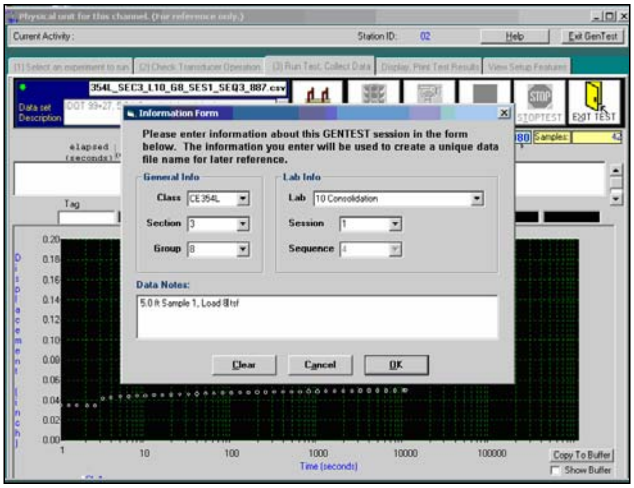
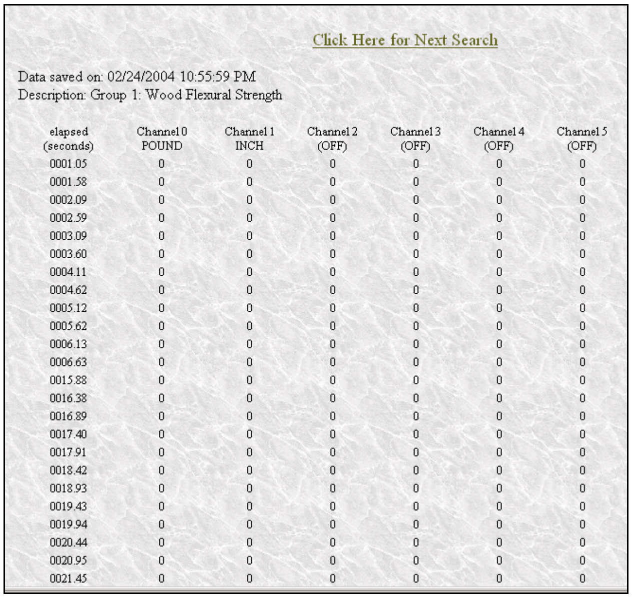


Figure 7: User information form in GENTEST.

A portion of a typical GENTEST data web page is shown in Figure 8.



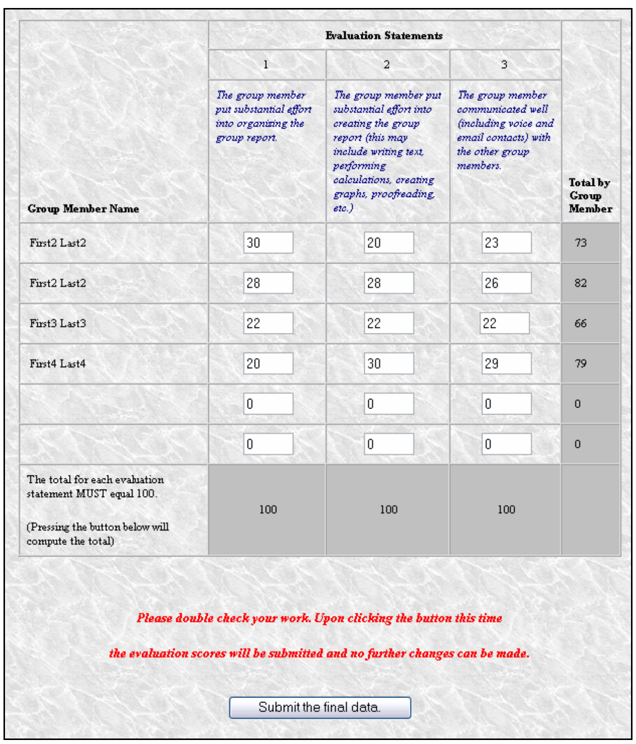
Click Here for Next Search

Data saved on: 02/24/2004 10:55:59 PM
Description: Group 1: Wood Flexural Strength

elapsed (seconds)	Channel 0 POUND	Channel 1 INCH	Channel 2 (OFF)	Channel 3 (OFF)	Channel 4 (OFF)	Channel 5 (OFF)
0001.05	0	0	0	0	0	0
0001.58	0	0	0	0	0	0
0002.09	0	0	0	0	0	0
0002.59	0	0	0	0	0	0
0003.09	0	0	0	0	0	0
0003.60	0	0	0	0	0	0
0004.11	0	0	0	0	0	0
0004.62	0	0	0	0	0	0
0005.12	0	0	0	0	0	0
0005.62	0	0	0	0	0	0
0006.13	0	0	0	0	0	0
0006.63	0	0	0	0	0	0
0015.88	0	0	0	0	0	0
0016.38	0	0	0	0	0	0
0016.89	0	0	0	0	0	0
0017.40	0	0	0	0	0	0
0017.91	0	0	0	0	0	0
0018.42	0	0	0	0	0	0
0018.93	0	0	0	0	0	0
0019.43	0	0	0	0	0	0
0019.94	0	0	0	0	0	0
0020.44	0	0	0	0	0	0
0020.95	0	0	0	0	0	0
0021.45	0	0	0	0	0	0

Figure 8: A view of a typical web page showing actual lab data collected and uploaded by GENTEST.

(6) A new feature was added to the LADI database in 2005 and improved in 2007 to allow students to evaluate themselves and their group members on their contributions to a group report. The student's group report grade consists of the base report grade and a grade corresponding to the student's individual contribution to the overall effort. The instructor evaluates and assigns a grade to the report itself. Typically, this grade represents 70 percent of the total score that any of the contributing group members could receive. The remaining 30 percent of the score depends on the contribution that each member made to the report effort as determined by all members of the group through the online group member evaluation application. An example of the questionnaire is shown in Figure 9. The final grade that each student receives for a group report is the sum of these two grades.



Group Member Name	Evaluation Statements			Total by Group Member
	1	2	3	
	The group member put substantial effort into organizing the group report.	*The group member put substantial effort into creating the group report (this may include writing text, performing calculations, creating graphs, proofreading, etc.)*	*The group member communicated well (including voice and email contacts) with the other group members.*	
First2 Last2	30	20	23	73
First2 Last2	28	28	26	82
First3 Last3	22	22	22	66
First4 Last4	20	30	29	79
	0	0	0	0
	0	0	0	0
The total for each evaluation statement MUST equal 100. (Pressing the button below will compute the total)	100	100	100	

Please double check your work. Upon clicking the button this time

the evaluation scores will be submitted and no further changes can be made.

Submit the final data.

Figure 9: Lab Group Member Evaluation form.

Experience with the Updated Web Sites

The updated lab web sites have been used for the past two semesters. Students have experienced very few changes, except on the login page and a few places in the GENTEST program, during their operation. However, instructors and lab managers have enjoyed much-needed improvements because of these modifications. In the LADI database, these modifications improved the database structure that makes updating a much easier job to perform. In the GENTEST software, the linkage between the web browsers and GENTEST is much improved allowing students to gain access to their collected data immediately after data collection is completed. Overall, these database modules and GENTEST are much better integrated which makes the web-assisted teaching sites more flexible and adaptable for future enhancements.

Future Recommendations

The LADI system and GENTEST program will continue to be updated in the future. There are two areas that we would like to concentrate on for future enhancements. One is to incorporate updated security features in the system. The system has not experienced any known security breach since we implemented the system. These new features have to be compatible with the security system used on the SIUE campus. The other proposed improvement is to implement a new feature allowing students to turn in their reports on-line so that instructors can use tablet PCs or other means to grade these reports on-line. This feature would provide a paperless environment for lab courses.

Conclusion

A good web-assisted teaching site should be efficient not only in terms of user operation but also for maintenance. It is relatively easy to create a web site but it is more difficult to properly maintain it over the long term. Also, if the developer and the person who is in charge of the maintenance work are not the same person, then more time may be wasted in trying to properly perform routine maintenance jobs.

There are valuable lessons that the authors have learned over the past eight years. These lessons include:

(1) The possibility of future expansion must be seriously considered during the design phase of any project. A lot of enthusiasm is generated and commitments are made at the start of a project. The main focus as the project moves forward should be on how to make these exciting ideas work. Too little consideration is often given to planning for future expansion. Our original effort is a perfect example of not thinking sufficiently far ahead. As a result, more work has been needed when an expansion was desired.

(2) To operate a web site more effectively, a well-designed database is definitely a critical component. The data tables used in the database should not be independent of each other. Instead, there should be efficiently designed relationships among the data tables to eliminate repetitive input and to make future updating work much easier.

(3) In developing an interactive website for student use, it is better to use drop-down lists rather than fill-in-the-blank text boxes where feasible to help users make proper selections. The information in the drop-down lists should, if possible, come from a data table in the database system. By doing so, updating or expanding choices through simple additions to a data table can be done more easily than updating the web page form files. This helps the web manager keep the site fresh.

(4) It is very important to assign logical names for web page script variables and database tables. Most operating systems used in today's computers allow long names to be assigned. A name with a full description of its function can be a great help to a reader. It is especially useful when a maintenance person and a developer are not the same person.

(5) The selection of programming tools is another important step toward a successful implementation of a web site. The tools we chose work very well for us. These tools provide us with flexibility and full control of the development environment. The key to a proper selection is based not only on the initial cost but also on whether the development tools provide long-term stability. Because high cost is usually associated with this type of software, institutional support and commitment are needed for long-term success. It is also desirable to use enterprise software for a web site's development tool for writing code to develop the web site as this may help alleviate the need for highly trained programming staff dedicated to developing and maintaining the project. However, you need to anticipate the need and prepare for third party personnel to perform some maintenance work.

(6) In the development environment, it would be good if the program developer and the maintenance person are the same person so that consistency can be maintained for maintenance activities. However, this is typically difficult to accomplish due to frequent personnel changes often found in the university environment, especially with student employees. In our case, graduate assistants (GAs) were used to assist us in writing web page code and related modifications to GENTEST. The employment duration of these GAs is usually no more than two years (for masters students). Thus, it is very important to keep a complete set of documentation during the development process so that design decisions and problems encountered and solved can serve as guidelines when future maintenance is required. A database can be designed for keeping records throughout this development process. This database can be used not only as a set of guidelines but also as a training tool for

new members in the maintenance team. The same database can also be used to keep records about the various updates being completed on the web sites.

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Biographical Information

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