WebLab: a New Approach to Undergraduate ME Laboratory Training at Georgia Tech

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Abstract

This paper describes the development and implementation of Internet-based technologies into a required undergraduate laboratory course, ME3056, at the Georgia Institute of Technology. The education of a large group of undergraduates (120 per semester) in laboratory techniques through hands on experience is a challenge to educators and institutions in many ways. This includes providing laboratory space, providing resources for equipment and graduate teaching assistants, and providing sufficient student time in the laboratory. ME3056 is a laboratory course in experimental methodology that focuses on the experimental process, teamwork, laboratory and instrumentation skills, data analysis, and proper presentation of results. It touches on all major areas within mechanical engineering, thus encompassing a wide range of subject matter. The students are divided into groups of 12. Each group has two required hours of laboratory time per week with a third optional hour available. This makes pre-laboratory student preparation critical. WebLab was developed as a pre-lab training tool so that the students would be familiar with the operation of complex equipment and procedures prior to their laboratory time. This has shifted the focus of the student's laboratory time from becoming familiar with the equipment to using the equipment to collect quality data. The organization of the course, integration of WebLab and WebCT, and the effect of Internet-based technologies on the students' experience are discussed.

Description of course

ME3056 is a required course for all undergraduate ME students at Georgia Tech. It is given each semester, including summer, and has an average enrollment of 120 students. Students spend one hour per week in lecture and two hours in the laboratory. The lectures are divided into two sections of 60 students, taught by the professor. They consist of presentation of laboratory procedures and equipment and the appropriate theory required for the week's lab. Attendance is taken and counts for 5 points out of a total of 100 for that week's lab report grade. The laboratory sessions are divided into ten sections of twelve students, taught by two graduate teaching assistants. Each teaching assistant teaches two lab sections per week, and all are required to hold scheduled office hours each week (2 hours per teaching assistant) to help students with data analysis and their lab reports.

Outside of the scheduled lectures and laboratories, the students are expected to spend time preparing for the weekly labs and then analyzing data and writing lab reports. Students are required to purchase a lab manual written in-house, describing the experimental procedures, applicable analysis techniques, laboratory equipment and reference information for each week's lab. This information must be studied before coming to the scheduled lab session so that the student knows what data will be taken as well as how and why it will be taken. A pre-lab quiz is given during the first five minutes of each lab session which covers this preparatory information. It is a five question multiple-choice quiz and comprises five points out of a total of 100 for that week's lab report grade.

During the lab, students will work either as a single large group or in smaller groups of three to six students each, depending on the details of the week's lab. At the end of each lab session students are divided into groups of two (with one group of three if there are an odd number of students in a lab section). These groups then must analyze the data and prepare the lab report together. The students have one week to prepare their lab reports. A standard report format is provided to the students, along with example lab reports illustrating proper and improper style. Reports are graded by teaching assistants. Graded reports are provided to the student for review after lab sessions and during office hours, but they are not permitted to keep graded labs in order to discourage the circulation of graded labs among future students.

Relevant URLs for the course (class webpage and ABET syllabus) may be found in the bibliography.[1,2]

Moving the course online

With the introduction of a central WebCT server at Georgia Tech, ME3056 was investigated to determine which parts of the course could be implemented online to improve the learning experience for the students and to streamline the teaching and grading process for the professor and teaching assistants.

Originally the only part of the coursework implemented using computers (other than certain in-lab experiments) were the pre-lab quizzes (PLQ). A central server held the quiz questions, and students in the lab would use a client which presented the questions and scored the student's responses. Once complete, a teaching assistant would make the rounds of the lab and record each student's grade in a notebook. Since WebCT has modules for both quizzes and grade recording, it was clearly an advantage to use WebCT for the PLQs, since the paper notebook could be eliminated. WebCT has the ability of restricting quizzes by time and by IP address, so the system was configured to allow students to take the PLQ only during the first ten minutes of class and only using computers in the lab. This was a simple way to enforce a penalty against tardiness (zero points on the PLQ if the student is late) and to prevent students from taking the quiz at another remote location.

Since the grades for the PLQs are automatically recorded by WebCT, it was decided that all grades for the course (attendance and lab report grades) would also be entered into WebCT. This

way, students could check their progress at any time during the semester by logging in to their WebCT account, and also had access to statistical information about grade distributions and their relative performance compared to their classmates. Since students are not allowed to keep their graded lab reports, this system provides them with an easier way to keep track of their grades throughout the semester, and track whether the quality of their lab reports are improving or declining. Students are able to login to their WebCT account from any computer with access to the Internet, making it unnecessary to come to office hours or even be on campus to check grade information.

Even though there are many hours of help available to students each week given the number of teaching assistants (typically 9) holding office hours, sometimes students need help late at night or when off-campus, or just have a simple question that may be answered by another student. An online discussion group for ME3056 was set up to facilitate discussion on data analysis and report writing between the students and to provide simple answers to students more quickly. Teaching assistants monitor the discussion group, answering questions and ensuring that no improper behavior (cheating or collusion) takes place. If a question is too complex to handle online, a teaching assistant suggests that the student come to office hours to discuss it with a teaching assistant face-to-face. Simple questions (such as constants used in the lab, equations, or formatting questions) can be answered quickly, allowing the student to continue working on their report without having to wait until the next scheduled office hours.

Students have responded favorably to the availability of their grades and of course grade distributions, and to the opportunity to have a central discussion area for course material. The WebCT implementation of the PLQs have streamlined their administration and using WebCT to record all course grades has taken load off of the professor. Before, the professor would gather lab report grades from the various teaching assistants and enter them in a personal database, but now teaching assistants may directly enter grades into the WebCT system, eliminating the professor as middleman, saving time and improving recording accuracy.

Using WebLab to improve in-lab efficiency

The previous section discusses portions of ME3056 that were implemented online using tools that were already available: WebCT and discussion forum software. This section introduces a new concept in laboratory equipment training called WebLab, which was conceived and implemented specifically for ME3056.

A significant portion of the laboratory time available to the students was being used learning how to use pieces of equipment. This was particularly true in the first few weeks of the semester. There were several problems related to this fact. First of all, with only two hours per week, laboratory time is at a premium, and it was thought that that time would be better spent taking data than learning how to use equipment. Either more data could be taken (for additional experiments or sets of conditions, or to improve the validity of experimental results), or students could have more time to carefully take quality data and not feel as rushed to complete all of the experiments.

In addition, students within each lab section have differing levels of experience with some of the lab equipment. For example, the first lab introduces the students to an oscilloscope. Some students had used oscilloscopes in other labs and were very familiar with their purpose and operation, others had limited experience, and still others had no experience at all. Oftentimes when students were divided into groups of three or four to perform the experiments involving the oscilloscope, the student with the most experience would breeze through the procedures and data collection, and some of the less experienced students would not adequately understand the operation of the oscilloscope and how to use it. This handicapped these students in later labs, when the oscilloscope was used to take data and, having been introduced to it in the first lab, there is little to no time designed into the lab procedures for those students to become proficient at operating the oscilloscope.

The WebLab was conceived as a tool to familiarize the students with laboratory equipment before they enter the lab each week and to simulate hands-on experience, so that they would be prepared to come in, use the equipment, and carry out the procedures spelled out in the week's lab. This saves time in lab and also allows students to work at their own pace. Students are expected to complete the WebLab along with their other preparatory work before coming to the lab each week. PLQs were modified to include equipment-specific questions.

At a bare minimum, each WebLab contains photos of the equipment for that week's lab, annotated with descriptions of component parts, and accompanied by an explanation of how the equipment works. For more complicated equipment, the student is walked through the operation of the equipment while clicking on photos of the equipment. For example, the student is asked to turn on an oscilloscope, and must click on the power button on the photo of the oscilloscope. This way, the student can interactively step through the specific features of the equipment that will be used in the lab.

Figure 1 shows a sample page of the WebLab which explains the operation of the oscilloscope used in the lab. At this point, the purpose and basic operation of the oscilloscope has been presented, and the student has been told that a function generator set to generate a square wave of 1 volt amplitude at 200Hz has been connected to the oscilloscope. The student is told to adjust the vertical resolution of the scope by using the Volts/Div control. When the student clicks on the Volts/Div knob on the photo, a new page loads, shown in Figure 2. Now the image of the waveform on the screen has changed, and the oscilloscope screen reflects the change in resolution (from 500mV/div to 1V/div).

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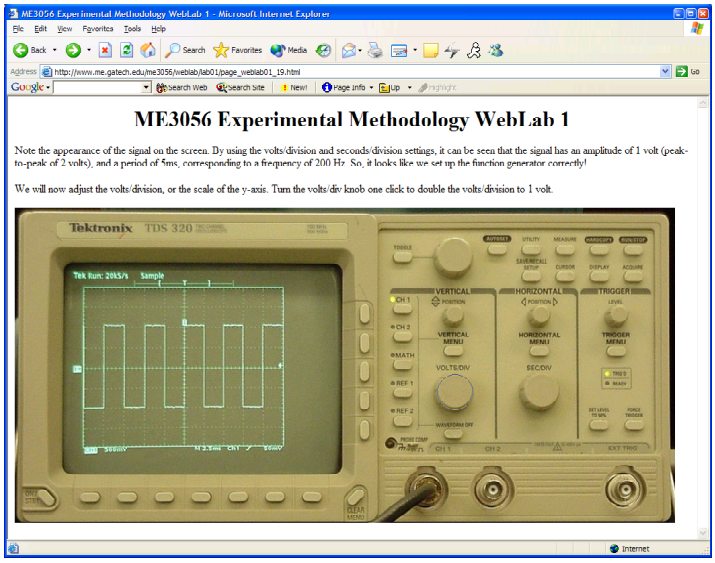

Figure 1: Oscilloscope WebLab – Vertical Resolution Adjust – Before

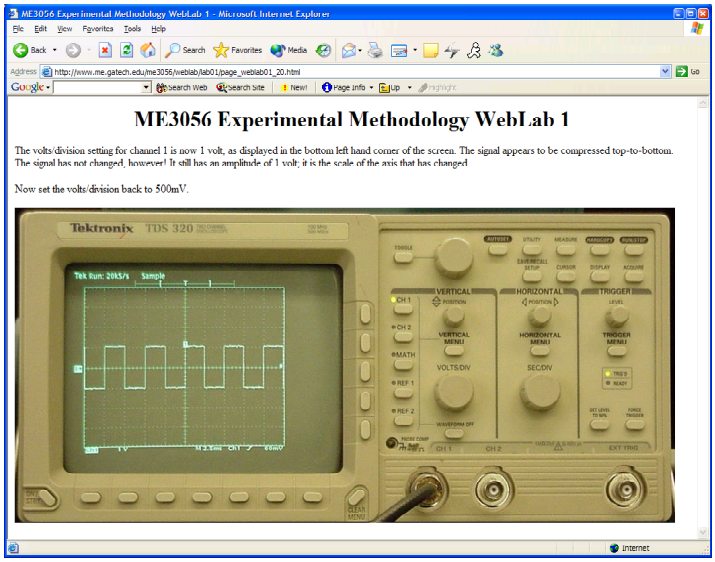

Figure 2: Oscilloscope WebLab – Vertical Resolution Adjust - After

Figure 3 shows a page from the WebLab used for a system dynamics lab involving the study of forced and unforced response of a mass-spring-damper system. This is an example of a WebLab which is not very interactive, since the number of controls on the mass-spring-damper setup is limited. It does, however, still help the students understand the operation of the setup and the location of the actuator and sensors. Before the implementation of the WebLab, it was often found that students took data without truly understanding which physical measurements they represented, trying to make this determination outside the lab while analyzing the data. The WebLab better informs students about the physical setup of the equipment; this results in the acquisition of higher quality data (since the student is better able to catch a problem with the data or the experimental setup and decide to repeat some data acquisition) and better understanding of the data during analysis and report writing.

The WebLab was first used with only six out of thirteen labs completed. Both students and teaching assistants reported a favorable opinion of the WebLab during its first semester of use. The teaching assistants were thought to be the better evaluators of performance, since they had exposure to the course with and without the use of the WebLab. Some teaching assistants reported time savings of up to thirty minutes (of a two-hour lab session) when using the WebLab. This was attributed directly to the students not having to waste time learning the operation of the equipment, and being able to almost immediately start performing the experiments and taking data.

The URL for the WebLab may be found in the bibliography.[3]

Figure 3: Mass-Spring-Damper WebLab – Apparatus Information Only

Conclusions

The integration of this introductory mechanical engineering laboratory with online tools and content has been a success. The use of WebCT to unify quiz-taking, grade tracking, and discussion forums has resulted in a more streamlined administration for the course, very important in a course with 120 students, 10 laboratory sections, and 9 teaching assistants. It has also provided for faster response to students regarding inquiries about grades and course content. The custom web-based WebLab training tool has resulted in better-informed students and provided for more efficient lab work resulting from less time spent learning how to operate equipment and more time spent taking quality data.

Initial response from the students and teaching assistants regarding these changes has been positive. Students feel that the WebLab better prepares them for experimental work each week, and teaching assistants have reported faster progress and a better understanding of the experiments by the students.

There are currently three labs (out of thirteen) that do not have completed WebLab materials. One of these three is actually a continuation of a previous lab and a separate WebLab is not planned. The remaining two are planned to be implemented by the end of the current school year.

Although there is convincing evidence for the efficacy of the WebLab, it is anecdotal. In the coming semesters a survey will be given to students to better evaluate their assessment of the WebLab.

Bibliography

[1] ME3056 Course Webpage. http://www.me.gatech.edu/me3056/

[2] ME3056 Course Description/Syllabus. http://www.me.gatech.edu/me/semester_conversion/ME3056.html

[3] ME3056 WebLab. http://www.me.gatech.edu/me3056/weblab/

Biosketches

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