Supplemental Teaching Modes for Engineering Mechanics: Statics

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Abstract
When a new section of engineering mechanics: statics was created for students in the Laptop Program at Clemson University, an opportunity was created to incorporate new teaching methods into the curriculum with the hopes of deeper understanding and higher retention among the engineering students enrolled. Methods using computer technology and hands-on activities were developed which allowed the students to play a more responsible role in their learning. Computer usage and hands-on activities will first be discussed in this paper, followed by implementation procedures and expectations. Also given are observations from the first offering of this course, including the unique cohort of students and aspects of time management. Finally the results of these supplemental teaching methods and suggestions for future offerings are provided.

Introduction
In the fall of 1998 freshmen entering the College of Engineering and Science at Clemson University were offered a seat in the first semester of the Pilot Laptop Program. The program, in which each student enrolled in the program would purchase a personal laptop computer (make and model selected by College) and take core classes in rooms with Internet capability, was designed to improve retention rate, communication skills, and cooperative learning skills among those enrolled. These freshmen were guaranteed laptop sections for their required courses in general engineering, and as they progressed into their sophomore year, new laptop courses were added to the course offering. Although adding additional laptop sections becomes more difficult as the students begin taking less general classes and more within their major, a new section of engineering mechanics: statics was created since this course is taken by students of most engineering majors.

Since many higher-level engineering courses build off the fundamental concepts learned in earlier engineering mechanics courses, it is important that the students fully grasp these concepts at this initial stage. The desire to increase the students’ level of understanding and retention led to the development of the supplemental methods presented here. This first offering of this specific course provided an excellent opportunity to implement these methods into the curriculum. This was done primarily through two methods: use of computer technology in and out of class, and use of hands-on group activities. With students having their own laptop computers the instructors could better utilize the world’s growing computer technology, including the Internet, communication tools, and educational software. The hands-on activities were designed to help the student better understand the material through both the physical models and by working in small groups.

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Computer Integration

Our first step in integrating the laptop into the course was creating a course-specific website. WebCT was selected for the website environment since it was supported by the College. WebCT provides a website shell making it simple for instructors to set up a convenient, organized course website. The site for this course helps the student become more comfortable with using computer resources and provides an one-stop course resource guide for those enrolled. Several functions of WebCT were used, including posting of documents, communication tools, links to helpful sites, and on-line quizzes. Each component added to the structure and the technical environment of the course.

![Figure 1: Engineering Mechanics: Statics homepage on WebCT](image)

Posting documents is the most primal and simplest function of WebCT. This is a great way to pass information to students without having to make paper copies and pass them out. The student can obtain the information at their convenience, anytime and anywhere an Internet connection is available. Even if students lose the original copy, they can easily access new copies through the site. There is no need for them to venture to the library for solutions, and everyone has fair access by posting on the web there is no risk of paper copies being stolen as sometimes happens when copies are posted on a real bulletin board. Both the course syllabus and the semester set of homework problems assigned for the semester were posted on the site. The homework assignments were posted at the beginning of the semester to help students form an expectation for routine involvement in the class and set the standard that homework is the student’s responsibility. All posted documents are written as text documents or scanned as expected and then posted as PDF documents for best print quality. WebCT allows the instructor to hide documents and set a function that will automatically release the item to the students on an appropriate date. Therefore, solutions were downloaded to the WebCT site at the beginning of the semester and made inaccessible until after the assignment was turned in. Power Point presentations of chapter reviews developed by the publisher of the textbook were also posted.

Communication between instructor and students was improved by use of the web. A calendar was set up that allowed important dates such as drop/add dates or test dates to be posted. Also linked to the days on the calendar was a set of objectives for that class period for quick reference. WebCT’s calendar tool allows instructor and students to post private notes, which can only be seen by the person who made the entry. The on-line grade record is a favorite of students. This feature keeps students updated with their individual course progress and also gives feedback relative to the other students. An email feature enables students and instructor to send web-based email without knowing university email addresses. A bulletin board and public and private chat rooms
are available, as well as a whiteboard, which can be useful in discussions over the phone in which a figure is helpful. Both the calendar and bulletin board alert the user of any new entries when logging on.

Students brought their laptop to class everyday, so the quiz module was used to give weekly on-line quizzes during class. Each quiz asked students simple questions based on theory and most took only about five minutes to complete. These concentrated quizzes helped keep the students up to date and grasp the main points of the course material before a large exam. These quizzes, like posted documents, may be written at the beginning of the semester and automatically released as the instructor desires. Links to outside sites and software packages were provided to direct the students to course-related sites. The Multimedia Learning Environment, an interactive tutorial developed by Siegfried M. Holzer and Raul H. Andruet at Virginia Tech, was linked through the website. This program was provided as an additional resource outside of class time, giving the computer-age student a computer-based study guide.

WebCT organizes this supplemental material under icons, which makes maneuvering the website simple and understandable. The course site may be as plain or as elaborate as desired. No hypertext mark-up language (html) knowledge is necessary, although it can be used to embellish the site, as in inserting headings and images.

Although WebCT makes it simple to set up and manage a new site, and WebCT support is available, it may be desirable to have an assistant such as a graduate teaching assistant manage this. However, the instructor should be familiar enough with the basics to know the possibilities of the program and to make changes to the site if necessary.

**Hands-on Activities**

Recall the old proverb, “I forget what I hear; I remember what I see; I know what I do.” This statement is especially applicable in a classroom situation where students are learning concepts for the first time. These activities made another distinction between this section and other engineering mechanics sections and served multiple functions. First, these physical models help students visualize the new material, which is especially

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Figure 2: Flowchart of EM201 Website

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helpful for students when first learning 3D concepts. These activities provide an application, however simple, of the theory, which gives a sense of purpose to learning. The activities provide the students with a break for the lecture format, and the group work opens communication and improves collaboration skills. Perhaps the best feature of these activities is that the students find them fun, which gives them a positive learning experience; what they see as “playtime” is actually a valuable educator.

Each activity is broken into two parts: theory and physical experiment. The theoretical portion stresses equations, definitions, and derivations taken from the lecture and the text. By referencing these sources in the activities, the instructor ensures that the students will at least look at the notes or text given, and the student will be more apt to reference these sources on their own throughout the semester. Many of the theoretical questions ask for a translation of equations or other theory into the students’ own words, which improves their written communication skills and helps them remember the material. These theoretical questions should not only review new material, but also set up the students so they will be prepared to perform the experimental portion of the activity. The experimental portion should likewise tie into the theoretical questions. Simple models using simple, inexpensive yet durable materials can be designed to show how theory can be applied. Since it is the thought process that is important, these activities need not be exact; they can provide valuable understanding even without accurate results. These hands-on activities may cover topics such as vectors and vector properties, spatial equilibrium, and center of gravity. Groups of two to three students work well to ensure that each student has a hand in the activity.

Figure 3: Particle Equilibrium Activity
Implementation and Expectations

A four-person team was formed to design and implement these new teaching modes: the instructor, a graduate teaching assistant, and two part-time undergraduate assistants. The instructor formed the lesson plans, provided documents to be posted on the web, and designed activities with the graduate teaching assistant. The instructor was also responsible in providing any necessary equipment and software such as a scanner or image editing software. The graduate teaching assistant took the ideas for the activities and wrote activity sheets, which asked questions that led the students through the theoretical and experimental portions of each activity. The teaching assistant also managed the course website. The undergraduate assistants were responsible for taking the plans for the activities and building physical models. In the case of a small class enough models can be built so that each group has its own model. With larger classes, the activities could be performed outside of class, with students arranging staggered meetings with the instructor or teaching assistant. With this format, only two or three models would be necessary for the entire class. As with any project it is important to remember that communication between everyone involved is vital to the success of the project.

Perhaps the most important factor to consider when teaching with new methods for the first time is the time commitment. A large commitment is necessary when developing and planning new material. Once these initial
steps are taken maintenance should not require as much time, and with most things, the more you accomplish at the onset, the less you have to do throughout the semester. A functional site may be made in as little as a few hours, depending on what functions are desired. Maintenance of the site throughout the semester also depends on how elaborate it is and how much was done initially. It is also very important to note that time for any in-class activities or quizzes must be incorporated into lesson plans. This seems straightforward, but if not considered can cause stress on both the students and the instructor.

**Challenges and Suggestions**

As the semester progressed these supplements were found to be very helpful, however, some challenges were encountered. Here are several problems and some suggestions to alleviate each.

When using technical equipment it is possible to experience temporary “downtime”. There are two probable cases for this inconvenience: the server not functioning properly, or a student’s personal laptop needing serviced. The first is probably a larger problem since the instructor has no control over it. Although this should not occur often, when it does, it is important that the instructor regains control. If computer usage such as an on-line quiz or tutorial is planned for a class, the necessary equipment should be checked beforehand to allow time for adjustments in lesson plans. When planning lessons it would be desirable to have a backup plan in case of an unexpected incidence. The second problem, a broken laptop, can be temporarily fixed by allowing the student to share a classmate’s computer or providing a loaner laptop if available through the support team. The students should be directed to the proper support authorities as soon as the problem arises.

The initial time commitment is a very important item to consider. Again, depending on the depth to which supplemental tools will be used, a large start-up time may be necessary. By forming a team as described, this workload can be alleviated.

In addition to time required for development, time is also required for delivery and execution, especially if conducting in-class activities. Each student works at a different pace, but each must be able to work at their own speed in order to fully comprehend the relevance of the activities. If students are rushed, they may become frustrated and lose concentration. One possible solution is to have the students complete the theoretical portion of each activity before coming to class and then perform the experimental activity during class. When time restrictions make in-class activities impossible, conduct short demonstrations or other short tutorials in class and allow the students to perform the activities outside of class. If this is done, time requirements should still be carefully regarded, considering the busy schedule of the engineering student.

The instructor should pay close attention to how these methods are being used. They should never replace the instructor or traditional teaching methods, but should be a supplement that when used jointly with traditional methods improve the student’s learning experience. The instructor should have a thorough understanding of the website and any software packages used before introducing them to the students. Lastly, if the students are initially told that computers will be used in the course, plan them into the lessons throughout the entire course. There are many existing programs that may be adapted to specific courses. In addition to on-line quizzes and interactive tutorials, everyday software such as spreadsheet programs may be incorporated to give students application usage. Some publishers may even include software with the text, such as The Beer & Johnson New Media Version CD introduced in the 7th edition, which includes Working Model, a tutorial, and an FE Exam Interactive Review.

**Observations**

There are two main phenomena that occurred within this particular section of engineering mechanics. The first is the unique bond between students. One of the reasons for this is that the students in the laptop program have taken most of their classes in laptop sections. These sections may be smaller than regular sections, so the
students become more familiar with each other. Also, because of block scheduling, these students had moved through courses together and knew each other from being in class together previous semesters. As a consequence the students were able to form very productive teams on the first day. The group activities also helped give an informal, community atmosphere to the classroom. Working together in small groups of two or three allowed more personal involvement in the activities and increased the bond between classmates.

The second noteworthy observation is the time that these in-class activities required. Proper time management is always vital to the execution of lesson plans. This becomes more difficult when incorporating new teaching methods for the first time. The on-line quizzes did not pose as big a problem, as the only lasted approximately five minutes. These quizzes were given once a week to promote material retention and continuous involvement throughout the semester. The hands-on activities require a larger time allotment. At least twenty minutes should be allotted for each activity, but more time may be necessary depending on both the activity and the pace of the students. It is a good idea to leave some padding for “in-between” time (switching from one activity to the next); when the classroom environment changes it will take a moment for the students to redirect their attention. When not using laptops or activity materials, have the students put these items away so that they may focus on the current task at hand.

**Results**

At the end of the semester an online survey was conducted using WebCT. Students responded anonymously to questions about the effectiveness of the activities. Students responded that the activities helped them to visualize and grasp new material and remember the material at the end of the semester. Students could spend less time reviewing, or relearning, old material, which allowed more time to understand the material at a higher level. The students also enjoyed being able to work in groups to perform the activities. The use of the computer is good as long as it is used appropriately. It can improve the availability and accessibility of information as well as student-instructor communication. Responsibility for obtaining some material shifts slightly from instructor to student, which promotes students to participate more actively in their learning. Similar answers were provided in response to a questionnaire given after the first month of the second semester offering. With the change from in-class activities to out-of-class activities, several groups said they used the materials provided for the activities to build models of homework problems to help them visualize. This manipulation of the supplied material promoted the students’ basic engineering skills and also showed how the students viewed the hands-on aspect beneficial to their understanding.

These supplemental modes will not cure the difficulties of teaching, but are meant to enrich the students’ understandings and experiences. As long as managed properly, these methods can be very beneficial for both instructor and students.

**References**

http://www.ces.clemson.edu/laptop/lapover.html

http://cesun1.ce.vt.edu/statics
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Ms. Henkel is a graduate student in the Civil Engineering Department at Clemson University pursuing her Master’s degree with a concentration in structural engineering. During the Fall 1999 semester she had a quarter-time assistantship to help deliver the multimedia portion of the class. Before receiving her B.S. degree in Civil Engineering from Clemson in August 1999 she worked for the department as an undergraduate teaching assistant in the Structural Mechanics (Strength of Materials) laboratory. During the summer, prior to starting her MS degree, she developed the WebCT website and in-class activities for the Engineering Mechanics course at Clemson University. Ms. Henkel is an active member in Clemson University’s student chapter of American Society of Civil Engineers.

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Dr. Schiff is an Associate Professor of Civil Engineering at Clemson University. He came to Clemson University in 1989 after completing his Ph.D. in Civil (Earthquake) Engineering and M.S. degree in Civil (Structural) Engineering at the University of Illinois at Urbana-Champaign. In 1982, he received his B.S. degree from the University of Cincinnati in Architectural Engineering.

Dr. Schiff has taught undergraduate and graduate course in the structural engineering area. He taught the first laptop section of engineering mechanics: statics in the fall of 1999 with newly developed teaching methods. In 1994, he received the Outstanding Teacher Award presented by the Chi Epsilon Chapter at Clemson University. Dr. Schiff is a member of the American Society of Civil Engineers, the Earthquake Engineering Research Institute, and the American Association of Wind Engineering.