# Delivery and Assessment of Teaching Statics over the Internet to Community College Students

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**Abstract**

This paper presents the methods and results of delivering a basic Statics course to Pellissippi State Technical Community College (PSTCC) students located in Knoxville, Tennessee over the Internet. All aspects of the course, including textbook, lectures, class meetings, student discussions, homework and tests were conducted through the Internet. The online course material included animations, simulations, narrations, and graphics. Homework and tests were also conducted over the Internet. For comparison purposes, a traditional Statics class was conducted by the same instructors (the authors) at PSTCC using traditional delivery methods with on-campus lectures and office hours. The two classes covered the same material at the same rate, and students took the same multiple choice tests and final exam. Both classes had access to identical course content on the Internet as well as a standard print textbook. Comparison of the test results of the two classes shows that the online delivery of basic engineering content through the Internet provides as good, if not better, education than traditional delivery methods. In summary, the online class students performed better on the exams by over a half-grade level.

## Introduction

There has been a tremendous interest and need in using technology and computer networks to enhance engineering education and to provide learning opportunities to students at a distance. It has been assumed that technology has the potential through 3D animation, simulations, user interaction, user tracking, video, and audio to increase both the learning efficiency (learn faster or learn more) of the student and the teaching efficiency of the instructor (teach faster or teach more). However, it is also known that technology has not had a great track record in implementation [1]. This could be due to a large number of reasons, such as lack of good electronic engineering media, institutional reluctance to implement technology, instructor's lack of desire to change, and the initial high cost of development and implementation. In addition to these issues, there is a shortage of studies on showing how electronic media and the Internet can improve learning and teaching efficiencies. One the other hand, there are individual classes that have been developed and implemented that has shown that distance engineering education can work [2].

The research conducted for this paper involved addressing a number of issues regarding the use of electronic media and the Internet. The framework for this work involved developing and delivering a complete online course, including all course content, to students at small local colleges that prepare students for the last two years of the traditional 4-year engineering programs at universities or colleges. Students at these local colleges, such community colleges, junior colleges, traditionally liberal education colleges and vocational institutions (referred to as simply community colleges in this paper) have a particular interest in online courses for basic engineering courses due to work or family schedules, lack of class choices, long commuting distances, and lower cost of tuition. Thus, one of the main objectives of this project was to delivery a high quality Statics class to community college students over the Internet. If successful, then other courses could also be developed and delivered to those students that do not have an opportunity to take the class at their local school for whatever reason. While community colleges are the main target, online engineering classes can also help students in larger 4-year engineering programs by providing an alternative for on-campus students with scheduling issues, interns and coop students, or students in the military to start or continue their engineering education..

For comparison purposes, two classes were used in this study, one section for online delivery and another section for on-campus delivery. There was no pre-selection of students in either class and students had the option, during the standard registration period, to choose either section. Both classes held meeting times 3 times a week. The online classes were conducted over the Internet using network software that was specially developed by one of the authors, Kurt Gramoll [3, 4]. The Internet-based tool uses the Flash Communication Server and allowed real-time collaboration for drawing, lecturing and discussions by both the instructors and students.

This research is part of a three-year NSF-funded project to develop and deliver Statics, Dynamics and Introduction to Chemical Engineering courses to students at community colleges, junior colleges and liberal arts colleges that would not otherwise have access to engineering courses. By taking these sophomore-level courses during their sophomore year at the community college, students can reduce the time needed to complete their education at the four-year engineering schools after they transfer.

## Course Organization

The course was organized to promote both efficient learning and teaching through the use of electronic media and technology. The method of delivery, while important, was considered secondary to good student learning and efficient instructor delivery. As a result, the course organization could be used with on-campus students as well as with distance students. In fact, one of the authors has used the same course organization to teach Statics, Dynamics and Mechanics at the University of Oklahoma for a number of years. However, this is the first time the course was offered to true distance students in the state of Tennessee.

From the start, it was assumed that this course would be an instructor-lead and not an independent study course. This is a fundamental choice that was made before any material or tools were developed. There were a number of reasons for this choice. Students at community colleges generally expect easy contact with an instructor. In fact, this is one of the strong recruiting tools that community colleges have over large 4-year research institutions. Another reason is difficulty in developing the self-paced course content that is effective and re-usable. Finally, the authors felt that the future of electronic media is not in the replacement of instructors, but to provide the instructors more tools to effectively teach their students, both on campus and at a distance.

The course was developed to be self-contained so that distance students would not have to travel or locate external materials. All technical material was included as an online textbook, called an eBook. Formal course lectures were also made available as streaming Flash video files. All problems, examples, and test questions were viewed and submitted online through the course web site. A real-time, online collaboration tool was available to all students for voice over IP communication and drawing sharing. Questions about the problems or course could be posted on the web-based, class discussion board (web board) and were answered by the instructor within 12 hours (90% answered within 6-8 hours). Various simulations and analysis tools were developed to assist students in learning specific concepts.

All online material and tools were provided without any additional cost to the students. This was possible since all material and tools were developed by the authors and no commercial programs or software were used. Even the course management system and online collaboration tool were developed specifically for delivering engineering courses through electronic media. This has also made it possible to open the system at www.eCourses.ou.edu to any instructor or institution in the world for free use of the material for their classes, either on-campus or distance. Details about each of the main components of the course are given below.

eBook - The online eBook (Figure 1) was accessible at anytime and was linked directly to the syllabus by sections for fast and efficient access. The content of the eBook covered all Statics topics in a manner similar to that of a traditional textbook. However, the material was organized around a typical engineering case study to enhance the students' interest. The eBook made extensive use of simulations, animations, and narrations, which are the three major advantages of eBooks over traditionally print textbooks. The content and organization of the eBook has been reviewed by St. Clair and Baker [5]. They reported that it was the most complete electronic resource for Statics and addressed all the different learning styles of students. It should be noted, that the students were not required to purchase a print textbook, but it was recommended for additional background information. The course syllabus referenced the section in the textbook to assist students. Through direct communications with students, approximately 60% of the students obtained a printed textbook for their use.

One strong advantage of electronic media is the ability of the web site to track users' viewing of the material. Similar to commercial web sites, all actions of students were tracked so that the instructor could better understand what the students had viewed. This was particularly helpful in addressing student's questions. In many cases, students were tactfully reminded that they had not read or viewed the material in the eBook that would help answer their question. It was felt that this improved the students viewing and using the eBook material for the course since they knew the instructor would know that they had not studied the material. Of course, tracking of users' viewing actions is not the same thing as tracking their reading and comprehension, which is not possible; but it is better than not knowing if they even opened the book as with printed textbooks.

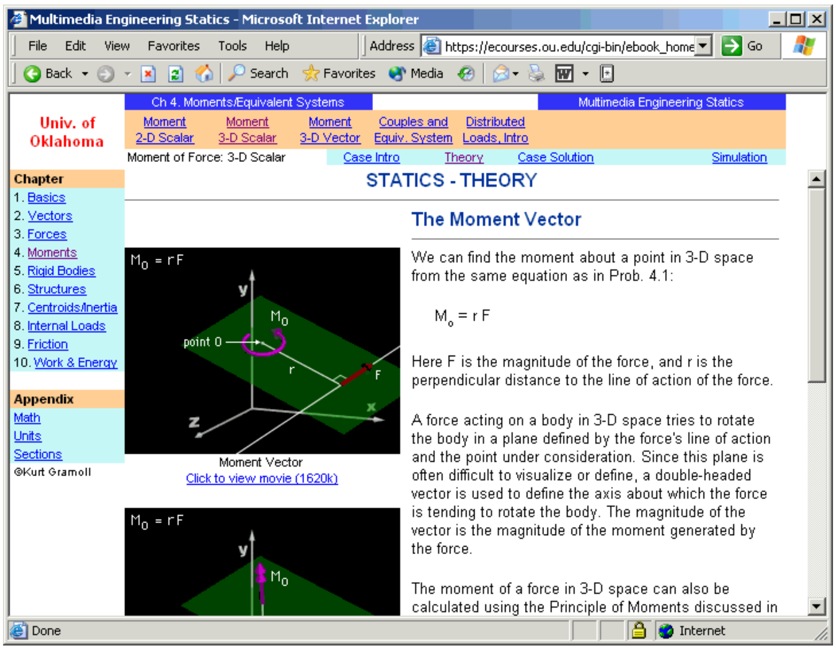


Figure 1. Electronic textbook (eBook) developed for online course

LectureBoard - To facilitate students meetings 3 times a week with the instructor, an online-collaboration tool was developed [3]. The tool, called LectureBoard (Figure 2), allowed all class members to attend class virtually over the Internet. LectureBoard, is similar to commercial collaboration tools, but included a number of features needed for engineering classes. LectureBoard allows both drawing and voice to be broadcast to all other class members. The whole session can be recorded as a native Flash file, which means all drawing is saved as vector-based objects similar to CAD programs. Flash files are also one of the most efficient files to play in any browser. One other important aspect of the tool is that is operates inside the browser itself so that students do not have to download, install or purchase any program. The tool was used for all class meetings and office hours.

LectureBoard provided a critical component of the course by allowing students to discuss problems and concepts openly, similar to a classroom setting. The authors feel that the LectureBoard also allowed the students to be more forth coming with questions and comments since their face did not appear. The tool could have been programmed to share video but that causes a number of additional issues, such as larger bandwidth requirements, students needing a web camera, and increased technical problems. The students were only required to have a microphone and speakers. Most students had both, but not all. The microphone was the biggest technical issue: 1. it had to be turned on, 2. the system voice input needed to be set to a correct level, and 3. it needed to be located a proper distance from the speaker (feedback problems occurred with the microphone close to large external speakers). For voice communications, it was determined that a simple headset (about $10-15) with a microphone boom worked well and was the least expensive.

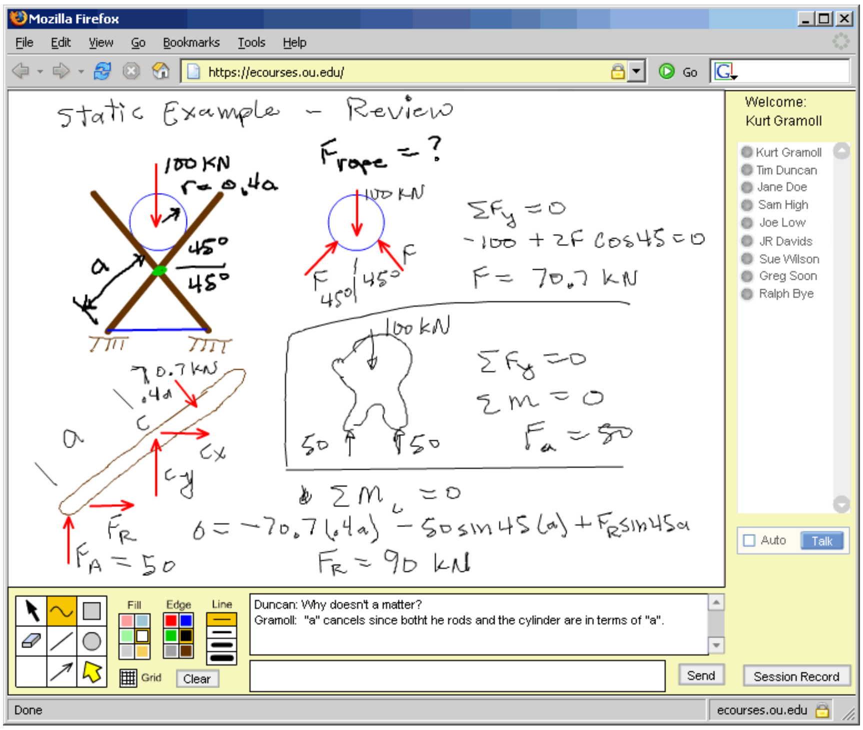


Figure 2. Real-time voice and drawing collaboration tool
used for class meetings and office hours

Homework and Tests - In addition to course reference material, homework and test problems were also accessed over the Internet. To facilitate online problem submission and correction, the problems were designed as multiple choice questions. The problems are stored in a database at eCourses.ou.edu and can be assigned to any homework, quiz, or test problem set [4] (see Figure 3 for an example). The course management system tracks each problem that is used and scores the submitted answers from the students. The instructor can randomize problem and answer orders, which is particular useful for exams. Also, one of the questions can be set to “none of the above”. However, this option was not used for the tests given in this study. All assignments and tests could be accessed within hours of the due time since they were automatically graded by the course management system. The delay of a few hours before releasing the answers to the students allowed time to correct any issue that may develop, such as a student having technical problems with the submission.

Exam security is an important issue with online classes and is one of the most difficult issues to resolve. It has been suggested that a video camera or spyware software be used on each students’ computer, but that adds another technical support issue and they can be defeated without too much difficulty. The most secure method is to have a proctor supervising the exam. Since this was a trial case and all the students, except one, lived within 50 miles of the school, all exams were conducted on campus. In the future, when this program is opened to any student in the country, a proctor system will need to be established. These types of systems are currently used in many distance education programs such as those managed by The University of Tennessee's Distance Education and Independent Study (DEIS) Division.

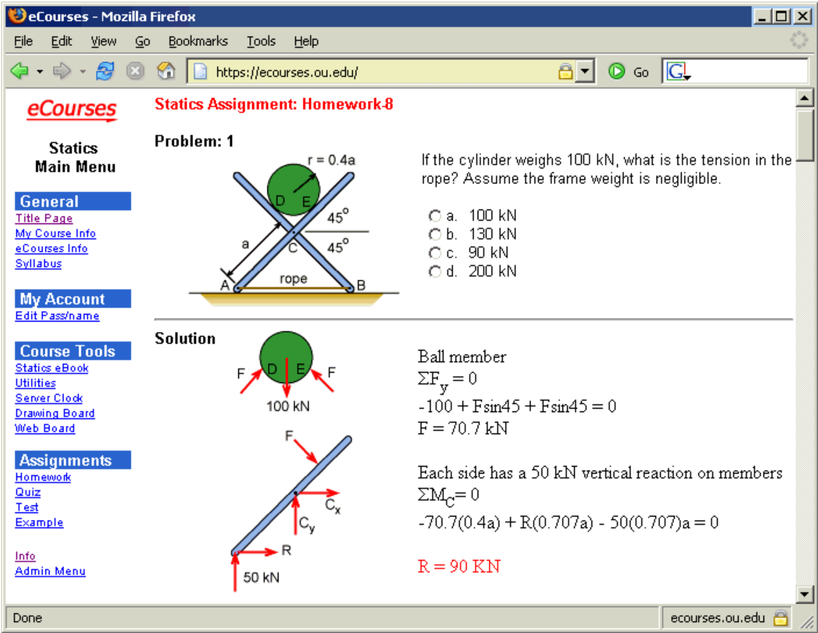


Figure 3. Typical homework assignment with solution

Web Discussion Board - Posting questions and comments on a web-based discussion bulletin board is a common tool for both online and on-campus classes. Of all the online tools, it seems that posting questions is the most used and appreciated by students and professors. It gives the students a convenient method to ask questions at any time, and gives the professor the opportunity to address them when he or she has the time. It also provides a mechanism for students to help each other. The online class made extensive use of the web discussion board which was implemented as virtual office hours. One reason it was successful was that the instructors made a strong effort to address all questions within 24 hours of when they were posted. In general, most instructor replies were posted within 4-6 hours. While this seems to be more work for the instructor, it was actually less work than the traditional 3-4 hours per week for office hours since questions were answered only once instead of multiple times that usually occurs with office hours.

## Class Teaching and Operation

The online course was designed to be similar to the traditional on-campus Statics class currently taught at PSTCC and that was used as a comparison class. Both classes met three times a week, had real-time discussion about concepts and problems, and had weekly assignments. The most significant difference between the two classes is that one hosted their meetings over the web using the LectureBoard and the other met in person in a classroom. There were several other minor differences in the operation of the classes, such as the on-campus class relied on the printed textbook more than the eBook, where as the online class relied on the eBook more. However, both classes had full access to both types of course content.

There was a different teaching style between the two classes that should be noted. The online class used the three weekly meetings (standard 50 minutes each) to coach the students rather than lecture. Since all the lectures were already available to the students (eLectures) it was felt the meeting time could be better spent directly addressing the students concerns and questions. Concepts and theory were reviewed, but rarely were details presented. Furthermore, the concept review was usually done in conjunction to a question from the students. This provided students with the required theory when they needed it. Initially, students were reluctant to ask questions since they expected a full hour lecture, but after the first week when they realized that they were expected to attend with concerns and questions, the meeting time was fully utilized as a coaching session. There were times in which the students did not have questions (i.e. had not look at that week's material or homework), especially the first meeting of the week, and the instructor needed to have some examples and simple review material prepared.

With the coaching style of meetings, it was interesting to note that more students participated in the on-line class. In general, almost all students that attended the online meetings participated and asked serious questions. There was one drawback to online meetings; however, in that attendance percentage was lower than the on-campus class. This was due in part to the busy schedules of the online students, which as one reason they took the online class. In general only 30-40% of the students attended a given class. Over the entire week, about 70-80% of all students would participate in at least one meeting. The meetings for each of the three weekly classes were at different times of the day to allow all students the ability to attend at least one real-time class meeting.

**Class Testing and Performance**

One of the main objectives in teaching this prototype online class was to compare it to a similar on-campus class taught at the same institution with the same instructor so that teaching and learning levels could be compared. Both classes were conducted with students enrolled at Pellissippi State Technical Community College (PSTCC) near Knoxville, Tennessee. There was no screening of the students that enrolled in either the online class or the on-campus class. Both classes were advertised in the school bulletin and class schedule as options just like any normal section. Students were informed at registration time that the online class would meet only on the Internet and class times would be flexible. Each student chose which section to enroll in.

The type of students in both classes ranged from new high school graduates to older adults returning to school after a long absence. Some students were only taking one class from PSTCC and others where taking a full load. In most cases, the students were planning to complete their engineering degree at one of the major in-state engineering schools, such as the University of Tennessee or Tennessee Technological University.

The online and on-campus classes were similar in that both had access to the online eLectures and eBook, and took the same exams. However, the on-campus class used a printed textbook for homework problems where as the online class used web-based homework problems (multiple choice). The textbook was recommended for the online class, but not required. The online class and on-campus class were both taught by two of the authors: Kurt Gramoll and Mary Kocak. The on-campus class was primarily coordinated by Mary Kocak and the online class by Kurt Gramoll. However, both instructors were present for all online classes.

There were a total of 6 tests over the Spring 2004 semester. Each test counted from 7% to 20% of the student's total grade (see Table 1). The variation in percentage was due to the amount of material covered. Each test was a multiple choice test with questions similar to those shown in Figure 4. Both classes were given the same test and the same amount of time was allowed to complete the test. Also, both classes took the test through an online web page in the same room using computers at PSTCC (no personal computers). Students in both classes where exposed to multiple-choice questions through homework for the online class and quizzes for the on-campus class.

| | **Tests** | | | | | | **Course Average** | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 (final) | Weighted | Normal |
| Online score Average | 90.8 | 77.3 | 80.0 | 71.3 | 74.0 | 69.8 | 77.0 | 77.2 |
| (# of students) | (13) | (12) | (12) | (12) | (12) | (12) | | |
| On-campus score Average | 80.2 | 73.8 | 70.8 | 68.8 | 76.0 | 61.7 | 70.7 | 71.9 |
| (# of students) | (24) | (24) | (20) | (19) | (19) | (19) | | |
| Class grade weight | 15% | 7% | 15% | 15% | 8% | 20% | | |
| Number of problems | 8 | 7 | 7 | 7 | 7 | 11 | | |
| Points deducted | 8 | 8 | 8 | 8 | 8 | 7 | | |
| Test time (mins) | 60 | 60 | 60 | 60 | 60 | 120 | | |

Table 1. Class test information and results

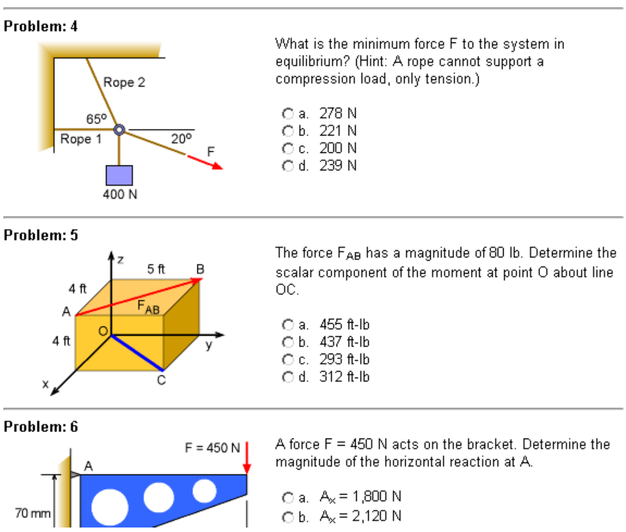


Figure 4. Typical test questions format

The class average for each test is listed in Table 1 along with the total class average for all 6 tests. The "weighted" average takes into consideration the percent weight that each test counted towards the final grade, where as the "normal" column is just a simple average of all 6 tests. The number of students taking each text does vary over the semester since some students drop the class or stop participating in the course. All tests deduct a set number of points for each wrong answer. Thus, if a student missed one problem on text 1, his or her score would be 100 - 8 = 92. Since test 1 only had 8 problems, it is possible for a student to get a test score of 34 even if they miss all problems. This was done for two reasons. First, it was decided that the student should still make an A if they make one mistake and get a problem wrong thus no more than 10 points can be deducted for a incorrect answer. This would minimize the effect of making a simple calculation error. Second, to simulate partial credit, it was decided that a base score, such as 34 for test 1, would be given just if the student took the test. The questions ranged from basic, 1-2 step problems to complex, 3-4 step problems (Figure 4). All problems had the same points deducted if it was wrong regardless of question difficulty.

The time was considered critical and extra time was not given to students even if they did not finish the test. Since it was open book and open note exam, time was limited to restrict the student's ability to study during the exam. The books, notes and web site were available during the exam for reference. If the student did not know the material and had to search the course material for assistance, they general experienced time problems and did not finish the test.

**Results Discussion**

The test scores in Table 1 are plotted in graphical form in Figure 5. In all tests except for the fifth test, the online class did better. The overall test score average for the online vs. on-campus class was 77.0 vs. 70.7 for the weighted average and 77.2 vs. 71.9 for the straight average. The weighted average used the same percentages that each test was weighted for the class grade (for example, the final was worth 20% where as the other tests were between 7 and 15%). In either case, there was over a 5 point difference, which is equivalent to a half grade.

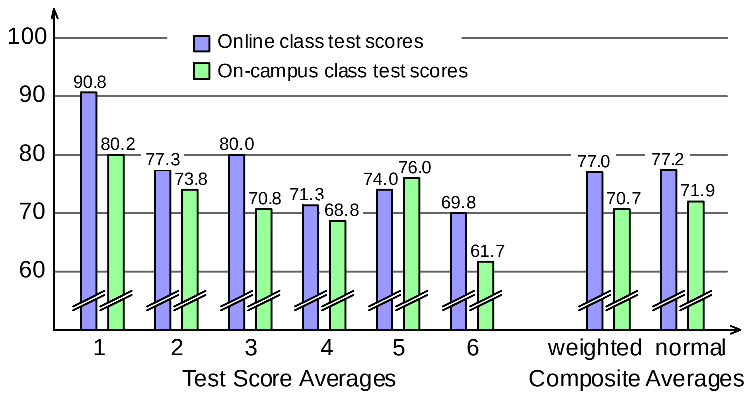


Figure 5. Test scores

Since the two classes used different homework assignments (the on-campus class also had quizzes) the final grades were not compared. It was felt that there were too many variables with the homework and quizzes to make any valid comparisons.

There are a number of possible reasons for the difference in test results. The teaching style for the online students was more coaching than lectures. In each of the online weekly meetings, at least 30 minutes were devoted to directly addressing questions and issues from the students. It was expected that the students had viewed the online pre-recorded lectures. Also, the online meetings were less formal and thus students seemed to participate more freely. There were less students online (3-5 each meeting) and so more personal help could be extended.

Another possible reason for the test scores being different is the students that took the online class are fundamentally more active-oriented since they picked the online class. Also, students that had work conflicts took the class, and they could be viewed as being more responsible and diligent. Neither of these social character traits can be proven as a solid reason for the better performance.

One of the main objectives of this study is to determine if an online course could provide the same level of education and learning experience as an on-campus course. After considering the online student's strong performance on the tests, the authors feel that online courses provide equal education, if not better, than on-campus classes. Of course, online courses that are poorly structured or do not make use of real-time collaboration tools will probably not be able to teach students as well as on-campus classes. But, if the online students have similar course materials (eBooks, eLectures, textbooks) and real-time online meetings that simulate a standard classroom, then online class can be as successful in teaching students.

What was not evident in the test scores were all of the other benefits to online classes. The convenience of online classes is the top reason for taking the class (ranked first in the survey). The other two main reasons were work conflicts and distance to campus. These non-test score issues were better identified with a class survey. Parts of the survey are shown in Table 2.

| Score | Question |
|---|---|
| 1.64 | Course Syllabus on the Web |
| 3.09 | eBook on the Web |
| 2.00 | Textbook (any textbook) |
| 2.00 | eLectures on the Web |
| 2.27 | Examples on the Web |
| 2.09 | Class meetings on the Web |
| 2.36 | Web Board questions/answers/notes |
| 1.82 | Homework on the Web |
| 1.27 | Homework solutions on the Web |
| 1.73 | Test on the Web |
| 1.91 | Web course content during test |
| 1.18 | Online grade access |

Scale: 1 = Very Useful, 2 = Useful
3 = Somewhat Useful, 4 = Not Useful

Table 2a. Usefulness survey questions

| Score | Question |
|---|---|
| 2.64 | The online course as a whole |
| 2.73 | The course content |
| 2.64 | The effectiveness of the online course |
| 1.82 | Instructor feedback |
| 1.64 | Timeliness of feedback |
| 2.27 | Reasonableness of assigned work |
| 2.18 | Grading techniques |
| 2.00 | Course organization |
| 2.09 | Instructor's explanations of concepts |
| 2.09 | Instructor's overall effectiveness |
| 2.45 | Amount you learned in the course |
| 2.91 | Effectiveness of meeting time on web |

Scale: 1 = Excellent, 2 = Very Good, 3 = Good
4 = Fair, 5 = Poor, 6 = Very Poor

Table 2b. General survey questions

The usefulness-type survey questions, Table 2a, identified that "online grade access" and "homework solutions on the web" were the two most useful features of the web based classed. This surprised the authors that had assumed that online class meetings, eBook, and web-based discussion board would be the most useful features. In fact, the students generally regarded the online eBook just as negatively as the printed book. In retrospect, maybe this should not have been surprising in that both the eBook and printed textbook require the students to put effort into studying on their own. This points out that just because a book is electronic with animations, simulations and color graphics, students still do not want to spend the time or effort to read and study on their own.

The general-type survey questions, Table 2b, identified quick feedback and instructor feedback was very good. The instructor feedback was performed through an online web-based discussion board. Posted questions or comments were generally answered within 6-8 hours. This helped identify that students just need feedback, whether with physical office hours (not possible with distance learning course) or the online discussion board. The general survey questions also note that the meeting time on the web was not as effective as thought by the instructor. The students did give written comments that they liked the online meetings, but were not comfortable with the non-structured format. Recall, the online meetings were more like coaching sessions without a fixed lecture. Students were expected to study the online material (eBook, eLectures, textbook, etc.) and then be prepared to discuss concepts and homework questions. It seems that this format still needs improvement since the students only thought it was good and not very good or excellent.

Overall the survey responses were positive and showed a strong positive attitude to the online class structure and teaching method. The students also gave a number of written comments that ranged from negative ("…concepts are hard to grasp on a screen") to positive ("I felt the online lectures were great."). One clear comment was that 70% of the students would recommend the online class to others and would take another one if offered. This indicated to the authors that the students were generally satisfied with the course and would like to have the opportunity to take more online classes. In fact, two students at PSTCC approached the instructors to see if an online Dynamics class could be offered the following semester (one even appealed to the Department Head to provide one). Some written comments focused on the operation of the web site, such as needing a drawing tool to submit diagrams with text questions for the web board discussion. Many of these features have already been developed and are being implemented into the eCourses web site.

**Summary**

In summary, a Statics class was delivered using the Internet and compared with a normal on-campus class. In most aspects, the learning method for each class was similar. Both classes had regularly scheduled meeting times in which students participated with other students in an instructor-lead discussion and lecture. One class was delivered over the Internet, the other in person. Both classes had access to similar learning materials: a printed textbook for the campus based students and an online electronic textbook for the internet-based students (both covered the same material). The traditional on-campus students had office hours in person while the online class asked questions and discussed problems over the Internet. Also, both classes had weekly assignments that were graded, even through one was done on paper and the other was done over the Internet with multiple choice questions.

So if the two classes were really fairly similar, what contributed to the better test scores for the online students? This could be due to a wide range of reasons, but the authors feel that it was due mainly to the better contact between the students themselves and the instructor. Active participation was strongly encouraged over the Internet so the instructor would know they were still online. Unlike a traditional classroom, the instructor cannot see the students (video connection could be used, but may produce bandwidth problems for remote users). Online students can virtually disappear if active questioning and participation is not demanded. Thus, online classes need to be taught by an instructor that can foster active student participation.

Another key reason for the better performance of the online class may be the effect use of electronic technologies such as multimedia. The electronic textbook presented simulations and animations in addition to text and graphics. In addition to the online eBook, all the lectures were recorded and available to the students. Thus, the online students had a large number of methods to learn Statics: eBook, eLectures, weekly meetings, online web board discussions, email, and immediate assignment grading.

Another possible reason for the better test results, in the authors' opinion, was the students that elected to participate in the class were more mature. This may have been related to the fact that a higher percentage of the students were working or interning. While it cannot be proven, it was the author's option that the online students took the class more seriously.

In summary, the online delivery provided an education that was as good, if not better, than traditional delivery methods. The NSF sponsored program is still being conducted and future on-line classes will be offered for Statics, Dynamics and Introduction to Chemical Engineering in the coming year.

## Acknowledgments

This project is funded by the National Science Foundation, Division of Engineering Education and Centers, through the Engineering Education Program grant number 0212224.

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