

AC 2007-670: USING TECHNOLOGY TO ENHANCE THE TRADITIONAL LECTURE

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Using Technology to Enhance the Traditional Lecture

Abstract

The advancement of information technology has provided faculty with many opportunities to adopt and incorporate it into traditional classroom teaching. However, the new technology is not always better. For many topics, the best strategy is still the traditional chalk-and-talk lecture. There are three critical requirements that must be met before new technology is adopted on a large scale.

1. The new technology should be able to facilitate student learning and understanding. It should be better than a traditional lecture.
2. The new technology should be easy to use. Learning to use the technology should not create excessive work for the faculty member. Class preparation should take approximately the same amount of time as for a traditional lecture.
3. The new technology should be reliable and convenient.

The author is currently using a technological method for teaching engineering mechanics courses that meets the criteria listed above. A key component to the method is that the faculty member projects complex figures on the board and then uses chalk (or markers or a smart board or a tablet) to modify the figures. This teaching method blends the traditional lecture with the new technology, utilizing the new technology to improve the quality of the traditional lecture. From the instructor's perspective, preparing the lecture takes approximately the same amount of time as preparing a traditional lecture. The use of technology has been well received by the students, improving student satisfaction, and also improving student performance on the department final exam.

The new technology has also been very helpful in providing distance office hours. Distance office hours are not just for distance students; the on-campus students have benefited more from the distance office hour sessions than the distance students. Students no longer have to make the trip in to the faculty member's office to get help with the homework. They can get help from their dorm room or apartment. The author has been setting a couple of hours aside the evening before homework is due, and providing office hours from his home, sitting in his recliner, and approximately one-third of the students in the class log in to get help with the homework. It is convenient for faculty and students, and is a very effective teaching tool.

Introduction

The chalkboard is a very effective tool for teaching. It frees us from our short term memory. With the chalkboard, the teacher can put several ideas up at once, and show how the ideas are related, or how one idea flows from another. The students can watch ideas and arguments develop in a logical manner, and the process can be paused and restarted to be sure the students understand and keep up with the lecture. Figures can be drawn to utilize our visual learning capabilities. The chalkboard is useful in teaching all subjects, but is especially indispensable in teaching mathematics and science. Following is a quote from Samuel May:

“... in the winter of 1813 & '14 , during my first College vacations, I attended a mathematical school kept in Boston by the Rev. Francis Xavier Brosius . . . On entering his room, we were struck at the appearance of an ample Black Board suspended on the wall, with lumps of chalk on a ledge below, and cloths hanging at either side. I had never heard of such a thing before. There it was—forty-two years ago—that I first saw what now I trust is considered indispensable in every school—the Black Board—and there that I first witnessed the process of analytical and inductive teaching.” [Samuel J. May 1855] (Anderson, 2004)

The chalkboard is a very powerful tool for teaching engineering mechanics courses. Students can watch the derivations and example problems evolve and develop on the board in a logical sequence. They can copy the figures and text as notes, using the "see it, hear it, write it down" method of learning. The strengths of the chalkboard are that it is a very versatile tool, it is very reliable, it is inexpensive, and it doesn't require the faculty member to learn a complex software package.

The disadvantage of the chalkboard in teaching engineering mechanics courses lies primarily in developing three dimensional figures and drawings of gears or other complex objects. It is very difficult to draw a good figure in a reasonable amount of class time. In most cases, the faculty member can practice in the office and draw a decent figure on the chalkboard, but the students have not had the opportunity to practice, so the figures in their notes are atrocious. This makes their notes of questionable value. As we look to technology to improve the traditional lecture, one way is using technology to generate better figures in the lecture and in the student's notes.

Goals

The primary goal is to improve student learning in the statics and mechanics of materials classes. Research shows that information technology can affect learning in at least two ways: it can deliver some routine activities more efficiently and it can facilitate engaging, participatory activities for students (Niederman and Rollier, 2001).

We wish to use technology to enhance the traditional chalk and talk lecture method, not replace it. Specifically we wish to improve the quality of the lecture and the quality of the notes taken by the students during the lecture. As students learn more during the lecture and take better quality notes, they will be more productive during their homework and study time. These goals must be accomplished subject to the constraints listed below.

1. The improvements in student learning cannot require significantly more class preparation time by the faculty than a traditional chalk and talk lecture. Faculty are busy, often being asked to "do more with less". Learning improvements that require a large amount of faculty preparation time are often not sustainable. Some faculty will put in the extra effort for a while, but in the long term these types of improvements will be discarded.

2. Faculty should not be expected to learn a complex new software package specifically for doing the lecture. The software needs to be intuitive or most faculty will not be willing to take the time to learn to use it.
3. Faculty should be able to prepare lectures only a day or two before the lectures are to be given. It is not realistic to expect most faculty to prepare lectures weeks or months in advance.
4. The technology must be reliable and convenient to use.

Incorporating Technology Into the Lecture

Many faculty find drawing three dimensional figures on the board frustrating. It takes a significant amount of class time to draw and dimension the figure, and many of the students in the class will not understand the figure, and will ask for a lot of clarification. If a student does not understand the figure, he/she will not understand the lecture. It is frustrating for teachers and students. Even if the teacher can draw an accurate figure, the students will not be able to duplicate the drawing in their notes, and their notes will be of little use in helping them study. This is an age old problem, and it has always been a barrier preventing many students from understanding some of the more complicated problems in the courses. As computers and projectors have become commonplace in classrooms, it is now possible to help a larger percentage of students break through this barrier and learn to work the more challenging problems. Lecture blanks are prepared for the students so that they will have high quality graphics in their notes. They can modify the graphics in their notes the same way the teacher modifies the graphics on the board. The students find this process beneficial, as shown in the results section of the paper.

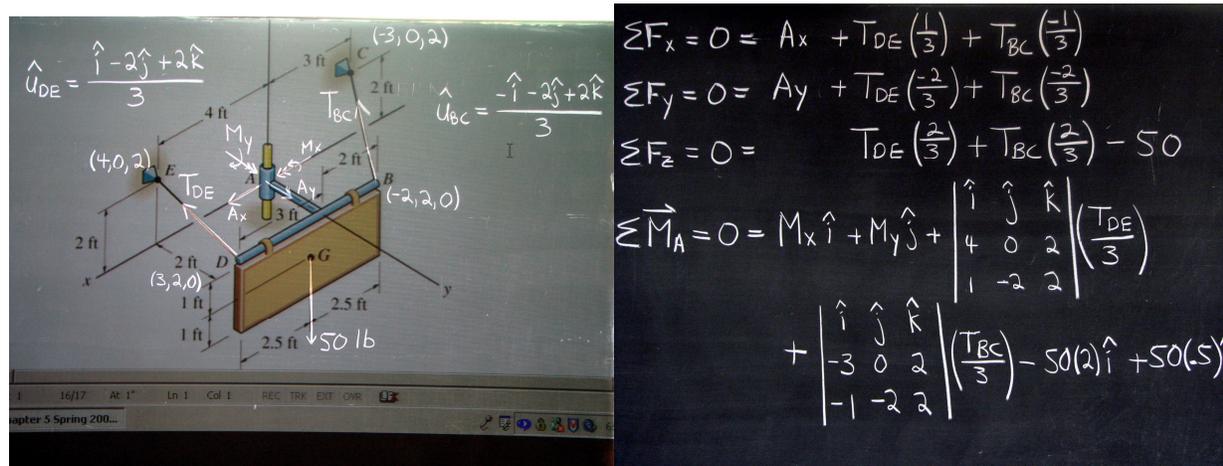


Figure 1. High Quality Graphic and Blackboard Equations

Figure 1 illustrates the lecture process. The figure was projected on the left board to start the process. The teacher discusses the supports and adds the support reactions using chalk. The x-y-z coordinates of the key points are labeled and unit vectors are developed for the cable supports. The equations of equilibrium are developed on the right board and the mathematics to solve the problem will be continued on other boards. As the high quality graphic on the board is modified, the students will modify the high quality graphic in their notes. The equations

developed on the right board will be placed under the graphic on their paper. Figure 2 is a copy of the lecture notes, and illustrates the students' notes. The result is a high quality lecture presentation and high quality student notes. The students go through the "see it, hear it, write it down" learning process in a very high quality environment. It is very difficult to work this problem in a traditional chalk and talk lecture because it is not possible to draw a high quality graphic on the board. Even if the faculty member is capable of drawing such an image, most students will not be able to duplicate it in their notes.

Problem 5-82

Determine the tensions in the cables and the components of reaction acting on the smooth collar at A necessary to hold the 50 lb sign in equilibrium. The center of gravity for the sign is at G.

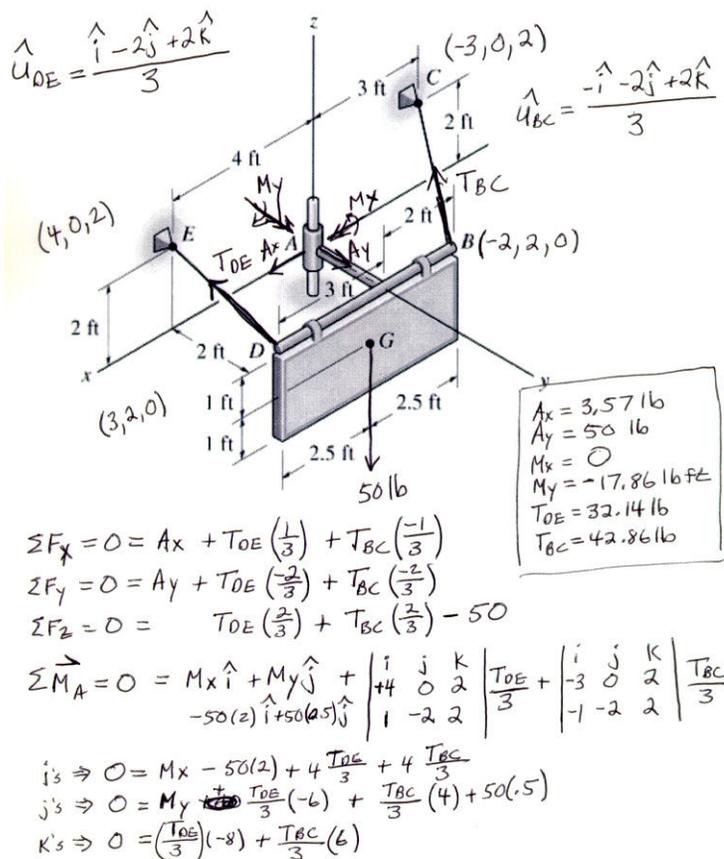


Figure 2. Notes Developed During Class

Preparing the Lecture

The software used to create the lecture files is Microsoft Word[®], or any word processor. Textbook companies make all of the figures in the text available to faculty, either on a CD or at a web site. For derivations, appropriate figures can be copied and pasted into the Word[®] document, leaving plenty of blank space to develop the derivation by hand. Example problems can be copied and pasted one problem per page so that there will be plenty of space to work out the solution. There will be four or five pages per lecture file, and it takes 15 or 20 minutes to create the lecture file. The file is emailed to the students, or made available to them on a web site. The students print the file, and bring it to class in a binder. The students learn very quickly

that they must have the printed notes to keep up in the lecture, so after the first week, virtually all of the students bring the printed notes.

The preparation time for this lecture method is approximately the same as for a traditional chalk and talk lecture. Nearly all faculty know how to surf the web and use a word processor, so no new software must be learned to use this lecture process. The classroom should have a projector that shines on the board and a computer installed in the classroom so that the faculty member can use the technology conveniently. Networking the computer allows the faculty member to have access to his/her accounts stored on the network, which is an added convenience, especially for absent minded faculty who might forget to bring a file for one of the tables or pictures he/she might need. It is difficult to predict what students will ask in class.

During class, the Word[®] document is opened and the zoom factor is adjusted to make the images and text the right size on the board. Only a portion of the page will be projected on the board. Chalk is used to modify the figure as appropriate and develop the mathematics on chalkboards adjacent to the figure. The students follow along taking notes on the pages that they have brought to class. With this process, less time is spent writing and drawing on the board and more time talking and pausing to allow the students to ask questions. Less class time is spent writing down problem statements and drawing figures, making it possible to work one more example problem in a typical 50 minute lecture than would be possible using the traditional chalk and talk lecture method. The students find this process makes it easier for them to take notes. The quality of their notes is better, and they feel that they get more out of the lecture. The author has tried many innovative teaching methods over the years, and nothing has been so unanimously well received by the students as this lecture process.

Smart Boards and Tablets

One problem with using this lecture method is that in many classrooms, the projector cannot be adjusted to shine on the board. This problem can be overcome if a smart board or tablet is incorporated into the classroom. The figure can be projected on the screen, and the smart board or tablet can be used to mark it up by hand, just as it would be marked up on the chalkboard. The resolution of the smart boards is not as good as a chalkboard, so the handwriting will be harder to read. But in many classrooms, especially large classrooms, the smart boards and tablets may be the best overall solution.

Figure 3 shows the same problem as in Figure 1 in a large classroom with a smart board. The figure has been marked up in the same way as figure 1, but the handwritten parts are more difficult to read because of the resolution on the smart board. The tablets have much better resolution than the smart boards, and yield a figure that is clearer than the chalkboard. The smart board is on the left side of the figure.



Figure 3. Large Classroom with Smart Board and Projector

Distance Office Hours Education – Tablet PC Computers

In order to conduct office hours for distance students, homework files were developed, with one homework problem per page. The homework files are similar to the lecture files, but consist of the homework problems the students are assigned to work. To start the virtual office hours, the instructor creates a session using Webex as a host. Students can join the session by signing in through Webex using their computers at home, at the library, or even at a coffee shop. When a student logs into the session, a bell rings on the Tablet PC to alert the instructor that a student has arrived virtually for office hour help. The content of the Webex session from the instructor's Tablet PC computer will then be displayed on the student's computer. The student can ask questions regarding the assignments using a chat box. The instructor can answer the questions by writing on the touch screen of his Tablet PC using a digital pen (see Figure 4). Control of the screen can be transferred back and forth between the students and the instructor. The handwritten notes can be automatically converted to text messages that appear in the chat box. The instructor can demonstrate to students how to solve problems in their assignments by drawing and writing on the Tablet PC. The instructor can also provide hints to students on solving certain problems by highlighting key words in the problem statement (see Figure 5).

After working one-on-one with a few students doing the virtual office hours, it was decided to try opening the session up to all of the students, including the on-campus students. A two hour block of Webex[®] office hours was set up each week the evening before a homework

assignment was due. It is possible for faculty to conduct the office hours from any location connected to the internet. Students can access the office hours from home, or from any computer; it is very convenient. The students have taken advantage of this service, with 20 to 30 students logging in and participating each time. The format is that a student will ask a question about a particular homework problem. The faculty member will bring that problem statement and figure up on the screen, and using the tablet feature, will get the students started. He then pauses to allow them to work on the problem. If the students need more help, he will add further explanation.

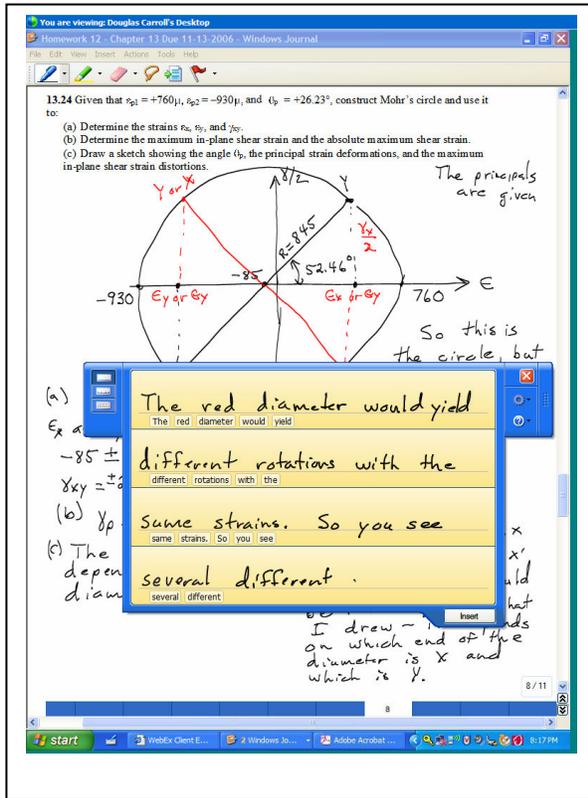


Figure 4: Screen Shot 1

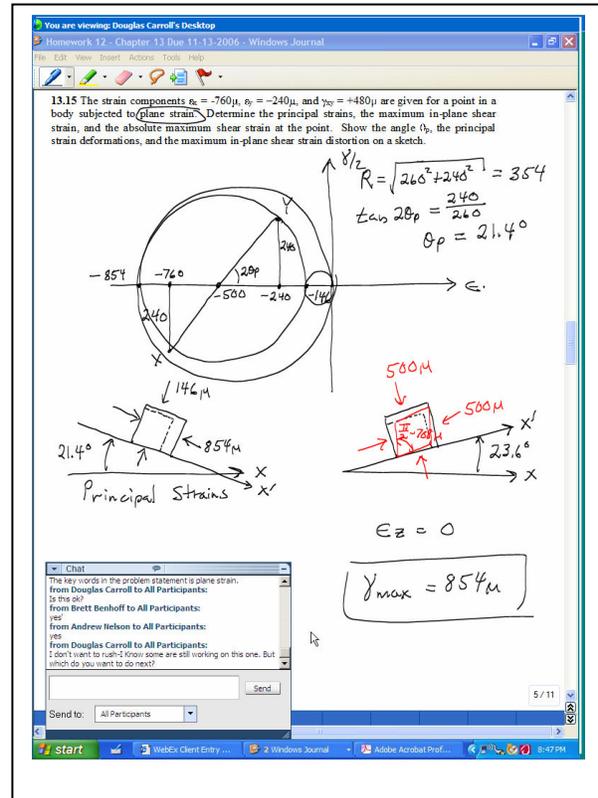


Figure 5: Screen Shot 2

A survey was developed to measure the effectiveness of the Webex office hours. Based on the theory of cognitivist, feedback, questioning, and answering are features of interactivity that can improve student learning. Measurement for interactivity in the survey was adopted from Siau et al. (2006) in which interactivity was measured as the degree of students' involvement in the class, students' participation in the class discussions, and students' receiving instructions and feedback from the instructor. The first five questions in the survey were developed to measure interactivity. Each question is measured using a 9-point Likert scale with 1 representing "strongly disagree" and 9 representing "strongly agree".

The questionnaire was also designed to gain a more comprehensive evaluation of the technology, including its perceived usefulness and perceived ease of use. Perceived ease of use and perceived usefulness were adopted from Technology Acceptance Model (TAM) (Davis, 1989; Davis et al., 1989) which is used to predict the users' intention to use new information technology. Perceived usefulness is defined as the extent to which a person believes that using a particular technology will enhance his/her performance, and therefore, is an indicator of an individual's extrinsic motivation to use a technology. Perceived ease of use refers to the degree to which a person believes that the use of a particular technology will be free of effort, and is therefore an indicator of an individual's intrinsic motivation to use a technology (Davis, 1989). Questions 6 to 8 measured ease of use, and questions 9 to 11 measured usefulness of the Webex technology.

The reliability of the instruments was assessed. The Cronbach's alpha coefficient for interactivity level is 0.904. The Cronbach's alpha coefficients for interactivity exceeds Nunnally's (1978) threshold of 0.70 which suggest that the instruments are highly reliable. The mean for interactivity is 7.56 (out of 9). The relatively high mean suggests that students perceive the interactivity to be high when Webex is used to conduct virtual office hours by the instructor. This also suggests that Webex is an effective way to ensure interactivity.

The mean for perceived usefulness is 7.76 (out of 9) and the mean for perceived ease of use is 8.02 (out of 9). The relatively high means suggest that the students perceive the use of webex to be free of effort, and they believe that using Webex makes it easier for them to interact with the instructor. The reliability tests show that the Cronbach's alpha coefficient for perceived usefulness is 0.94 and that for perceived ease of use is 0.92. Both are above the 0.70 threshold (Nunnally, 1978). In summary, the survey results indicate that the students found the Webex software to be useful as far as helping them learn the material and be successful in the class. Webex gave them a high degree of interactivity with the professor, and it was easy for the students to use.

Results

At the conclusion of the Fall 2006 semester, eight classes had been taught using this new teaching method, including four sections of Statics and four sections of Mechanics of Material. Dr. Carroll has been teaching these classes for many years using the traditional chalk and talk lecture method, so analysis was done to compare the effectiveness of the new teaching method to the traditional lecture. The Interdisciplinary Engineering department offered seven or eight sections of Mechanics of Materials each semester, and between eight and ten sections of Statics each semester. There is a common final for these courses, so it is possible to compare the performance of sections taught by Dr. Carroll to sections taught by other faculty. It is also possible to compare the performance of students taught by Dr. Carroll using the traditional lecture method and the new method.

Student Evaluations. Figure 6 shows the student teaching evaluations for Statics and Mechanics of Materials classes taught by the author. At the end of each semester, there is a standard university process where students provide an overall evaluation of the instruction they received

in each course that semester. The ratings are on a scale of zero to four. The average for all faculty at the University of Missouri-Rolla varies from 2.8 to 3.0 over the period shown on the graph. All of the data points for Dr. Carroll are above the university average.

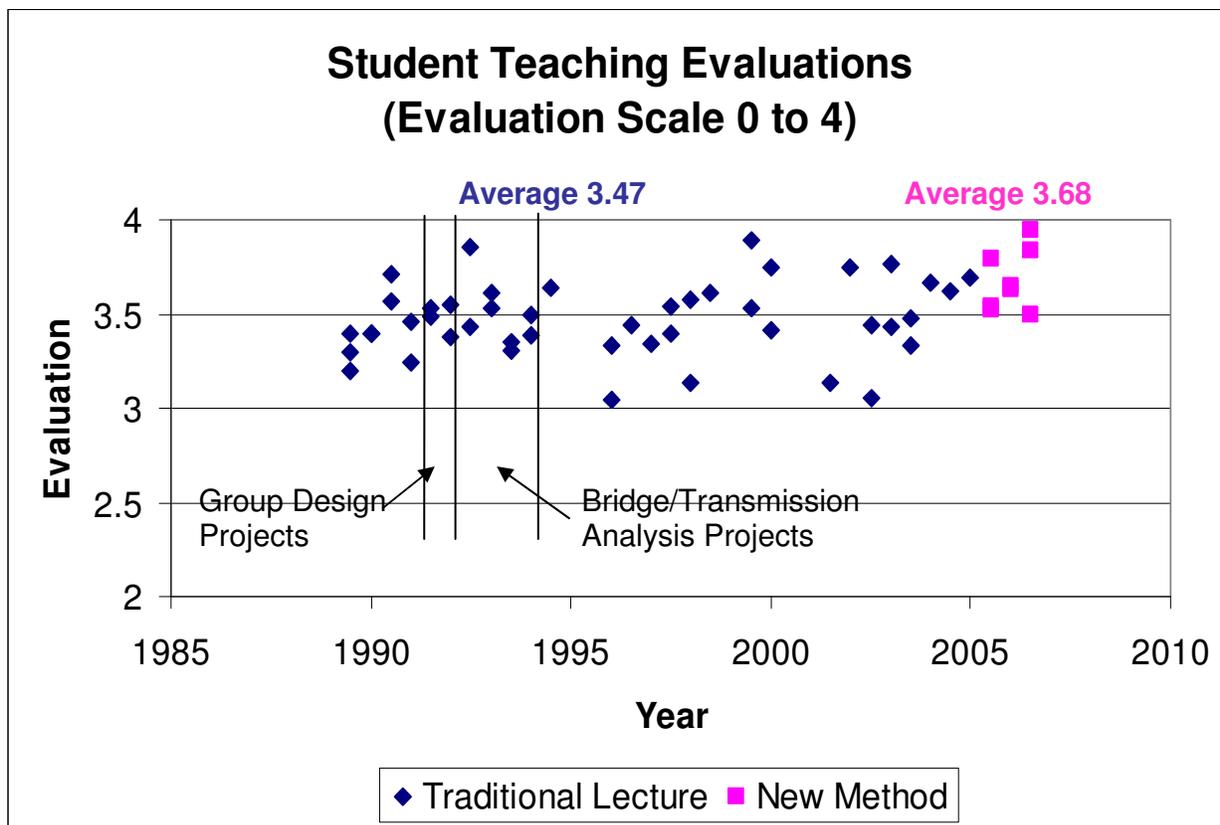


Figure 6. Student Teaching Evaluations

The traditional lecture method was used from 1989 until 2005 with an overall average teaching evaluation of 3.47/4. The new teaching method was used in the three most recent semesters with an overall average of 3.68/4. This is not a huge increase numerically, but it is important to recognize that the maximum possible score is 4.0. There was not a lot of room for improvement in the scores. During the 1991-1994 time frame an experiment was conducted where projects were included as part of the Mechanics of Materials classes taught by Dr. Carroll, but not in the classes taught by other faculty. Four classes were taught where students were divided into groups and did a group design project. Eight classes were taught where students did individual projects as a part of the course. The two individual projects were to analyze the truss members and connections of an old truss bridge, and to analyze power flow and torsional shear for a manual transmission. Including the projects as part of the class had very little effect overall as far as student evaluations of the class. Getting the projects organized and ready for the students was a tremendous amount of extra work for the faculty member, which is one of the main reasons the projects were discontinued. The new teaching method developed and used in the last eight data points on figure 6 is not a lot of extra work for the faculty member, and the data shows that the students like the new teaching method better than a traditional lecture.

Performance on Final Exam. Each semester the department offers between eight and ten sections of Statics and either seven or eight sections of Mechanics of Materials. All students take the same final exam at the same time during final exam week. Grading is divided so that the same faculty member will grade the same problem(s) on the final for all students taking the final exam. That is, faculty member A may be assigned to grade problems 1 and 2 for all students taking the final exam that semester. This insures that all of the finals are graded consistently. Performance on the common final is a good indicator of how well the students learned the material taught in the class. An average is generated each semester for each section of the class, and an overall average for all students taking the class.

We were able to recover the majority of final exam data for the eighteen years that Dr. Carroll has been teaching at the University of Missouri-Rolla. Unfortunately there was no systematic department effort to keep records, so there are still 13 missing data points out of the 58 sections of Statics and Mechanics of Materials that Dr. Carroll has taught over the past 18 years. It is unlikely that these missing points would significantly impact the results.

The average on the final exam varies considerably from semester to semester. The most reasonable way to present the data is to take the difference between the sections taught by Dr. Carroll and the overall average. The assumption is that sections that scored above the average on the common final exam learned the material in the course better than average, and those that scored below the department average learned the material worse than average. The common final exam is not a perfect measure of how much students have learned, but it is a good indicator. Faculty do their best to design the final exam to measure how well the students have learned the material in the course. Figure 7 shows the difference between percent average on the final exam of sections taught by Dr. Carroll and the overall average.

Summary and Conclusions

It has been possible to use the lecture process described in this paper for several years. Figures could be copied from the text on to transparencies and handouts could be copied for the students. A very organized faculty member could prepare the whole semester of lecture notes in advance and have the bookstore make the copies and sell them to the students in the class. The overhead projector could be used to project the images on the board during the lecture. It is not necessary to have computers and projectors to use this lecture process. The problem has always been that it takes excessive effort on the part of the faculty to prepare the lecture notes and transparencies and make them available for the students.

Technology has become available in the last few years to facilitate the preparation of the lecture notes. Many classrooms now have a projector mounted on the ceiling and a computer system that is reliable and networked. Faculty can walk into the classroom, log in, and bring up the lecture notes just as they would bring them up on the office computer. Textbook companies are making the graphics in the text available so that the faculty member can copy and paste them into a word processor in preparing the notes. It is much faster than scanning or Xeroxing and it generates higher quality results. The four or five pages for a lecture can be prepared very quickly and conveniently. Preparing the files is a quick process; most of the preparation time is spent deciding which figures to use and developing the handwritten notes that are to be put on the board. The files can be emailed to the students, or they can be posted on a university web site such as Blackboard[®]. Students download the files, print them and bring them to class for the lecture.

The distance office hours, conducted using the tablet computer and Webex[®] software has worked out very well for the students. Students are most likely to need help the night before a homework assignment is due. Being able to conduct office hours from home is a real convenience to the faculty member. It also provides the students with the assistance that they need. Far more of the on-campus students utilized the Webex office hours than came by the author's office for regular office hours.

Results show the new method to be superior to a traditional chalk and talk lecture. Student teaching evaluations for Dr. Carroll improved from an average score of 3.47 using the traditional lecture method to a score of 3.68 using the new method. This indicates that the students like the new teaching method better than the traditional lecture method. The Statics and Mechanics of Materials classes have a common final exam for all sections each semester. Historically, sections taught by Dr. Carroll have scored slightly below the department average (0.16% below average) when using the traditional chalk and talk lecture method. With the new teaching method, students in sections taught by Dr. Carroll have scored an average of 4.16% above the department average, which is a significant improvement. This shows clearly that students learn more using the new teaching method, as compared to a traditional lecture. The new method improves student satisfaction and student learning; it is a superior method.

This lecture process has raised the author's personal satisfaction in teaching the statics and mechanics of materials courses. It is possible to spend more time talking with the students during class, and less time writing and drawing on the board. The students are able to spend

more time thinking and less time writing. There is more interaction and more time for questions during the class. A higher percentage of students are able to keep up and follow what is presented. They are able to use their lecture notes when studying. Students are able to work more challenging problems on the exams. Written comments received from the students at the end of the semester are very positive about this lecture method. Working with the high quality graphics during class makes the lecture more enjoyable for both the faculty and the students. The students learning experience with this lecture process is more beneficial and rewarding than the experience in a traditional classroom.

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