Using Technology to Improve the Traditional Chalk and Talk Lecture

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Introduction

This is a report on several years of experimentation trying different ways of incorporating technology into teaching basic engineering mechanics courses of statics and mechanics of materials. I've taught at least one section of statics or mechanics of materials almost every semester for the last 18 years, a combined total of over 60 sections of statics and mechanics of materials. I'm a popular teacher with the students and have won many teaching awards. Most of my attempts at bringing technology into the classroom have failed, and I discarded them and returned to the traditional chalk and talk lecture process. In this paper I am documenting a process that has worked very well for me, and which has been very well received by the students.

The chalk board (or marker board) is a very powerful tool for teaching basic 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 chalk board 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 chalk board in teaching basic 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 chalk board, 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 when studying to do the homework or for an exam. As we look to technology to improve the traditional lecture, the focus should be on 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. We wish to use technology to enhance the traditional chalk and talk lecture, 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 very busy, often being asked to "do more with less". Learning improvements that require a large amount of faculty

preparation time are doomed to failure. 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 must be able to prepare lectures only a day or two before the lectures are to be given. It is not realistic to expect faculty to prepare lectures weeks or months in advance.

4. The technology must be reliable and convenient to use.

Incorporating Technology Into the Lecture

Like most faculty, I am always frustrated in drawing three dimensional figures on the board. I know that a large percentage of the class are having great difficulty in understanding the figure, and that they are not going to get much out of this part of the lecture. When students come by my office to ask questions, I look at their lecture notes and often neither of us can make any sense out of them. 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. The students like this process; in many cases it will serve as a motivational tool to get them to try a little harder. The three dimensional problems are important; students at a top quality engineering school should learn to work the hard problems.

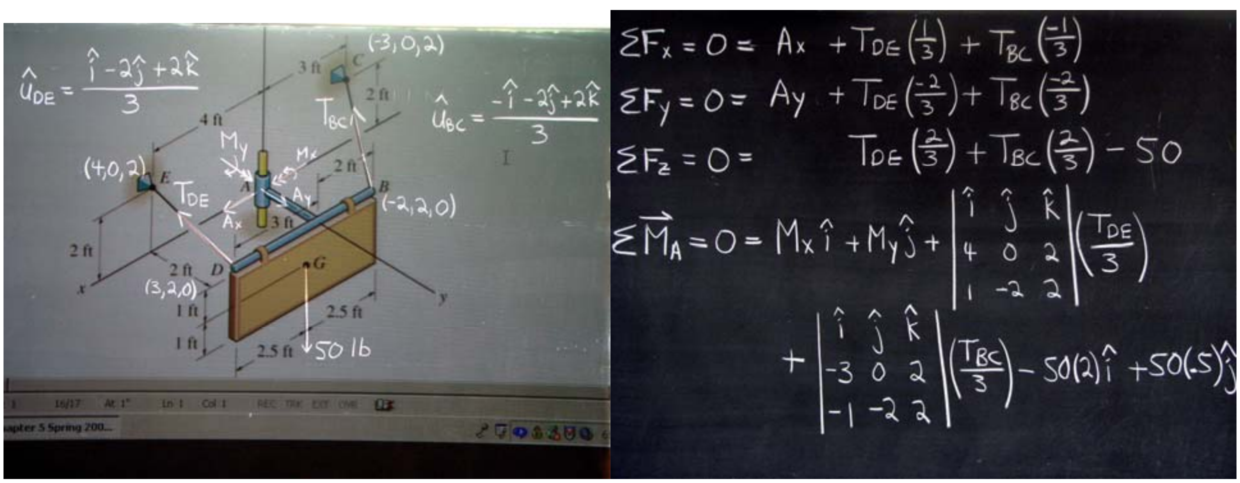

Figure 1. High Quality Graphic and Blackboard Equations

Figure 1 illustrates the lecture process. The figure was projected on the left board to start the process. I talk about the supports and add the support reactions. I label the x-y-z coordinates of the key points and develop the unit vectors for the cable supports. I then develop the equations of equilibrium on the right board and will continue the mathematics to solve the problem on other boards. As I modify the high quality graphic on the board, the students will modify the high quality graphic in their notes. The equations that I develop on the right board will be placed under the graphic on their paper. Figure 2 is a copy of my lecture notes, and illustrates what I expect to see in their 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 not possible to work this problem in a traditional chalk and talk lecture because it is not possible to draw a high enough quality graphic on the board. Even if the faculty member is a wonderful artist capable of drawing such an image, the students will not be able to duplicate it in their notes.

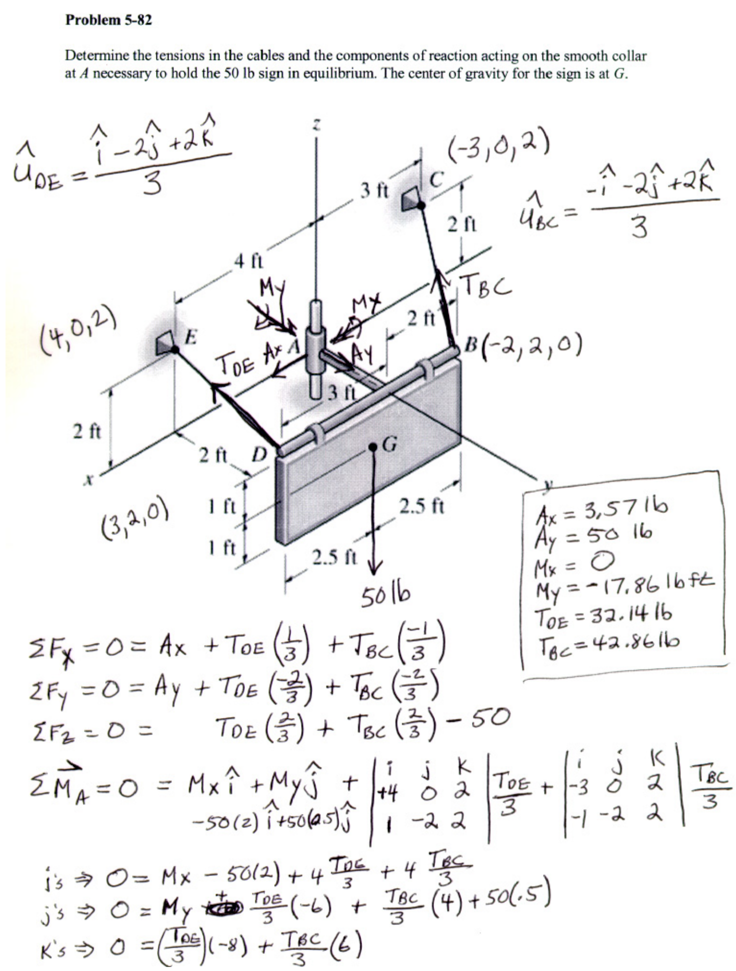

Figure 2. Notes Developed During Class.

Preparing the Lecture

The software that I use to create the lecture files is Microsoft Word®; any word processor would work. The textbook companies make all of the figures in the book available to faculty, either on a CD or at a web site. For derivations that I plan to present in class, I copy the appropriate figure from the web site and paste it into the Word® document, leaving plenty of blank space to develop the derivation by hand. For problems I plan to work in class, I choose problems from the textbook and copy and paste the problem statement and figure into the Word® document, 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. I print one copy of the file so I can develop the lecture notes for class. The file is emailed to the students. The students print the file, three hole punch it, and bring it to class in a small 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 will bring the printed notes.

The preparation time for this lecture method is approximately the same as for a traditional chalk and talk lecture. I can create the file, print one copy, and develop the lecture notes in approximately the same amount of time as developing traditional chalk and talk lecture notes on blank paper. All faculty know how to surf the web and use a word processor, so there is no new software that must be learned to use this lecture process. The classroom must have a projector that is mounted in the ceiling and shines on the board and a computer installed in the classroom that is networked so that the faculty member can use the technology conveniently.

During class I open the Word® document and adjust the zoom factor in Word® to make the images and text the right size on the board. Only a portion of the page will be projected on the board. I use chalk (or markers) to modify the figure as appropriate and develop the mathematics on chalkboards adjacent to the figure. The students follow along taking notes in the note pages that they have brought to class. With this process, I spend less time writing and drawing on the board and more time talking and pausing to get the students to ask questions. It saves some time in writing down problem statements and drawing figures, and I can work one more example problem in a typical 50 minute lecture than I could using the traditional chalk and talk lecture method. My personal satisfaction is higher because I feel I am doing a better job in transferring the knowledge. The students love this process. It 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. I've tried many things over the years, and nothing has been so unanimously well received by the students as this lecture process.

Smart Boards and Tablets

One of the problems of using this lecture method is that in many classrooms, the projector cannot be adjusted to shine on the board. The projector may shine on a screen that is above the board or beside the board, but it is not appropriate to mark up the figure on the screen with markers. 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. Projecting the image on the board is superior to using a smart board or tablet for two reasons. First, the resolution of the smart boards and tablets is not as good as a chalk board or marker board, so the handwriting will be harder to read. Second, the image is separated from the mathematics by a larger distance, which makes the overall appearance more disjointed. But in many classrooms, especially large classrooms, the smart boards and tablets may be the best overall solution.

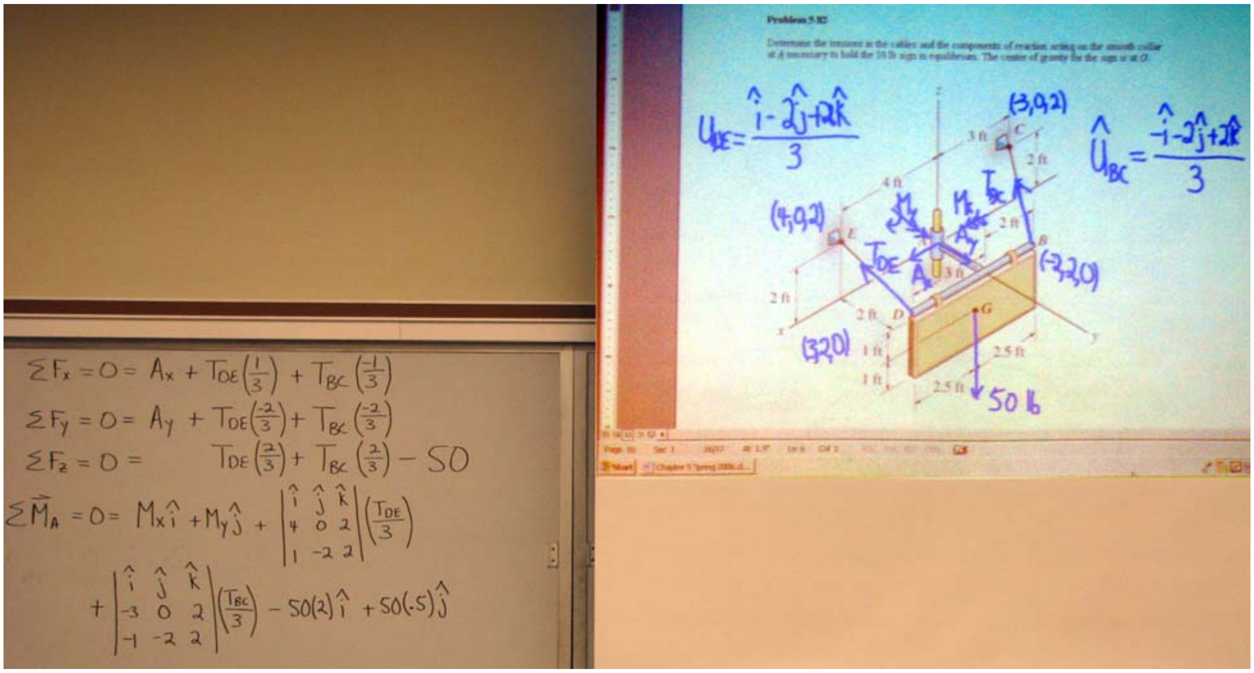

Figure 3. Smart Board and Projector Presentation.

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. In writing on the smart board, there is a perceived thickness distance between the marker and the figure, which makes it difficult to get the writing placed exactly where I want it to be. This is especially frustrating when trying to place an arrow exactly on top of an existing line in the figure (for support reactions). It is difficult to get it lined up properly. The mathematical equations were put on the board as close to the figure as possible, but the different mediums (screen and board) combined with the distance between the screen and the board makes the problem appear disjointed. This is a good lecture process; it is an improvement over the traditional chalk and talk lecture. It is not quite as effective as being able to project the figure directly on the board. Figure 4 is included to show the whole front of the classroom and illustrate how the smart board and projector are integrated into the lecture process. The smart board is on the left side of the figure.

Figure 4. Front of the Classroom.

Distance Education

The process described above using the smart board is well suited to distance education. In the early days of distance education, we would shine a camera on tablet, and the faculty member would write on the tablet with a marker. The camera gave a very good image in the classroom, but as we went to web based instruction it was discovered that the image was unreadable by the distance students. (This may be a problem local to the University of Missouri-Rolla, or it may be a general problem.) Writing on a tablet or smart board comes in much clearer for the distance students, so faculty are writing their handwritten notes on a tablet or smart board. I believe that the lecture method discussed in this paper would work out very well in teaching statics and mechanics of materials as distance courses.

Other Applications

I have only used this lecture process in teaching statics and mechanics of materials, but it seems to me that the process would work well for other courses. In the basic material science courses, students learn about crystal structure and crystallographic planes and slip angles. Starting with a high quality graphic on the board and in the student notes, and modifying that graphic to illustrate the fundamental concepts could be a powerful tool. In the basic circuit courses, the faculty member will spend a lot of time illustrating how to analyze circuits. Starting with a clear problem statement and high quality graphic of the circuit projected on the board and in the student notes would be beneficial. There are several engineering courses where faculty develop graphs on the board as they explain a process, and how modifications to the process impacts the results. The best learning happens when the students watch the graphs be developed on the board. For these presentations, the faculty member could start with a blank graph that has properly labeled axes and some grid lines to help with the accuracy of the drawing as it is developed on the board. This will save a little class time, improve the quality of the graph developed on the board, and greatly improve the quality of the graph in the student notes.

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. One of my professors used this process, back when I was a student, so the idea has been around for a long time. It is not necessary to have computers and projectors to use this lecture process. The problem has always been that it takes too much extra 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 that makes it much easier to prepare 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. I have found it most convenient to prepare a whole chapter of notes at one time, which is four or five lectures. 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.

This lecture process has raised my level of personal satisfaction in teaching the statics and mechanics of materials courses. I am able 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 questions during the class. A higher percentage of students are able to keep up and follow what I am presenting. They are able to use their lecture notes to help with studying and working the homework. I can now put more challenging problems on the exams, and the students are able to work them. My student evaluations have gone up. The written comments that I receive from the students at the end of the semester are very positive about this lecture method. I enjoy working with the high quality graphics during class; it makes the lecture more enjoyable for me. I feel that I am providing a better learning experience for the students.

Biographical Information

Dr. Douglas R. Carroll PE is a professor in the Interdisciplinary Engineering Department at the University of Missouri-Rolla. He is best know for his work with solar powered race cars, winning two national championships and publishing a book on solar car design. He has been married to Karla for 28 years, and their two sons, Zachary and James are both engineering students at the University of Missouri-Rolla.