High/Low Tech Approach for Success in Statics

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Abstract *– Nationwide, Statics is the bedrock of the engineering curriculum, especially in Civil and Mechanical engineering and considered by students as a difficult course. Statics requires an understanding of geometry, trigonometry, vector algebra, and the ability to visualize objects in two and three dimensions. A mastery of technique in problem solving is also required, yet often lacking. History has shown a high withdrawal rate along with a large percentage of failures in Statics. The approach to teaching has changed with emphasis on student learning. Student nurturing is also a key component in the success rate seen over the past three years. Significant use of the Internet for communications with the development of a tutoring center has contributed to a marked decrease in the withdrawal rate. Those students remaining in the course are also demonstrating greater understanding of the material.*

INTRODUCTION

Approximately thirty and forty years ago, the authors of this paper were sophomores taking Statics. Before taking this course, students then were required to take two semesters of engineering graphics and a four-credit course in Physics. The Statics course was also four credits with a homework load that is double that required by today's students. The scope of the material covered was not significantly different than the current curriculum but was non-vectorial with emphasis on free body diagrams and visualization. In earlier years, the engineering graphics course included descriptive geometry that clarified the meaning of parallel, perpendicular, projection, and angles. The hours spent in carefully constructing the graphics exercises prepared the student for the meticulous type of work expected of an engineer. It set the tone for learning by doing. It also helped with visualization.

Today's engineering student has a brief experience with engineering graphics with the emphasis on computer aided drafting and three-dimensional design software tools. Very little hand drawing is required of today's engineering student. The use of vectors to analyze force systems in equilibrium has been seen as a weakness in many students. This weakness can be attributed to an abstract preparation in math and physics. The Physics course has been changed with less application toward the area of Statics and more emphasis on software tools. The use of programmable calculators has eliminated the need for a student to fully understand concepts while cranking out answers by guessing which formula fits the data given in the problem. The art of thinking through a problem seems to have been lost to the technology we impose on them. As a result, there is a high withdrawal rate in the Statics course, as students tend to drop the course as soon as they are faced with a challenge. Students attempt to take the course without doing the time consuming homework required to learn the material.

With a new generation of high-tech, video-oriented students, a whole new approach to teaching an age-old topic was necessary. The material is the same, but the presentation has changed with the times. A lecture/recitation format is now used with team teaching. One instructor presents the concepts in lecture format using vivid graphics and animation in Power Point. Another instructor meets with the students in smaller recitation classes to demonstrate the hands-on application complete with props and use of the Internet.

THE LECTURE

All engineering students enrolled in Statics today will attend a class once a week en masse for the lecture portion of the course. The students are encouraged to read ahead in their textbook, then to attend the lecture and primarily listen, taking minimal notes as needed. Students have been conditioned to take very detailed notes from previous college courses and even from high school. But how much can they hear or understand if they are busy trying to copy notes from a chalkboard? It is more important for them to absorb the concepts being presented in the lecture while seeing pictures of real world examples and watching the step-by-step development of the concepts in colorful Power Point slides. Giving their full attention to watching and listening has proven better than hurriedly trying to take notes and capturing only a fraction of the lecture.

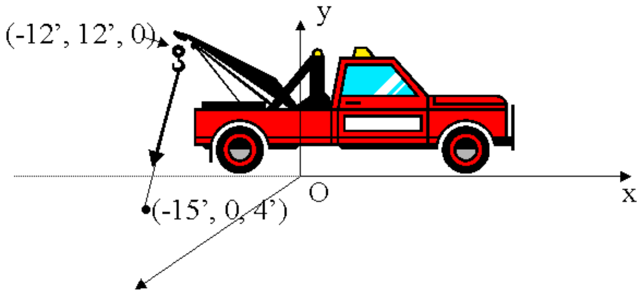

FIGURE 1
A REALISTIC PICTURE OF FORCE.

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Many of the figures used in the lecture are available to the students on a course website. They prepare for the lecture by downloading these figures and comparing them to material in the text. This, too, ensures a better quality of notes without extensive writing.

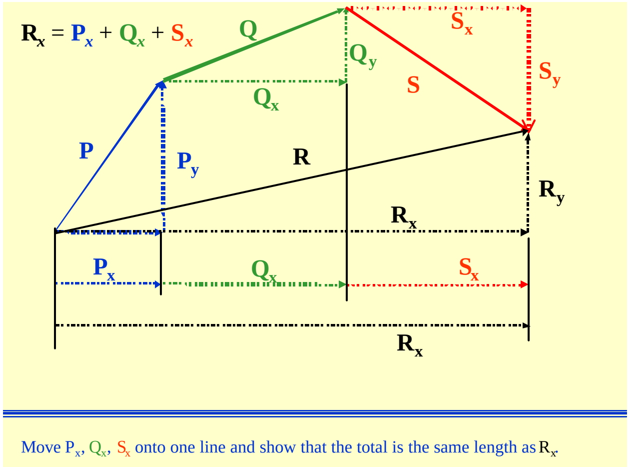

FIGURE 2
SUMMATION OF FORCE COMPONENTS

At the beginning of one semester, the students happened to meet with the recitation instructor first. The course format was explained to the students and the website was presented. The students were told, "When you go to the lecture, sit there with your arms folded and just enjoy listening to the presentation". The students did just that which raised an eyebrow of the lecture instructor. A little humor doesn't hurt either. Which is why we also use figures such as these to keep the attention of the students.

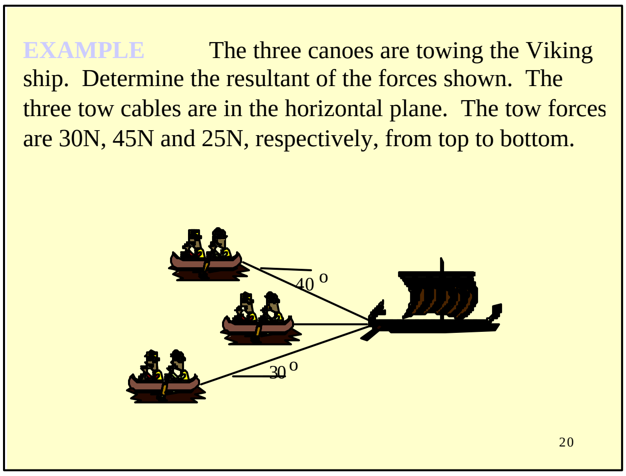

FIGURE 3
A HUMOROUS LOOK AT CABLE TENSION.

The change in the presentation of the lecture is also due to the fact that today's students need to be stimulated by visual effects. A picture of a backhoe or a tow truck with a car in tow or numerous pictures of different style bridges enables the student to relate the topics to the physical world around them. This provides the visualization paramount to understanding applications. Colors also help them to distinguish various components of space vectors. This helps them to understand the relationship developed in the formulas. This approach encourages the students to ignore the formulas and to develop a sense for determining the components based on their visualization of the vector orientation.

THE RECITATION

Students separated by different sections meet on another day of the week for the recitation portion of the course presented by a different instructor. Class sizes are twenty or less which presents a more intimate setting for better communication between student and instructor and among the students themselves. The use of high-tech equipment such as computers and projection systems in the classroom has provided the ability to portray rigid-body equilibrium problems more realistically to enable a better understanding of Statics. Access to the Internet in the classroom also allows a review of the solved example problems available on the course website. All of the recitation examples are provided in a .PDF form. Nothing fancy, most are hand drawn and hand calculated with some added notes and suggestions for alternative approaches to solving the problems. This also provides an example of the quality of work expected of the students.

Some of the textbook problems have been solved in a slide-by-slide progression using Power Point. Students are encouraged to view these problems prior to the recitation meeting and to download these examples for review. This allows many more examples to be presented with alternative approaches highlighted on the chalkboard next to the viewing screen.

The following set of slides is an example of the progression shown in Power Point.

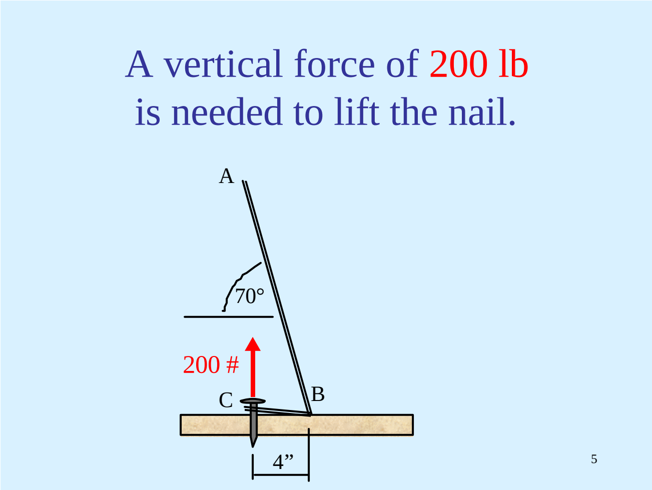

FIGURE 4
DEFINES THE SITUATION.

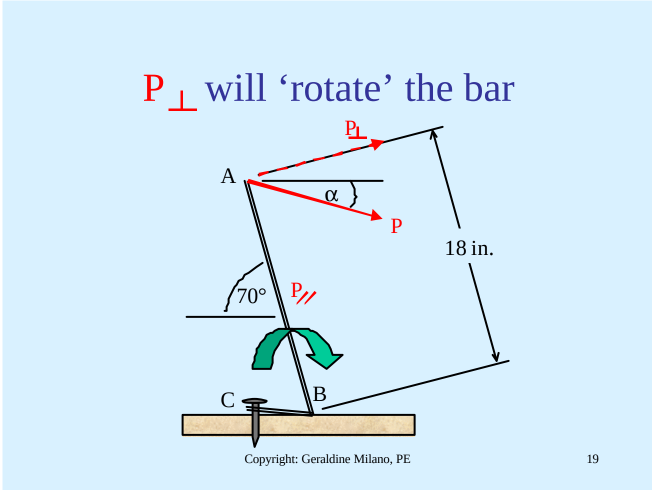

FIGURE 7
DESCRIBES THE PERPENDICULAR FORCE COMPONENT.

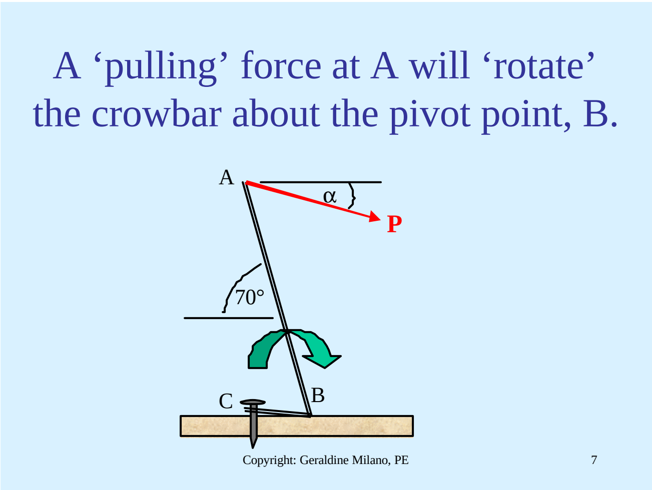

FIGURE 5
DISPLAYS THE APPLIED FORCE .

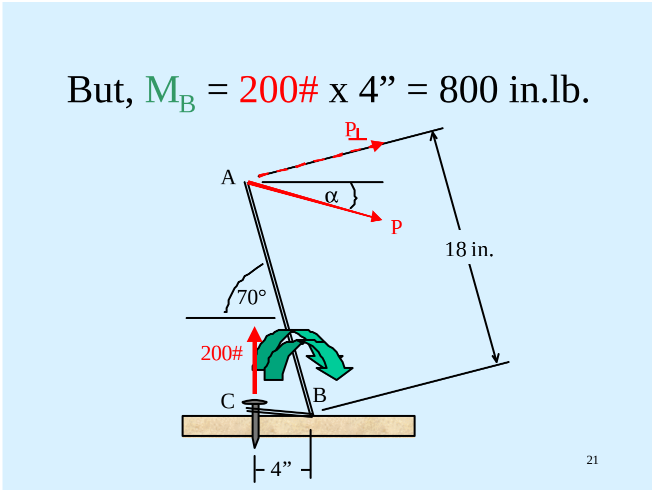

FIGURE 8
EXPLAINS THE REQUIRED MOMENT OR TORQUE.

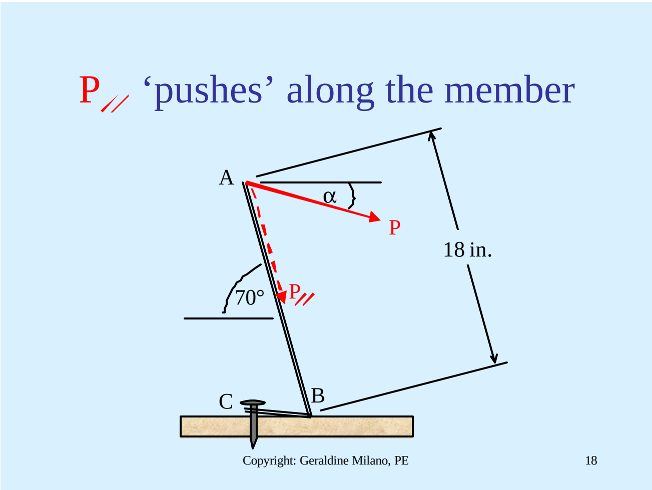

FIGURE 6
DESCRIBES A PARALLEL FORCE COMPONENT.

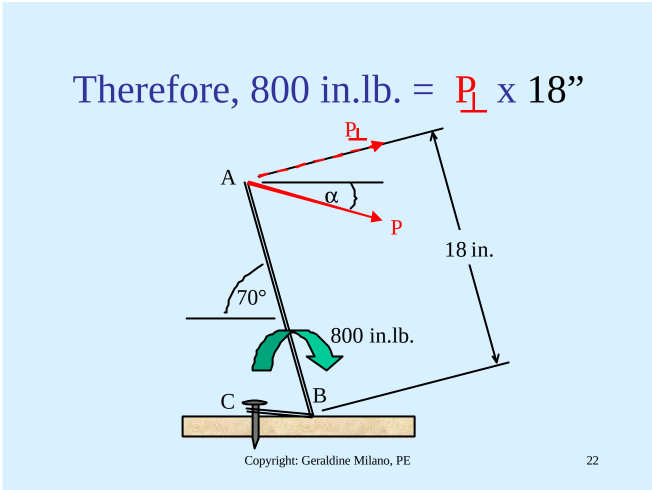

FIGURE 9
DETERMINES THE REQUIRED FORCE , P.

Homework is assigned in the recitation portion of the course and collected the following week. The same week that the homework is collected, the solutions are posted to the website in .PDF form. The published syllabus serves as the location for the hyperlinks to these homework solutions. Students can immediately review the solutions and prepare questions for the next class when their graded homework is returned. As an incentive for students to do their homework, 20 percent of their overall grade is awarded to homework. A minus one will be recorded for problems not submitted. This again acts as an incentive.

NURTURING

It is widely known that college students in their early years feel intimidated by their professors. In some classes, there is actual fear of asking a question during class, whether this is the fear of feeling stupid or fear of interrupting the professor's oration. To minimize this agony, electronic communication has provided an outlet. Students e-mail their questions at any time of the day or week and can expect a response without that awkward feeling of being singled out in class or that uncomfortable face-to-face meeting in the professor's office. The use of Word and its draw features enables a reasonable way to offer hints about a homework problem. The Word document is then attached to the e-mail reply. You'd be surprised how this stimulates continuous communication throughout the semester. A student who feels more comfortable with their instructor is more inclined to stay in class and to work harder. Gradually, a comfort zone opens up class discussions and visits to the professor's office.

A tutoring center is also available with two graduate level teaching assistants keeping regularly scheduled hours each week in a private office. Students are encouraged to attend with a friend. There seems to be comfort in numbers. When two or more students seek help from the tutors, more communication takes place and more time is spent learning.

An interesting phenomenon has occurred over the past couple of years. Students are no longer satisfied to just pass the course. They want to do well. Students who receive mediocre grades on their homework request additional problems to prove that they really know the material. Students who perform poorly on exams ask if they can take another exam to show that they have mastered the topic after reviewing it. What more can we ask!

IS IT WORKING?

Several of the authors' colleagues have asked for proof of the success of this approach. To do so would entail years of data with some sections taught in the traditional mode and compared with those in an experimental mode. Data has been collected over a two-year period during implementation of this approach. The course was known to have a fifty percent withdrawal rate. Of the remaining fifty percent, half of those students would fail. In the past few years, the withdrawal rate has improved along with a higher passing rate. The direct evidence is this:

- Students attend class. There is over 90% attendance throughout the semester.
- Students remain in the course. The withdrawal rate has decreased from 50% to 15% with one semester boasting 11%.
- Students are working harder. Almost all of the students do 80% to 100% of the assigned homework.
- Students perform better. 62% are earning C or better with 20% earning A's.

Questionnaires were used to measure the students' satisfaction with this new approach. Overwhelmingly, the students gave positive feedback with regard to the use of computer technology and the Internet. The following is a sampling of the feedback on some of the questions.

TABLE I
FEEDBACK FROM QUESTIONNAIRE

Do you like Power Point lectures?			
Year	A Lot	Sometimes	Not at All
1999-2000	37 %	41 %	22 %
2000-2001	47 %	47 %	6 %
Do you prefer to take your own notes?			
Year	A Lot	Sometimes	Not at All
1999-2000	10 %	49 %	41 %
2000-2001	30 %	44 %	26 %
Did you view examples from the web?			
Year	A Lot	Sometimes	Not at All
1999-2000	70 %	27 %	3 %
2000-2001	70 %	26 %	4 %
Did you view homework solutions from the web?			
Year	A Lot	Sometimes	Not at All
1999-2000	64 %	33 %	3 %
2000-2001	55 %	40 %	5 %

CONCLUSIONS

An analysis was done by the university's department of Institute Research and Planning. The Director of Outcomes and Assessment compared the entrance characteristics, such as SAT scores, high school rankings, and placement exams of the students enrolled in Statics in the 1998-1999 academic year and those who took the same course in the 1999-2000 academic year. After a lengthy and laborious search of background data, it was found that "there was not a measure of difference in the SAT scores for those performing better over the past two years than those enrolled prior to 1999"[1]. It was concluded that, "Further analyses did not establish any statistically significant correlation between the above variables and Mech234/235 grade"[1]. The report went on to state that, "When students from 1998-99 and 1999-2000 were compared, there was a statistically significant difference between the two groups. The probability that the difference between two groups can be attributed to treatment is higher than 99.99 percent"[1].

The true effects of this course have yet to be documented since that entails the tracking of students through subsequent courses such as dynamics, strength of materials and discipline specific courses. If the students have retained more of the material on vector analysis and can better apply the concept to other application courses, it is expected that withdrawal rates will improve in those subsequent courses and performance will improve as well. The ultimate goal is to ensure a breed of engineering students that can analyze a problem logically through visualization and realization and to depend on technology and software as only tools to assist with their calculations

Currently, we have only anecdotal comments from students that encourage this approach to teaching.

- "I wish all the professors would put their notes on the web."
- "Can we see that Power Point again?"
- "Are you two going to be teaching any other courses?"
- "Oh, gee, I didn't think I'd see distributed loads on beams again, but I have to use that stuff a lot in my strength of materials."
- "Gee, I wish I could take Statics all over again because this time I'd really pay more attention because this stuff shows up again in dynamics and strength of materials."
- "My friend had this course last year and told me to make sure I do all the homework because it really helps."

The best reward for anyone teaching is when a student sends an e-mail and says,

- "Thank you, I learned a lot in your class".

REFERENCES

[1] Briller, Vladimir, Director of Outcomes and Assessment, Dept. of Institute Research and Planning, New Jersey Institute of Technology.