2006-2156: INTEGRATING MULTI-MEDIA AIDS (TABLET-PC, STREAMING VIDEOS, ELECTRONIC SLIDES) TO THE FUNDAMENTAL INSTRUCTION IN MECHANICS

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Integrating multi-media aids (tablet-pc, streaming videos, electronic slides) to the fundamental instruction in mechanics

Abstract
This paper is a narrative of how classroom instructions were developed during the past few years – transitioning from chalkboard to integrating several multi-media aids for classroom use. To being the transition from chalkboard, overlaid transparencies were created, which were later transferred to meaningfully animated electronic slides. These slides were then combined with fill-in worksheets for classroom use, along with the addition of streaming videos for asynchronous instructions. Qualitative feedback indicates a positive response from students. Rigorous assessment is planned for evaluating the efficacy of these technologies.

Introduction

Boyer[1] in his report talks about reinventing undergraduate education by taking several steps which include the use of information technology creatively for enhancing undergraduate education. Hake[2] has shown that interactive engagement increases the conceptual understanding and problem solving ability of students in a mechanics course. Cooperative learning[3, 4], and peer instruction[5] have shown to be beneficial in classrooms and in the enhancement of student learning. According to Patricia Cross (a leading educator), "We have more information about learning available to us than ever before in the history of the world" [6].

Statics, one of the first and fundamental engineering courses taken by an estimated 100,000 students each year is still largely taught by the use of blackboard and lecture. Recently Kurt Gramoll [7] has developed macromedia™ based lectures that use current technology to mimic classroom lecture and made these available online for students. NextGeneration principles [8] have been used to include some of the educational research findings in classroom instruction for statics. The questions developed by Sudhir Mehta and Scott Danielson [8] fall into different levels of Bloom's taxonomy and their use and initial results have shown to be promising.

Astin's [9] correlational studies has shown that two factors – interaction among students and interaction between faculty and students affected general education outcome far more than other content factors. NSEE [10] report has indicated that level of academic challenge, active and collaborative learning, student-faculty interaction, enriching educational experiences and supportive campus environment are collectively used by students to evaluate their educational quality.

Even though education research has shown several benefits as listed above, it is still surprising that many engineering educators (who are baby-boomers) continue the use of blackboard to lecture and solve problems, as was done in their student years. It is true that the baby-boomer generation learned most of their engineering by this modality along with self-study, which included solving several problems from many textbook. Based on observations and discussions, it is clear that present day students, are exposed to a very different set of learning experiences when compared to their instructors. From observing grade school students it is clear that they are continuously exposed to hands-on activities, play a lot of educational and entertainment video games, and by personal estimates are more interactive learners when compared to the baby-boomers who are instructing them.

Based on the above observations and personal experiences, work has been done over the past few years to incorporate several of these findings in multimedia teaching aids using overlaid transparencies, electronic slides, fill-in worksheets, streaming videos, tablet-pc, one minute clarification, etc. The next few paragraphs will describe several of these modes used in the classroom and discuss the observations and feedback of students.

Chalkboard to Transparencies…

To begin the transition from chalkboard teaching, about four years ago work on creating thoughtful and content driven transparencies utilizing several overlays and colored pens were commenced. For example, to demonstrate the idea of reduction of a system of forces on a rigid body to a single force and moment of couple overlaid several slides (figure 1) were created. First the idea of reducing one force to an equivalent force and couple is demonstrated along with derivations on the chalkboard (slide #1, figure 1). In slide #2, figure 1, this concept is revisited and its reduction is shown again. As shown in slide #3 of figure 1, overlays are used to add more forces (shown in different colors) to reinforce the idea and its generalization to the concept of a system of forces and their reduction to a single force and a moment of couple (slide #4, figure 1). This overlay clearly demonstrated to the students how a simple concept can be repeatedly applied to handle a problem with a number of forces. This overlay was then used when solving problems to demonstrate the application of the principle. The final copy of the overlaid slides was made available to students – but they could not re-create the overlay when studying on their own. In a similar manner, transparencies were created for basic vectors operations like addition using parallelograms, resolution along any two non-perpendicular directions, components of vectors in space, dot products, cross product and its application to moment of a force and couples. Overlaid transparencies were used to illustrate drawing free body diagrams, analyzing structures, frames and machines and for shear force and bending moment diagrams.

Transparencies to Electronic Slides…

With the increasing use of computers for classroom instructions, in the next few years these transparencies were made into electronic slides using Powerpoint™ with meaningful animations added (figure 2 and 3 are examples of reduction of system of forces). The meaningful animations here refer to mimicking the act of drawing on the board to illustrate the concept, rather than the jazzy transitions provided by PowerPoint. The animated slides were available for students to use outside the class and assisted them to re-create the lecture – much like replaying a video game, till they gained some mastery at their own pace. Some of the animations were created using Visual Basic™ programming. Animated electronic slides were created for several other topics like – vectors (addition using parallelograms, resolving vectors along any two non-perpendicular directions, writing components for vectors in space, dot product, and cross product), drawing free-body diagrams, equilibrium, shear force and bending moment diagrams, and, distributed forces and their reduction. Other than making use of these slides for classroom instruction, they were also made available for student use outside of class.

The transparencies and electronic slides described above were initially used to discuss the concept with the students in class. After this discussion, a worksheet was distributed in class for students to fill-in to check their understanding, while the instructor walked around the class checking student's work. After giving the students enough time to complete their work – electronic document cameras (Elmo ^{TM}) were used to finish the solution and close the discussion. This technique provided appropriate classroom assessment[11] and immediate feedback to both the students and the instructor. This also contributed to student-student interaction and student-faculty interactions – a strong component of student education outcome mentioned in Astin's [9] studies.

Tablet-PC and other multimedia aids…

Problem-based learning has been described in numerous references[12, 13] as an important component in education. Problem-based learning most naturally mimics the way engineers in the real world work. It is a common understanding that problem solving skills are one of the major components of engineering learnt in introductory mechanics courses. Initially, real world problems would be presented and students would discuss the solution to these by trying to apply concepts they learnt. Based on the discussion, a model of the problem would be summarized using the principles learnt. This was followed by a detail solution to the problem. Several fill-in workbook style sheets were designed which were aimed at solving problems in class. (figure 4). With these worksheets – several different approaches were adopted. For the first example of any new topic – the concept and application was explained in full and the problem was worked out in great detail with active participation of the students. For later problems – the class formed small groups and discussed the solution for an assigned time and then the solution was discussed by the whole class. Following the discussion, each student was asked to work individually and proceed with the solution to the problem. During this time, the instructor walked around assessing students' work and looking for holes in the comprehension of the concept. Finally the problem was solved in full and was posted on the web for access outside of class. With the availability of a tablet-pc towards the end of fall 2003 – a transition from overhead cameras to tablet was made. The transition brought a change in quality of image projection and an overwhelming positive response from the students. The following fall – only tablet-pc was used for all classroom instructions – replacing overhead transparencies and document camera. The approach used here clearly brought about student-student interaction, student-faculty interaction, active and collaborative learning, peer instruction and creative use of information technology – ideas that have been shown by education researchers to be effective and beneficial.

In about the same period the above transitions occurred, several short streaming video segments were created for instruction on individual concepts as additional resources. These videos were created to be used like "do it yourself" videos, which is a very familiar concept to many students. (Many new appliances come with such instructions and so do some video games.) **NOTE : links have not been provided as author identity will be disclosed and compromise the blind PEER REVIEW process.**

One-minute clarifications were a simple concept that was used effectively during class – this involved giving the students a one minute quite time at the end of a concept or principle and asking them to write down what they learnt OR what was not clear to them.

At the end of the minute – answers to the questions were provided and the concept summarized. Students have indicated that this break gave them time to collect their thoughts and stay focused in class.

Benefits and discussion

The fill-in problem sheets enabled the introduction of differentiated instruction (a method commonly used in some grade schools where the class is made up of students of several academic needs) in the class room. Several fill-in sheets were laid out with two approaches – symbolic solutions and numerical solutions. Symbolic solutions were assigned to challenge the students who completed the numerical solution, while the numerical solution helped the average and below average student solve the basic problem. (Observations have led to the belief that students who are performing well in class will benefit from general solutions using a symbolic approach). Advanced students were also encouraged at generating plots for the solutions and discussing them to enhance their broader application as a study of solutions with varying parameters. By varying the amount of information provided in the fill-in sheets for subsequent problems – students get a grasp of their weakness (if any) and the instructor has an opportunity to reinforce general concepts that are not clear. This provided for drill in problem solving – another necessary skill for engineers.

In addition to all the above benefits, the fill-in worksheets also enabled an increase in the number of solved problems in a semester. From about thirty fully solved (using chalkboard) in class problems (ICE) before the worksheets were introduced – using the tablet-PC, with fill-in workbook style sheets, the number of in-class fully solved problems were increased to nearly sixty in a semester – a 100% increase. Aside from these an equal number of problems were given as homework with varying degrees of fill-ins to inculcate and train students in problem solving, solution layout, and, several other important engineering practices. Additionally, detailed solutions were made available on the web to improve problem solving skills, while teaching methodologies and procedures for solution layout and presentation.

Besides the above mentioned technologies, physical models were used to demonstrate concepts of co-ordinate systems, projection of vectors, equilibrium of particle etc. Future plans include creation of more physical models to assist the visual and kinesthetic learners in the class.

Initial results from informal student survey are very promising and feedback indicates that these technology aids have helped student learning (see table 1 and 2). From table 1 it is clear that at the end of the semester the students are sure of drawing free body diagrams. While the standard deviations were under 0.05, the variations from year to year cannot be assigned well observed reasons. One reason for variations among the sections for any given year maybe attributed to the fact that these classes are taught back to back by the same instructor, and there maybe variations due to quick repetitions. No surveys were conducted before these methods were used to compare and discuss trends and benefits of these technologies. Students have constantly provided oral feedback comparing their mechanics class experience with other classes, and commenting that the methodologies used were extremely useful for their overall understanding and comprehension of the subject. Informal discussion (no formal survey conducted) with faculty who teach dynamics, mechanics of solids, system dynamics have indicated that over the past few years – student performances have improved. Students are drawing clearer free body diagrams, using vector solutions in correct manner, and have shown improved problem solving skills. Future plans include carrying out formal surveys by identifying assessable variables that can be used to measure the effectiveness of these approaches.

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Are you sure of drawing Free Body Diagrams?

Year	Sec 001	Sec 002	Sec 003
Fall 2002	4.72	4.39	NA
Fall 2003	4.78	4.67	4.72
Fall 2004	4.6	4.36	4.43
Fall 2005	4.62	4.62	4.6

Table 1. : Results of student survey on drawing Free Body Diagrams on a scale of 1 (not sure) to 5 (very sure). Standard deviation was under 0.05

Was the fill-in worksheets useful in understanding class material?

Year	Sec 001	Sec 002	Sec 003
Fall 2002	4.26	4.39	NA
Fall 2003	4.22	4.33	4.56
Fall 2004	4.55	4.05	4.24
Fall 2005	4.43	4.72	4.6

Table 2. : Results of student survey on fill-in worksheets on a scale of 1 (not sure) to 5 (very sure). Standard deviation was under 0.05

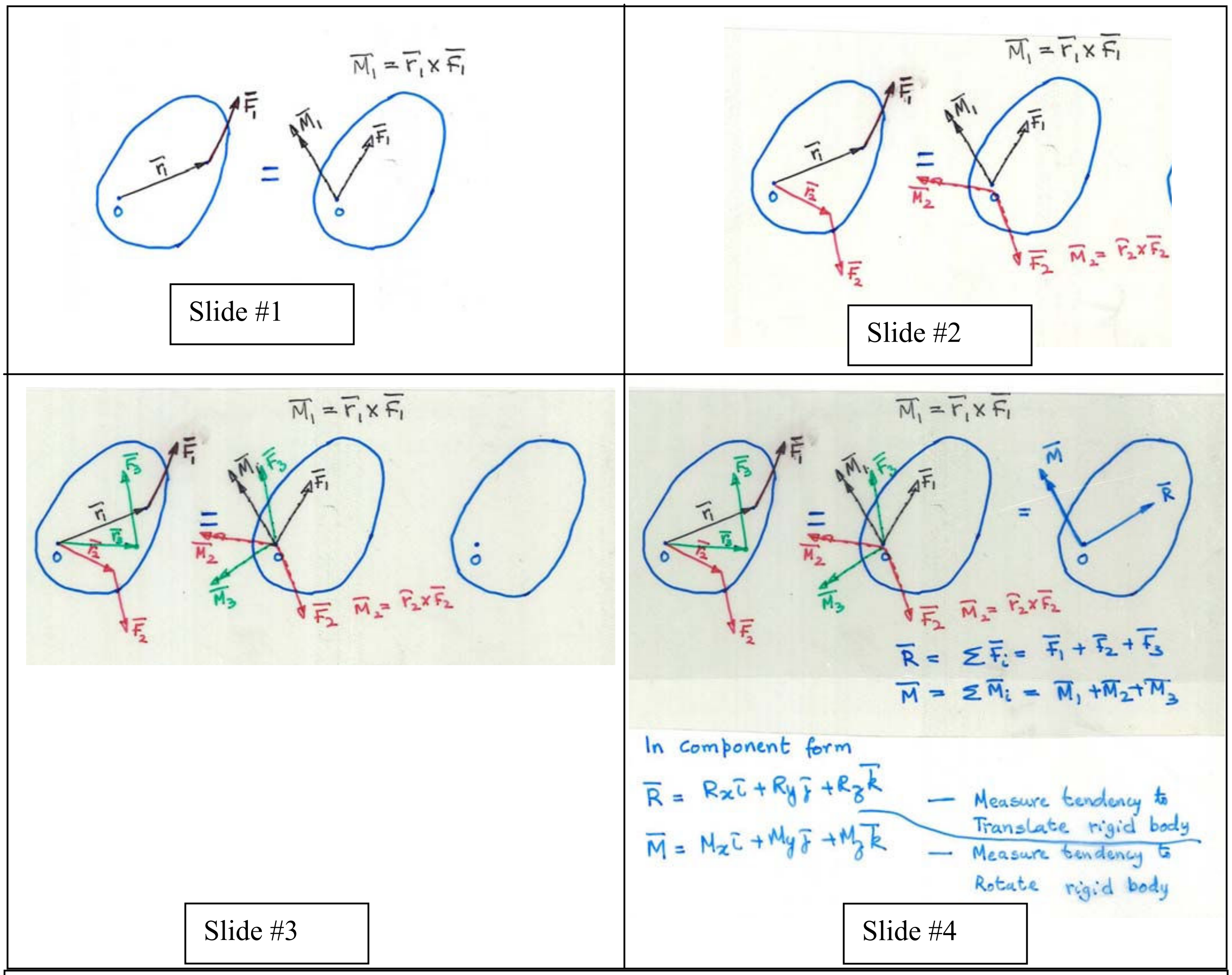
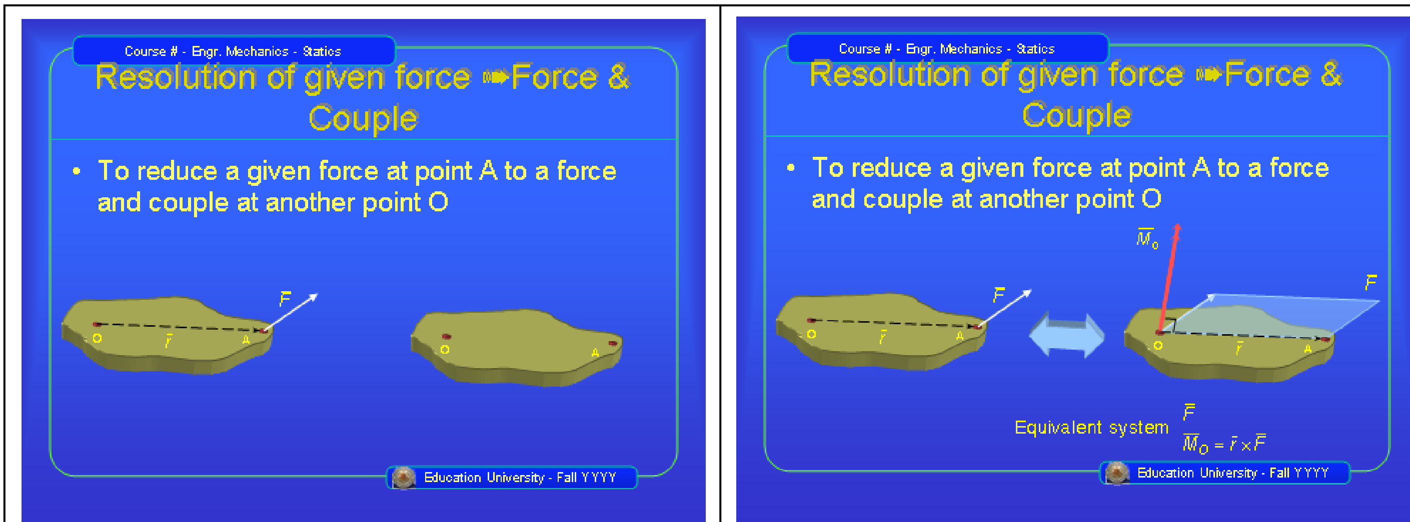
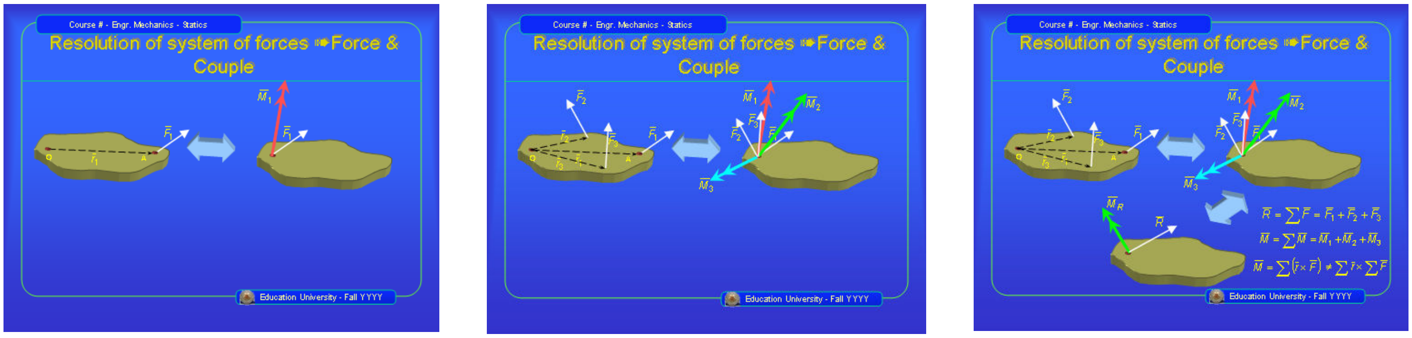


Figure 1. : Example of transparencies used to illustrate reduction of system of force to a force and a moment of couple.



Slide 1 : Single force shown and problem stated	Slide 2 : Animation and principle illustrated

Figure 2 : Example of electronic slides used to illustrate reduction of a given force to force and a moment of couple



Slide 1 : Force reduction	Slide 2 : Multiple force reduction	Slide 3 : Final reduction to a single force and moment

Figure 3: Example of electronic slides used to illustrate reduction of a system of forces to a force and a moment of couple

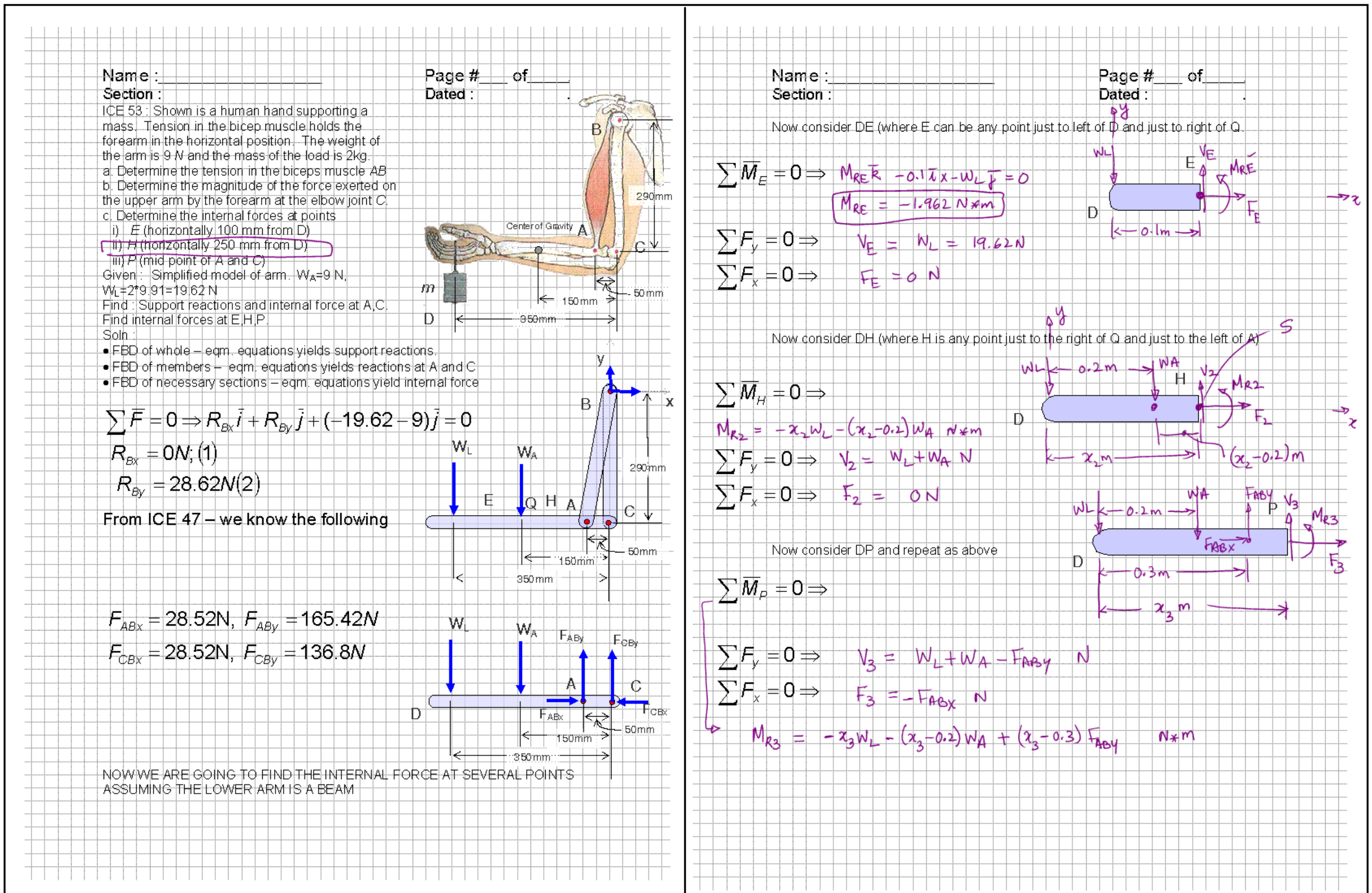


Figure 4 : Sample fill-in sheet used in class for problem solving.