AC 2010-1022: FACULTY'S USE OF TABLET-PC TO ENHANCE LEARNING FOR TECHNOLOGY STUDENTS

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Faculty Using a Tablet-PC to Enhance Learning for Technology Students

Engineering as defined by the Accreditation Board of Engineering and Technology (ABET) is "*The profession in which a knowledge of the mathematical or physical sciences gained by study, experience and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind* ".[1] The American Society for Engineering Education's (ASEE) Engineering Technology Council has defined Engineering Technology as "… *the profession in which knowledge of the applied mathematical and natural sciences gained by higher education, experience, and practice is devoted to application of engineering principles and the implementation of technological advances for the benefit of humanity. Engineering Technology education for the professional focuses primarily on analyzing, applying, implementing and improving existing technologies and is aimed at preparing graduates for practice in that portion of the technological spectrum closest to the product improvement, manufacturing, and engineering operational functions.*"[2]

It is a well known fact that engineering technology students differ from their engineering counterparts in several ways[3,4]. From the above references we can say that most technology programs focus on hands-on experience in laboratories and rely on student learning knowledge by following problem solving methods utilized by instructors. "*While they are different in scope, both disciplines require the same elements of knowledge and skill although they will vary significantly in their different levels of emphasis and depth*".[4]

The author moved from exclusive blackboard teaching to utilizing Tablet-PC in an engineering college, before moving to teach at a technology school. This paper briefly outlines the tribulations and lessons learned during this move and how he adapted his teaching to benefit technology students. He maintained the rigor of theory by using fill-in sheets for the development of theory, while continuing to use problem sheets for solving problems.

From the very first class, it was obvious that technology student's motivations were vastly different from engineering students. On the author's campus which has both technology and engineering programs, most of the technology students were older and attended school while working to further their education. In several instances they held a day job, had family with children and took mostly night classes to improve their education to advance in their career at work or to take on a new job on graduation. What the technology students lacked in mathematics when compared to the engineers, was more than made up in their hard work and determination to stay focused and learn. Some of them seemed to be less focused on the rigorous theoretical development and deductive reasoning used in engineering. They were more inclined to look at an equation, determine how to apply the same, solve many example problems to reinforce the concepts. They generally followed a "template" or "recipe approach" to solving problems. The working students also brought varied and very interesting experiences from their job to the class.

In contrast, most of the engineering students were coming fresh from high school, attended the first two years of their four year program, and moved on to the main campus for the last two years. Having taught engineering students for several years, the author was very much in tune with the detailed development of the theory from basic calculus approach, which was later on followed by solving problems which combined general solution with numerical solutions. This approach worked well with engineering students in general with some variations.

For the past several years, the author had become accustomed to teaching with the use of a tablet-pc and digital ink technology. Digital ink-technology is the term used for writing on a tablet-pc screen using free hand writing. The students in the class did not use tablet-pc. The author had developed complete PowerPoint™ based lectures, several animations, multimedia content and several example problems around this approach targeted to engineers.

Based on all the information that was given at the interview and from what had been gleaned from literature, the author decided to start his new job by utilizing the blackboard to teach in the traditional method to address the falsely perceived lack of depth and rigor. The lectures were mostly oriented to writing the notes and solving several example problems on the chalkboard. At the end of the first year, the author's student ratings were hurting; he was struggling to cover the syllabus and could not solve a large number of problems in class. (It is a real setback when one gets used to teaching engineering classes with a Tablet-PC). There is a lot of frustration when one also realizes that the class is not prepared for in-depth derivation and solving very involved problems. The author immediately realized the dire need to do something otherwise his job was at stake. The solution was to combine his previous use of Tablet-PC with needs of the technology students. This is easily said, but a lot of changes were needed from previous experiences.

To achieve the goal of increasing the number of in-class-examples, while not sacrificing the needed rigor, the use of tablet-pc was adapted to assist with both the goals. To ensure that the rigor was maintained, theory was introduced in class. To assist the students in following the theoretical development, simplified calculus or geometrical based approach was used. Most of the theoretical developments were written or typed out on a worksheet. The lecture followed the written notes in introducing the theory, occasionally requiring the students to fill-in several steps along with the author who filled in using the tablet-pc with ink-technology. Figure 1 shows the handout that was used to derive the flexure formula in the strength of materials class. Printed or typed content was provided as part of the handout, while the written content was done in class using digital ink. The author used a media projector as he filled in the handwritten content, while the students followed along. For some students who did not care about the derivation, attention was drawn to the important formula by highlighting the same. Important assumptions and limitations of the formula were discussed at length in class. Multimedia lectures for the more mathematically inclined or interested students were posted to be used outside the class. These multimedia lectures covered the topic with greater depth with respect to the necessary theory by utilizing the necessary mathematical tools like calculus, differential equations etc. Some of the multimedia lectures had been created previously for the engineering classes the author taught. The theory in class was handled by providing handouts and following the steps with the students, thus leaving no student behind.

The second objective was to increase the number of solved examples in class. To address this need several worksheets with blanks that could be filled in class with the students were created.

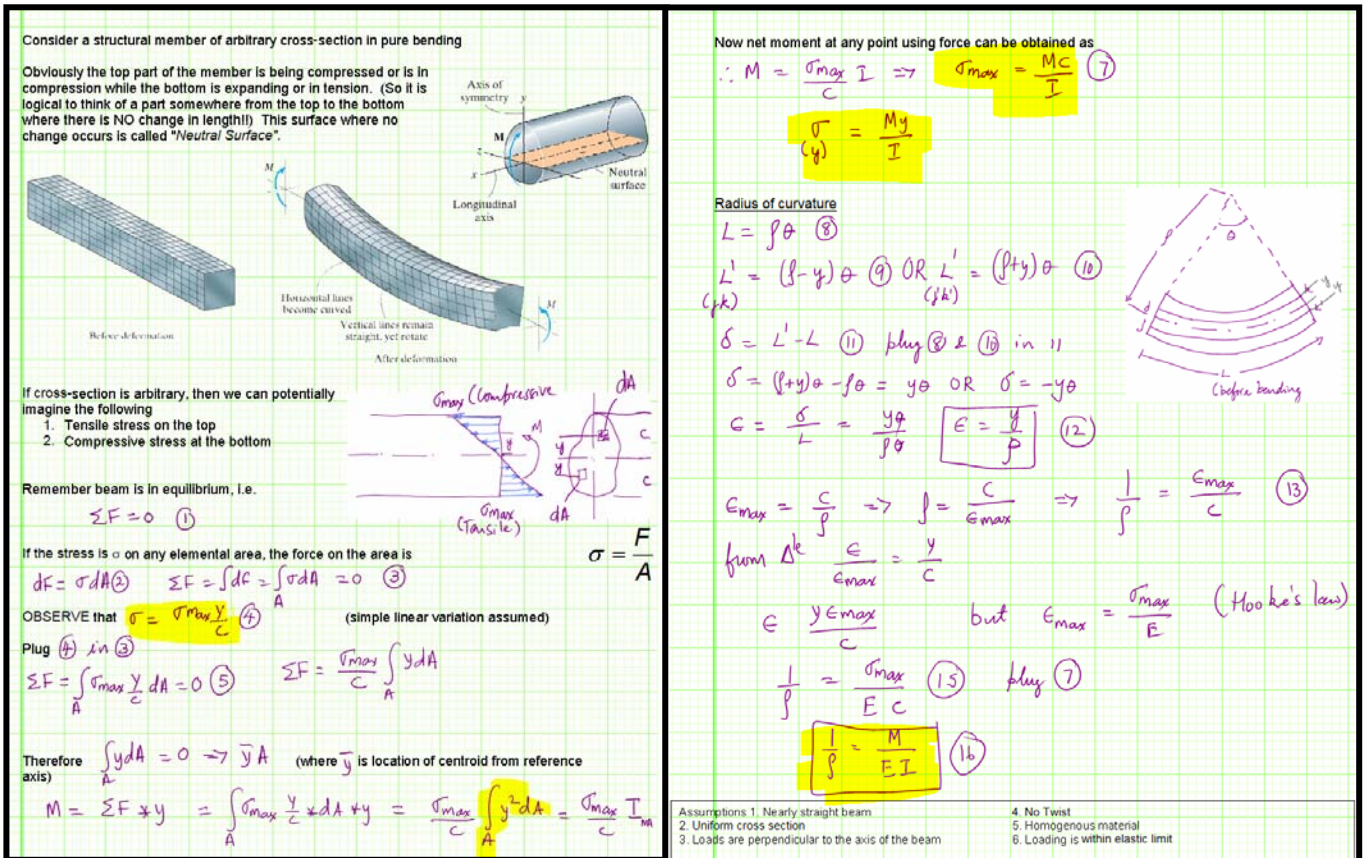

Figure 1. Handout showing the flexure formula derivation. Highlighted equations were stressed as important for students who did not care much for the derivation.

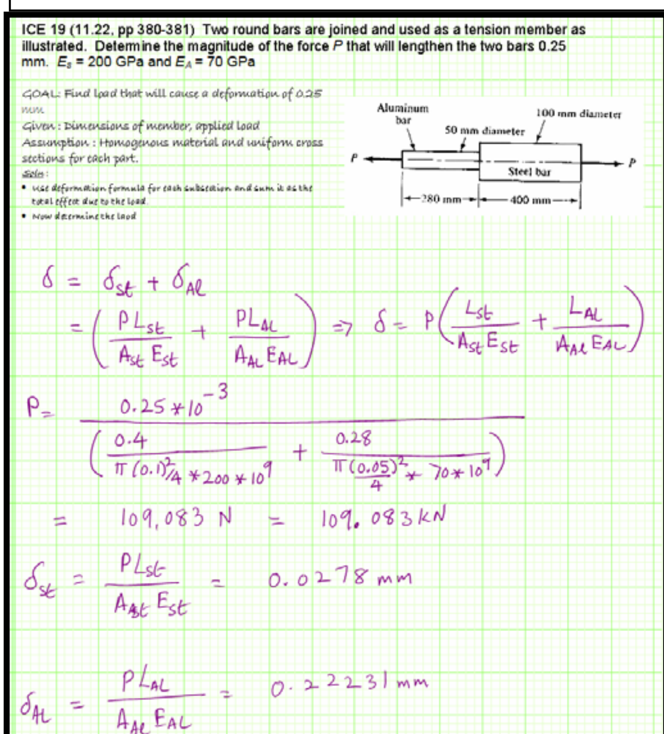

Figure 2. Problem handout sheet. Ink is filled in class with student interaction.

Figure 2 shows a handout that was used to solve examples in class. Depending on the problem, the handout was carefully planned. The problem statement and reference was typed in along with the figure from the textbook. In the lecture the problem was first introduced and the solution briefly discussed before the handouts were distributed. This provided an opportunity for the author and class to discuss the solution strategy and any assumptions that were made in solving the problem. Once the handouts were distributed, the class filled-in the preliminary information of given, to find etcetera, while the author also did that in some problems using ink-technology OR had it typed out in the projected version only (see figure 2). These fill-in sheets also allowed the author to form self-selected peer groups that solved the problems together, enabling active learning

cators have used techniques like active[5] and cooperative learning[6, 7], inquiry and problem based learning, team projects, service learning and undergraduate research. Active Learning[5], Cooperative Learning[6, 7], and Peer Instruction[8] have also shown to be beneficial in classrooms and in the enhancement of student learning and engagement. Some of the example problems used in previous engineering classes were modified to be more numerical so that they could be used in the technology classes.

These handouts also created opportunities for the author to assess student learning and focus on aspects that were not clearly understood in the class. Many times, the slide was used to briefly discuss the solution, and then students worked in their peer groups solving the problem. The author could walk around to gather information about student struggles. This also provided for immediate assessment of students, their struggles and misunderstandings. If there were common misconceptions, they could be immediately addressed by the author. This just-in-time assessment and instruction really enabled the technology students a lot in setting them up to solve problems on their own. The fill-in handout also enabled the class to focus on the necessary concepts to setup and solve the problem, while skipping well understood details like solving equations in one unknown, simultaneous equations etc. Homework was similarly made up with fill-in sheets to guide and cultivate similar habits with students and problem solving.

An added benefit that came out of using the fill-in sheet was the increased number of solved examples in the classroom. Approximately forty problems were solved in class in 2007 when the class met twice a week for four hours. In the next two years, the use of the tablet-pc increased the number of problems solved in class to eighty (2008) and well over one hundred. (2009)

Comparing the class average grade it was clear the students were learning more when compared to teaching only with the chalkboard. For example in the year 2007 (10 students), the class average score was 82.3 %, but it has improved to 91% and 90.3% in 2008 (5 students) and 2009 (18 students) when the tablet-pc with fill-in sheets were used. (Table 1 summarizes these results) The student rating of the instructor on a Likert scale of 7 has improved from 4.8 in 2007 to 5.2 in 2009. Both in the mid-term and end of the semester survey, students have indicated that the use of Tablet-PC with the fill-in sheets has been very beneficial for their learning. The fill-in sheets were very useful as templates for homework, tests etc. Informal discussions with faculty who teach system dynamics and capstone design have indicated that over the past few years – student performances have improved in design and analysis. Students are drawing clearer free body diagrams, have shown improved problem solving skills and use more analysis than before in the capstone design projects. Observers from the Schreyer Institute for Teaching Excellence had the following comment on the fill-in sheets and use of tablet-pc: "Students seemed to understand concepts and fill-in sheets, and they had a sense of accomplishments." Below are some of the comments from students to the question "Please give me your feedback on the use of the fill-in handout sheets that we work together in class with me using the Tablet-PC":

- It helps understanding easily.
- I like using them, they are very helpful.
- Good.
- Very effective.
- Awesome. It is helping me a lot.

Academic Year	Class Average %	# of students	Std. Dev
2007	82.3	10	9
2008	91.1	5	5.5
2009	90.4	18	5.4

Table 1. Class average to show improvement based on use of tablet-pc.

- I love them; I don't have to keep drawing diagrams.

This paper outlined some of the steps the author undertook to enhance student learning as he migrated from a four year engineering school to teaching at a four year technology school. The use of the tablet-pc by the faculty and fill-in sheets by students has clearly increased student learning as indicated by student grades and student rating of the instructor. Faculty teaching follow up courses have also provided informal feedback about students improved performance in advanced courses.

Bibliography

1. "Engineering, Technology, Science and the Related Arts and Sciences – The ABET Definition of Engineering", http://www.ewh.ieee.org/cmte/pa/Status/Engineering.html (visited on Jan. 5, 2010)
2. "Engineering Technology Defined", ASEE Engineering Technology Division, http://www.purdue.anderson.edu/etd/
3. Weese, J. (1994). *The advance toward distinction in Engineering Technology*. Journal of Engineering Education. Volume 83 (1), pp 41 – 46.
4. Holling, G. H. (2003). *Engineering Versus Engineering Technology: Enemies or partners.* Proceedings of the 2003 ASEE Annual Conference & Exposition, June 22-25, 2003, Nashville, Tennessee. Session 1547.
5. Prince, M. J. (2004) Does *Active Learning Work? A Review of the Research.* Journal of Engineering Education, Volume 93, pp. 223 – 231.
6. Johnson, D., Johnson, R., & Smith, K. (1998). *Cooperative Learning returns to college: What evidence is there that it works? Change,* July/August, 27 - 35.
7. MacGregor, Jean, Cooper, J., Smith, K., and Robinson, P. (2000). *Strategies for Energizing Large Classes: From Small Groups to Learning Communities,* Jossey Bass Publisher, San Francisco, CA.
8. Mazur, Eric (1997). *Peer Instruction*. Prentice Hall, NJ.