AC 2010-2087: FILL-IN WORKSHEETS: A TOOL TO INCREASE STUDENT ENGAGEMENT

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Fill-in Worksheets: A Tool to Increase Student Engagement

Abstract

Every engineering educator strives very hard to increase student engagement in the classroom. Techniques like Problem Based Learning (PBL), Active Learning (AL), Cooperative Learning (CL), Service Learning and Undergraduate Research are some of the prevalent methods currently in use to increase student engagement. This paper is about "Fill-in Worksheets", a tool that was developed to increase student engagement in classroom and allows for incorporating PBL, AL and CL along with Peer Instruction (PI). The paper describes the steps and thought process that was used in developing the fill-in worksheets over the past several years. The worksheets have enabled the author to increase student engagement, include AL, CL and implement PI in the classroom.

Introduction

"Educators, researchers and policy makers have advocated student involvement for sometime as an essential aspect of meaningful learning."[1] To engage students, educators have used techniques like active[2] and cooperative learning[3, 4], inquiry and problem based learning, team projects, service learning and undergraduate research.

A decade ago, classroom instruction was limited to the use of blackboard to lecture and solve problems in most institutions for many engineering courses across the USA and the world. Student engagement as we all know was typically limited to copying notes. If students managed to follow, a question or two maybe asked to clarify some doubts could be added in. While many of the baby-boomer generations learned most of their engineering by this modality along with self-study, which included solving **several** problems from many textbooks, present day students are exposed to a very different set of learning experiences and generally are a very different set of learners. From personal observations and discussions with K-12 teachers in neighboring school districts, **(**Exeter Township, Muhlenberg, Lower Merion, Reading, Wyomissing**)** it is evident that there is an increased use of handouts, workbooks and worksheets in grade school education. These implements are used for both in class learning and for homework assignments. From the same conversation, it is also apparent that for in-class assigned problems and homework assessment, the teachers read out the answers and generally the students verify their own work or in some cases exchanges papers and correct the answers. Even though the teachers insists and require that steps and work be clearly and neatly shown, most students do the work in any convenient manner and just make sure they obtain the answers, because final answers are being checked and graded.

As engineers and engineering educators we are all well aware that understanding the concept and applying them to problem solving is very important[5]. Equally important is to develop our own problem solving strategies[6] based on working out a large and varied number of problems. Even though our students are reminded and aware of this, they generally operate on an optimization principle based on the objective function "Minimize effort to maximize grade". This objective function also includes "Solve the **least** number of problems to score the maximum points". (Typically this means assigned homework, or use fraternity/sorority house question banks!) Hake[7] has shown that interactive engagement increases the conceptual understanding and problem solving ability of students. CL[3, 4], and PI[8] have also shown to be beneficial in classrooms and in the enhancement of student learning and engagement.

From above it looked like worksheets could prove to be a non-alien tool to increase student engagement. It could also be utilized as a medium to inculcate and train students in problem solving, solution layout, and, several other important engineering practices.

Basic Framework

Typically most instructors pick a teaching and learning methodology and continue to use this based on previous experiences and success they have had with this approach. The methodology is fine tuned on an as needed basis, but generally does not undergo major changes. We as instructors are in the same situation as our students, who once remarked to me, "You are trying to undo in one semester, what we have been doing for four years", when the author tried to force a clear layout to follow for problem solutions. In a similar way, as instructors we will also need time to undo and redesign our teaching and learning methodologies.

Using ideas and concepts from previous work listed above, the author undertook a redesign of classes he teaches to include interactive engagement, CL, AL and PI with the help of the non-alien worksheets. Basically this involved three aspects of a class. First the redesign of any given class of approximately an hour (three credit class meeting on Monday, Wednesday and Fridays) or hour and hand half (three credit class meeting on Tuesday and Thursdays). The second aspect was to redesign the class based on when theory was introduced or when problems were being solved. This had to be followed by how the author redesigned the homework assignments.

The basic class framework was redesigned with the concept of mini lectures based on *informal cooperative learning* experiences of Johnson, et.al.[3] and *bookends on a class session*[1]. Based on previous year experiences, the author created an approximate class template as shown in figure 1. (Changes were made to this as needed and required for

1- 2 min. Announcements	5 min. Review, Homework	1 min. Today's topic	10 – 12 min. Today's topic & mini lecture	2-3 min. Activity	10 – 12 min. Today's topic & mini lecture	2-3 min. Activity	8 - 10 min. Today's topic & mini lecture	2-3 min. Activity	1- 2 min. Summary and next class

Figure 1. Approximate template for one hour class (slight modification needed for one and half hour class)

specific classes.) The first minute or two was used to make any announcements, address general concerns (like course website related, test dates, homework dates) etc. The next five minutes were dedicated to a review of previous class, any homework related questions etc. This was then followed by what was planned for today's class with tie-in hooks or anchor points to what was already done. The rest of the class time was broken down into smaller chunks consisting of ten to twelve minutes followed by two to three minutes activities. Depending on the content planned for the specific class, these blocks were modified to suit the needs.

Theory Framework

Whenever the author had to introduce theory, he used some real life situation. For this the author has used a camera to take pictures or videos in and around the university campus which students identify with. In some cases the author has used pictures of famous structures that most students are aware of. In some instances, problems from the author's research have been used to introduce the need for the theory. Before the next step the author always worked out the complete derivation on paper and had to make decisions about what is the important or take home message that needs to be conveyed to the students. Based on this the author used one of the mini lectures to walk the students through the derivations using a media projector and a slide, while the students are required to only listen. If required, the author broke the derivation into two or more mini lectures. After this students were given a few minutes to discuss among themselves in pairs or groups, providing an opportunity for AL, CL and PI. If needed clarifications are provided after this group activity. Sometimes clarifications are postponed and addressed when the written derivation is complete. After the group activity, the class is provided with a worksheet as shown in figure 2.

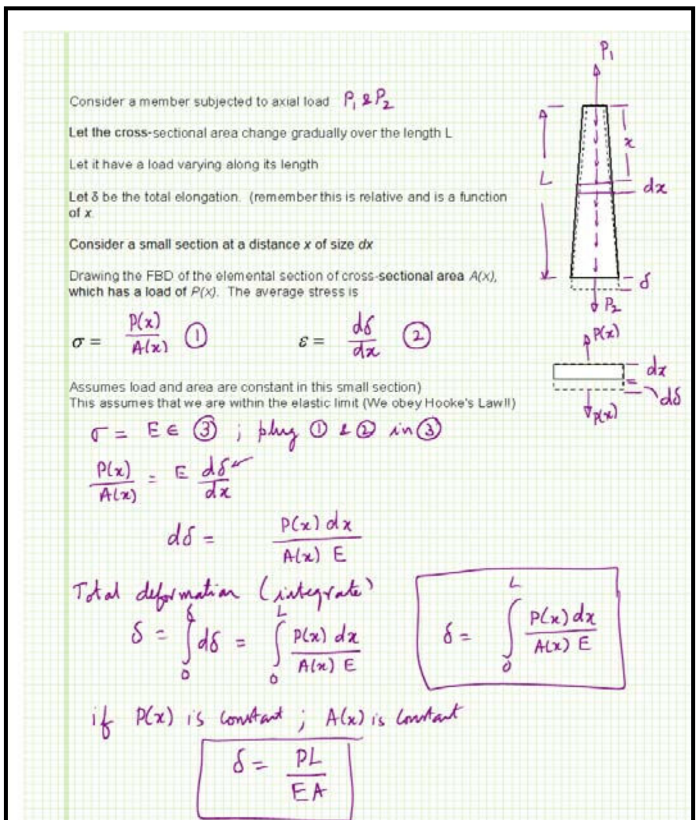

Figure 2. Fill-in sheet for derivation of theory for elastic deformation

Figure 2 is an example of a fill-in sheet used to derive the basic concept of deflection under axial loading. Typically in the past the author would have written on the blackboard the figure, all the text and the derivation. With the fill-in sheet the author had to carefully think of what were the important concepts that he needed the students to be aware of. (Individual opinions will vary about what is important!) While redesigning this, the author thought that the basic outline of the member under load need not be drawn in class. So this was provided on the handout, while the length, loading and location of the section which are important concepts were not shown, but written down in class using ink technology on a Tablet-PC.

Students are also copying the information with the instructor on their fill-in sheets. Similarly one can see typed text in the handout, which the author considered was not important to be copied down in class, but required to make the derivation complete. In a similar manner based on the complete derivation done before on paper, the author selected information to be provided or to be written in class. Notice that most of the derivation is not typed in, but inked in class. In the author's pedagogy style, these are important for students to follow along and help them see the development of the basic concept of elongation under a load. At the end of the derivation postponed discussion/questions from before OR any new questions are answered. This is followed by a few minutes discussion among the students in group again providing an opportunity for AL, CL and PI and student engagement. In a similar manner the author has developed fill-in sheets for most of the theory he teaches in various mechanics classes.

Problems Framework

In redesigning my class for solving problems the author had to be sure he could address several learning objectives.

- Application of just learned theory or concept
- Develop a basic style of solution layout
- Develop strategy for problem solving
- Develop a logical and deductive approach using necessary mathematics
- Sanity check of solutions
- Incorporate AL, CL and PI to engage students

In the past problems were written out on the chalkboard along with sketches and the full solution laid out. (Again in the author's opinion several of these steps consumed invaluable class time, while not contributing to learning the important concepts and theory).

In the beginning of developing the fill-in sheets, the author picked simple examples that needed only a straight substitute and evaluate into formula approach. In these problems, the author typed out the problem statement as shown in figure 3. Then he introduced a basic template (given, find, assumptions in any, sketch and

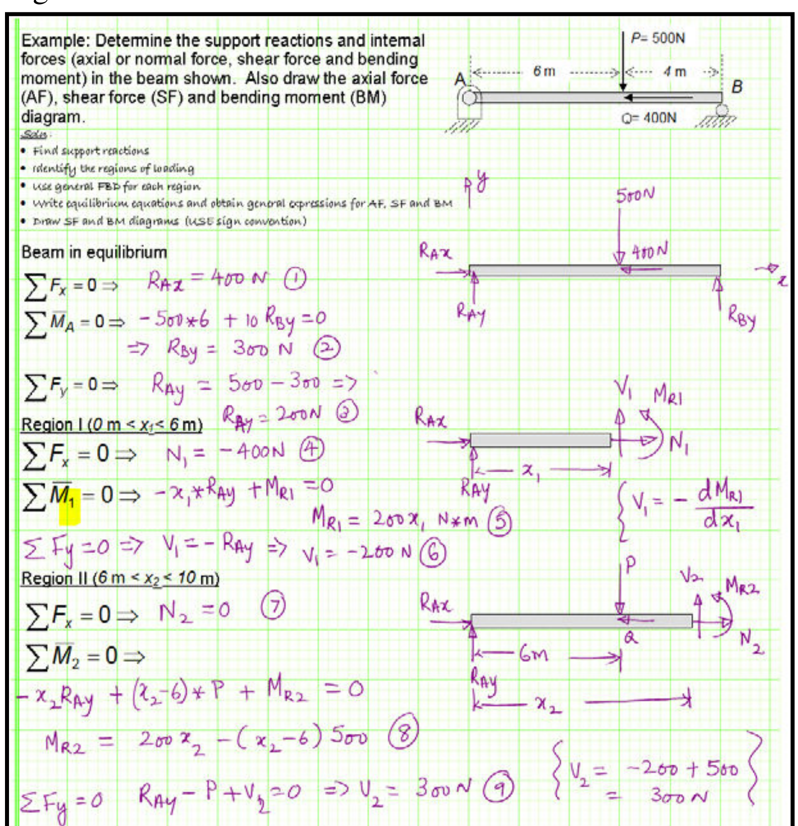

Figure 3. Fill-in sheet for solving problems

solution outline in description) for solving problems. This template could later on be developed into problem solving strategies.

As mentioned previously in theory, the problem had to be fully solved by the instructor first before embarking on the design of fill-in sheets. Then as an instructor the solution permits one to categorize the information. For example the concept/theory along with the mathematical equation is important. Information that required for the complete solution, but can be segregated as prior knowledge from previous courses OR prior knowledge from this class etc. Armed with this categorization, one can proceed with the development of the fill-in sheets.

The fill-in sheets had the problem statement fully typed out along with any figure that would describe the problem. (see the figure in figure 3) Then blanks are provided for given, find etc. After this any figure outlines needed were put in the fill-in sheet. In figure 3 see that the outline of the beam is shown as part of the fill-in sheet. The example shown in figure 3 was at the introductory stage and hence the necessary mathematical equations are shown. In later examples they were not necessarily shown.

As in the theory, electronic slides are used before the fill-in sheets are handed out to the students. About a minute or two is given to students to first think about the solution on their own and then in small self selected peer groups. This is followed by students (sometimes volunteered, sometimes called on) describing the solution with cues and hints provided by the whole class. Again this really engages the class and provides an excellent platform for AL, CL and PI. At the end of this discussion the handouts are distributed, while I project the fill-in sheet using the media projector from my Tablet-PC. Now students are required to fill-in the basic information such as what is given, what has to be found, any assumptions, and if any sketches were needed. The author then projected his filled in information for them to compare. The peer groups are allowed to discuss among themselves during this and next several steps. The fill-in sheets then outlined the problem solution in words without using equations where possible. If the problem is on a new topic, the author walked the class through the steps as he filled-it in using ink technology. If the problem is later in a sequence of problems, the peer groups are asked to work unto certain break points and stop so the author could do the same on the slide while answering any questions. This also helps him keep the whole class in synchronization, rather than each group at different steps. As the complexity of the problem increases the interspersion of lecture and group work is mixed to keep within the bookend format. Sometimes the lecture part is reduced to a few minutes, but the constant back and forth interaction is kept active.

At the end of the problem students are provided time once more to discuss among their peers. At the end of the time allotted, a review was provided and final run down of the solution is provided by the author. This created an opportunity for the author to address any misunderstandings, or add clarifications and more explanations etc. on the problem or the underlying concept or topic. As the class progressed into longer and involved problems, larger parts of the solutions would be assigned to the students, while still maintaining the five minute windows.

Homework assignments are similarly designed with fill-in sheets that provide with hand-holding in the first few problems and almost no handholding in later problems in the same assignment. This provides the students an opportunity to practice problem solving skills and develop problem solving strategies.

About thirty problems were solved in the strength of materials class when chalkboard was used exclusively. Transitioning to not writing and sketching the problem (by providing students with reference figure in the textbook) increased the number of solved problems to about thirty-five. Using the fill-in worksheet (figure 3) and a Tablet-PC, the class went onto solving approximately fifty-five to sixty problems in a semester.

Conclusion

In this paper, the author describes the steps and thought process of developing the fill-in sheets that have enabled me to a) increase interactive student engagement, b) include active and cooperative learning and c) implement peer instruction. In addition, the fill-in sheets have enabled differentiated instruction in the class room, by adding symbolic solutions to challenge the advanced student, while helping the average and below average student solve the basic problem using numbers. Aside from these an equal number of problems are given as homework which have varying degrees of fill-in to inculcate and train students in problem solving. Additionally, detailed solutions are made available to improve problem solving skills, while teaching methodologies. Student surveys indicate that these fill-in sheets have increased their learning.

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