Hybrid Class Experiences: Flipping Mechanics Courses and Homework Feedback

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Abstract

Introductory mechanics courses are ideal courses to use with a hybrid teaching style. These courses build the foundation of the student's knowledge in their engineering discipline that will be used in upper level courses to define the mechanics related to the individual's discipline. The learning is typically performed in the process of completing homework using knowledge gained from lectures, online examples, or textbook examples. Sometimes disconnects between their notes and the practice problems impede the learning. The author uses flipped mechanics courses to overcome these issues seen in a typical lecture based mechanics course. The notes are provided online as interactive files that the students can download and review at their convenience. Class time is used for "hands-on" activities, homework questions, and additional example problems. Online immediate feedback is used to assist students with homework problems.

1. Introduction

"The predominant delivery method to engineering education today is a didactic, passive approach using lectures and textbooks."[1] This delivery method allows students to act as a passive participant in the learning processes. Some teachers are using the abundant information found in the education literature to change this approach in mechanics courses. Typically, the first mechanics course taking by engineering students is statics or some variation of similar topics with a different name. Several researchers are using this introductory course to introduce concepts from the education literature.[1-3] Steif and Dollar[3] explains how statics is different from physics courses that cover similar material and created a concept inventory that students need to understand about the topic. After determining this inventory, Steif and Dollar created learning modules[2] that are focused on assisting students in mastering the content of this inventory. The mastery of these inventory concepts in the introductory class is essential for students as they continue through the engineering curriculum as additional mechanics courses build on these concepts.

Concept inventories have been suggested for other mechanics courses as well.[4-6] These suggestions have not produced as many publications nor the interest as those for the introductory statics course. The originators of these concept inventories typically use delivery methods to education that is not a "… didactic, passive approach using lectures and textbooks." These delivery methods influence students learning in mastering the concepts. One delivery method that has gained in popularity is the concept of the "flipped" classroom. This delivery method consists of class notes, lectures, and/or reading material being presented to the students before

classroom discussions. Therefore, the students are able to review the content and use the "traditional lecture" time to ask questions, perform labs, do additional examples, or some other hands-on activity. Some publications show through student surveys that students feel learning is enhanced with a majority of the students preferring this model.[7] An introduction to this delivery method can be found here.[8]

The author decided to use the flipped classroom approach for teaching mechanics courses because of personal experience during a graduate level math course and because of experience teaching mechanics courses. The math course was taught as a distance course at multiple locations, so each lecture was recorded and posted to the internet. At times, the author had difficulty understanding specific points of the course from the review of the author's written notes taken during the lecture. Typically a review of the recorded lecture would clarify those points without need to contact the instructor or spend countless hours searching for help on the internet. The author also noticed during the first year of teaching mechanics courses that some students would ask questions over concepts and ideas that were covered during lectures. A review of the student's notes showed a gap in the needed detail within the notes in those topics. Some students also requested more examples or practice problems be given. The flipped classroom was the delivery method chosen to accommodate this example request and provide better notes for the students. This option allowed the students to review the course material at their leisure and provided more time in the classroom to answer questions and do examples.

Another point of concern for the author was time. During the author's first year of teaching, grading homework was very time consuming. Sometimes the homework was not graded in a reasonable timeframe and the author noted that some students did not grasp the learning objectives covered in those specific assignments as seen later during exams. Therefore, the author decided to change the student feedback in order to correct this timing issue for both the author and the students. The author chose to use the embedded tools available in Blackboard and allow for students to submit homework online for immediate grading. This option eliminated the need for hand grading and allowed the students to receive immediate feedback on their progress. Feedback is another topic of interest to researchers that has been studied in abundance.[9]

The following sections will discuss how the mechanics courses taught by the author were implemented, discuss what was learned during this process, and end with conclusions.

2. Implementation

The courses taught in the fashion were statics, dynamics, and strength of materials. Each class was designed where every week contained specific content to learn with the accompanying notes and an associated homework assignment that covered that content. The combination of the weekly notes and homework assignment together will be referred to as the *weekly assignment*. New *weekly assignments* were made available each Friday. This option allowed the students the weekend to look over the notes and assignment before meeting during class time. The class periods of the week were used to answer questions about the new content, answer questions about the homework assignment, perform labs and/or hands on activities related to the *weekly assignment*, and to go over additional examples. The students were allowed an infinite number

of submissions for the homework and the submission option was closed at the end of the second weekend for each *weekly assignment*. This timeframe gives the students access to each homework assignment for ten days.

The lecture notes consisted of interactive pdf files. These files have embedded audio and video that introduce the content and provide examples to the students. The pdf format was chosen because students could download them to their own machines and view them at home with the basic reader program. Each page of the file covered a topic with the audio explaining the concepts. Videos were used to show content that could not be explained in a picture and also were used to show how to solve example problems. Adobe Flash controls the interactive portions of the files. Figure 1 shows an example of sample pages of an interactive file. The example on the left of Figure 1 introduces the students to 3D space and how we define the axes by introducing the right-hand rule through a picture. The black rectangle at the bottom contains the controls for the audio associated with that page which is embedded as an mp3 audio file. This type of audio file is compatible with numerous platforms and worked well for students with PCs, Macs, and some handheld devices. The example on the right of Figure 1 shows an example problem presented with an embedded video. The example was recorded using a document camera with audio and embedded as an MPEG4 file. As with the audio file, this video format is compatible with PCs, Macs, and some handheld devices. The video examples were typically between 2 to 10 minutes in length. The typical size of a single interactive pdf file was between 50 to 150 MB and the users could download them to their machines and review them as desired.

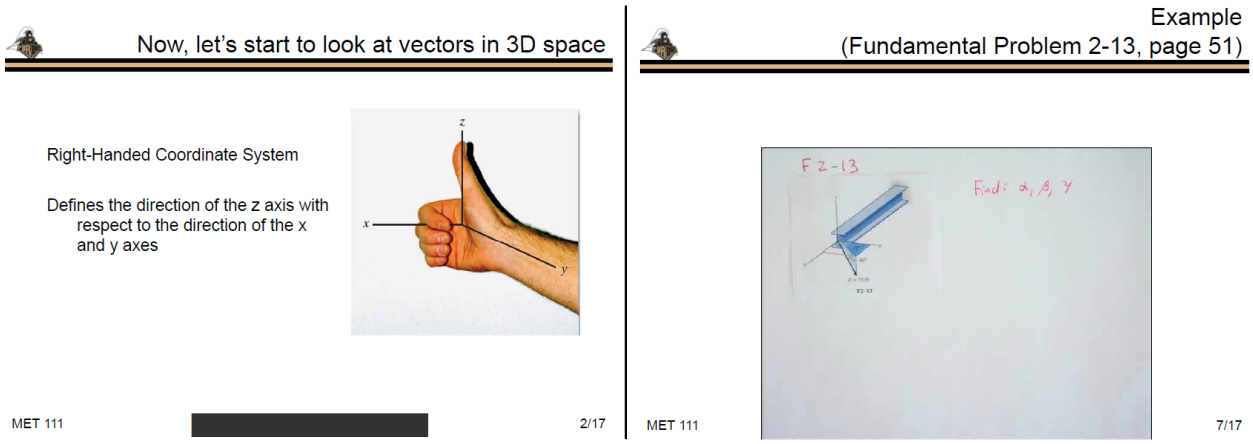

Figure 1. Examples of the interactive pdf files used in mechanics courses.

The homework problems were assigned using Blackboard. Problems were typically assigned from the text. The author typically uses numerical answers for the homework because Blackboard can be programmed to accept a solution through a defined range. Once a student submitted the solutions, Blackboard was programmed to inform the students of their score. Each homework assignment typically had 10 questions worth a point apiece and the students were allowed to submit answers as many times as desired throughout the time allotted for the *weekly assignment*. The solutions to the homework were provided to the students once 80 percent of the solutions were correct or at the end of the allotted time. The solutions were a pdf file that consisted of a copy of the solutions that the author solved (called the static solution) and an embedded video of each problem with instructions of the steps to obtain the solution. These pdf files were also downloadable for the students to use to review their homework.

The class time was used for answering homework questions, performing labs, doing additional examples, and clarifying points from the notes. Typically students got stuck on parts of the homework that could be related back to the concept inventories of that course. The students had difficulty relating the covered concept to a different problem. Therefore the author had time in class to review that concept and emphasize what the concept means and how it was related to multiple types of problems. This process usually involved showing additional examples as well. The labs were typically designed to cover topics from the *weekly assignment*. This activity allowed the students to get hands on experience related to the covered topics. Specific procedures were not provided to the students for the labs. The materials available were explained, any equipment needed was demonstrated, and the expected requirements were explained. The students were allowed to use the lecture notes, the internet, and ask questions to determine what procedures were needed to obtain the expected requirements. A lab report for each group was required the week after the lab was assigned.

3. Discussion

Implementing these mechanics courses in this manner requires a considerable amount of time to prepare. The implementation is typically less time consuming and allows the author more time to assist the students on an individual basis and perform other required academic activities. The notes and homework need to be recorded prior to the start of the weekly assignment. These recordings (mp3 and MPEG4) can take a considerable amount of time. But, using the pdf format allows the notes to be easily updated and/or changed. Some teachers use recorded videos of entire classes for this type of course; but updates, corrections, or changes require video editing or complete rerecording of the class. With the notes as interactive pdfs, additional pages and corrections can be made on a page by page basis. Individual pages can be extracted or inserted with the embedded audio and video.

Student reactions to a course taught in this manner have varied. The author expected non-traditional students to resist this type of course offering. On the contrary, non-traditional students have embraced this course offering method because it allows them more freedom with respect to work schedules. Some students have difficulty attending class every day and this method allows them to focus on their class over the weekend and only need to attend class on lab and exam days. Some traditional students have preferred reverting to a traditional lecture because this method requires them to be more involved in their own education. The student has the responsibility to review the notes and ask questions.

The homework implementation has been of most concern to the author and the author continues to adjust and change this portion of the class. This portion of the class is where the students receive feedback on how well they are doing at mastering the material. The author notes that the homework only requests numerical solutions, so derivations with variables are not included. The author has included these activities in the labs where the students do hand in reports. Another concern is having a single student or two obtain 80 percent early during the weekly assignment and sharing the solution pdf. This concern has occurred, but the students understand that exams are more important and mastering the material is necessary to perform well on the exam. The

author has noted more group work on homework assignments and more students teaching their peers. The last concern is with respect to the students mastering the concept inventories for the courses. The homework questions can be asked in ways to check specific concepts involved within a question. For example, in a strength of materials course, a problem in the book may ask for the maximum stress in a beam. The homework problems can be set up to guide the student through the solution and check for mastering specific concepts. The questions may ask 1) what are the reactions on the beam, 2) what is the area moment of inertia, 3) what is the shear force at the point of interest, 4) what is the internal moment at the point of interest, and finally 5) what is the bending stress that that point. Additional questions could ask about the bending stress on the other side of the beam. Organizing the problems in this manner helps the students to learn the process and understand the different concepts. Once the students have been directed through the concepts, another problem may ask for only the stress of an entirely different problem and test the student's ability to go through each part of the process without direct directions. With unlimited submissions, most students will submit the solutions after each problem to check that they are getting each concept correct before continuing to the next concept.

The students also use the embedded video examples to study over the static solutions. The author typically sees students listening to and reviewing the video examples and homework solutions before tests. They use the examples to remind themselves of the different concepts and the processes for solving different types of problems. Recording these videos is time consuming, but the author feels is very beneficial to the students.

4. Conclusions

Offering hybrid classes to mechanics students puts more pressure on the student in mastering the material and gives more time to professors to interact with the students and answer questions. In traditional courses, the author has seen students wait until the day before homework is due to start the homework. Student involvement in hybrid classes has increased as students begin to review material and start homework earlier. The author has used this style of class for three semesters in mechanics courses and has seen an improvement in students understanding and dedication in mastering the concepts.

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