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Design of a Hybrid Classroom Structure for Engineering Mechanics of Materials

Dr. Andrew Peter Vogt, Salt Lake Community College

I received my BS in ME at the University of Idaho and my MS in ME and PhD in ME at the University of Utah. My PhD research emphasized in biological instrumentation. I teach Mechanics of Materials, Dynamics, Mechanical Engineering Design, and Engineering the Guitar at Salt Lake Community College. I am most interested in using engineering to study how humans interact with their environment.

Design of a Hybrid Classroom Structure for Teaching Engineering Strength of Materials at a Community College

Abstract

Teaching fundamentals of engineering Strength of Materials (also called Mechanics of Materials) is challenging as a semester long course because there are nine chapters of required content. This article discusses new hybrid classroom methods and survey results implemented in the spring of 2015 at Salt Lake Community College. The hybrid classroom uses lecture videos, which students are to review outside of class, to present theoretical principles and simple examples; this allows for more class time to spend working on more complicated applications.

These videos provide students another way to see theoretical principles prior to lecture. Students can play the videos multiple times before lecture so they are better prepared interact with other students in class. We anticipate these techniques will increase the efficiency of learning course materials presented in class and enable more advanced discussion and topics to be covered.

In addition to standard teaching evaluations the flipping techniques are evaluated based on an extensive array of survey questions. These questions will ask students for numerical reflective evaluations on their learning and retention of class materials.

1 Introduction

Many community colleges, including Salt Lake Community College (SLCC), have increasingly complex demographics. To name a few, this includes traditional, non-traditional, working full-time, and family committed students. SLCC's mission is directed toward such a body of students because it is an ". . . open-access, comprehensive community college committed to serving the broader community. . ." [1]. It achieves this mission statement by focusing on 4 core themes. 2 of these 4 are most applicable to the topic presented in this paper which are *Access and Success* and *Transfer Education* [2] .

In addition to obstacles presented college-wide, engineering students face significant intellectual challenges. To be successful, they must have strong work ethics and be wiling to go above and beyond what is required of them. This becomes even more difficult when work, family life, or other important commitments compete with time students need to spend on their eduction. However, the quality of education cannot be sacrificed. This is a prime example the SLCC core theme of *Access and Success* which targets giving students access to a high quality education while ensuring their success.

SLCC provides students with the opportunity of obtaining an Associate of Pre-Engineering (APE) degree in Chemical, Civil/Environmental, Computer, Electrical, Manufacturing, Material Science, and Mechanical Engineering. Unlike a Bachelors of Science in Engineering, the APE degree given from SLCC is generally not regarded as a degree which can place students in an engineering profession. Therefore, the ability of engineering courses and programs to transfer is extremely important.

To meet these challenges, a variety of courses in the engineering department at SLCC are forgoing traditional classroom structures for either flipped or hybrid classroom structures. These different structures are defined as the following:

- **Traditional Classrooms** are such that a professor delivers lecture material, such as theory and examples, and student work on homework assignments outside of class.
- **Flipped Classrooms** implement technology to allow students to access lecture material outside of the classroom so that in-class time can be spent on active learning (such as working on homework assignments) [3, 4].
- **Hybrid Classrooms** combine the structure of Traditional and Flipped Classrooms.

This paper assesses the impact of a hybrid class for engineering Strength of Materials (also called Mechanics of Materials) taught in the Spring 2015 semester at SLCC. Strength of Materials was selected to be implemented into a hybrid structure because of the large amount and complex material covering 9 chapters from Mechanics of Materials, 8th Edition by James Gere and Barry Goodno. The following paper discusses the general structure and assessment of the hybrid class structure for Strength of Materials.

2 Class Structure

For the 2015 Spring semester there are 3 sections of Strength of Materials taught at SLCC. One of these courses is taught using a hybrid structure. All sections meet 4 hours per week. The course

objective provides students with a clear understanding of the theoretical and empirical application of mechanics to engineering materials. By the end of the semester, students should understand the study of internal forces and their extension to:

- Tension and compression
- Normal Stress and Strain
- Mechanical Properties of Materials
- Axially Loaded Materials
- Torsional Loading of Materials
- Shear and Bending Moments in Beams
- Stresses in Beams
- Application of Plane Stress
- Deflection of Beams
- Buckling of Columns

Also, students should be able to generalize

- Relations between loads applied to a non-rigid body and the deformations which are dependent on the material
- Relations between loads applied to a non-rigid body and the stresses produced on the body
- Relations between stress and strain from various materials and conditions
- How to design materials to account for different loads and conditions

Students are evaluated with 4 standard exams, 1 final, weekly quizzes, random class activities, a semester project, and homework assignment for each of the 9 chapters covered.

Unlike the 2 traditional sections of this class, students in the hybrid class are required to view a pre-lecture video before coming to class which discusses theoretical concepts and a quick example. The hybrid section meets for 2 hours twice a week on Tuesday and Thursday. Lecture formats are essentially the same for both days, except that there is a quiz every Thursday (unless there is an exam or project presentation). The advantage of the hybrid structure is that it allows the professor to immediately begin looking at example problems. The students are quickly engaged and ready to begin discussion at the beginning of class rather than waiting for the professor to lay out the theory before the heart of the class-wide discussion can begin.

To engage different learning styles, sometimes the class will begin with an example led by the professor, and other times students will get to spend time working on a homework assignment [4]. Professor led examples give them an understanding on how to set up problems properly, while class time to work on homework gives them the opportunity to think critically with the benefit of their classmates and guidance from the professor.

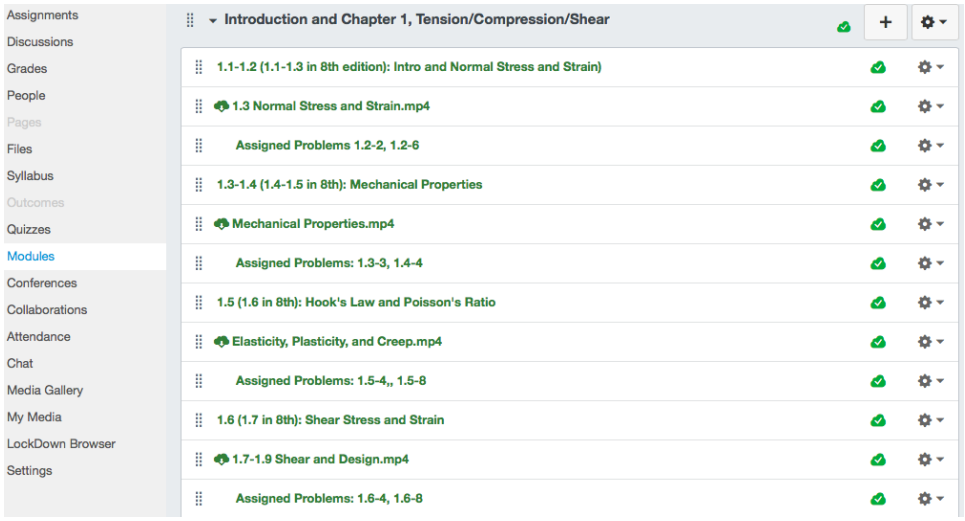

Figure 1: Screen shot for the Chapter 1 module in the Canvas Learning System. Each section, such as 1.1-1.2 represents the topics which will be presented for a given lecture. In addition the lecture topics also include any pre-lecture videos and assigned homework problems.

2.1 Integration Using Canvas Learning System

The Canvas learning system is an online tool used to organize content from the classroom. This is an essential part of a successful flipped or hybrid classroom. The content for the class is organized into modules as shown in Figure 1. Since the hybrid section is a block class, there are two lecture presented in a given day. For example, 1.1-1.3 (from Mechanics of Materials, 8th Edition by James Gere and Barry Goodno) is presented in the first hour of class. Then, students are allowed to take a 5-minute break, and then 1.4-1.6 (in the 8th Edition) is covered in the second hour of class. Notice that for each of these sections there is also a posted pre-lecture video (in .mp4 format) that the students are required to watch before class, and the assigned homework are listed below the videos. Since this is hybrid class, there is a combination of professor-led examples and student-run class actives; often times the class activities give students a chance to begin their homework problems.

2.2 Pre-lecture videos

The purpose of pre-lecture videos is to provide the theoretical and simple example foundations of lecture material. Sample clips from a lecture on *Combined Loadings, Stress Transformations, Mohr's Circle, and Hooke's Law for Plane Strain* are shown in Figure 2 and Figure 3. The video sample illustrates a multiple step process to identify a generalized stress state. Most videos are created from animated presentations using Apple's Keynote program, and then they are recorded using Camtastia. Students can download the 5-15 minute videos from the password-protected Canvas Learning System.

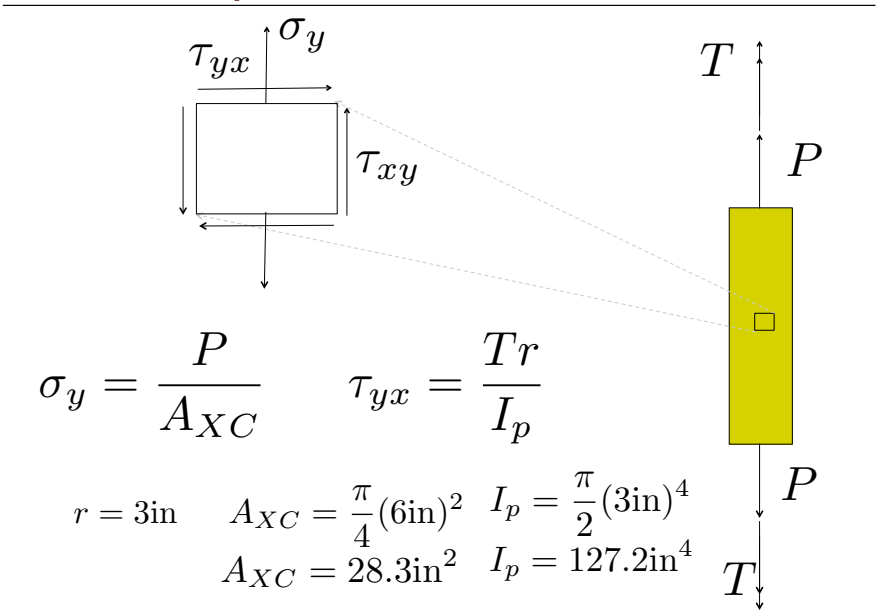

Figure 2: Example clip from a pre-lecture video showing how students can identify stress elements and solve for the stress elements.

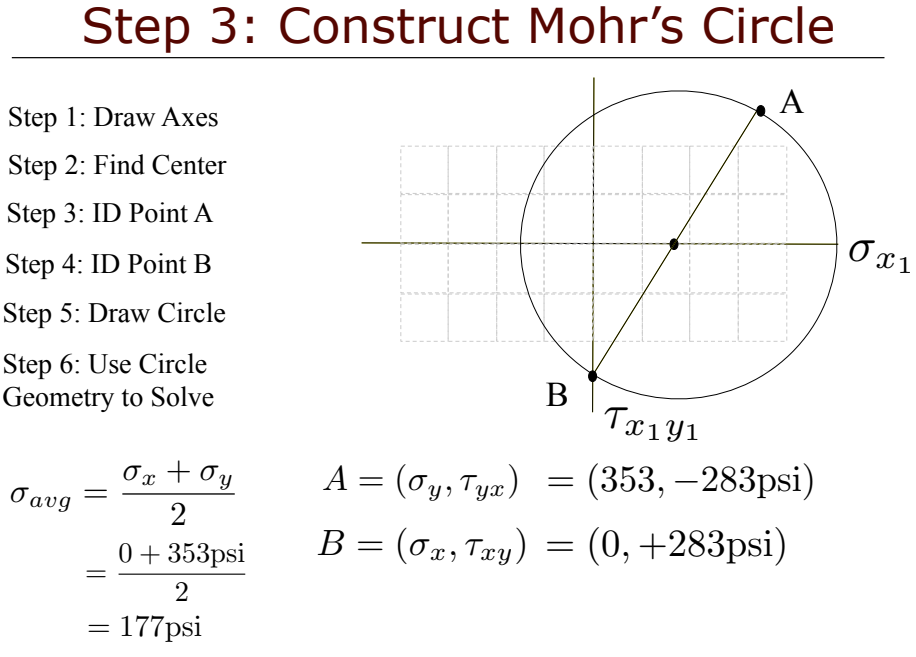

Figure 3: Example clip from a video showing how students can use Mohr's Circle to solve for a stress element in various orientations.

3 Assessment

3.1 Methods

In addition to course and instructor evaluation, collected at the end of the semester, the effectiveness of the hybrid structure is assessed using hybrid/flipped specific surveys given the 1st week of class, the 3rd week, and the 15th week of the Spring 2015 semester. The surveys are administered using the Canvas Learning System and the categories and questions are as follows:

- Basic Demographics
  - What's your gender?
  - What's your major?
  - How old are you?
  - Have you taken any type of online course before? Possible answers: I've taken a class that was designated as an online course; I've taken a class that was designated a "flipped class"; I've taken a class that was designated as a hybrid course; I've never taken an online course.
- Flipped/hybrid Specific Questions. Each question is to be answered in the range between 0-5 (0: irrelevant to you at this point in time and 5: very true of you at this point in time)
  - You know what flipped classrooms are.
  - You concerned about the amount of time this class requires.
  - You are concerned that a flipped classroom will have a greater time commitment.
  - You think you will learn more in a flipped classroom environment.
  - You are a student who likes to learn theory.
  - You are a student who likes to learn applications.
  - You would rather have the instructor work through problems as opposed to student run classroom activities.
  - You effectively comprehend all lecture material presented in a traditional classroom.

Since the students have had time to use the hybrid materials, the 3rd and 15 week surveys add the following Flipped/hybrid specific questions and ask for essay answers:

- What elements of this class, so far, are helping you learn?
- What elements of this class could be changed to improve your learning?
- What elements of the "flipped videos" do you like?
- What elements of the "flipped videos" do you feel could be improved upon?

3.2 Results

3.2.1 Basic Demographics

Of the surveys taken, the 1st week had 16 responses and the 3rd week had 10 responses. For the *1st week survey* the responders were 81% male and 19% female; 94% were engineering majors; 25% between ages 19-24, 56% between ages 25-34, 13% between ages 35-44, and 6% between ages 45-54; and 75% have taken an online class, 31% have taken a flipped class, 25% have taken a hybrid class, and 88% have taken any or all of these formats.

For the *3rd week survey* the responders were 80% male and 20% female; 100% were engineering majors; 30% between ages 19-24, 60% between ages 25-34, 0% between ages 35-44, and 10% between ages 45-54; and 50% have taken an online class, 30% have taken a flipped class, 40% have taken a hybrid class, and 88% have taken any or all of these formats.

3.2.2 Flipped/hybrid Specific Questions

Some of the survey results do not show a significant difference between the 1st and 3rd week. Those which do show significant differences, or are topics of interest are illustrated in Figure 4. The following are some of the answers provided directly from students to the essay questions provided in the 3rd week survey:

- What elements of this class, so far, are helping you learn?
  - going over examples
  - I thoroughly enjoy the videos. Its a nice introduction to whats next in class. By far the biggest help has been the professor showing examples and ”holding my hand” at first [. . .]
  - I really like the online videos
  - The quick video before classes
  - Elements of this class that are helping me learn so far include quiz questions and example problems discussed during class, and the videos are helpful when viewed before lecture.
  - In class quizzes, and worked problems, open discussion.
  - being able to watch lecture videos more than once
  - I like the available videos because you can watch them more than once and that they stick closely to what is represented in the textbook.
  - Well watching the videos before class has helped me understand the material much better, since on the video I am able to play it as many times as i would like.
  - Flipped class room allows for the ”pre-lecture” thoughts and questions, helping the in person lecture be more productive.
- What elements of this class could be changed to improve your learning?
  - More solving problems

  - I think opportunities to teach would help reinforce-it
  - Would help if more people viewed the videos before class so that more time was available to discuss important topics and work through example problems.
  - more focused class time. [It doesn't] seem like we cover enough in class
  - I feel like there are still holes between what is being taught in the video and what is being presented in class. I'm not sure of how to fix this but I feel like my understanding of the material is still somewhat spotty. Maybe if there was a printable sheet that had a summary of equations used in the video that I could use during the video to take notes on it would help to get a better idea of what is actually being covered in that video. I also liked the idea of putting worked out sample problem videos so that we could see the equations applied to a real world problem.
  - Overall I feel that classroom is set up the way it should be for me.
  - Nothing

- What elements of the "flipped videos" do you like?
  - they are short and to the point
  - the instruction and detail
  - The online videos.Doing homework in class
  - That they are short and get to the point, and when I'm asked questions in class I know some answers
  - They provide a convenient material review before lecture.
  - Its hard to find time to pre-read a chapter before a lecture. The video lectures are more of an incentive to keep pace and be ready for the in class lecture material. The ability to return to the material is very beneficial. I often will print screen shots of video material to supplement my notes. This particular course has a minimal (realistic) time requirement for video lectures and it is a positive experience.
  - I like the diagrams used from the book, they are very clear and having an instructor talk about them helps me understand more afterI have read the text. The length of the video seems to be appropriate as well.
  - That I am able to pause them, and also to replay them over and over, which helps me understand the material much better.
  - The short theory presentation

- What elements of the "flipped videos" do you feel could be improved upon?
  - all formulas that will be needed to successfully pass homework and exams.
  - Do some example problem to help with homework
  - The videos seem fine so far.
  - Very good so far.

- we need to move a little quicker in class, we are getting ”quality” but we need a bit more ”quantity”.
- showing which problems are assigned at the end of the video would be helpful so that we don't have to go search for them on canvas, but that really isn't a major issue.
- I wish I had access to the slides, so I could print them out and write on them as you talk.
- Every few videos an example with real numbers could be given, in that videos could be watched for a quick review several sections later.

3.3 Discussion

The basic demographics between the two surveys are reasonably close to each other, so comparisons between the other questions can be made. Even though there are more significant differences between those who have take online, flipped, or hybrid classes, a high percentage of the students are familiar with one or all of them. This implies that the students are knowledgeable of online tools (such as the Canvas Learning System) needed in all of these classes.

The results from Figure 4 provides some great insight. First, it seems that students already have a positive interpretation of a flipped classroom environment and in both instances; they think they will learn more in flipped classroom. It's a little difficult to quantify, at this point in time, but it seems those impressions have improved between the 1st and 3rd week.

It's also apparent that students like learning applications more than theory. Certainly theory is a critical part of this class, but it's no surprise that students like learning applications more and are thus more likely to comprehend the material if it's class time is more application based. After seeing the flipped materials for the first few weeks, it seems as though the students are even more inclined to learn applications opposed to theory.

The other interesting point is that the students would rather have professor run examples opposed to student run class activities. It's difficult to tell whether this has changed between the 1st and 3rd week or if it's still early in the semester. The survey in the 15th week will provide more information on this.

The best feedback is written feedback. Students seem to have a very positive outlook on the videos. It's interesting that they provide a critical tool to help better comprehend the text book and therefore one could imply this increases the importance of the textbook. An outside observer of the class could even argue that class discussions have better participation when comported to the part traditional course. All of these comments are certainly helpful in continuing to improve the class and hopefully given clearer 15th week survey results.

4 Conclusion

This paper looks at creating a hybrid Strengths of Materials class at the Salt Lake Community College for Spring 2015. This class used short lecture videos to provide students more time to work on applications in class. Thus far, the results are very promising and it will be exciting to see how students evaluate the structure of the class toward the end of the semester.

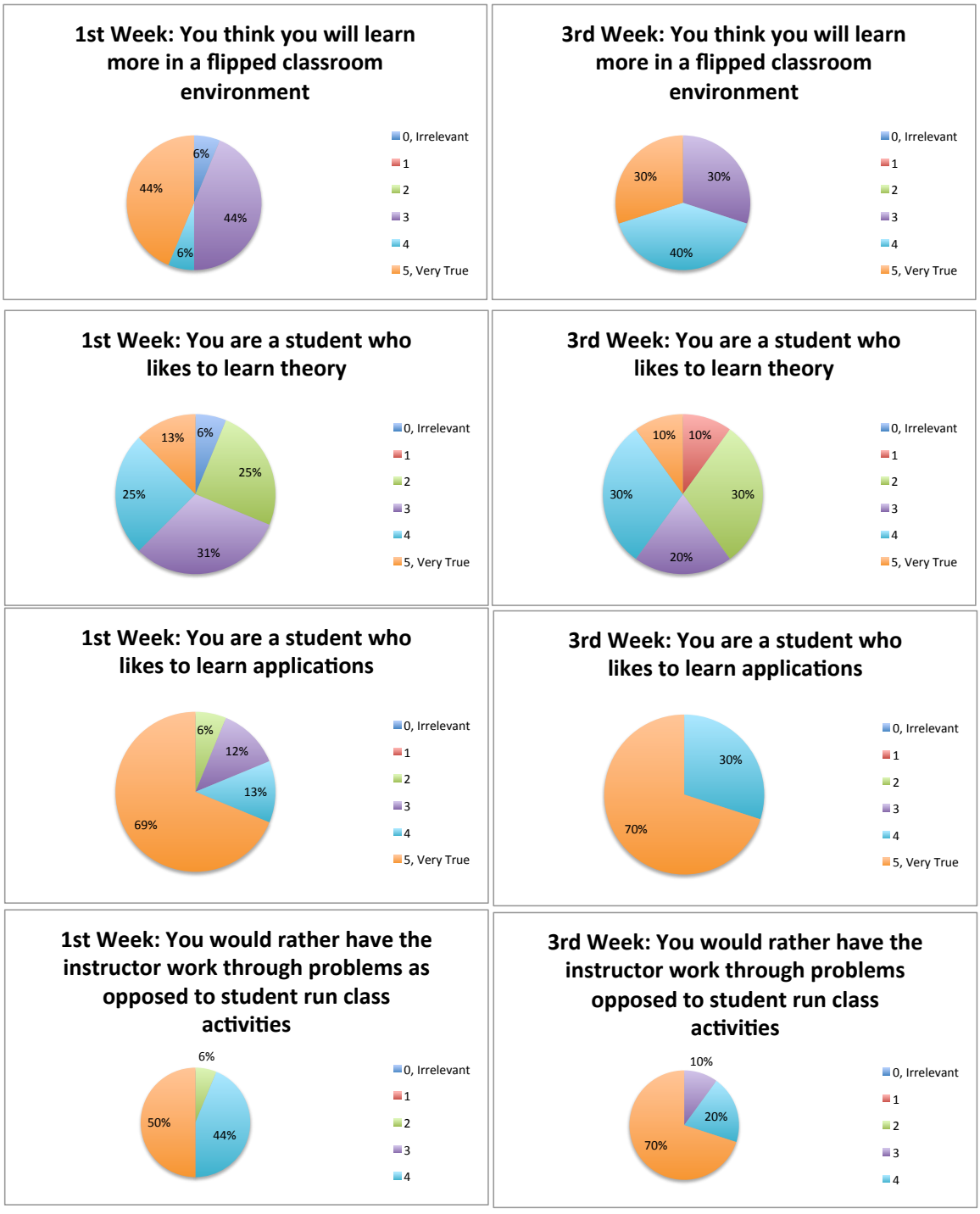

Figure 4: Comparisons of surveys between the 1st and 3rd week of class.

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