Blended Instructional Delivery for a Large Engineering Course: A Step by Step Case Study Description.

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Abstract

The increase in students' enrollment for the majority of the engineering colleges and universities has been a marked tendency during the past years and it looks like it is not going to stop any time soon. The trend is to keep growing at an even more accelerated rate. Due to that increase in population, the sizes of the courses also need to increase accordingly unless more sections of the same course are opened to satisfy the new demand. However, the size and number of the classrooms are limited. Another associated logistic issue is the need of more parking spaces to satisfy the growing demand. The construction of more physical plant is a costly and long-term solution, most of the time not feasible. Another possibility is offering Massive Open Online Courses (MOOCs) which is becoming a very popular alternative; unfortunately, most of the engineering courses need the face-to-face and peer interaction component, as well as, hands-on activities and project-based/experiential learning. Blended instructional delivery, also known as mixed-mode, has become a very feasible alternative by integrating all the benefits of online and face-to-face modalities. This paper describes a Mixed-mode implementation for a large (3 credit hours) engineering course: Engineering Analysis-Statics. The online component, delivered via Canvas Learning Management System (LMS), contains video lectures, study sets, e-homework, hands-on project based homework, and proctored quizzes and exams. The face-to-face component includes group quizzes, class discussion learning activities, and problem solving sessions.

Keywords

Mixed-mode, Blended, Instructional Delivery Methods, Active Learning

Introduction

According to the National Center for Education Statistics (NCES), students' enrollment in postsecondary education increased from 13.2 million to 16.8 million (27%) between 2000 and 2018 and is expected that by 2028 the total enrollment would be around 17.2 million[1]. This rate of growth is not the same for all colleges and universities. At the University of Central Florida, the number of students have increased from 31,000 by the end of 1999 to more than 69,000 in 2019 (more than 122%) and it is projected to keep growing at approximately 2-3% per year. As expected, the size of the classes also increased. By 2019, the typical number of students in a sophomore engineering course is anywhere between 150 and 300. As a consequence, classrooms that accommodate that amount of people are becoming scarce since physical plant is not growing at the same rate as the students' population. To mitigate this problem, MOOCs have been used as a solution. Advantages and weaknesses of MOOCs are well documented [2-3]. Some of the disadvantages include reduced student retention, lower engagement, lack of practical lab-type implementation, and diminished students' satisfaction if compared the face-to-face interaction.

In addition, engineering education research shows that incorporating high impact active learning strategies such as project based homework and experiential learning increase students' preparation, class success, retention, and graduation rates [4-7].

More recent tendencies opt for a hybrid method by using the massive reach capacity of online delivery with the benefits of face-to-face learning [8]. Several names are used for this type of approach being among the most common "Blended" and/or "Mixed-mode". The idea is to invest the class time on practicing problems with the students, conducting discussions, and answering questions. Conveying of the lectures is achieved through on-line videos which students are required to pre-learn on their own outside class time [9-12]. Of course, this type of approach requires a more efficient time management and delegates a bigger responsibility to the students, who are in charge of learning the material on their own by using some provided tools. The following sections describe the implementation of a blended Engineering Analysis (Statics) course that tries to make the best use of both, online and class-time, addressing the well documented issues of students unpreparedness before class [13] by incorporating controls such as pre-quizzes and very detailed study-sets of example problems comprised of videos and written solutions.

Blended Statics Course (BSC)

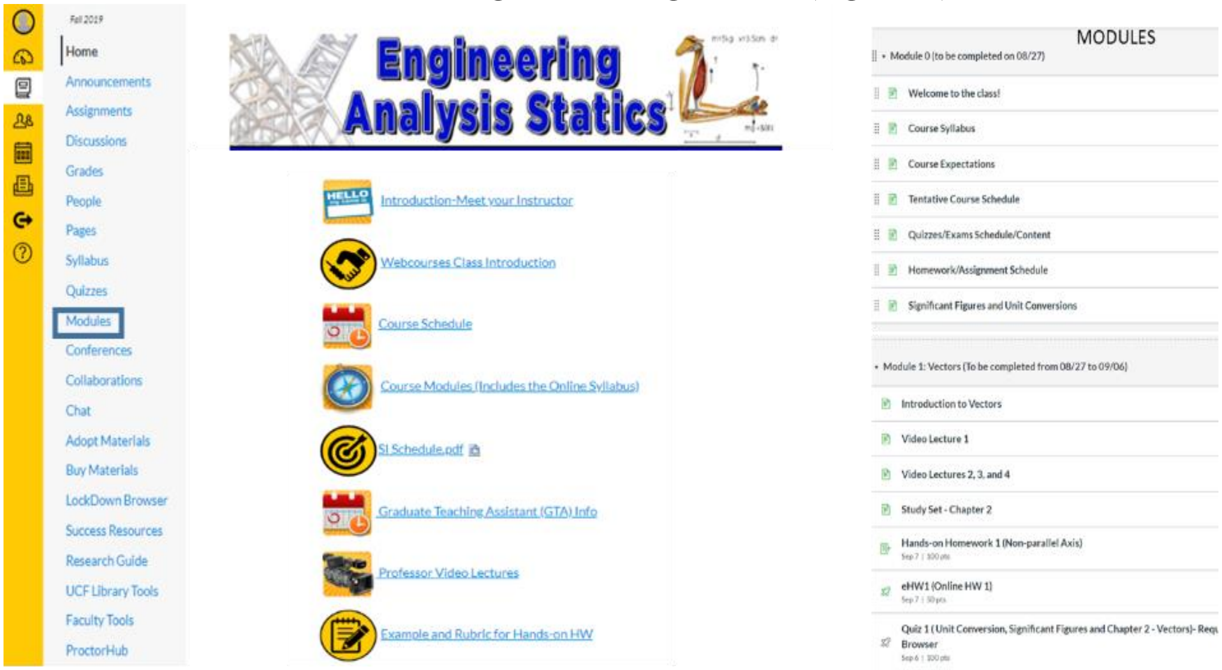
This first attempt for a mixed-mode implementation comes after several years dedicated to measuring and detecting the biggest challenges to Statics' students. The BSC is aimed to: 1) allow a more efficient use of the time in the classroom by first determining the level of the students via a pre-class quiz, 2) direct the face to face time by emphasizing in the concepts where the students struggle the most, 3) incorporate hands-on active learning project based homework, and 4) develop the much needed metacognition in the engineering students. All of the above are expected to increase the success rate in the class, retention, and graduation rates.

Course Organization

The BSC is divided in online and face-to-face components. Each one with approximately 75 min per week corresponding to 50% of the regular class time.

Online Component

Delivery of information: BSC uses Canvas LMS (adopted university-wide) to host the tools needed for the students to acquire the required level of knowledge per learning objective. Figure 1a shows the principal page for the course containing general information, syllabus, class assessment schedule, available tutoring, and learning modules (Figure 1b) .



a) Home Page b) Learning Modules

Figure 1. BSC in Canvas LMS

Learning Modules

Every module starts with a brief introduction to the topic, the objectives, required reading, video-lectures, study-sets, activities, and assignments.

Video-Lectures: Videos created by the instructor are provided. All video lectures include animations and practical demonstration as well as embedded poll questions (Figure 2).

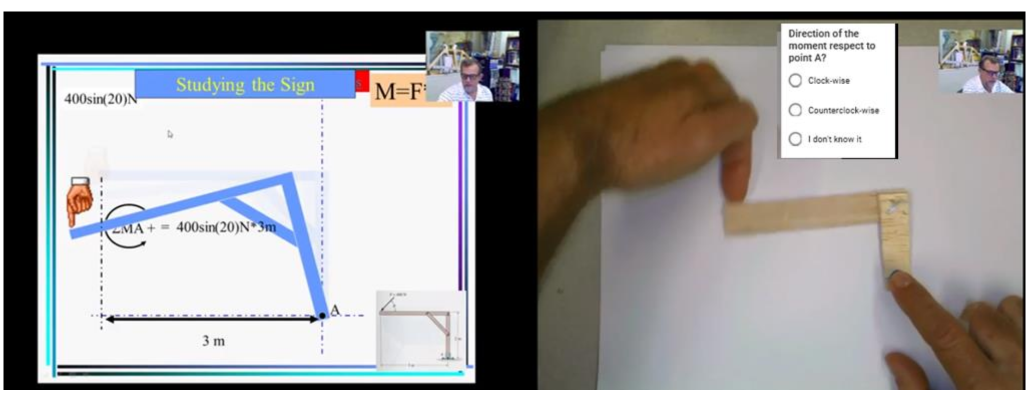


Figure 2. Video Lectures

Online Study Sets: Several representative application problems selected by the instructor are provided via Canvas LMS with video and written solutions. Practice problems are adapted to represent real-life scenarios and they are analyzed, solved and discussed by using several possible approaches (Figure 3).

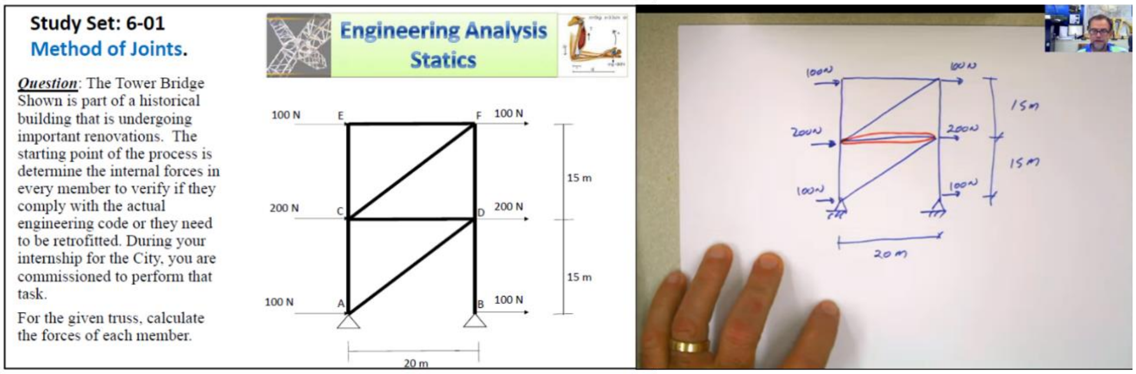


Figure 3. Online Study Sets

Online Homework (e-HW): "Practice leads to mastery". This is common concept for every discipline, especially for engineering. The practices engaged by students as they acquire new concepts shape what and how they learn. For the BSC, hand-picked problems have been selected by the instructor to achieve the lesson goals reinforcing the video-lectures and study sets. All the e-HW have been created in Canvas LMS by using algorithmic questions. This type of practice is important because it allows the students to fail and learn from their failures in a safe environment. Homework provides the students with the possibility to re-work the problems in case they are wrong up-to a number of times selected by the instructor. However, BSC includes a significant difference: every time the students decide to use a new attempt, a whole homework is generated again with new numbers and type of problems. The idea is give the students the opportunity to make-up for their errors but at the "cost" of having to practice even more, preventing them from just guessing the correct answers.

Hands-on Project Based Homework (PBH): BSC includes active learning project based homework. A complete description of PBH can be found in [8]. Alongside with regular e-HW students must create a physical model of one of the regular homework problems (selected by the instructor). Once the model is created, the students design and perform experiments and take measurements to compare with their original analytical calculations. The submission of this activity includes a report and a 5-min video clip of them explaining their model, experiment, and discussing how their experimental results compare with the purely theoretical calculations. The professor provided videos of himself performing the experiments as a guide however, the students are encouraged to be creative, modifying, improving, and crafting their own models (Figure 4).

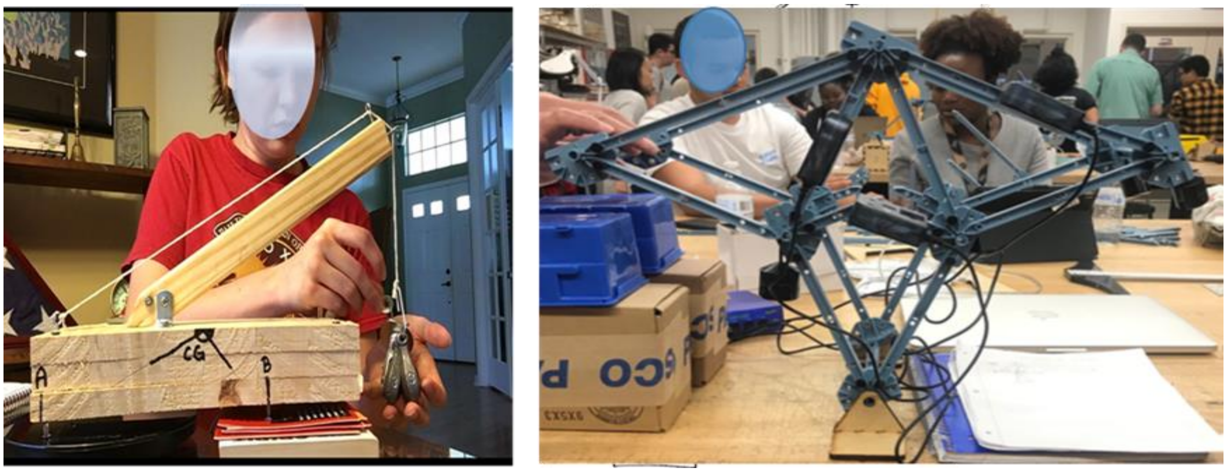


Figure 4. Examples of Project Based Homework. (Left: Rigid Body Equilibrium; Right: Trusses)

Online-Proctored Quizzes and Exams: formal assessment is an integral part of any engineering program. The BSC covers this base by using a proctoring center which is part of the University of Central Florida as shown in Figure 5. After the students finish their proctored assessments, they can review their errors with the teaching assistants and learn from their mistakes. A detailed description of this testing center can be found in [13].

Figure 5. University Proctoring Center

Face to Face (In-Class) Component

Group Quizzes (in pairs): at the beginning of each face to face meeting, the students are required to complete an assessment consisting of one question corresponding to the material they are required to learn before coming to class (usually 5-10 min). This question covers the basic principles to be deepened during the face to face time. The main objectives of this activity are 1) give the instructor a baseline for directing the class discussion and 2) keep the students on-top of the material and attending to class. Figure 6 shows an example of a group quiz.

Figure 6. Group Quiz (Left: Question Asked, Center: Students Working in Pairs, Right: Follow-up PBH)

Discussions Clarifications: After the students complete the quiz, a discussion follows. The instructor first asks the students what were their main doubts when trying to solve the question and proceeds to explain the correct approach to achieve a favorable outcome. More questions are asked and replied using the Socratic Method. This session may last for about 15-20 min and it is followed by the selected in-class problem solving.

Problem Solving: The instructor proceeds to discuss the representative selected examples, giving step-by-step problem-solving methodologies, tips, and strategies. In some cases, students ask for specific examples and the instructor addresses them too.

Preliminary Results

Two different types of results are presented herein: 1) Numerical data and trends of the students' performance for the first 10 weeks of class and 2) Students' opinions about the blended approach.

Students' Performance: the charts below (Figure 7) show the trends and students' performance for the first 10 weeks of class (approximately mid-semester). Figure 7a shows the course average for the group-quizzes. It is evident the class' lack of preparation on the on-line content of the course corresponding to those first weeks. Despite the fact that the class learning material and assessment dates were posted in the syllabus and modules, the most common excuse was: "I didn't think the professor was going to really apply a quiz without discussing the material first". After the first in-class group quiz, the class started performing better, maybe because they realized they needed to really understand the basics of the material before coming to class. Same behavior can be observed in Figure 7 (b and c) learning curve for the proctored quizzes and hands-on homework.

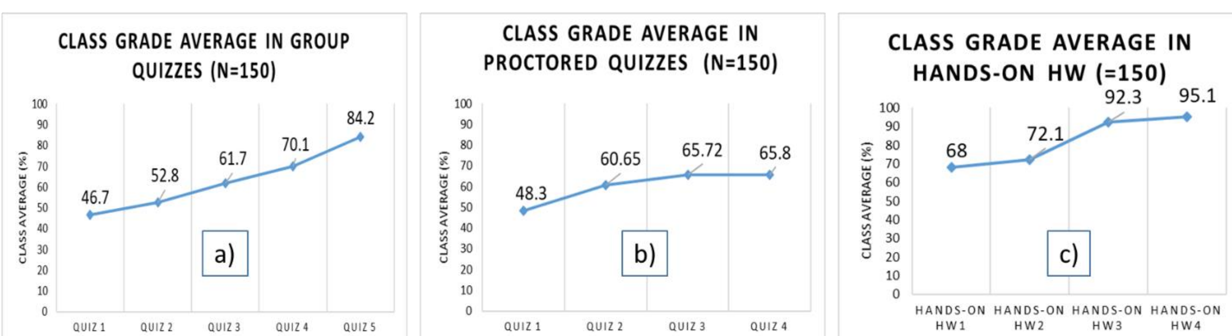


Figure 7. Students' Performance for the First 10 Weeks of Class

Students Opinions: an Anonymous 5 point Likert scale survey was distributed to the students asking their feedback concerning video lectures, study sets, e-homework, in-class group quizzes, and hands-on PBH (Figure 8). 74.1% of the students strongly agree or agree with the effectiveness of the video lectures as a learning tool. 70.7% found the study sets very helpful and 67.3% recognize that the provided e-Hw makes them practice and better understand the class topics. The in-class group quizzes were referenced by 75.5% of the students as a good tool that made them study and be prepared before class and 85% of the poll expressed that PBH helped them to better understand the class topics and make connections with real life engineering scenarios.

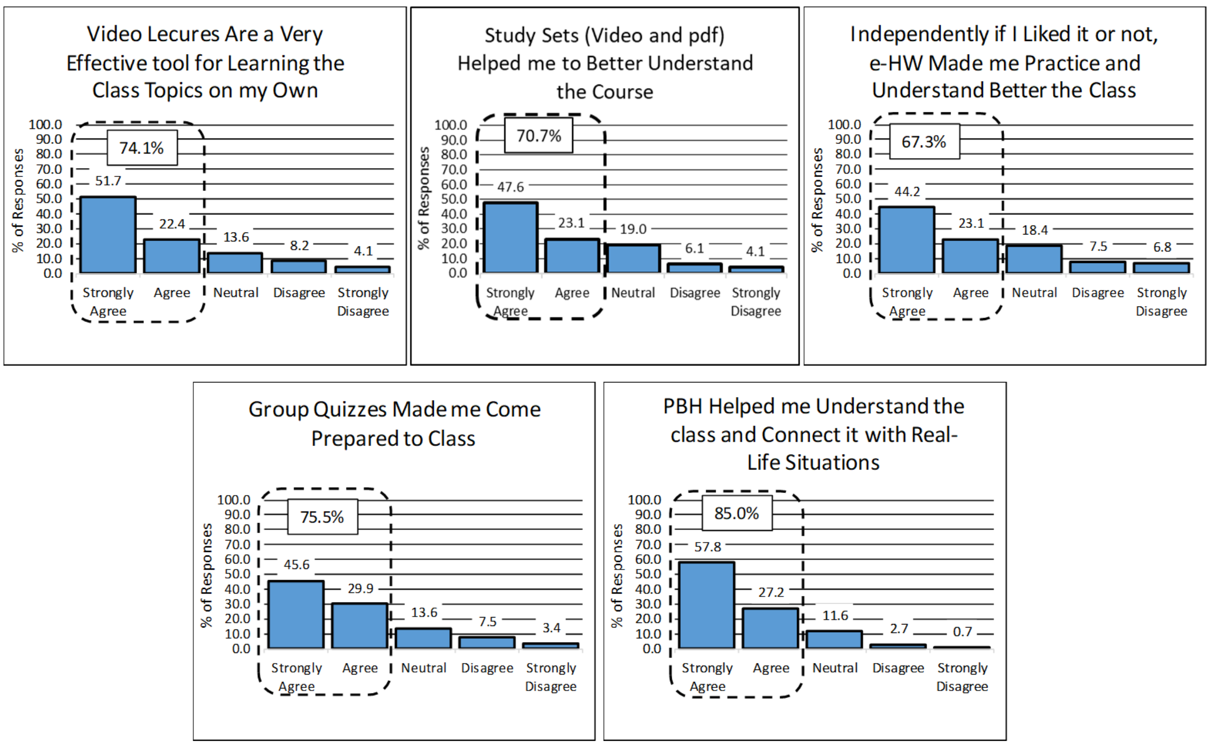


Figure 8. Results from Students Opinion Survey

Conclusions

This paper described the author's first attempt and some preliminary results of the redesign implementation of large engineering course: Engineering Analysis-Statics. A Blended (Mixed-mode) approach was used with online and a face-to-face components equally weighted (50% of the regular class time). The online part of the course, hosted and delivered via Canvas LMS, contains video lectures, study sets, e-homework, hands-on project based homework, and proctored quizzes and exams. The face-to-face component includes group quizzes, class discussions, learning activities, and problem solving sessions. The preliminary results are very promising and show very positive feedback from the students.

To determine the impact on student learning and class success of this course redesign data will be compiled at the end of the semester, compared with other sections taught by the same instructor (by using a traditional approach), and presented in the 127th ASEE Annual Conference.

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