2017 Pacific Southwest Section
Meeting: Tempe, Arizona Apr 20 Paper ID #20682

Divide and conquer: an example from Fluid Mechanics class

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Divide and conquer: an example from Fluid Mechanics class

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Abstract

Fluid Mechanics is a required course for Civil Engineering, Mechanical Engineering and Chemical Engineering students at California State University, Long Beach (CSULB). For the students, this course is the first introduction to the concept and principal of Fluid Mechanics. The student learning objective is the ability to apply fundamental fluid flow analysis techniques to various fluid systems. The students' performance is assessed based on homework, quizzes, midterms, and a final exam. In the first Midterm, students' performance has been below expectation where students were tested with questions on hydrostatics. However, later in the semester, students start to have better understanding of the course materials and their performances improve. But, because of their poor performance in the first Midterm, students' overall grades suffer. To increase better understanding of the first Midterm's course materials, students require additional practice time or reduction of course materials. In Spring 2016, the number of Midterms were increased from two to three with the objective to reduce the course load per exam and allow more practice time on the concepts. The result was compared to the class of Spring 2015 which shows by splitting the course materials into three (i.e. two midterms to three midterms), students' performance improved. The percentage of students receiving between 70% and 80% increased by 10% and the percentage of students receiving 70% or less decreased by 10%. Although the percentage of students receiving 80% or higher was nearly unchanged, the results are encouraging. Similar to the trend in Midterm exams, students' performance also improved in the course with increasing percentage of students receiving 70% or higher and reducing percentage of students receiving less than 60%. Thus, dividing the course material can improve class performance.

Introduction

To increase student learning and classroom participation, many different techniques are applied in engineering schools. Some instructors use the traditional instructor-led method, some use a hybrid method or flipped classroom. In a traditional instructor-led class, faculties give lecture on the topic where the instructor generally controls the materials and pace of learning[1]. With the ease of making lecture videos, in a hybrid class, instructors can now blend lecture videos for additional assignments with the class room lecture materials. This increases classroom discussion time on theories and key concepts. On the other end of the spectrum, in a flipped classroom, lecture materials are available to students through online videos while entire in-class time is focused on problem solving and discussions[2]. All these methods have their pros and cons. Engineering schools constantly debate about which method of teaching is best to maximize students learning and improving overall performance[3, 4]. No matter which teaching method is applied, students' success depends on how well they understand the concepts and their ability to correctly apply the concepts in a test or in any assessment method. Their understanding and success is commonly measured using exams scores or letter grades at the end of the semester.

In an undergraduate engineering curriculum, the many different types of classes pose challenges and difficulties for students. To achieve a letter grade B or better, some courses are more demanding and require more effort than the other courses. For instance, Fluid Mechanics is considered one of the conceptually challenging classes at the California State University, Long Beach (CSULB). Students are challenged to integrate knowledge from their prerequisite classes (math and statics) to understand the Fluid mechanics concepts and principals. Specific topics covered in the course include Fluid Statics, Fluid Kinematics, Pressure Variation in Moving

Fluids, Conservation Laws (Mass, Momentum, and Energy), Boundary Layers and Dimensional Analysis. The student learning objective of the course is the ability to apply fundamental flow analysis techniques to fluid systems. At CSULB, the students' performance is assessed based on quizzes, midterms, and final exam.

To improve students' engagement and performance in Fluid Mechanics class, in my traditional instructor-led classroom, I assign in-class tasks that students can complete in 5 to 10 minutes either working independently or in groups. In the follow-up discussion, I encourage students to ask "Why?" for each of their answer choices. This method has increased the students' motivation in Fluid Mechanics and interest to follow the lecture throughout the class time. Despite the increase interests in the topic, students' grade distribution in the class has often been bimodal. In the two midterms and a final exam setting, students' performance in the first Midterm was below expectation (average score of ~50%) where students were tested with questions on Fluid Statics or hydrostatic force calculation. The students struggle with the theory of hydrostatic force which is covered during the first five weeks of the semester. Later in the semester, students start to have a better understanding of the course material and their performances generally improve. However, because of their poor performance in the first Midterm, students' overall grades suffer. Every semester, more than 15% of the students drop or fail the class after the first or second Midterm exam. Those who barely pass the class with a letter grade D are required to repeat the class to get a grade C or better to enroll in upper division classes where Fluid Mechanics is one of the prerequisite courses. This setback significantly delays their graduation time.

To increase better understanding of the first Midterm's course materials and improve the average score of the first Midterm, students require more time to practice the theory of fluid statics. This paper describes a simple change in the course syllabus that was adopted to allow students with more time to grasp the challenging concepts of the first Midterm. The purpose of this study is to improve students' success rate in the class with specific goal of increasing the number of students receiving points 70% or higher (C or better letter grade) and reducing the number of students receiving less than 60% (D or F grade).

Syllabus and data collection

In the adjusted syllabus, students' performance is assessed in three Midterms instead of two Midterms. To allow additional time to grasp the challenging concept of the Fluid Statics – particularly the computation of hydrostatic force on plane and curved surfaces, the chapter content is divided into two halves and students' performances are evaluated within the first two Midterms. In the first Midterm, students are tested with the hydrostatic force on plane surfaces and in the second Midterm, students are assessed for the hydrostatic force computation on curved surfaces which requires application of statics and mathematics as well as the concept of hydrostatic force on plane surfaces. Therefore, in the three Midterms course outline, students get more time to grasp concept of hydrostatic force computation first by application on plane surfaces and then on curved surfaces. With two Midterms course outline, the students were tested with hydrostatic force computation for both plane and curved surfaces in their first Midterm.

Three Midterms were given to Spring 2016 class and their results are compared with the Spring 2015 class. The Spring 2015 class that had two midterms was chosen for the evaluation of the effectiveness of the adjusted syllabus as the number of students in Spring 2015 class were similar to the number of students in Spring 2016 class. The Spring 2015 class had total of 20 students where 2 students did not continue the class after the first Midterm. Spring 2016 class had 18 students and 2 students did not continue after the first midterm. Furthermore, the same amount of course material was covered in both the classes.

Results

Spring 2015 and Spring 2016 grading criteria is shown in Table 1. For comparison, Spring 2016's midterms total points are converted to the equivalent of Spring 2015 total midterm points of 50%. Figure 1 shows the total points students received in both the semesters at the end of all the Midterms. Average Midterm exam score and standard deviation of Spring 2015 was 32 (total score of 50) and 7.06 respectively. Midterm exam statistics improved in Spring 2016 with an average score of 33.47 (total score of 50) and standard deviation of 5.79. The black dash line indicates the number of students receiving more than 35 (70% of the total Midterm points). In Spring 2016, eight students got more than 35 whereas in Spring 2015, 6 students got more than 35. Figure 2 shows percentage of student receiving more than 80%, between 70% to 80%, between 60% to 70% and finally less than 60% points in Spring 2015 and Spring 2016 Midterms. Results show that in Spring 2016, the percentage of students receiving more than 80% and between 60% to 70% points decreased by 0.74% and 1.47% respectively. That said, the encouraging results is that the percentage of students receiving less than 60% point has decreased by 8% while percentage of students receiving 70% to 80% has increased by 10.3%.

Table 1. Grade distribution in Spring 2015 and Spring 2016

	Spring 2015	**Spring 2016**
Homework	10%	5%
Quizzes	10%	10%
Midterm 1	25%	20%
Midterm 2	25%	20%
Midterm 3	-	20%
Final Exam	30%	25%
Total	100%	100%

Figure 3 shows the total final points with 95% confidence intervals at the end of the Spring 2015 and 2016 semesters. The class performance in Spring 2016 has improved with higher mean and smaller standard deviation. The breakdown of final grade percentage is shown in Figure 4. The final grade percentage (Figure 4) shows a similar trend of the Midterm percentage (Figure 2). The percentage of students receiving between 60% to 70% decreased in Spring 2016. Like the Spring 2016 Midterm grades, percentage of students receiving points between 70% to 80% increased by 21.32%. The percentage of students receiving 80% or more and 60% or less decreased by 13% and 7%, respectively.

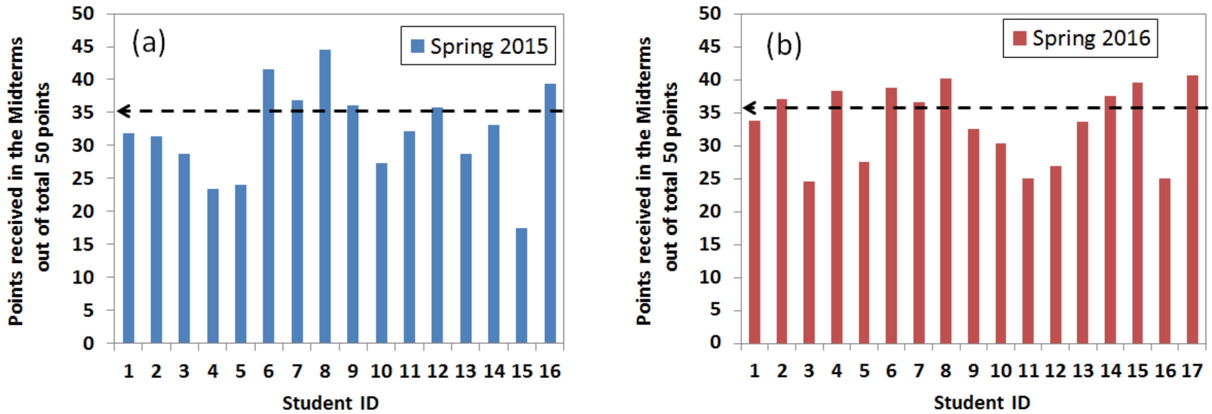

Figure 1. Points earned by individual student in the Midterms of (a) Spring 2015 and (b) Spring 2016. The black dash line indicates the number of students obtaining more than 70% of the total points of 50.

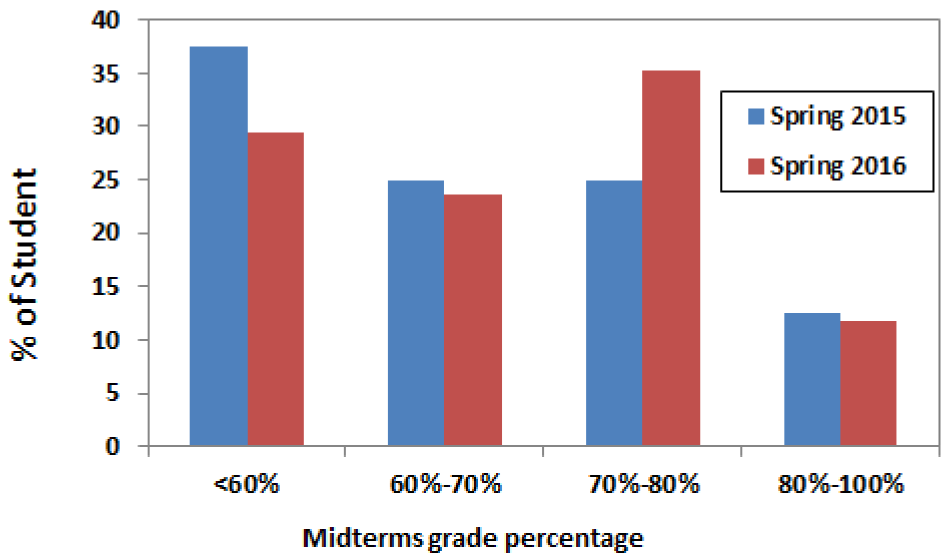

Figure 2. Students' performance in Midterms of Spring 2015 and Spring 2016.

Discussion of the Outcomes

The purpose of the study was to improve students' success rate by increasing the percentage of students receiving points 70% or higher, while decreasing the number of students receiving points 60% or lower in the Midterms. The results from only the Spring 2016 semester shows that dividing the course material and assessing the students by three Midterms instead of two Midterms helped to reach the study objective. Overall, the class performance reflects the favorable trend of increased percentage of students receiving points 70% to 80%. However, the students enrolled in the class of Spring 2015 and Spring 2016 might have had different intellectual and learning ability. Therefore, an assessment coining the students' past GPA, grades earned in Statics and Mathematics with the performance in the Fluid Mechanics class would provide a more conclusive outcome of the study. Furthermore, the result of this study is only based on one semester data with small class size. Assessing the outcome of three Midterms in future classes with more number of students will prove a decisive trend.

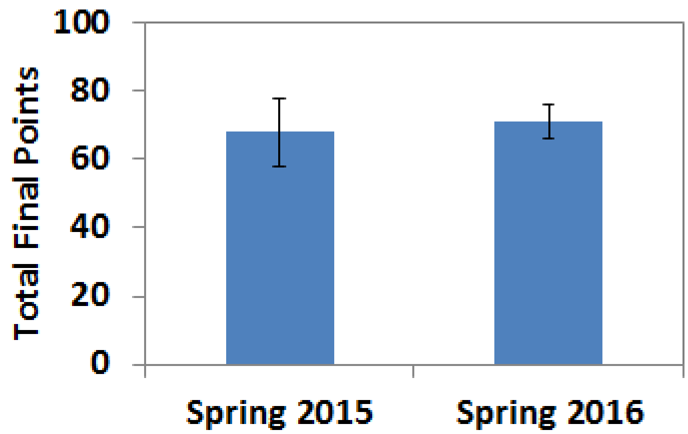

Figure 3. Total final grades with 95% confidence intervals at the end of Spring 2015 and Spring 2016 semesters.

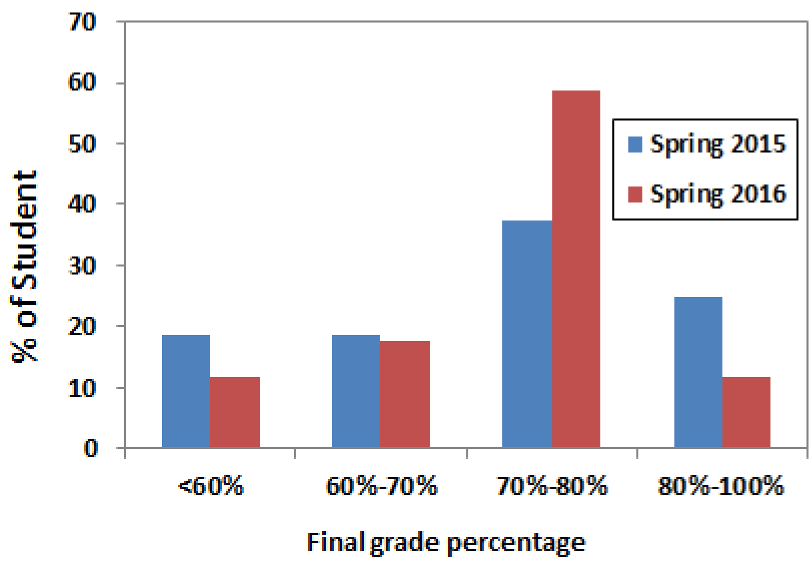

Figure 4. Overall class performance in the Spring 2015 and Spring 2016

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