EDUCATIONAL RESEARCH MINI-GRANT
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FINAL REPORT

Using "Conceptual" and "Assessment" Problems to Enhance Student Learning of Fundamental Concepts Taught in an Undergraduate ThermoFluid Mechanics Class

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Summary

Most textbooks provide exercise problems at the end of each chapter that requires students to use the theory/ principles/ concepts taught in class to set up and solve problems on their own. A large number of these problems are assigned as homework problems by instructors. However, many students have access to unauthorized sources (e.g., solution manual) and receive high scores on assignments yet do poorly on exams. Through this research, the P.I. tried to explore a method for assigning homework problems that provide students a deeper understanding of the subject matter, minimize cheating and reduce their dependence on solution manual to do homework assignments, thereby improving their overall performance/grade. The results of this research project indicates that a) students find "concept problems" to be extremely helpful in understanding basic concepts of fluids course; b) larger percentage of students are now using office hours; c) the P.I. observes a logical consistency between students performance on homework's and their exam scores.

Purpose of Project

The undergraduate course in Fluid Mechanics (ME-231, renumbered as ME-3131) builds the foundation for the thermo-fluid science courses in an undergraduate mechanical engineering curriculum. Students who master the fundamental concepts typically do well in the follow up course (Intermediate ThermoFluid Mechanics - ME-5131), perform better on Fundamentals of Engineering (FE) exam and senior assessment exam. Therefore, assessment of student knowledge in this course is essential for student success. Assessment of student knowledge is achieved through homework assignments (15%), and four exams (85%). To do well on problem based exams in this coursework, students must have a good grasp of fundamentals of basic engineering sciences and understanding of principles of fluid mechanics. Students develop their problem-solving skills by doing homework problems assigned to them on a weekly basis. The assignments make an important first step in helping student's bridge the gap between theory and application. However in the recent years many students have access to variety of unauthorized resources, e.g., solution manual, internet resources (e.g., cramster.com). The availability of solution manuals has adversely affected student learning. In using solution manual, students avoid the time and struggle necessary to solve homework problems to gain a deeper understanding of the subject. Students who use solutions manual typically develop a shallow understanding of the topics presented in the course. Some students simply copy from the solutions manual in completing their homework assignments. Even those who try to understand the solution steps used in the manual or those who use the manual to check their answers before submitting their assignments, develop little confidence in their work.

The proposed method of assigning homework's will effectively compel students to engage and to put in more effort to do assignments leading to increase in office traffic during regular and virtual office hours, in email inquiries and phone calls. The better understanding of the subject material could lead to improvement in their overall performance in class.

The purpose of this project is multifold:

a) To reduce the dependence of students on unauthorized resources to do assignments.

b) To develop logical thinking and problem solving skills of students of ThermoFluid mechanics.

c) To increase textbook reading. It is unfortunate that some students use textbook to do assignments only. P.I. believes reading text/ reference book is essential for student learning/ success and to develop reading comprehension and inference skills.

d) To increase faculty-student interaction.

Methodology

To provide students a deeper understanding of the subject matter, minimize cheating and reduce their dependence on solution manual to do homework assignments, the P.I. developed a data base of a large number of "concept" and "assessment" problems on selected topics from each chapter. The "concept" problems were posted on BlackBoard in the beginning of the semester. A brief description of concept and assessment problems is given below.

1) Concept Problems: I believe the best way to show students how to apply the theory and concepts to solve engineering problems is to solve a bunch of example problems in class. Students like to see a step-by-step explanation of an example problem discussed in class. However, due to time constraints, instructors usually have to make a balance in time spent solving examples in class and to finish the chapter/syllabus in time. Keeping this in mind, the “Concept" problems were developed. These problems are completely worked out problems showing step by step solution in detail. Each problem is different from other but will provide additional reinforcement of concepts already discussed/taught in class. This will improve their basic understanding of the fundamental concepts and will better prepare them for the assignment problems. The concept problems comprised of a) multiple choice; b) problems with statement (with or without figure/ diagram); c) understanding and correctly reading graphs/ tables.

2). Assessment Problems: Various research articles/ surveys and my personal experience of teaching undergraduate courses indicate that a larger number of students are using textbook solutions manual in doing their homework assignments. Research suggests that assigning problems on homework from other reference books do not mitigate the cheating problem as students manage to find solution manual of reference textbooks. The P.I. believes that about 30-40% students are blindly cheating from the solution manual. A good indication that students are using solution manuals is when there are errors/ typos in the solution manual or in a similar resource, and a group of students submit solutions containing exactly the same errors. These are the same students who have perfect scores on the homework assignments but could not solve similar or much simpler problems on

exams. Another aspect to this is that having solution manual gives an unfair advantage to such students over others who either do not have resources to arrange solution manual, or would consider using solution manual unethical (although percentage of such students is usually less than 10%). The P.I. believes that an instructor's main desire is not catching students for using solution manuals and charging them with cheating/ plagiarism, but is finding ways to help students learn the subject material and succeed in their courses.

In Fall semester 2013, a new approach was adopted to assign homework problems in the ThermoFluid Mechanics coursework. Each assignment comprised of few textbook problems and "Assessment Problems". The assessment problems were developed/ designed by me to improve problem solving skills and lead them through a number of steps to a deeper understanding of subject matter. The assessment problems will assess a student's level of understanding of fundamentals of topics covered in class and his/her ability to think logically and solve problems. These problems are written in such a way that minor changes in the problem statement (or figure) makes it an entirely different problem, i.e., same set of problems can be used (with some modifications). Some of these problems are taken from reference books but with problem-statement and diagrams modified.

To evaluate the effectiveness of the new approach of assigning homework's, the homework policy was made amply clear to the students that the overall homework grade will carry a weight of 15%, of which assessment problems will carry a weight of 10% and textbook problems will carry 5%. With assessment problems carrying more weight and solution manual (and other internet resources) not providing help in solving the assessment problems, there is a high likelihood of students putting in more effort in solving assessment problems. This **may** lead to a) increased usage of text/ reference books; b) increase in student-faculty interactions with larger number of students seeking instructor's help which bodes well for their success; c) increase in class attendance and class-participation; d) larger number of students trying to understand and solve concept problems to be able to solve assessment problems assigned on homework which may lead to improvement in their exam grades.

Evaluation

I had given clear instructions (refer red colored boxes in the assignment sheet) to the students that they should first try to solve and understand similar concept problems posted on Blackboard, before trying to solve assessment problem (refer Homework-1 next page). Problem # 5 from assignment-1 was identified to be used for evaluation purpose. Each students grade on this problem was noted down to be compared with their performance on a question on exam-1 that will be similar to this assessment problem.

HW – 1/ ME 231/ Thermo-Fluid Mechanics 1/ Due 8-29 (Thursday) in Class

Max: 90 Points

Problem 1 (10 Points): Textbook Problem 1.9

Problem 2: 4x5 = 20 Points
Problem 2a: Textbook Problem 1.10
Problem 2b: Textbook Problem 1.12
Problem 2c: Textbook Problem 1.16
Problem 2d: Textbook Problem 1.21

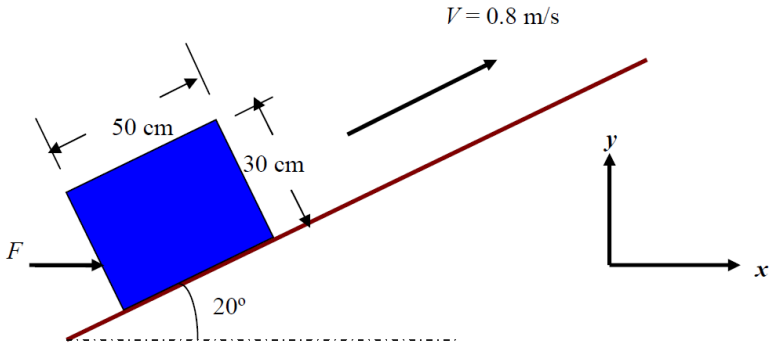
Problem # 3, 4 and 5 are 20 points each

Problem 3: The viscosity of blood is to be determined from measurements of shear stress, τ, and the rate of shearing strain, du/dy, obtained from a small blood sample tested in a suitable viscometer. Based on the data given below, determine if the blood is a Newtonian or non-Newtonian fluid. Explain how you arrived at your answer **Refer Concept Problems/ Set-1/ Problems 2, 8, 9 and 11.**

τ (N/m^2)	0.04	0.06	0.12	0.18	0.30	0.52	1.12	2.10
du/dy (s^{-1})	2.25	4.50	11.25	22.5	45.0	90.0	225	450

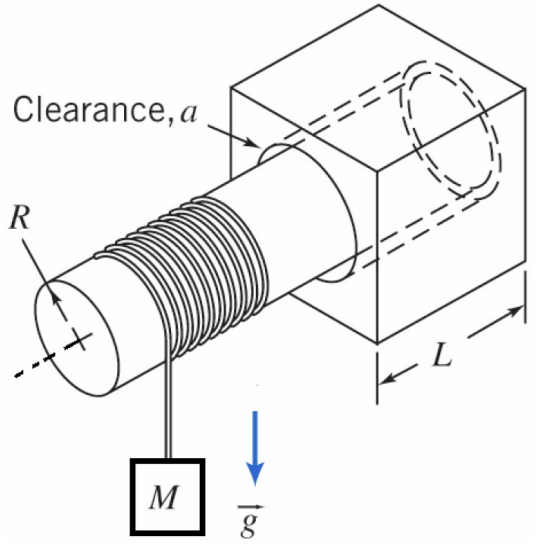
Problem 4: A 50-cm x 30-cm x 20-cm rectangular block weighing 150 N is to be moved at a constant velocity of 0.8 m/s on an inclined surface with a dry friction coefficient of 0.27. *(a)* Determine the required force F that needs to be applied in the horizontal direction. *(b)* If a 0.4-mm-thick oil film with a dynamic viscosity of 0.012 Pa-s is applied between the block and inclined surface, determine the percent reduction in the required force to achieve the 0.8 m/s velocity. Make following assumptions:

1) The friction coefficient and the oil film thickness are uniform; 2) The weight of the oil layer is negligible; (3) Linear velocity profile in the oil gap; 4) Assume oil to be Newtonian fluid. Note: To get full credit:
a) You must draw complete free body diagram; b) Use the coordinate system that is shown in the figure; c) Force balance equation(s) should be written as per sign convention.
Refer Concept Problems/ Set-1/ Problems 3 and 8.



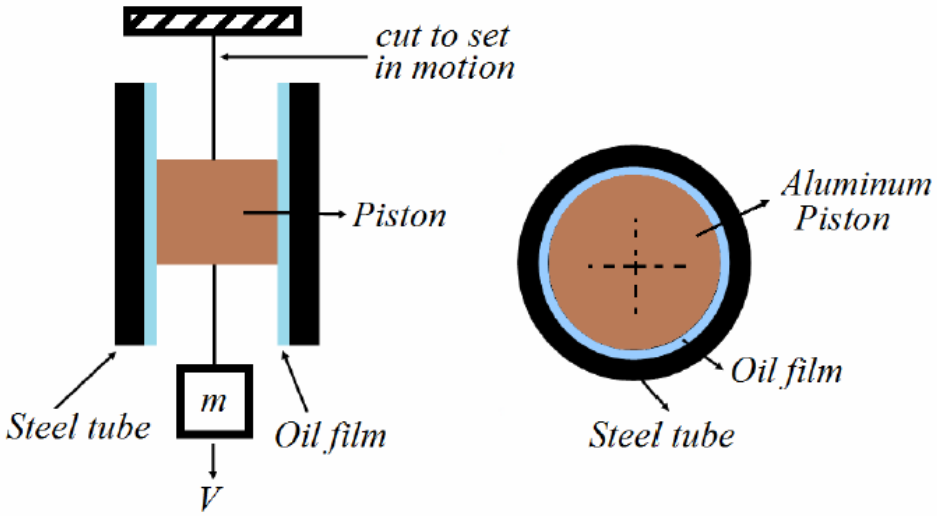
Problem 5: A circular aluminum shaft of radius, R, mounted in a journal is shown in the figure. The symmetric clearance gap, a, between the shaft and journal is small and filled with a Newtonian fluid (assume linear velocity profile). The shaft is caused to rotate clockwise by the attached mass, M, and massless cord. Develop the first order differential equation for the angular speed, ω, of the shaft as a function of time. Assume, I, to be the mass moment of inertia of the shaft about its axis of rotation.

Hint: Try solving concept problem/ set-1/ # 9 before you solve this problem.



The following question was given on midterm exam-1 to assess the understanding of "concept" and "assessment" problems.

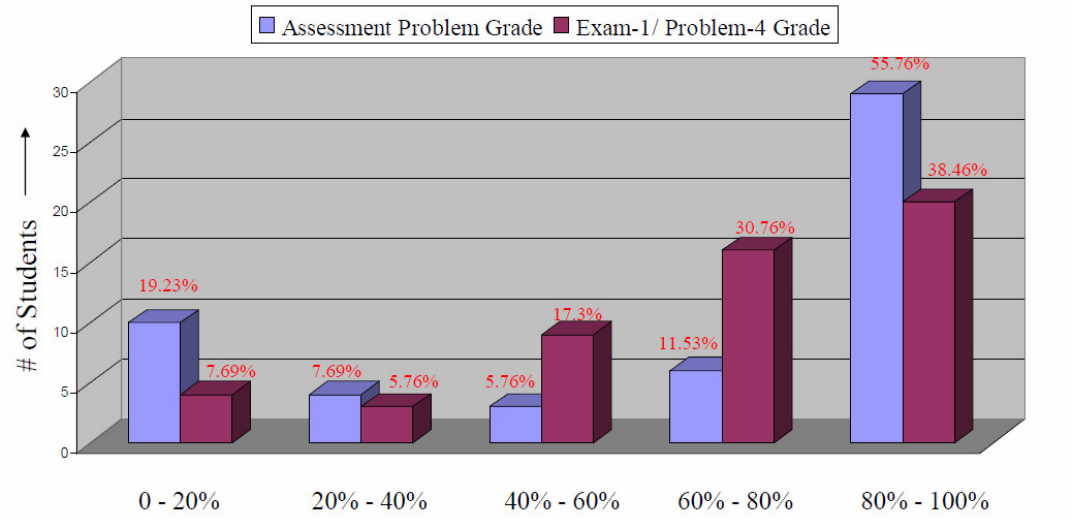
Problem 4: A 73-mm-diameter aluminum (S.G. = 2.64) piston of 100-mm length resides in a fixed 75-mm inner diameter steel tube lined with an oil (μ = 0.13 N.s/m^2). A mass m = 2 kg is suspended from the free end of the piston. The piston is set into motion by cutting a support cord. What is the terminal velocity V of mass m? Assume a) linear velocity profile within the oil; b) oil as Newtonian fluid.



Results

The results shown below are for the Fall-13 semester for the ThermoFluid Mechanics-Section A (total students enrolled - 52) course taught by me. This course has four midterm exams. On each midterm exam, one question was assigned to evaluate and assess the level of understanding of "concept" and "assessment" problems and to check if there exists a relation between their assignment grades and exam performance. Results for each exam are shown below. In fig.-(a), approximately 55.76% students got a B (or better) on the assessment problem while on the midterm exam-1, 38.46% students got a similar result. This is a significant improvement, considering the same problem was assigned few years ago and only few students had managed to score 80% or more.

Distribution of Student Grades on Assessment Problem and Exam-1/ Problem # 4

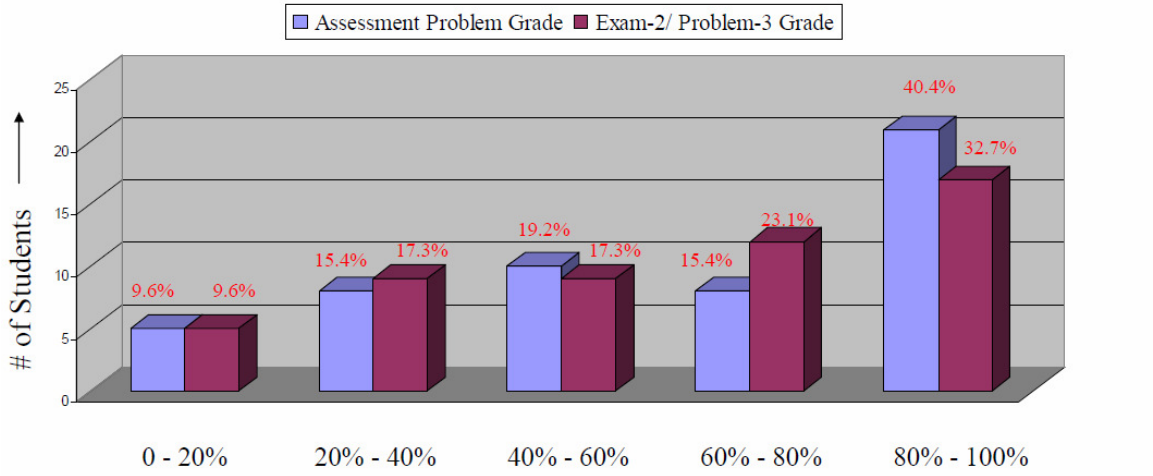


Numbers in red indicate the percent of students scoring in the range shown along the x-axis

Figure - (a)

In fig.-(b), approximately 40.4% students got a B (or better) on the assessment problem while on the midterm exam-2, 32.7% students got a similar result.

Distribution of Student Grades on Assessment Problem and Exam-2/ Problem # 3



Numbers in red indicate the percent of students scoring in the range shown along the x-axis

Figure (b)

In fig.-(c), approximately 57.7% students got a B (or better) on the assessment problem while on the midterm exam-3, 73.1% students got a similar result.

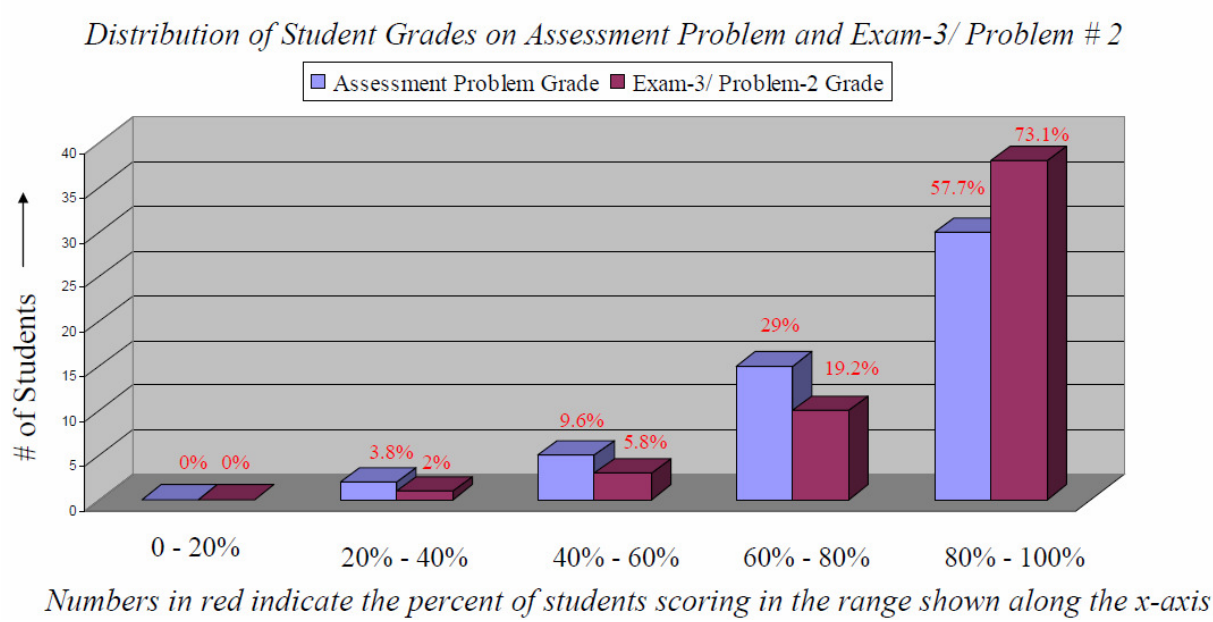


Figure - (c)

In fig.-(d), approximately 52% students got a B (or better) on the assessment problem while on the midterm exam - 4, 40.4% students got a similar result.

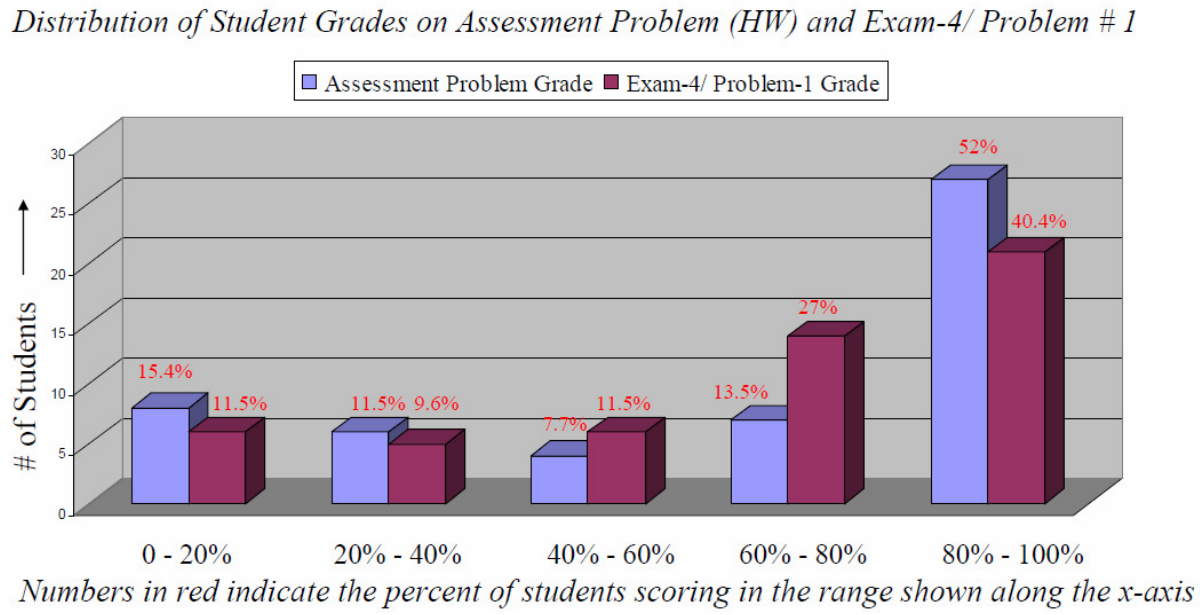
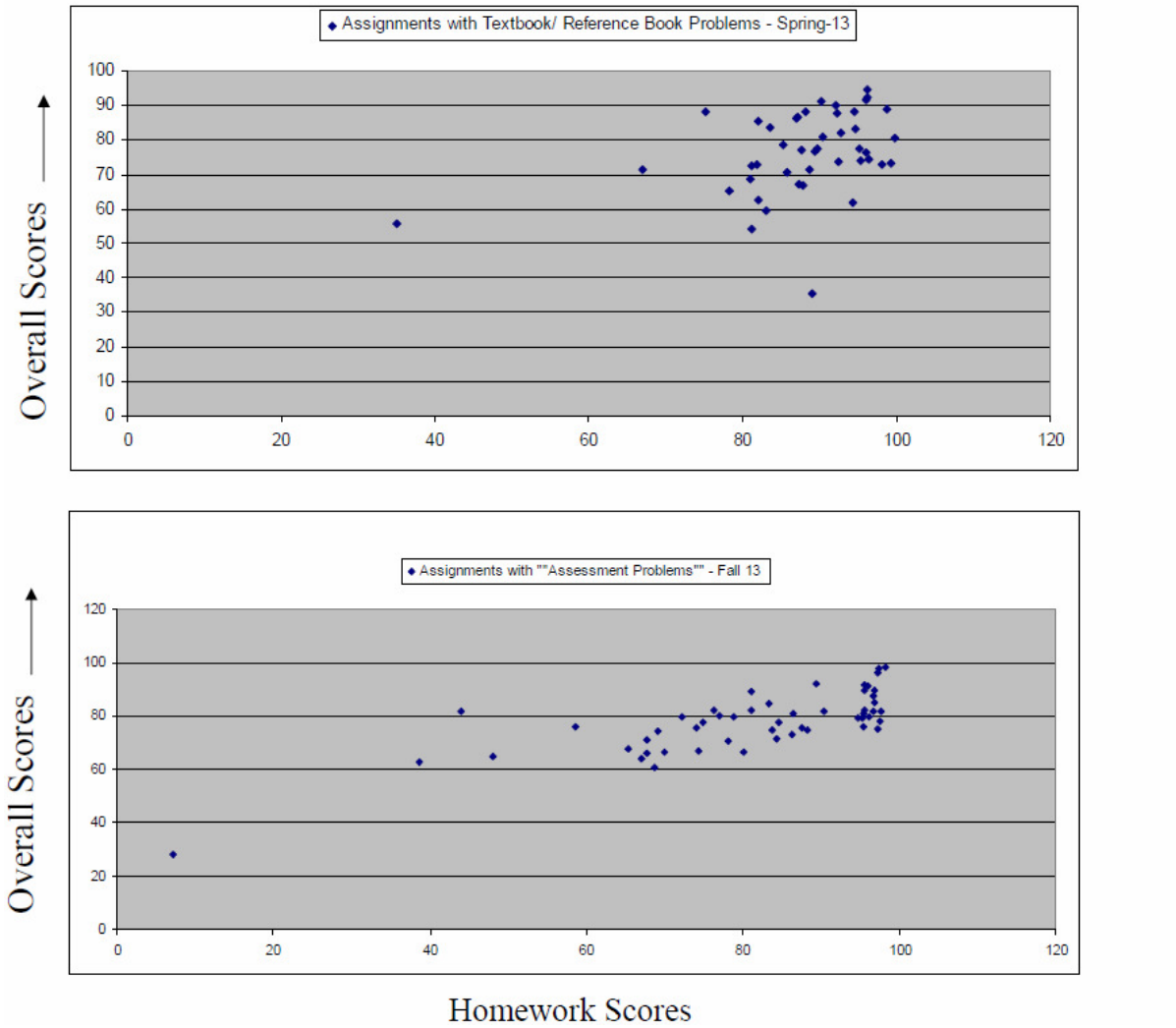


Figure - (d)

The new approach also brought a change in the grade distribution of homework for the class. In the figure below, the overall score of students for the semester versus overall homework score is shown. The data shown are for two semesters (Spring-13 when assignments were primarily textbook based problems and Fall-13 when assessment problems were used). The data comparison clearly indicates that in Spring-2013, majority of students did well on homework's as the scores are mostly clumped in the range of 90 - 100. However, the large range of test scores suggests that high homework scores did not necessarily translates into high test scores as there is no consistency between their assignment grade and overall scores. Clearly, these are the students who are somehow managing to do well on assignments (either have access to resources to find solution of assignments or have very poor exam taking skills). In Fall-13, when the assessment problems were a part of assignments, the homework scores seems to be somewhat consistent with their overall score. It appears that the majority of students who got a B (or better) in class, also did quite well on the exams.

Comparison of Homework Scores with Overall score at the end of semester



Conclusion/Future Implications/Plans for Further Dissemination

These results are encouraging and it seems that the new approach is having an impact on the overall student learning and they have a better understanding of the subject matter. Since, the "concept" and "assessment" problems were prepared for selected topics from the coursework, the P.I., wishes to expand the data base of questions and include problems for the entire coursework. This is currently a work in progress.

The P.I. is currently teaching ThermoFluid Mechanics-1 in Fall-14 and will have additional data by the end of this semester. Further, i wish to do some statistical analysis and submit this report as a manuscript for publication in ASEE journal.

Acknowledgement

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