

Homework: To Do (assign and grade) or Not To Do (only assign)

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Introduction

It is a well known fact that adults learn about 10% of what they hear, but 90% of what they do (Dale, 1954). This, by itself, is a persuasive argument for assigning homework, especially for those of us that still teach primarily in the lecture mode. Though I still interact with a few engineering educators that do not assign homework, the vast majority do assign homework problems, but many do not collect and grade these homework assignments. Assigning and grading homework is the focus of this paper. The value of homework is supported by grading data for two courses and survey results from a senior level mechanical engineering class. This paper continues by presenting this data, which is then used in discussions on several of the issues associated with homework. These discussions also rely upon anecdotal information from the authors eighteen years of teaching. The paper concludes with some final remarks.

Data on the Value of Homework

Any discussion concerning homework needs to support the contention that homework is important and valuable in the facilitation of student learning. Certainly, the 10% - 90% observation that is stated in the introduction provides support for this contention. Most faculty would support the use of homework from their own experiences as students, as well as from their teaching experiences. Wankat & Oreovicz observe that homework is beneficial as there is evidence of a strong correlation between homework effort and test scores. To further substantiate this contention, data is presented in Figures 1 and 2, in which a student's homework score for a course is plotted against their course score. Figure 1 is for a senior level mechanical engineering course in heat transfer, while Fig. 2 is for a sophomore level course in thermodynamics taken by mechanical engineering, electrical engineering, engineering arts, and civil engineering majors. The correlation coefficient for Fig. 1 is fairly strong (0.76) and is moderate (0.61) for Fig. 2. It seems that the trend is clear; a student who does well on the homework has a much better chance of doing well in the class. In Table 1, the homework average for various course grades is presented for these two courses. The trend for ME 410 also supports the contention made above. However, for ME 201 we see a major inconsistency in the trend for the homework average associated with students who received a 2.5 in the class. Several reasons could explain this, including the maturity of sophomores when it comes to taking exams and the issue explored later in the paper concerning team efforts in homework assignments.

Figure 1. Correlation between Homework Score and Course Score for ME 410, Heat Transfer

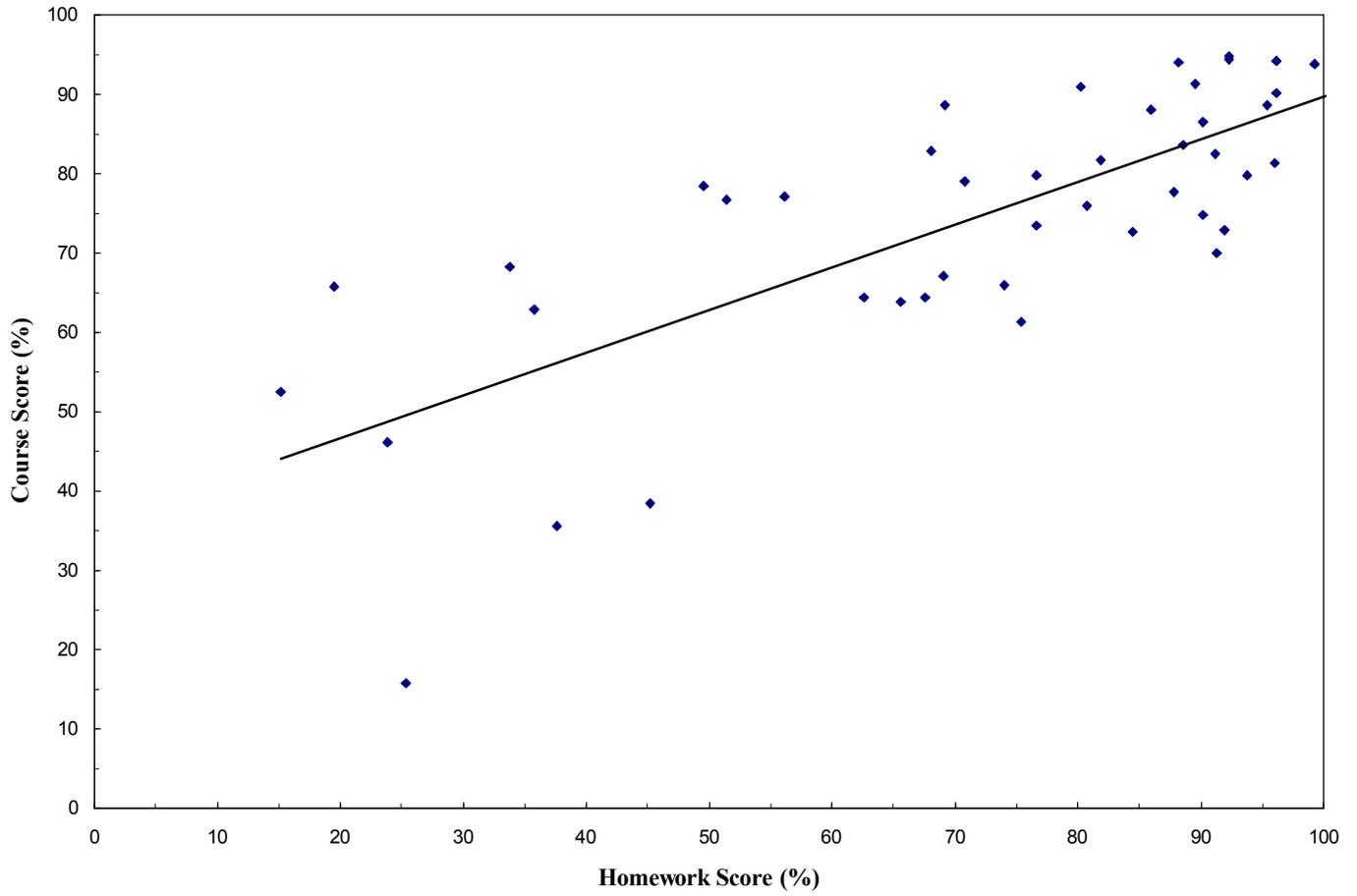


Figure 2. Correlation between Homework Score and Course Grade for ME 201, Thermodynamics

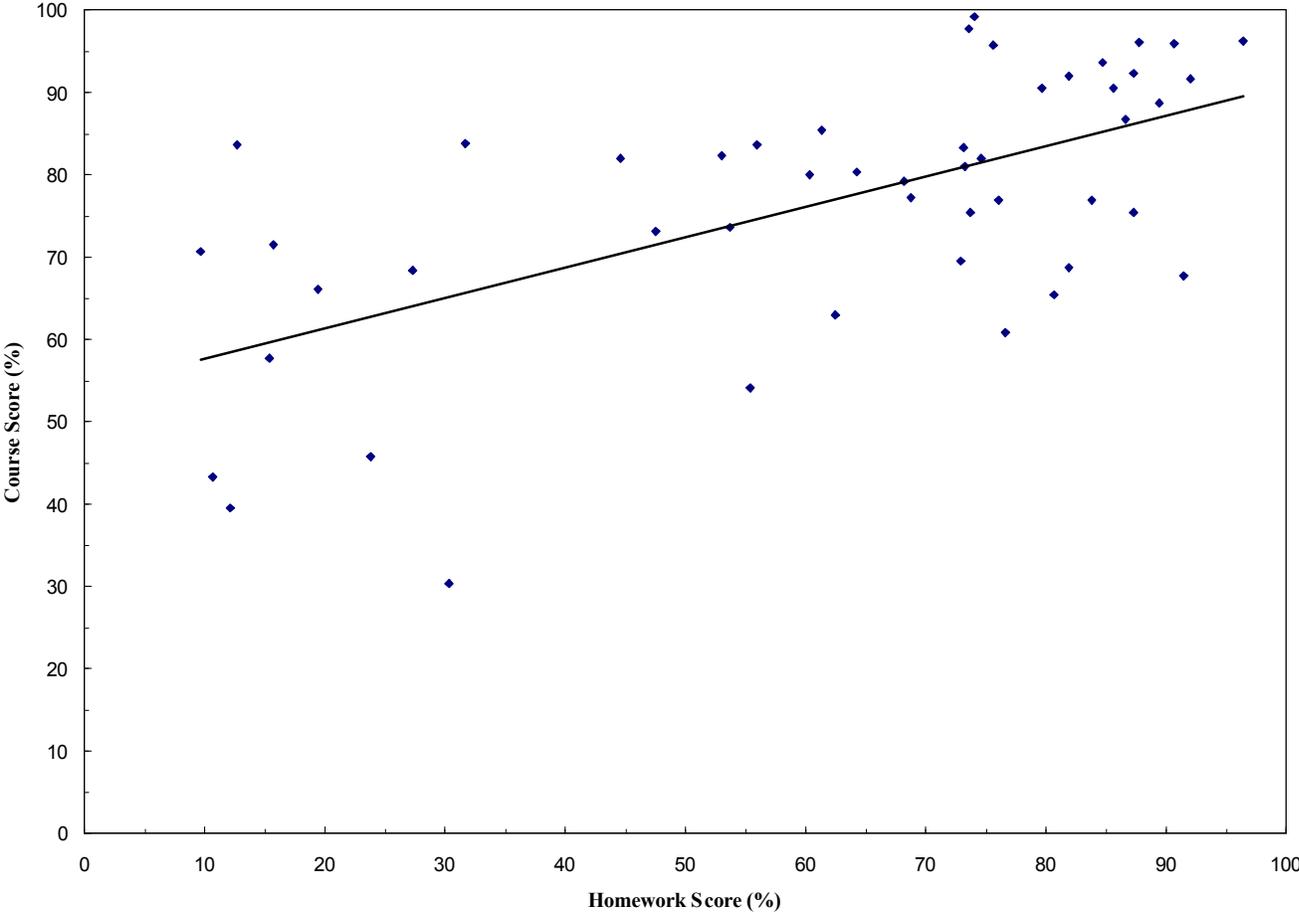


Table 1. Homework Average Corresponding to Course Grades

Course Grade	Homework Average	
	ME 201	ME 410
4.0	71.0	93.2
3.0	55.5	84.6
2.5	81.6	63.6
1.0	51.5	71.3

I was interested in how students perceive the usefulness of homework. The survey shown in Fig. 3 was administered to a senior level mechanical engineering course in thermal design. There were no homework assignments in this class, only projects, and only one of the 55 students in the class had been in a previous class of mine, so that there should be little bias towards my view of homework. The results of the survey are provided in Table 2. The response to the first question demonstrates that most students appreciate the value of homework in enhancing their learning. They also are very definite in their thinking about other aspects of homework, and these results will be discussed further in this paper. Many of the students provided written comments, per question #5 on the survey. Some of the more interesting comments will be provided where appropriate. Concerning its value in learning some students commented:

“Engineering homework is a vital part of learning”
“... because doing homework is the only way to master a course.”
“... given enough time to ask questions and work on it properly, homework helped me learn the concepts.”
“Homework can be really beneficial depending on how the teacher’s method of discipline towards grading.”
“Homework to me functions as a jump start to understanding the material.”
“I have found that in most cases, homework fills in the missing holes in learning.”

Then from another perspective,

“I seem to half ass the HW whether its collected or not.”

Homework as an active learning tool

The conversion to a more active learning approach in engineering courses has been spurred by the 10% - 90% argument of the introduction. Yet most engineering courses, especially engineering science courses, still rely heavily on a lecture format. Then how do engineering students learn at the levels we observe? I would argue that much of this learning is accomplished as the students work on homework in study groups. The culture of our students is to work in study groups, and I urge students to work on the homework together. I also spend considerable effort in office hours working with students on homework assignments. I find it

Figure 3. Student Survey on Homework

Survey on Homework

Please respond to the following questions using our typical 4.0 grading scale to indicate your learning enhancement. Consider that a 4.0 would indicate that your learning has been greatly enhanced while a 0.0 would correspond to no enhancement or even a negative experience.

1. How has your learning in a course been affected by homework?
2. Homework can be handled several different ways. Indicate how each method has enhanced your learning.

Homework assigned, but NOT collected and graded

Homework assigned, collected, but only checked for effort

Homework assigned, collected, but only some problems graded

Homework assigned, collected, and all problems graded

3. In general there are two ways to handle the grading of homework. Indicate how each method has enhanced your learning.

Returned homework is graded in detail with explanations as to what was done wrong, while only rough solutions are provided.

Returned homework is checked for right and wrong answers with some partial credit, but detailed solutions are provided.

4. There are many ways that homework is used in determining a course grade. Indicate how each approach has enhanced your motivation to complete homework assignments.

Homework counts a small percentage (10-15%) of the course grade.

Homework counts significant percentage (25-35%) of the course grade.

Homework score for the semester can be used to replace the score of the lowest hour exam.

5. Please share any additional experiences or thoughts on how homework has affected your learning and course performance in your engineering courses.

Table 2. Results of Student Survey

	Average
1. How has your learning in a course been affected by homework?	3.03
Homework can be handled several different ways. Indicate how each method has enhanced your learning.	
2a. Homework assigned, but NOT collected and graded	1.26
2b. Homework assigned, collected, but only checked for effort	2.62
2c. Homework assigned, collected, but only some problems graded	3.08
2d. Homework assigned, collected, and all problems graded	3.20
In general there are two ways to handle the grading of homework. Indicate how each method has enhanced your learning.	
3a. Returned homework is graded in detail with explanations as to what was done wrong, while only rough solutions are provided.	2.47
3b. Returned homework is checked for right and wrong answers with some partial credit, but detailed solutions are provided.	3.54
There are many ways that homework is used in determining a course grade. Indicate how each approach has enhanced your motivation to complete homework assignments.	
4a. Homework counts a small percentage (10-15%) of the course grade.	2.84
4b. Homework counts significant percentage (25-35%) of the course grade.	3.34
4c. Homework score for the semester can be used to replace the score of the lowest hour exam.	3.62

one of the great pleasures of teaching to have five or six students in my office working on homework. My availability in office hours also allows students to come by and check their answers. As one student observed in the survey,

“HW is a lot more beneficial and I am more likely to attempt it when I have answers. This way I can check my answer and re-attempt the problem if incorrect.”

If one is inclined to leave the comfort of the lecture mode, homework can be used directly during class time as an active learning experience. The statics course at Purdue has been conducted in this fashion, apparently with great success.

Whose homework is it?

As observed above, most of my students work homework in study teams or with me in my office. Then clearly the above question arises. As far as a student’s learning, this may not be an important question, but when it comes to counting homework in the student’s grade it becomes a very valid concern. The survey results indicate this:

“Most time once one person has the assignment done, everyone has it done.”
“Many students just copy homework and get full grades.”

Anecdotally, I recall a student who came into my office and worked with me on every homework assignment for a course. This student’s homework score for the course was very strong, but his/her exam scores were much weaker. Because of my grading policy, the student’s grade for the course was more reflective of his/her exam performance. When the student came by to discuss the course grade, and complained that it did not reflect the homework score, I very much wanted to tell the student (though I did not) that the homework score was as much mine as his/hers. Simply, when homework is allowed to be used in an active learning sense, the grading structure for the course must reflect the uncertainty of homework ownership.

Use of homework scores in course grading

So with the observation made above that there is an uncertainty in the ownership, how can one even consider using the homework score in the course grade? The challenge is that without counting the homework in the course grading, most students will not use the homework to enhance their learning experience. The survey results, questions 2a, 2b, 2c, and 2d, clearly show that homework, which is not collected and graded does not enhance the student’s learning experience (and is probably not done), as compared to a system in which homework is graded. Student survey comments also support this observation.

“HW points are always a good thing. Any points outside of exam only courses help.”
“When homework is collected it forces one to complete. The more weight it carries, the more serious it is usually taken.”
“If it is not collected, not as much time is spent on HW problems. Thus, resulting in less knowledge on the subject.”

“Assigned homework that is graded is key to learning. I have learned the most in these classes.”

“If HW is not collected it will never be done. We have so much other things in ME collected already.”

Part of the issue is that a professor's class must compete for the student's time and effort with other classes the student is taking. A strategy is to have a grading policy that will seem to the students that the graded homework will impact their course grade, when, in fact, the numerical score will have little impact. I have found that assigning the homework score a 10% component in the course grade is such a strategy. Unless the student genuinely learns from the homework (and we hope performs better on exams because of it), the final course grade is affected little by even 100% homework score. Another approach that is even more effective is to allow the homework score to replace the lowest exam score (excluding the final exam). We see this in the students' response to survey question 4a, 4b, and 4c. Though this will give many students significant motivation to complete the homework, it only addresses the second part of the strategy (the homework numerical score having little impact on the course grade) for courses that have several exams (3-4) during the term. I would not support such an approach for courses with only one or two exams during the term.

Ways of grading homework

In my experience I have tried two different ways of grading homework. One approach is to provide the students with a solution in outlined form, often what one will find in a typical solution manual for a textbook, but grade the homework in some detail so that from the graded homework it is clear to the student what they did wrong. The second approach requires the instructor to develop a detailed solution using the problem solving method that is presented in class. Homework is then graded by marking right and wrong answers, and identifying some intermediate numerical results that can be marked for partial credit. I have found that the second approach provides a greater enhance for student learning. The student responses to questions 3a and 3b supports this notion. Some pertinent comments:

“Detailed solutions should always be provided after the hw assignment.”

“Good if not harshly graded. That gets frustrating and I don't do it.”

The detailed solution can also be used to cover additional topics beyond the lecture and I have found it to be a useful teaching tool. Because of my experiences as a student, I have always graded all problems submitted. However, my colleagues have employed two other approaches. Some only grade thoroughly one problem from a homework set, while others only check to see if a student genuinely attempted the problems. I was surprised by the survey results (questions 2b, 2c, and 2d) that students are not greatly opposed to these two other approaches.

How hard should homework be?

To be effective, homework must be at an appropriate level of difficulty. It cannot simply be a regurgitation of the examples worked in class. It should really demonstrate the principle that engineering practice is based on extrapolation. That is, rarely does an engineer see the same problem twice. However, the engineer will see similar problems and the successful engineer will

be able to extrapolate from a previously worked similar problem to the current unsolved problem. On the other hand, if the homework is too difficult then the students will become frustrated and lose their motivation. As one student noted in the survey,

“Homework has been great! Motivates me to study as long as the level of difficulties is reasonable.”

To be honest the level of difficulty will only come from experience, though the problems in the textbook may provide some guidance. I tell my students (and I believe that it is true) that most of my homework problems are more difficult than my exam problems, primarily because of the time constraint imposed on exam problems and the tools, such as Excel or MATLAB, that are available for homework but not for exams..

Frequency of homework assignments

So we all give a weekly homework assignment of ten to fifteen problems. Actually, I have found that it is much better to assign a small homework assignment at every lecture. I normally make it due two lectures following. In this way students are forced to keep up with lectures and teaching in lecture becomes easier. I will use the next lecture after making the assignment to answer questions about the assignment or to share clarifications that have come out of office hours or email questions. Again, some student comments that support this approach are given below:

“Long homework assignments that take 10-20 hr, i.e. Dynamics, makes it tough to learn because it is a waste of time, and not much is really learned.”

“Assignment that cover a certain topic more than once or twice are a waste of everyone’s time.”

“Short assignments are easier to get started and finish.”

“Would rather do a couple problems, get them correct than busting ass on 15 problems and not getting them correct.”

It is also very important to time the homework, so that students have the opportunity to complete assignments and review solutions before they are tested on the material. It is not good to have students turn in an assignment on the day of the exam that covers the material of the assignment.

Where to get homework problems?

Good textbooks have good problems. Unfortunately, they are not written in the way that the course instructor might write a problem. Also, once a textbook has been used for a course, be aware that solutions to textbook problems are going to be available to the students. As a tenured faculty member, I have the luxury of taking the time and writing all of my own homework assignments. Occasionally, I borrow from a textbook here and there. I also try to tie the problem to a real life, engineering situation. Problem relevance can play a role in motivating the students to learn the subject matter. Though I do not view that the principal reason behind homework is to prepare students for an exam, I have found that since I began writing my own homework problems, students have less trouble understanding my exam problems. As some students observed,

“Homework was good to learn the problems before a test or exam, provided that the question types were similar.”

“I also noticed in many classes that the homework didn’t reflect the test problems.”

I would strongly urge that new engineering educators not write all of their own homework problems. Use the good problems from a good textbook. I do urge new engineering educators to write a few of their own homework problems. In this way students can get use to the way the instructor would word a problem that might appear on an exam. It can also provide some practice in writing good exam problems.

Final Remarks

If handled properly, homework can significantly enhance a student’s learning experience. I hope that this paper can serve as a guide to new engineering educators as they contemplate ways to use homework to enhance student learning.

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