# AC 2007-523: SELF GRADING FOR IMPROVED LEARNING

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# Self Grading for Improved Learning

A primary goal of homework is for students to learn as much as possible, especially perhaps, from their mistakes. The typical homework format, however, has impediments to the learning process: 1) slow feedback, 2) penalties for mistakes, and 3) no encouragement to discover mistakes and correct them. In recent years, several new approaches to homework have been introduced, but none addresses all three learning limitations listed above: a) Homework is assigned but neither required nor graded. b) It is automatically graded online. c) Detailed solutions are provided online.

Four years ago we began developing a self-graded aspect to our homework assignments with the goal of improving student learning while minimizing the burden to the course instructor. In this new strategy, some homework problems on each assignment are graded by the instructor in the traditional manner. The remainder are graded by the student from solutions provided in advance of the due date. The student is expected to attempt solving the self-graded problems prior to viewing the solutions; however, when grading, if the student finds an error, he/she is urged to correct his/her solution prior to assigning a grade. It is expected that the student complete, grade and correct the self-graded problems first, in order to learn from these self-graded problems before attempting instructor-graded problems.

Although the self-graded homework problems outnumber the instructor graded problems, their portion of the overall course grade is typically many times smaller, around 5% of the course grade. This percentage has been high enough to motivate students to do the homework, but low enough so that routine scores of 100% on the self-graded homework do not significantly inflate the course grade.

We have also introduced metacognition to our homework assignments. One of us requires that each student evaluate and explain his/her errors in addition to redoing problems correctly in order to receive full credit. The other often requires each student simply to write a paragraph summarizing what he/she learned in doing the self-graded homework and where his/her errors typically arose.

The self-graded homework has been extremely well received. When surveyed, 86% of the students indicate that it is beneficial for their learning and 93% indicate that it should be continued. Students concur with us, also, that the self-graded homework helps them to take responsibility for their own learning. In addition to apparently improved student learning, an added benefit to the faculty member is less grading. Self grading also creates a natural opportunity to address ethics and integrity issues with students. The drawbacks for the faculty member include: twice as many homework scores to document and the need to provide detailed, correct, homework solutions. Further, when assigned, the faculty member may choose to read the metacognition responses and, perhaps, respond to the student. Despite the added time requirement, forming the detailed solutions can benefit the instructor by requiring him/her to mentally engage the material more fully, and metacognition responses are very illuminating regarding student misconceptions and behaviors which can lead to classroom changes to better facilitate learning.

## Introduction

It is well known that timely feedback is important for learning [1, 2]. In recent years, educators have been exploring just what form that feedback should take for student homework. The balancing act is between providing fast feedback to the student countered by the labor intensity of providing quality, complete, valuable feedback. Meanwhile the student needs to be motivated to do the hard work of solving the quantity and variety of problems needed for learning, without demoralizing penalties for making mistakes while learning. Further, many professors prefer to use homework scores as a significant portion of the final course grade because it is difficult to test students on such a wide variety of problems.

To achieve these goals, several homework options exist for the professor: traditional homework, homework that is graded online [3, 4], and homework that is assigned but not graded. Each of the various approaches addresses the homework balancing act differently, and each has its drawbacks (Table 1). An alternative approach described in this paper incorporates many of the benefits of these various methods in a manner that enhances student learning: a combination of traditional homework and self-graded homework.

| | **Benefits** | **Drawbacks** |
|---|---|---|
| **Traditional homework** | • Contributes to the final grade<br>• Grade reward provides motivation<br>• Partial credit possible | • Penalty for mistakes<br>• Time consuming grading<br>• Students often do not look at their errors or the solutions<br>• Feedback is slow<br>• Minimal motivation for students to correct their mistakes |
| **Homework graded online** | • Immediate feedback<br>• Minimal instructor time<br>• Grade reward provides motivation<br>• Possibly no penalty for mistakes | • Answers must be in an exact format and the student is tied to the computer to do homework<br>• Often no feedback regarding the cause of errors<br>• Complete solutions are often not available to the student<br>• Possibly penalty for mistakes<br>• Partial credit not an option |
| **Homework not graded** | • Immediate feedback<br>• Minimal instructor time<br>• No penalty for mistakes<br>• Allows student to take charge of his/her own learning | • Minimal external motivation for the student to do the work<br>• Often students do not do the work<br>• Complete solutions are often not made available to the student |

Table 1.

We have been using this combination approach for four years, and have found it very valuable. A literature search came up empty on this topic, but a web search revealed that several other

professors have adopted self grading[5, 6, 7, 8] to be included in the course grade. Here we offer the details of our implementation.

**Methods**

There are a number of issues to be addressed for this combined approach to homework. Here we list these issues and the methods we derived after some trial and error. In some cases, the two of us prefer different methods as you will see.

Issues to be addressed include:

1. The number and type of problems to be self graded.
2. The number and type of problems to be instructor graded.
3. The due date for self graded problems – before or at the same time as the instructor graded problems?
4. The means of providing complete solutions to the students for the self graded problems.
5. The timing of providing the solutions to the self graded problems.
6. The handling of mistakes and wrong answers on the self graded problems.
7. The percent of the total course grade attributed to self graded homework.
8. The percent of the total course grade attributed to instructor graded homework.
9. Specific requirements and instructions for the self-grading.

The methods that we derived:

1 & 2. We assign between one and three self graded problems for each instructor graded problem. Depending on the topic, it is best to have at least one self graded problem that is easier than the corresponding instructor graded problem in order to provide practice and promote student confidence. It is also sometimes beneficial to make the most challenging problems self graded so that the student can tackle them without fear of penalty and with the option to obtain hints from the solutions.

3. One of us assigns a due date for the self graded portion that is before the instructor graded portion to encourage students to complete the self graded problems first. The other of us simply assigns the same due date for both.
4. We typically provide solutions through a password protected course web site. We prefer to simply provide students with the solutions to assigned problems from the solution manual accompanying a course text book provided that each solution is thorough, correct, and uses the preferred approach. When this is not the case, we write or type up our own complete solution. In the Fall 2006, one of us used a textbook that had some online solutions complete with hints for the students through JustAsk! [9], so those problems were used when appropriate.
5. One of us supplies the self graded solutions at the same time that the assignment is given. The other supplies the self graded solutions at a slightly later date in order to encourage students to work through the problems without the aid of the solutions.
6. Both of us encourage the students to find their own mistakes and correct them, allowing them to earn full credit. One of us requires that the student clearly indicate his/her mistake and the correction. The other instead asks the students to write one paragraph summarizing the errors made on the entire self graded portion of the assignment.

7. Since it is common for students to earn 100% on the self graded portion, we keep the percentage of the course grade based on the self graded homework at roughly 5%. This is high enough of a grade reward to motivate students to complete the assignments, but it is also low enough to avoid significantly raising the course grade.
8. We have chosen to keep the total homework percentage of the course grade at roughly the same as we did before implementing self grading. Thus, the instructor graded homework portion is roughly 5% less than it would have been before.
9. To aid the student in learning, both of us require students to do a metacognitive reflection on what he/she learned when working through the homework assignment.

Our syllabi and homework assignments convey these methods and expectations to the students. The exact verbiage is provided in the appendix.

Our primary means of assessing our homework approach has been threefold: student surveys (Figure 1), course evaluations, and personal observations. We also looked back at homework scores and final exam scores in our classes for the years both prior to and since implementing self graded homework. These data are suspect, however, because we have changed other aspects of our courses over the years. Unfortunately we have not had the option of having a control group because our class sizes are roughly 20 students, and we teach each course just once per year. In addition, since we are enthusiastic about this homework approach, we are unwilling to withdraw its use for research purposes.

Our course evaluations include written responses to the following questions:

- Please specifically identify the aspects of the course that **worked well** toward helping you learn.
- Please specifically identify the aspects of the course that **did not work well** toward helping you learn.
- What comment would you most like to share about what would have helped you learn more?

We have now used our self-graded homework approach in (15) engineering classes, averaging roughly 20 students/class. Many students were in several of these courses. The courses included sophomore, junior and senior levels.

**Evaluation of the Self Grading process**

1. How often did you complete and grade the self-graded homework questions before working on the instructor graded questions?

   always usually sometimes never

2. When you did work and grade the self-graded problems first…
   a) To what degree did you learn more than you would have if all of the questions had been instructor graded?

   Much more no difference
   4 3 2 1 0

   b) To what degree do you think you earned higher grades on the instructor graded homework than you would have without the self graded problems (with provided solutions)?

   Much more no difference
   4 3 2 1 0

3. If you answered "sometimes" or "never" to 1), then,

   Why did you not complete and grade the self-graded homework questions prior to working on the instructor graded questions?
   time constraints other _____

4. Should the self-grading remain a part of this class?

   Yes No

1. What ways could the self-grading process be improved?

Figure 1.

**Results**

*Survey*

We handed out the survey in six classes in 2005 and 2006 of which 99 students turned in responses. Here are the survey results.

| Do self grading first: | always | sometimes | usually | never | |
|---|---|---|---|---|---|
| *Student responses* | 57 | 27 | 11 | 1 | |
| Learn more doing self grading first: | much more | | | | no difference |
| *Student responses* | (4) | (3) | (2) | (1) | (0) |
| | 62 | 23 | 10 | 2 | 0 |
| Likely earned higher grades: | much more | | | | no difference |
| *Student responses* | (4) | (3) | (2) | (1) | (0) |
| | 36 | 35 | 13 | 12 | 1 |
| Should self grading remain? | Yes (some emphatic) | | No | | blank |
| | 92 | | 4 | | 2 |
| Reasons cited for not completing self graded first: | • time constraints<br>• student works problems in order<br>• student had difficulty figuring out self graded problem | | | | |

Table 2.

*Course evaluations*

On the course evaluations, roughly 25% of the students specifically mentioned the value of the self-grading method under the course evaluation item asking what worked well in the course to aid learning.

Selected student comments:

- "It is definitely a boon to learning."
- "Having both self graded and instructor graded homework was also a good way to practice circuits skills and then test them."
- "I've never had a class that did this, but it really is helpful to be able to see first hand how the instructor expects the problems to be done."
- "It can give confidence to methods before instructor graded problems are started. Plus it is always good to try a problem and work through it again with the solutions. You learn the process/methods better."

The most negative comments were a) a few students requesting that the self graded problems be made optional, b) a few students requesting fewer problems, and c) a few students requesting the omission of the reflective paragraph.

*Personal Observations:*

We have observed that with the self graded assignments, students definitely engage the solutions and work to achieve the correct answers. The students are enthusiastic about this method and repeatedly report that it helps their learning. Their questions in class and in office hours are

typically less basic. The students are able to gain initial hints from the solutions and are less likely to come tell us that they are "completely lost".

*Student homework and final exam scores:*
We examined the average (instructor graded) homework scores and average final exam scores from several courses for a few course offerings before and a few course offerings after switching to self-graded homework in hopes of somewhat measuring an improvement in student learning. We found that homework scores increased roughly 5% and final exam scores increased roughly 3%. We fully recognize, however, that these scores are dependent on many factors other than student learning. Further, we present these data reluctantly because we made many other changes in the courses over the years and a sampling of just 20 students per course over just a few course offerings makes any trends highly suspect.

*Student comments from homework assignments about their errors and learning:*
Student reflections on their errors and on their learning are likely predictable and typically fall into a few categories. Some struggle with concepts from the prerequisites, especially math, be it algebra or differential equations. Often students discover that they are applying either the wrong tool or using it incorrectly. Others confess that they simply do not yet understand a particular concept. Still others simply start the assignment too late, work through it too quickly, are distracted, or are lacking in sleep.

**Discussion**

The survey results indicate that 86% of students find the self-graded method very beneficial for learning (Table 2), and 93% recommend that the method be continued. Course evaluations comments related to the homework method are overwhelmingly positive, and often specifically mention the benefit for improved learning. Homework and test scores are up slightly as well; although these are only loosely indicative of learning corresponding to the self-grading method. Finally, as faculty, we have a strong sense that the learning process has improved, though we find it difficult to measure!

As with all methods, the combination of self graded and instructor graded homework assignments has its benefits and drawbacks (Table 3). The benefits include likely improved learning, more student ownership of the learning process, and student satisfaction. Self grading also creates a natural opportunity to address ethics and responsibility with the students. A benefit specifically for the instructor or grader is reduced grading time compared to the traditional homework format. Drawbacks include more administrative overhead for the faculty member, and a more complicated system to which the student must acclimate. Further, the instructor must select the problems carefully, and ensure the solutions are accurate, complete, and follow the desired approach. In the absence of sufficient, available solutions, the instructor must generate these solutions, which can be very time consuming. However, since these problem selection and solutions are used for self-grading, they can be re-used each time the course is taught; so the time intense aspects only apply for the first implementation. We found two perhaps unexpected benefits of producing the solutions: we can determine unexpected difficulties in advance by having to consider the solutions so carefully, and we can demonstrate the specific solution methods that we wish our students to use. Finally, reading the

metacognitive reflections takes further time on the instructor's part, but it definitely helps the instructor to gain insight into the students' difficulties, behaviors and thought processes.

| | **Benefits (highlights)** | **Drawbacks** |
|---|---|---|
| **Combined self-graded and instructor-graded homework** | • Grade reward provides motivation<br>• Partial credit possible<br>• Practice on problems with no penalty for mistakes<br>• Students required to locate their errors and make corrections<br>• Prompt feedback<br>• Allows student to take charge of his/her own learning<br>• Students embrace the method | • Time consuming for the instructor to select the problems and generate the solutions – first time only<br>• More homework scores to record<br>• Takes a while for students to acclimate to the method |

Table 3.

Since we make the self graded solutions available in advance of the due date, we necessarily rely on the honor system for it to work as intended. The reader may have noticed that in many ways, self-graded homework is similar to the 'traditional' homework scenario in which homework solutions from previous implementations of a course circulate among students, with the supply coming from more senior students. The primary difference with self grading is that the solutions are provided by the instructor and use of them is encouraged, but for only the self graded portion of the assignment. (The instructor may choose to change the instructor graded problems, which are fewer in number, from year to year.) As we see it, the comparison between these two homework scenarios highlights two important issues: learning and honesty. The availability of the solutions provides a valuable learning opportunity in both cases, but in the self-graded approach, the honest student can take advantage of this opportunity without guilt.

The learning opportunity afforded by the accessibility of the solutions, however, can be squandered if the student chooses to simply copy the solutions, thus cheating. It ultimately depends on each student's internal moral compass and desire to learn. In the end, though, cheating on the self-graded portion of homework will not raise the student's grade because the self graded portion of the homework is just 5% of the total course grade, and the stunted learning will cause much lower scores in other aspects of the class which will far outweigh the 5% benefit. Further, students who are intent on avoiding doing their own work and skating by without engaging the material will reap other consequences. We must put the question to the students "if you cheat your way through your courses, what kind of engineer (and person) will you become in the end?" How will the student eventually solve his/her first design problem on the job when the answers are not supplied? As stated earlier in this paper, the self-graded approach provides a natural opportunity to address ethical issues and their importance in the engineering profession. As an institution Seattle Pacific University declares that it wants to graduate students of competence and character. This reinforces our work in the classroom where we aim to combine technical excellence with moral integrity, which is consistent with our Christian heritage. If students come to understand that cheating in the short term will lead to lack of success in the long term, then they have a strong incentive to be honest. We believe that

the large majority of our students are honest about this and appreciate the trust we extend to them.

## Conclusion

The self grading approach is valued by students and faculty, and seems to facilitate learning. Even after using this approach for several years, we are still struck by the degree to which students comment about it positively. We note that effective informal learning is often accomplished with trial & error accompanied by guidance. This approach to homework seems to incorporate that principle in a manner agreeable to both students and faculty.

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**Appendix – Description of the homework approach to the student**

*In the syllabus:*

One professor's method:

The following describes the procedure for homework. The procedure has been designed to facilitate students to really learn from the material and from their mistakes. A few of the assigned homework problems will be designated to be graded by the instructor and/or her assistant. The remainder of the homework problems will be graded by the student. Solutions to these problems will be available in advance of the due date. The student is expected to attempt solving the self-graded problems in advance of viewing the solutions; however, when grading, if the student finds that he/she was in error, the student is urged to correct his/her solution prior to assigning a grade. It is highly suggested that the student complete, grade and correct the self-graded problems prior to the instructor-graded problems. The intent is that the student will learn from these self-graded problems and will then perform well on the instructor-graded problems.

The other professor's method:

"Homework will be done and graded in two parts:(1) **self-graded and** (2) **instructor graded**.

Students will complete the self-graded parts by a give date, then grade their own work against a published set of solutions. Full credit can be achieved on any incorrect homework problem by doing the following: On a new sheet of paper **a.** write out **what** your error(s) was (were) and **why** you think you made that (those) errors, and **b**. on the same new sheet of paper redo the problem correctly. This you will grade yourself and place a score on the top of the first page. However, these papers will be reviewed by class teaching assistants. The corrected self-graded homework and the instructor-graded homework will then be turned in together on the published due date."

*m each homework assignment:*

- Do the non-bolded problems first. Then look up the solutions on-line. Determine what you did wrong. Correct your work. Assign the appropriate score to the corrected work.
- Write a paragraph explaining what errors you made on the self-graded homework, and what you needed to do to correct it. Put emphasis on any errors in your thinking. Also mention what you learned from the self-graded portion of the homework.
- Then work the bolded questions (the numbered textbook ones are also underlined) which will be graded by the course grader and instructor.

TURN IN THE SELF GRADED RESPONSES SEPARATELY FROM THE RESPONSES TO THE (INSTRUCTOR GRADED) BOLDED QUESTIONS.

Grading rubric:

Each problem (5, 10 or 15 points depending on difficulty level):

| | |
|---|---|
| 0% | No effort, almost no effort, or completely wrong approach |
| 20% | Minimal effort and somewhat correct approach |
| 40% | Reasonable effort, and somewhat correct approach |
| 60% | Correct approach, incorrect result |
| 80% | Nearly correct result or correct result but insufficient work shown |
| 100% | Correct result and sufficient work shown |