Peer Grading:
Sometimes It Should Be Done

Douglas F. De Boer
Dordt College Engineering Department
Sioux Center Iowa
June 18, 2010

Abstract
A problem-based method of teaching that engenders classroom discussion in lieu of lecture, and that fosters better study habits is presented. This method is especially recommended for lower-division introductory courses on technical subjects. This method is an example of the employment of inductive teaching and learning, as applied to a technical course (Prince and Flelder, 2006). Goals of the method are to motivate students to keep up with the course by establishing regular periodic study times, to move the student's focus from earning a grade to learning the material well enough to explain it to a classmate, to teach good written and verbal communication skills, and to rapidly identify weak students early in the semester so that they can be advised constructively and referred to appropriate assistance and campus offices. Results from this method, as measured by student evaluations of instruction, have been strongly positive.

Introduction
Lecture is the traditional way to teach highly technical courses. Lectures that take an entire class period have the advantage of offering lots of time to explain the details of a complex subject. Lecturing gives the instructor a sense of assurance that the students have been informed, but it is not clear that students can absorb the information presented in the lecture. On the other hand, students often to not know how to read textbooks effectively and so it may seem there is no alternative to lecturing in these technical courses.

In response to a 2006 paper by Prince and Felder (2006) in the Journal of Engineering Education, the author began experimenting with a problem-based method of teaching that engenders classroom discussion in lieu of lecture, and that fosters better study habits. Student learning outcomes have improved in terms of the enthusiasm of students for the course, the amount of material that can be covered in the course, and the early identification of struggling students. There may also be benefits in terms of retention of students in the course. It is not clear that students perform differently (better or worse) on tests during the course, but Prince and Felder's analysis shows that that, in the long run, students retain more of what they learn.

Peer Graded Courses Contrasted with Lecture Courses
No course is purely one style or another, but for a moment, consider how a predominantly lecture-style course usually works.

Prior to the course offering, the instructor reviews available textbooks and chooses one. Then the instructor develops a set of notes for the course to coordinate with the chosen textbook. An instructor teaching the course for the first time might take notes almost exclusively from the chosen textbook. A more experienced instructor might make notes based on a composite of knowledge in the field, but will still be constrained to coordinate notes with the outline of the textbook. The textbook becomes the primary organizational vehicle for the course. However, some students will not read much of the textbook, relying instead on taking notes during class.

The instructor uses the textbook-oriented notes for the classroom lectures, usually writing the notes on a whiteboard or presenting them via computerized projection while speaking. Students copy the notes, either by hand or by using a computer. The instructor's notes might also be made available to students as handouts or electronic files. Students may interrupt to ask questions, but they must take some initiative to do so, even if the questions are welcomed. The instructor periodically assigns homework, possibly weekly. Many students wait to the last minute to do the each assignment, then finish it in one sitting. If they encounter difficulties, there is usually not enough time to resolve them, so they turn in what they have. The homework usually is graded and turned back to the students for feedback. The students will review the homework just prior to the next test. There may also be a comprehensive final exam in the course which will prompt most students to review their homework again.

Consider how students might see the presentation of a particular subject in a lecture oriented course. Say the topic is, "Kirchhoff's Voltage Law" (KVL). The student probably is presented with KVL for the first time via a lecture since few students read ahead in the textbook. Some number of days later, the student will work a homework problem or two on KVL. This is the student's second exposure, but possibly days after the related lecture. Suppose now that the student does not correctly understand KVL and is unaware of the misunderstanding. He or she gets the homework wrong, but will only discover this after the homework is graded and returned, a few days after doing the homework. At this point the course has moved on to new subjects and so the homework will likely be saved away for study just before the test. Finally, the student will retrieve the homework before the test, maybe just the night before the test, and try to figure out what went wrong with the homework on KVL. This will be the student's third encounter with the subject. Again, this encounter occurs days or even weeks after the previous encounter. If the student does not succeed in understanding KVL while studying for the test, he or she might just go ahead and take the test anyway, hoping KVL will not appear on the test. The test is graded which offers a second opportunity for giving feedback to the student on KVL. If there is a comprehensive final exam the student may encounter KVL for a fourth time when studying for the final exam.

Altogether the student encounters the subject four times (Lecture, homework, study for test, study for final exam) and twice receives feedback that can be used for improvement (homework, test).

Peer Grading From the Instructor's Perspective

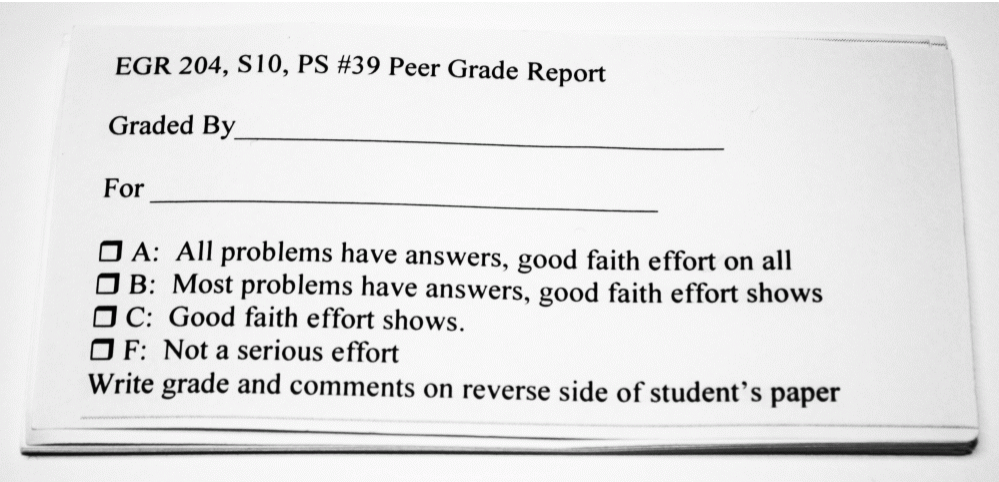
Now consider a different way of teaching the class that avoids long lectures and encourages discussion. Again, before the course starts the instructor reviews available textbooks and chooses one, but instead of preparing comprehensive course notes, the instructor prepares a list of homework assignments with coordinated reading assignments that cover the main subjects. The course becomes homework oriented and driven. Classroom time is used mostly to discuss homework.

Before each class, the instructor (or an assistant) grades any previously handed in homework. The instructor selects a section of the textbook for the new assignment and assigns homework that relates to that section of the textbook. The instructor posts this new assignment so that the class is aware of it. This can be done by writing it on a whiteboard at the start of class. However, course management software such as Blackboard, Desire2Learn, Moodle, etc. or a course web page can be very helpful for students since it eliminates transcription errors in

keeping track of exactly what the assignment is and it is available 24/7. The instructor also prepares a short (about 15 minute) lecture to introduce the new homework assignment. The lecture assumes the students have not read the relevant section of the textbook. Since time is short, the lecture can only motivate the students to read the section. This is done by pointing out important definitions, equations, illustrations, theories, etc. and relating these to the challenges posed by the new homework assignment. The new homework assignment will be due at the start of the next class period for "peer grading" which is a form of structured small-group discussion.

The peer grading is done during about the first ten minutes of class (assuming a 50 minute class period). At the end of the 10 minute peer grading interval the peer grade forms are turned in to the instructor and the peer graded homework is returned to the student who authored it. After class, the students have an opportunity to correct any mistakes they may have discovered during peer grading. This same assignment will be due again at the next class period for regular grading.

When the class starts, the instructor collects two sets of homework. One set is the set (the newer set) that will be peer graded. The other set (older) is the set that will be graded the normal way. Then the instructor passes the peer grading set back to random students. There must be two important exceptions: First, no student gets his or her own paper back. Second, any student who did not turn in a paper for peer grading does not get a paper to peer grade. (That student will just have to wait patiently for peer grading to end.) As the peer graded homework is passed back to random students, blank peer grading forms are passed out along with the homework. A sample peer grading form used by the author is shown in Figure 1. The grading rubric is also shown in the figure. The goal of peer grading is to establish mutual accountability for attempting the homework so that all students are prepared to discuss the homework in class.


EGR 204, S10, PS #39 Peer Grade Report

Graded By_____

For _____

❒ A: All problems have answers, good faith effort on all
❒ B: Most problems have answers, good faith effort shows
❒ C: Good faith effort shows.
❒ F: Not a serious effort
Write grade and comments on reverse side of student's paper

Figure 1, A sample peer grading form.

Students are instructed to do homework on only one side of each sheet of paper so that the other side may be used by the peer grader for comments. This way the regular grader can also obviously distinguish between the student's solution and the peer grader's comments. After each student is done peer grading, she or he gets up, drops the peer grading form off at the instructor's podium, and walks over to the student who was peer graded and discusses the homework with that student. The classroom becomes filled with chatter as students move about and discuss their homework. If two students have different answers, the students will naturally attempt to figure out who's answer is right. (For a few problems they may have correct answers from the

textbook, but no complete and known correct solution methods have been given.) Each student encounters two perspectives on the homework solutions other than his or her own. One is from the student she peer graded and the other is from the person who peer graded her paper. Students usually discuss the homework by way of comparing and contrasting their solutions and techniques. At the end of the peer grading time each student will have received his or her assignment back and will have an idea of how well the assignment was done. The peer grading process also tends to plant questions in the minds of the students on some of the more difficult aspects of the assignment.

While the students are doing peer grading, the instructor can return regular graded papers to the students. When it appears that peer grading is done, the instructor should count the number of peer grading forms turned in. Occasionally a student will forget to turn a peer grading form in. Also the forms should be checked for completeness. Occasionally a student will turn in a form that is missing a grade. At this time it is an easy matter for the instructor to walk over to a student and ask for a peer grading form to be completed.

After the peer grading is done the homework is discussed by the class as a whole. One way to initiate this discussion is to ask some benign question requiring students to categorize the homework, such as, "Which question was the hardest?" (To which a smart aleck might answer, "All of them" Just ask for a second opinion from the class!) Such simple questions will usually lead quickly to substantive questions. It is usually important however to make the students ask questions that require more than a, "yes" or, "no" answer. Questions such as, "Is the answer fifteen?" should usually not be directly answered. In answering questions it is productive to show students how to set up a solution to the problem, to name theorems or definitions that are relevant, to show how to check a solution for correctness and so forth. Possible a parallel but different problem and a complete solution can be shown by way of example.

After about 25 minutes of discussion, the last 15 minutes or so of the class period should be used for introducing the next assignment.

Peer Grading From a Student's Perspective

Consider the tasks and interactions of a typical but fictional student by the name of "Armani." Armani also interacts with "Jessie," and "Rory."

After class and before the next class, Armani will correct (or finish) the most recent past homework assignment. If needed, Armani will (re)read the textbook or find help from the professor, peers, or the campus academic resource center, etc. The urgency of this task will be apparent from the peer grading event that was held on this assignment. Armani will typically have two or three days from the time of peer grading until the final due date. This will be the fourth time Armani has encountered a particular subject (say KVL) in the course. (First the introductory lecture; second, working the homework prior to peer grading; third, the peer grading event.)

Also, before the next class Armani will try the new assignment. A diligent Armani will refer to the textbook and find help as needed and invent ways to check answers. Students like that would probably thrive under any form of instruction. However, maybe Armani will skip the assigned reading in an attempt to save time. Some answers will be correctly found, but many will not. If Armani does not have enough time or perseverance to finish well, the peer grading rubric will encourage Armani to at least think about and write something down for each problem. Also,

Armani will want to seem as intelligent as possible while participating in peer grading to get some more tips on how to solve the problems. If Armani just writes garbage, Armani comes across during peer grading as a leech. A few experiences like that usually change behavior. Making homework look as intelligent as possible (with a minimum of effort) might require at least scanning the textbook for something that relates to the problems at hand. Students like this will particularly benefit from peer grading. A very few students will be totally careless. They would probably fail under any system of instruction.

In class, at the start of peer grading, by random chance Armani received Jessie's homework for peer grading. Also Armani's homework was given by random chance to Rory. Armani will review and possibly write remarks on Jessie's paper, then bring it to Jessie and discuss it. Armani will have to work from memory and from what is presented on Jessie's homework in order to grade Jessie's homework since Armani's paper itself is in the hands of Rory.

If Jessie's homework is too messy to read Armani will probably talk to Jessie about that in order to understand the work and thus grade it. This helps Jessie conform to conventional standards of writing. Also, Armani and Jessie will employ the vocabulary associated with the subject and thus become more fluent in speaking about a technical subject.

Armani will also be approached by Rory and another discussion will ensue. Before the end of this discussion both Armani and Rory will have received their peer graded homework back. Then Armani and Rory might make some direct comparisons of each others papers.

When peer grading ends Armani might have seen some contrasting answers from Jessie or Rory. During the discussion period following peer grading, Armani will ask questions of the instructor to try to figure out who is right (if one of them is). A lively discussion usually ensues, which the instructor must moderate in order to give all the students and topics adequate time.

When the new homework is introduced, Armani will take out a notebook and follow the presentation closely because this is a prime time to get some tips on how to do the next homework assignment. Finally, Armani might be in a hurry to meet a friend after class. About three minutes before the end of the class Armani will start packing up and will operate a backpack zipper loudly and in a random chorus with other similarly hurried students to remind the professor that time is nearly up!

Goals of peer grading

The method of peer grading presented here is designed to promote four goals:

1.) To motivate the students to establish regular periodic study times for the subject and to keep up with the course effectively.

2.) To change the focus of learning from earning a grade to understanding the subject well enough to explain it to a peer. Then indirectly, to drive the students to the textbook or other sources more often and to help them identify when to seek help and to do it as early as possible.

3.) To learn how to communicate about technical subjects neatly in writing and to give students opportunities to use the technical vocabulary that goes with the course.

4.) To rapidly identify students who need help and to get them connected with campus resources and services as needed. Indirectly, helping students in a timely way improves retention in the course and in the major.

Mechanics of peer grading

Peer grading requires a different type of preparation for the semester and for each class as compared to a lecture-style course. Before the semester starts it is helpful to have stacks of blank peer grading forms printed, similar to those shown in Figure 1. It is also a good idea to set up some type of course management software so that assignments can be distributed effectively. Since two sets of homework are turned in with each class period, keeping track of what is due with each class is more difficult than with a lecture style class. The author uses a Web page for this purpose, as illustrated in Figure 2.

DORDT COLLEGE ENGINEERING DEPARTMENT
INTRODUCTION TO MICROPROCESSORS AND DIGITAL CIRCUITS--EGR 204
(Spring 2010)

PROBLEM SETS

(Last update: 1/14/2010 2:38 pm)

PS #	Assigned	Due	Returned	Problems Assigned (In Mano & Kime unless otherwise noted)
				Read Ch 2 Sec 2-5, 2-6, 2-7 Do 2-15*, 2-16, 2-19*, 2-31
				Read Ch 2 Sec 2-3, 2-4 Do 2-7*, 2-11, 2-12*, 2-14 Note errata on problem 2-12* Note errata on page 60, Figure 2-9(b) Note on 2-14: "Optimize" means to "simplify" as shown by several examples in section 2-4.
				Read Ch 2 Sec 2-1, 2-2 Do 2-1*, 2-2*, 2-10*
				Read Ch 1 Sec 1-4 through 1-7 Also read about binary prefixes from NIST Optional--read more about binary prefixes here. Do 1-10*, 1-22, 1-24, 1-25*
1	1/13	1/15 1/18		Scan Chapter 1. Read Sections 1-2, 1-3 Do 1-4, 1-5, 1-6, 1-7*, 1-8, 1-9* Note: The answer to 1-5 must be exact.

Figure 2, Posting of homework assignments for a peer graded class. The first due date is for peer grading. The second due date is for regular grading. Assignments without dates will be assigned next, allowing students to work ahead.

The author weights each student's average of all peer grades as 2.5% of the entire course grade and the average of the regular homework grade as 7.5% of the entire course grade. (Thus the homework as a whole is worth 10% of the course grade.) Many students request higher weighting for peer grades and for homework grades, but higher weights encourage too much copying and cheating. Even these relatively low weights adequately motivate students.

Some students will be absent from class from time-to-time for various reasons (sports, work, music, illness or medical condition, etc.) These students can be instructed to give their

homework to a classmate. The classmate then shepherds the homework through the peer grading process in class. This results in more papers to peer grade than there are students in the classroom to do the peer grading. Either the instructor can peer grade a paper, or if there are several, some students can be asked to peer grade two papers. The extra papers are then returned to the classmates who brought the papers to class.

In order to achieve the benefits of rapid feedback that peer grading can offer, it is important to grade all homework between class periods so that there is no grading backlog at all. It is also helpful to use course management software to distribute grades to students in a format that allows students to see the trends of their grades.

Finally, it is important to analyse the grades about every week during the first month or so of the class in order to rapidly identify students who need help. Figure 3 shows a spreadsheet of peer grades from an actual class the author taught. (The names have been changed.) Here a "4" represents an "A," a "3" is a "B," a "2" is a "C" and a blank or a dash is an "F." After just three peer grades (one week of class) it is clear that Jana Fulton, Jean Islos and Jarad Olthof, and Jenny Quade need help. Jenny and Jana's grades show improvement after intervention.

F	G	H	I	J	K	L	M	N	O	P
:	Assignmer	Assignmer	Assignmer	Assignmer	Assignmer	Assignmer	Assignmer	Assignmer	Assignmer	Assignmer
John Adams	4	4	4	4	4	4	4	4	3	4
Jane Baker	4	4	4	4	4	4	4	4	4	4
Jim Colter	4	4	4	4	3	4	4	4	-	-
Jill Doe	-	4	4	4	4	4	4	4	4	4
Joe Elton	4	4	-	4	4	4	3	4	4	4
Jana Fulton	4	-	4	-	4	4	4	4	4	4
Jake Gross	4	4	4	4	4	4	4	4	4	3
Jerry Hoff	4	4	4	4	3	3	4	4	4	4
Jean Islos	-	-	-	-	-	-	-	-	-	4
Jeff Knopf	4	4	4	4	4	4	4	4	4	4
Judy Lubbers	4	4	4	4	3	4	4	4	4	4
Josh Miller	4	4	4	4	-	3	4	4	4	-
Julia Nydam	4	4	4	-	-	-	2	4	3	4
Jarad Olthof	-	-	-	-	-	-	-	-	-	4
Joy Pearson	4	4	4	4	4	4	4	4	4	4
Jenny Quade	-	-	-	-	4	4	4	4	3	2
Jason Ross	4	4	4	4	4	4	3	4	3	4
Jessica Stryd	4	4	4	4	4	4	4	4	4	4
Jordan Todd	4	4	4	4	4	4	4	4	4	4
Jodi Ulman	4	4	4	4	4	4	-	4	4	4

Figure 3, Typical peer grades from about the first three weeks of a peer graded course. Students in need of help can be rapidly identified.

Although peer grading has drawn strongly positive reviews from students on end-of-semester course evaluations, a few students will object to peer grading. These objections tend to fall into three distinct categories.

First, there may be students who simply don't want to do homework, and will not do it, no matter what the system is. One or two of these may be geniuses who are not challenged by the material. For the sake of saving time, they will prefer to listen to the classroom discussion before attempting the assignment, if they even attempt the assignment at all. They will also be willing to suffer the loss of peer grading credit (and possibly homework credit) since they will easily make up for it with perfect or near perfect test scores. Others might not be geniuses. They

probably will fail for lack of a work ethic, no matter what style of course delivery is used. Either way, the student's objection to peer grading is really an objection, valid or not, to work in general.

Second, occasionally a student might be socially withdrawn or insecure when discussing mistakes on homework with another student. This type of student might turn homework in for regular grading but not for peer grading. The author attempts to reach out to such students and connect them with student organizations such as ASME, IEEE, or any affinity group that might be helpful. Grades do not typically measure social skill or self confidence, but this pattern represents an opportunity for the student to improve.

Third, there are students who object to peer grading because of the frequency with which they must do homework, compared to a weekly frequency. Perhaps they have heavy work commitments for three or four weeknights in a row. This complaint can be sidestepped by posting about a week of homework in advance. Then students who raise this objection can be asked to simply work ahead as needed. A few students will take advantage of this opportunity and truly benefit. In any case, complaints are avoided.

Results

Peer grading improves the attitudes of students toward the class and consequently improves scores instructors receive on student evaluations of instruction. The students get to know each other and the instructor better on account of the increased interaction. The author's institution has an open ended question on the prescribed evaluation from which asks, "What should the instructor continue doing?" In a recent peer graded class of 20 students, 14 responded to this question. Six of the responses were positive remarks about peer grading such as, "Peer grading is always helpful to me." In this particular class, there were no negative responses regarding peer grading in any portions of the student evaluations. Although sometimes there may be one or two negative remarks about peer grading, these are outweighed several times over by positive remarks.

More gets done in the course. More homework problems can be assigned since the students are working at them on a regular basis. More challenging work can be assigned since there are more opportunities to offer guidance in their solutions. More textbook pages can be covered since students are directed to the text more frequently. There is much more discussion in class and the discussion tends to be more focused on challenging issues.

Students develop better study habits. They learn that help is available if you tackle the homework early enough to have time to seek help before the due date. They learn constructive methods of collaboration such as discussing the theorems or techniques needed to solve the problem rather than answering simple questions such as, "did you get 52 volts for Problem 2?" In the author's experience, these good study habits get paid forward to other courses the students take later, even if those courses are not peer graded.

It is possible that retention could be improved by using peer grading. However the author has only had the chance to apply this technique to courses where retention was traditionally quite high, about 96% from the first week to the last week of the course. This was because the course was in the student's major. Thus the instructor does not have enough comparable data to make a statistically meaningful statement. Certainly students who are seriously struggling can be identified within two weeks. Help can be offered earlier by giving attention to peer grades

earned on the first two or three weeks of assignments. In the author's experience, only about half of these identified students respond constructively. However, that is a few students saved from failure or lower grades, who otherwise would not have received help in time for it to matter.

Courses that work best with peer grading

Peer grading works best with freshman or sophomore level classes where students still are learning how to study and how to manage their time.

Peer grading also works best in class sizes of about 6 to 25 students. If there are too few students then familiarity causes less accountability. The author has used it in classes of up to about 35 students, but then the logistics of carrying out peer grading during class in about 10 minutes becomes difficult. There will be too many students desiring to ask question to give everyone a chance to participate in the discussion. The discussion time becomes harried. There will also be one or two students who become passive and allow others to ask questions for them.

The course needs a good textbook. Students will be learning primarily from the textbook and the book needs to have an adequate variety of problems to cover each main topic in the text. Sometimes supplemental information also needs to be provided in written form. There will not be enough class time to lecture over supplemental information.

Course management software such as Blackboard, Desire2Learn, Moodle, etc, can be very helpful for keeping the peer grading process well organized and for informing students of trends in their performance.

Conclusion

Students like peer grading because it keeps them on task with a regular, predictable, workload and because it helps them know when to seek help. Faculty members like peer grading because more gets done in the course, the students are happier, and course evaluations improve. Sometimes peer grading is what should be done!

Reference

Prince, M. J., & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education*, 95(2), 123-138.

Author Biography

DOUGLAS F. DE BOER is a Professor of Engineering at Dordt College in Sioux Center, Iowa. His Ph.D. in electrical engineering is from the University of Colorado at Colorado Springs, 1995. His master's (1978) and bachelor's (1977) degrees are from the University of Michigan, Ann Arbor.