Session 3147

Promoting Critical Thinking Skills
Through Effective Grading Techniques

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Abstract

Walvoord and Anderson have demonstrated that "effective grading" techniques can be applied to promote and teach higher-level critical thinking skills in the classroom. Effective grading involves the appropriate structuring and communication of course assignments and grading systems which promote desired learning behaviors. Grading and assignment techniques which force the student's first exposure and reflection of the material "off-line," prior to classroom discussion, enable classroom interaction to leap beyond the dissemination of factual information and into the higher levels of Bloom's taxonomy: application, analysis, synthesis, and evaluation. Immediate feedback provided by in-class instructor-student interaction allow the instructor to guide and train students in the practice of critical-thinking at the "teachable moment" and prior to its exercise on major assignments or exams.

This paper provides examples of the application of effective grading techniques to promote higher-level critical thinking within the engineering technology classroom and suggests techniques and technologies which can be applied to overcoming barriers to these strategies.

I. Introduction

Common approaches to the promotion of critical thinking involve the application of "active learning" in the classroom and writing assignments outside the classroom.

Schrivner[1] has cited the difficulty in motivating students to participate, noting the importance of setting an expectation of participation in classroom dialog. Another common frustration is the difficulty in finding time to move class room time beyond the first few levels of course material introduction and application while still fitting all the desired topics into the course.

Writing assignments have gained popularity as a means of allowing students to practice their critical thinking skills. This resurgence is due in part to the Writing-Across-the-Curriculum (WAC) movement. WAC theorizes that in the process of writing, students practice better thinking skills.[2] Agrawal[3] and Sharp[4] are among some of the engineering educators who have incorporated such writing assignments into their curricula. Writing assignments may be in-class assignments, such as a minute paper. Sharp has noted one of the major deterrents of writing assignments: instructor time spent in grading. She suggests strategic alternatives to circumvent the grading chore: student conferences.

II. Walvoord and Anderson's Assignment Centered Course

Walvoord and Anderson[5] have noted that aside from the burden of grading written assignments, an even bigger problem is the inadequacy of instructor feedback on written work. Figure 1 depicts a course in which students must wait for written work or exams to be returned before they gain access to instructor comments that might help them better hone their critical thinking skills. By then, the student has likely lost interest; the "teachable moment" has been lost.[6]

Walvoord and Anderson's approach attempts to move the feedback stage earlier, into the classroom, by placing on students the responsibility of gaining initial exposure to the course material prior to the class meeting time. Grading strategies are developed which require student participation in strategic reading and critical thinking assignments in order to prepare students for an instructor-led discussion in the classroom. There is then time in the classroom to move students from their first-exposure, lower-level comprehension levels to learning levels involving application, synthesis, and evaluation. In Walvoord's model, students must bring two copies of their assignment to class: one to turn in for assignment credit, and the other for personal reference and student note-taking during the classroom discussion.[6]

The assignment-centered course brings instructor feedback into that teachable moment when students bring their unanswered questions or underdeveloped answers to class. Feedback is interactive, immediate, and shared with all students, not confined to a few words in red jotted on one student's paper returned another class period or more later.

Figure 1 depicts key differences between the assignment-centered class and a traditional class.

- Students get feedback on their work almost immediately upon submitting it, when many are still interested in the rightness of their approach.
- Instead of introducing the new material, faculty can take up where student preparation left off in order to hone student critical thinking skills.
- Faculty are alleviated from having to thoroughly mark-up myriad student papers. The students have obtained their feedback during in-class discussion.
- Faculty are alleviated from having to make repeated written comments when many students have similar problems in their work. Instead, the instructor addresses common mistakes once during the classroom discussion.

The Assignment Centered Course strategy may be considered a "grading" strategy for multiple reasons: (1) the feedback portion of grading is made more efficient and effective by brining it

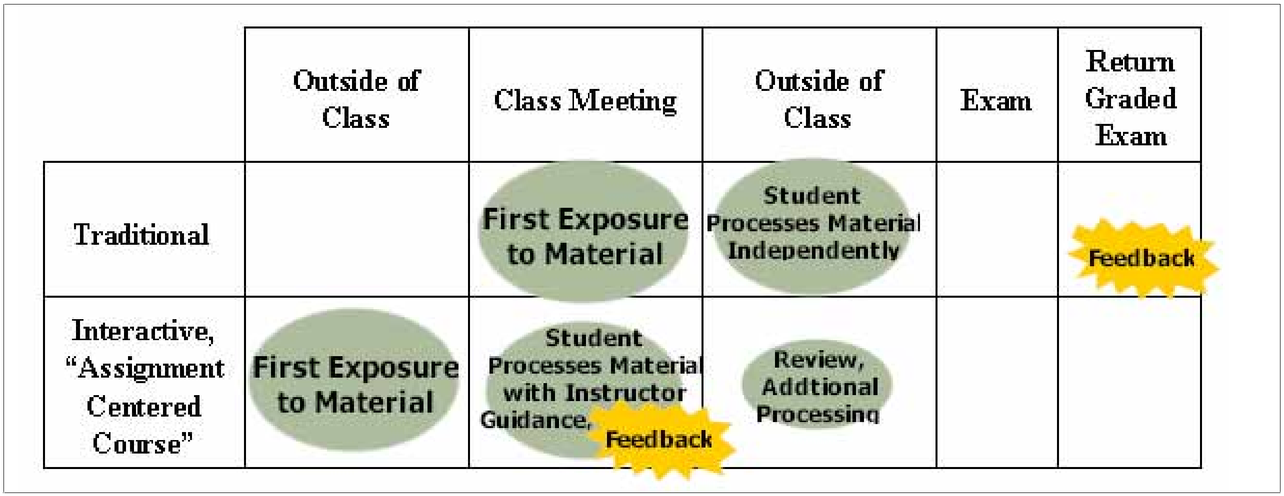

Figure 1. Timeline of student exposure and feedback on course material.

into the classroom, and (2) the requirement of doing the reading and putting a "good faith effort" into the written assignment is built into the overall course grading structure in order to ensure motivation for students to come prepared. The system provides students both motivation and guidance in their preparation and enables student and instructor alike to make the most of the class meeting time. Walvoord practices a dual system of grading which does not average assignment credit into the overall grade, instead allowing the student's overall course grade to be no higher than the lower of the "graded" work or the assignment participation. This prevents students from relying on exam grades to raise the ruin of meager participation credit.[6] I have found that students are motivated well enough simply by an averaged-in participation component.

III. Application of the Assignment Centered Course to the Engineering Technology Classroom

I began applying the concept of the Assignment Centered Course to two different Engineering Technology courses in an effort to combine my attempts to simplify grading, encourage more active participation in class, and to shift curricular topics toward higher levels of critical thinking: analysis, synthesis, and evaluation.

<u>Junior/Senior Level Automation Course</u>

I created a component in my course grading system called "participation and homework" and promised students one point of credit for every good-faith attempt at answering an assigned "reading question." Assignments earlier in the semester were chosen to help guide students through the readings and teach them how to classify, compare, categorize, differentiate, or value automation technologies and their possible applications. Figure 2 is an example of an assignment in which students exhibit comprehension (distinguishing between terms) and application (of manufacturing costs). Figure 3 provides an example of an assignment that asked students to synthesize (categorizing or deducing what sort of manufacturing system might be appropriate) and evaluate information (judging and defending an answer).

Reading Assignment

Read Sections 1-4 and 1-5 in your Rehg textbook (pgs. 7 - 17). Answer the following questions:

1. Differentiate between *order-qualifying* and *order-winning* criteria.
2. Suppose you had to determine the *burden rate* which would be applicable for a new automated machining cell. What kind of costs would you have to project in order to determine the burden rate?

Figure 2. Homework assignment challenging students to practice higher order thinking skills prior to classroom exposure.

Freshman Level Technical Problems

In a technical problems course in trigonometry and algebra, I found that students more easily approach application, evaluation, critical thinking, and judgment when they have been thinking about the problems before coming to class. In addition to traditional homework problems to be worked following a thorough class discussion, I also assigned a problem or two which stretched students into a preview of the next day's discussion. Preview problems stretched my students from a mode of "work following my example" toward an approach which required them to brainstorm from their own problem-solving knowledge or to research the text to develop a workable solution strategy.

One strategy to get students thinking about the material before the lecture is assigning select example problems for students to work through. I find this practice accomplishes two goals: (1) Student at least come the classroom having familiarized themselves with the type of problem we will be working. Hopefully they have identified what is being asked and maybe even started to look at the steps suggested toward a solution. (2) Students who put some attention into working the steps out often do identify steps that they don't understand, and they come to class ready for answers to the hurdles they encountered.

A second strategy is to assign simple introductory problems in the next section (yet to be discussed in class), but to introduce a few hints toward their solution. I encourage the students to at least set up the problem and put a good-faith attempt or start into solving it. This procedure also forces students to identify the problem. Unlike the assignment of an example problem,

ISTC 3640 Automated Production Techniques - Spring 2000

Reading Assignment

Read Sections 1-6 and 1-7 in your Rehg textbook (pgs. 17 - 23, including the figure and table on p. 23). Answer the following question. (For some there is more than one right answer.)

For the following products, suggest which type of manufacturing system would be appropriate: project, job shop, repetitive, line, or continuous. Explain your reasoning.

Product	Manufacturing System Type	Reasoning
ball point pens		
aftermarket automotive parts		
electronic calculators		
robot grippers (available from catalog)		
custom motorcycle parts		

Figure 3. Critical thinking assignment for the exercise of synthesis and evaluation.

students can't simply copy down the steps given in the book. This strategy may encourage students to look back at the example problems in the text for guidance, but it may also quickly discourage students who are less motivated toward learning on their own. When compared to the example problem strategy, this method does a better job of helping students identify the problem at hand, since they are held responsible for setting up the problem, if nothing else. Pre-worked example problems in the text sometimes do not make clear the distinction between the definition of the problem and the steps toward the solution.

Other strategies developed to stretch student thinking concerning math-oriented application problems included:

- Assigning students to “set-up” an application problem prior to coming to class. Students had at least thought about the problem before coming to class and had been given the opportunity to mull over it. Students tended to be interested in the answers they didn’t know.
- Assigning a “challenge problem,” which acknowledged that the problem went a little beyond the examples we had previously visited.
- Moving beyond the required solution of an application problem with higher-level questions over a just-worked problem: “How do we know this answer is reasonable?” “How confident are we in the precision of that answer?” “What would be another approach to the same problem?”

All of these strategies are furthered by a grading system that provides incentive and credit for putting a good-faith attempt toward the problems. This allowed the assignment of material that stretched students to attempt (and therefore expose themselves to) levels of work that have not yet been taught. Students were then ready for instruction on the points that proved to be hurdles.

IV. Results

New automation curricula, small class sizes, and lack of comparison control data prevent conclusive results. However, anecdotal evidence from the two classes suggests students who are more engaged in the learning process. I have noticed students more involved in questions beyond what was required to simply get a “right” answer: “I see now how that way is right, but I got the same answer doing it this way. How did that happen?” “Doesn’t this provide enough significant figures [for our purposes]?” “Couldn’t you use pneumatics for that application?” Questions like this from students also motivate me as an instructor to appreciate the depth and diversity of solutions and to share that appreciation with students.

Gauging from the feedback I received from class discussions in the automation course, I began including more and more exam questions requiring application, synthesis, and even some evaluation. I expected the open-ended questions to shake some students but the scores were very high, averaging in the nineties.

One concern regarding the in-class feedback method is that students must be responsible for gleaning their feedback from the classroom discussion, since individual student submissions will not be scrutinized by the instructor on a regular basis. Students must be able to ask questions and also evaluate comments on other student answers to determine the adequacy of their own work. In a way, this concern actually is another plus, since it forces concerned students into the role of one of the highest-levels of critical thinking: evaluation. However, students who struggle with this role may miss vital feedback and fail to recognize inadequacies in their work.

Diligence is required on the part of the instructor to watch for students who are struggling. The instructor still has the submissions of student work to look over for participation credit and can therefore get a sense of student performance and watch for struggling students. I look for opportunities to encourage and provide openings for struggling or hesitant students to ask questions, either as part of the class discussion, my interaction with small group in-class work, or more privately outside of class.

Ultimately, the responsibility does fall upon the student to be attentive to the classroom discussion, catch his own errors, and solicit feedback prior to the exam. I periodically remind students that the privilege of ungraded assignment credit comes with this responsibility, and I repeat my willingness to meet with students who still have questions about their work.

Another concern for assignment-centered courses in engineering technology is the need for text material or other media that adequately present comprehension-level concepts to the student. Walvoord cites an example of a physics professor who recognized that no text was available which undergraduate students would be capable of comprehending without lecture explanation. His approach to free-up classroom time to address problem solving was to videotape his lectures and then require students to watch the video on their own time; class time was reserved for instructor-led feedback and development on the homework problems.[6]

In my own classes, feedback from students following their attempts to work example problems in the text before a lecture sometimes revealed a lack of understanding of the textbook explanations. Students were more successful when presented with a little hint at direction toward solving the simplest of problems in that new set. Students who could not understand the text's worked examples, could often figure out solutions to problems in the homework section if a strategic hint was given beforehand. This may perhaps reflect more of a lack of persistence in attempting to understand a problem that is so easy to simply copy down without understanding. It could also attest to differences in learning styles and the unfamiliar route of deciphering a problem backward from its solution rather than forward from an unanswered question.

The reality of the situation is that even with good texts, many of our students have never been truly forced to digest the text explanations on their own. I have found that strategically chosen assignment questions can often lead students step-by-step through text material, presenting structure to material and direction to a reading that might have otherwise daunted them.

V. Conclusion

Although the assignment-centered course requires extra attention to assignments, classroom discussion questions, the instructor is compensated by the ease and efficiency of non-written feedback provided to students in class during discussion of their assignments.

Anecdotal evidence indicates that grading strategies that promote student preparation and instructor-led critical thinking in class can effectively increase student participation and ability to practice critical thinking in classroom discussion and on exams.

Bibliographic Information

[1] Schrivener, S., Fachin, K., and Storey, G., "Treating the All-Nighter Syndrome: Increased Student Comprehension Through an Interactive In-Class Approach," *Journal of Engineering Education*, April 1994, p. 152.

[2] Lang, D., "Critical Thinking in Web Courses: An Oxymoron?", *Syllabus*, Vol. 14, No. 2, September 2000, pp. 21.

[3] Agrawal, P. K., "Integration of Critical Thinking and Technical Communication into Undergraduate Laboratory Courses," Proceedings of the 1997 ASEE Annual Conference, Session 1213.

[4] Sharp, J. E., "'Ungrading': Adding Learning Intensive Writing Assignments without Increasing Grading Load," *Proceedings of the 1997 ASEE Annual Conference*, Session 2647.

[5] Walvoord, B. and V. J. Anderson, *Effective Grading: A Tool for Learning and Assessment*, Jossey-Bass Publishers, San Francisco, 1998.

[6] Walvoord, B. "How to Make Grading Fair, Time-Efficient, and Effective for Learning," Interim Workshops on Grading, Teaching and Learning Center, University of Nebraska-Lincoln, January 3, 2000.

Biographical Information

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