You Bet Your Grade! Using Exams to Promote Student's Self-Assessment

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Abstract

This paper reports on a technique used by the author in his ECET courses to help students develop an awareness of their own level of competence and knowledge. This knowledge, when successfully developed, enables the student to study more effectively and efficiently by concentrating on those areas in which his or her self-evaluation reveals weakness. It enables the student to avoid the nightmare scenario of believing she or he is thoroughly prepared for an exam (and possibly even walking out of the exam confident of receiving an "A") only to find his or her performance was much lower than expected.

The instructor may help the student develop this awareness by offering a tangible reward to those students who demonstrate it. The student is rewarded by requiring him or her to identify the exam problems she or he is most confident of having solved correctly, in effect "betting" on those problems. The point value of the problems the student "bets" on are approximately doubled, giving the student a significant incentive to "bet" wisely.

Exams are divided into three sections, with each section requiring greater problem-solving skill than the previous one. The student is required to "bet" on two problems in each section. After completing all three sections the student is asked to estimate his or her overall score, and receives 2, 1 or 0 additional points depending on the accuracy of her or his estimate. This is an additional reward to the student for accurately assessing his or her own knowledge level. The exams described here are too lengthy for most students to complete in one class period, so they are given as take-home exams.

Introduction

The technique described here was suggested by a presentation given by Prof. Randy Isaacson at IPFW in March, 2004 entitled "What Happens When Students Don't Know that They Don't Know"[1]. Experience has shown that students often think they are well prepared for an exam when they really are not well prepared. The result is that the student performs poorly on the exam and receives a lower grade than expected. Almost everyone has had the experience of going into an exam believing they knew the assigned material backwards and forwards, only to find that they were not as prepared as they thought. Most students (and instructors, who were once students) have also had the experience of taking an exam and thinking they performed very well, only to find that they received a much lower grade than expected. Both experiences are the consequence of not knowing that they didn't know what they needed to know. Students who exhibit this problem on a regular basis invariably become discouraged, believing that they are not smart enough to perform well or that the instructor is not doing a good job of teaching, and may unnecessarily drop the course or drop out of school. While the instructor may be partly at fault, the student's performance can usually be improved through better preparation and improved metacognitive knowledge monitoring.

Metacognitive knowledge monitoring is the skill of reflecting on one's learning to judge your level of mastery. Research on metacognitive knowledge monitoring has demonstrated a relationship between academic success and accurate reflection on learning. Research using the Knowledge Monitoring Assessment (KMA) developed by Tobias and Everson has shown that learners of all levels and developmental stages are impacted by their ability to monitor their learning. [3] Classroom research in college setting by Hacker et. al. (2000) [4] and Isaacson and Fujita (2001) [5] has illustrated a striking difference between high and low performing students in their ability to predict their test scores: successful students were able to accurately estimate their grades before taking a test, while students who were on the verge of failure were likely to over-estimate their future performance.

Many instructors have also encountered students who habitually overprepare for exams. While these students usually perform extremely well, they spend more time preparing than they need to. This may have an adverse impact on the student's personal life or on performance in other courses. The instructor may not be aware that a student has this problem, because this student usually gets good grades. Such a student doesn't know that he or she does know the material, and compensates by overpreparation.

The take-home exams described here are designed to encourage students to become aware of their own level of preparation, by rewarding them for knowing how well prepared they are and for thinking about ways to improve their preparation. The rewards are given in the form of points, some of which are given when students identify those problems which they are most confident of having solved correctly, some given when a student accurately estimates his or her score, and some are given for writing a statement reflecting on his or her preparation and ways to improve it in the future. Finally, students are invited to challenge, in writing, any problems they feel are unfair or contain errors.

These exams also test student knowledge in greater depth and breadth than would be possible if in-class exams were used, because they are given 24 to 48 hours to complete each exam. Students are permitted to use their textbook, notes, and other references, but are not permitted to work together.

Use of these exams has resulted in better student preparation, better learning, and better evaluation of student learning. In the course of taking an exam, a student may discover that his or her preparation was inadequate, but because it is a take-home exam that student has some time and resources to take remedial action. This results in better learning by motivating the student to fill those gaps in his or her knowledge right away instead of later. The student is also motivated to think about ways to prepare better for the next exam. Finally, the time given for a take-home exam allows the instructor to include more problems, and to include problems which require more thought on the part of the student. While any assignment which is completed outside of class presents an opportunity for students to cheat, cheating has not proven to be a serious problem with these exams. To some extent, cheating has turned out to be a self-correcting problem.

Three Sections

This type exam is usually divided into three sections, each of which contains six problems. The first section is designed to test the student's ability to apply basic principles, and contains problems which are relatively easy to solve. The second section consists of problems which are somewhat more challenging, and are designed to test the student's ability to synthesize two or more basic principles, and the third section is designed to test the student's ability to extend basic principles slightly.

A typical Section I problem for an introductory electrical circuits course would require the student to apply Kirchhoff's current law to a simple network to find the current flowing in a resistor, or would ask whether an LED is lit based on the polarity of the battery connected to the LED. Each Section I problem requires a simple calculation or analysis using a single principle, such as one (but not both) of Kirchhoff's laws or Ohm's law. Relatively little insight or analysis is required in Section I, and any student who has made an effort to prepare and understand the material is very likely to do well. Students who perform poorly on Section I do so because they are unprepared, and they are usually unmotivated. These students should be counseled by the instructor.

Section II problems require a somewhat greater degree of insight and are designed to test the student's ability to synthesize a solution using more than one principle. Referring to the bridge circuit shown in Figure 1, a Section II problem may ask the student to determine the value of R_4. This can be done by applying both Kirchhoff's voltage law to find the voltage drop across the resistor and then calculating the resistance using Ohm's law. Two basic circuit laws are used together to solve the problem.

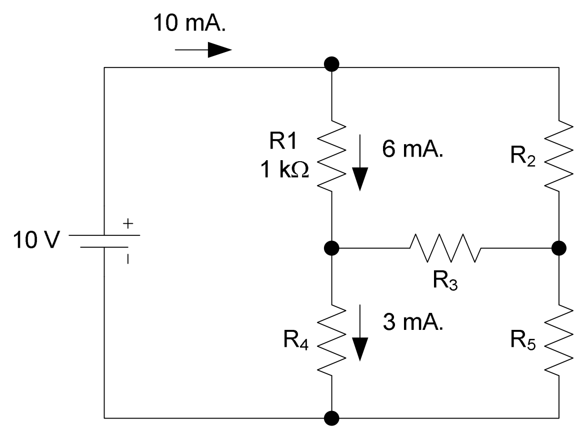

Figure 1
Bridge Circuit

Some students have difficulty with problems of this type, but anyone who has tried to prepare can completely solve some and partially solve all of them. The student who has difficulty with one or more Section II problems quickly becomes aware of the deficiency in his or her preparation, and because time and references (textbook, notes, etc.) are available may be able take corrective action while completing the exam. The student also begins to think about ways to prepare better for the next exam.

Section III problems require a significantly greater degree of insight and understanding than Section II problems, but they never require students to learn material which has not been presented in the textbook, the lectures, or both. Section III problems require students to assemble the "building blocks" (that is, the basic principles) they have been provided in ways which may be different than they are used to, or which may be more complex, or which require greater insight than Section I or Section II problems. For example, referring again to Figure 1, a Section III problem might ask "what is the resistance of R_3?" The student must recognize that Kirchhoff's Current Law can be used to obtain the current flowing through R_3, which is not very difficult. The student must also recognize that Ohm's Law gives the Voltage drop across R_1, also not very difficult. Next, Kirchhoff's Current Law yields the current flowing through R_5, which is slightly less obvious. Ohm's law provides the Voltage drop across R_5, and Kirchhoff's Voltage law yields the voltage drop across R_3. Finally, Ohm's law is used to calculate the value of R_3. Each individual part of the solution is simple and straightforward, but it is a challenge for the student to identify the principles which are needed and the order in which they can be applied to formulate a solution.

Section III problems are *not* "trick" questions, and are not intended to entrap students into giving incorrect solutions. The intent of Section III is to make the students think at a higher level, and the ideal Section III problem requires thought, insight, and a little creativity. Some students object to being required to think at this level, but any student who can solve at least two of the six and knows which two to check as "front" can get a decent overall score.

The very best Section III problems can be solved correctly using a very simple, easy, but unobvious approach, or a laborious, tedious, more obvious approach. The student who has enough insight to see the easy way to solve the problem is rewarded by not having to work as hard. Another student who takes a more plodding approach may have to work considerably harder, but still arrive at a correct solution and be rewarded for tenacity. Here's an example from a Digital Signal Processing class, intended to test the student's understanding of the phenomenon called "aliasing" using an everyday example: "An airplane is idling on the ground, with its two-bladed propeller turning at 1794 RPM. It's filmed using a camera which shoots 30 frames per second. To a person viewing the film, what does the speed of the propeller appear to be?" A clever student would realize that the apparent speed of the propeller is the difference between the actual speed (1794 RPM) and the "sample rate" (1800 frames per minute), or 6 RPM. A tenacious and competent student would reason it through by calculating the number of degrees the propeller turns between successive frames, and determine the apparent speed in that way.

The bridge circuit problem described above can also be used as a Section III problem if it is given before bridge circuits are explicitly covered in the text and lecture. While the students may not have learned specific techniques for analyzing a bridge circuit quickly and efficiently, as long as they are familiar with Ohm's law and Kirchhoff's laws those who think the problem through can arrive at a solution without too much trouble.

The motivated student can formulate partial solutions for most Section III problems, and come pretty close to a correct solution for two or three. The best students can solve most of them correctly, and come pretty close on the rest.

You Bet Your Grade!

Students are rewarded for developing awareness of their own degree of knowledge with regard to individual problems by requiring them to identify the two problems in each section they feel most confident of having solved correctly. These problems are marked "front", while the other four problems in each section are marked "back". Problems marked "front" are worth more points than those marked "back" in each section, so the student who knows which solutions are correct (i.e., the student who "knows what he or she knows") is rewarded with a better score than the student who "doesn't know that he or she doesn't know". Experience has shown that the best students consistently identify their correct solutions. Average and above-average students who have tried to prepare also do well, but are less consistent. These students usually improve their ability to identify correct solutions over the course of a semester. It appears that rewarding students for knowing what they know and what they don't know does, in fact, lead to improvement in this regard.

Poorly prepared students often make mistakes when they identify what they think are their best solutions, but even students seem to show improvement from one exam to the next, if they are motivated to improve their grade. The only students who don't seem to respond to this technique are, not surprisingly, those who lack motivation.

On a typical exam, Section I problems are worth 3 points if marked "back" and 5 points if marked "front", Section II problems are worth 4 and 8 points, respectively, and Section III problems are worth 5 and 10 points. The student who scores perfectly on the eighteen problems of Sections I, II and III receives 94 points for problems.

Next, the students are asked to estimate their score for the 18 problems and are rewarded with 1 point for coming within 5 points of their actual score, or 2 points for coming within 2 points. This is a small reward, but most students seem to value it. When exams of this format were first used this part was called a "bonus" question, but many students thought "bonus" meant "extra credit" and felt cheated because a perfect score and an accurate estimate resulted in an overall score of 100 points instead of 102. This part of the exam was renamed "You Bet Your Grade!" to correct the misunderstanding.

Reflective Statement

The Reflective Statement was added at the end of the Spring, 2004 semester in order to improve student preparation by explicitly rewarding students for reflecting on the methods they had used to prepare for each exam. The preceding sections of the exam reward students for identifying those areas in which they are well prepared (knowing what they know) and for identifying areas of inadequate preparation (knowing what they don't know). This section rewards them with a maximum of four points for reflecting on ways to improve their preparation in those areas they have identified as inadequate. Each student writes a statement, usually one or two paragraphs in length, in which they describe their preparation methods, analyze their strengths and weaknesses, and propose ways to prepare better for subsequent exams. This is easiest for excellent students, who need little improvement, and poor students who need to improve almost everything. Average and above average students need to put the most thought into it, but most students seem to derive a benefit from being required to think about ways to improve their exam preparation.

Challenge

The Challenge portion of the exam was also added at the end of the Spring, 2004 semester. Students are invited to challenge in writing any problem which they think contains an error or which they feel is unfair. This has proven beneficial in several ways. First, exams do sometimes contain errors which may be brought to the instructor's attention in this way. If a student identifies an error (which may show greater understanding of the material than a correct solution to a correct problem) he or she may receive partial or full credit for the problem. At the same time, a student who does not recognize the error (exposing a lack of knowledge) does not receive credit. This means a problem which contains an error in formulation may still be used to evaluate student learning.

A student may also challenge a problem as unfair, on the grounds that it requires knowledge of material which has not yet been presented. While it is rare for such a challenge to be successful, there have been occasions when unfair problems were inadvertently included in an exam and were successfully challenged. This situation is usually resolved by giving all students points in compensation. Students who successfully solve such a problem in spite of its unfairness are, in effect, rewarded for their extra effort with extra credit, while those who did not solve the problem are not penalized for the instructor's error.

Cheating

Take-home exams are inherently vulnerable to cheating, because students have the time and the opportunity to collaborate. Some instructors may choose to allow or encourage collaboration, because learning is often enhanced when students work together. This is, of course, up to the individual instructor. If an instructor chooses not to allow collaboration, many of the common techniques for control of cheating, such as multiple exam forms, are as applicable to take-home exams as to in-class exams. They have not proven to be necessary with the exams described here, because unauthorized collaboration can be addressed by preventive action at the beginning of a semester. This is done by detecting collaboration on the semester's first homework assignments, and confronting the students who have collaborated. When cheating students are shown how easy it is to detect collaboration, and when the consequences of future offenses are explained (e.g., failing the assignment, failing the course, or expulsion) are explained, most students recognize that it is better not to collaborate when collaboration is not permitted.

Cheating on take-home exams or homework assignments is usually easy to detect, for reasons which are easily explained to students: 1. excellent and above-average students usually don't cheat, because they don't need to; 2. average and below average students only collaborate with each other (see reason 1); 3. when a student who doesn't feel he or she can solve a difficult problem copies a solution from another average or below average student, he or she is likely to copy another student's incorrect solution; 4. While there are usually only one or two ways to solve a problem correctly, there are an infinite number of ways to solve it incorrectly; 5. When two students turn in identical incorrect solutions, there is a very high probability that one copied the other's mistakes. This is always explained to students on the first day of class, but some of them always seem to need to be caught in order to realize it applies to them. Most such students, when warned, don't cheat again.

Conclusion

The exam format described here has been in use for two semesters in courses which range from introductory electrical circuits (freshman year) to digital signal processing (junior year) with good success. The format seems to have improved both student learning and the evaluation of student learning. Opportunities for additional investigation include analysis of the correlation between identification of correct solutions and overall test score, and analysis of the link between the reflective statement and improvement on subsequent exams.

References

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