

No More Tests: Extending Cooperative Learning to Replace Traditional Assessment Tools

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Abstract

Active and cooperative learning address a variety of learning styles that lead to improvements in students' abilities to retain what they learn, as well as providing other positive educational outcomes. In contrast to cooperative learning, traditional testing methods have no correlation with engineering practice and assess only a limited set of lower order cognitive skills under unrealistic conditions. The whole argument for active and cooperative learning is lost at the critical step of assessing student performance when traditional testing methods are used. To address this issue, an assessment method that encourages cooperative learning and requires application of higher order cognitive skills was developed and used to replace traditional testing methods.

The assessment method uses an open-ended problem format. The students receive the problems at the beginning of each major topic sequence, usually working three to four problems during a semester. The problems are purposely designed to be difficult and broadly focused so that the students must seek help from their peers and the professor, and search the professional literature and use engineering reference works. Success is unlikely if students do not work together. The problems become the focus of in-class discussion and out-of-class work, creating a cooperative relationship among the students.

A survey was developed and administered to approximately 60 sophomore through senior civil engineering students who have experienced the assessment method. The survey was designed to help understand the students' perceptions of the problems relative to traditional assessment methods and to provide empirical evidence of how the problems have influenced their learning habits.

1. Introduction

It has been generally established that active and cooperative learning address a variety of learning styles, that they improve the students' abilities to retain what they learn, and that they lead to other positive educational outcomes [Felder et al, 1998; Terenzini et al, 2001]. Hagler and Marcy [1999] convincingly argue that the emphasis on learning is misplaced if the classroom is the primary focus since most of the students' time spent on learning is not spent in the classroom. Consequently, activities to promote learning that involves higher order cognitive skills [Zoller, 1993; Zoller et al 2002] outside of the classroom are vital and deserving of thoughtful attention if optimal learning is to occur. Also, traditional testing methods place students in an unrealistic setting that has no basis in engineering practice and are able to assess only a limited set of lower order cognitive skills under artificial conditions. The whole argument for active and cooperative learning is lost at the critical step of assessing student performance when traditional testing methods are used.

At a Sooner City [Kolar et al, 2000] workshop held on Oklahoma State University campus during early August 2000, the idea of assessing student performance by the traditional testing methods was discussed as unrealistic and poorly representative of what students know and how they would be required to use any information they may have learned. From this discussion, an assessment method that encourages cooperative learning and requires application of higher order cognitive skills was developed and used to replace traditional testing methods in several civil engineering courses at Virginia Military Institute (VMI). The assessment method has used "module problems" in up to four different courses every year beginning with the fall 2000 semester. This paper describes the use of module problems to assess student performance and provides empirical evidence of their efficacy in promoting learning.

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2. Module Problem Description

The traditional testing method typically involves covering material in lecture or through reading and class discussion and then essentially surprising the students with a test. The test is scheduled and announced, but the students see the test questions just at the moment when they are expected to answer them. The tests may be open or closed book, but the students are required to give the answer "on the spot" without the opportunity to consult with others or carefully consider published resources or personal notes. Thoughtfully formulating questions to encourage higher order cognition improves assessment, but the setting remains unrealistic of engineering practice.

Mourtos (1997) has reported some success in including a component of group work with other elements of traditional testing. This incorporates cooperative learning into the testing process, but it still presents the problem of spontaneity and an unrealistic setting for engineering work. Taking this concept one step further, instead of giving tests periodically throughout a semester as subject matter has been covered, module problems are presented to the students at the beginning of lecture segments. This typically occurs about four times during a semester. The students see the questions before the material is covered in class and know exactly what will be expected of them as the lecture material is presented. Compared to traditional testing, the module problem allows students access to unlimited resources and ample time. Both of these are needed because module problems are written to reflect actual engineering applications in an open-ended format. Questions may have several correct solutions, depending on assumptions made by the student and validated by their documentation and justification of those assumptions.

The module problem questions are complex enough to require group work to successfully complete them, an important criteria according to Haller et al [2000]. At VMI, class size is small, usually between eight to no more than 20 students, and students naturally form and reform alliances to complete the module problems. Sometimes the entire class will work together and other times groups may be self-limited to two students. How these groups are formed is left to the students to work out and, so far, no intervention to balance groups or otherwise manipulate their composition has occurred, although others have suggested that intervention is beneficial [Felder and Brent, 1994; Johnson et. al., 1991; Feichtner and Davis, 1991] and student responses to survey questions indicate that this issue needs to be reviewed.

The purpose of the module problems is to bring an assessment tool into play that is more representative of what students may expect as practicing engineers with the intention of promoting students' abilities to use engineering tools and to develop and apply critical thinking skills. Students are given the following typical instructions: "In completing this problem you may consult with other students currently enrolled in this class and you may use any reference materials you can find. Provide a complete justification for all assumptions and design choices that you make and identify all reference materials used and list all help received." Students are initially taken aback by the opportunity to work with unlimited resources and mistakenly assume that they are on course for an "easy A." However, they are thinking of text book problems when they make this assumption.

The module problems are not text book and, for most students, their first module problem experience is the first time that they are required to solve an open-ended problem where their assumptions and design choices materially affect the solution.

Each student is responsible for his or her own grade -- sometimes each student submits his or her own solution even though it was developed through team work, other times students are allowed to submit work as a group. In the small class size setting at VMI where familiarity between the students and the faculty is well developed, individual submittals allow an opportunity to identify students who are having difficulty or who may not be balanced contributors to group work.

3. Student Perceptions

To assess student attitudes and perceptions of their performance with regard to module problems, a survey was distributed to civil engineering students enrolled at VMI during fall semester 2003. The

students were sophomores through seniors who had had some experience with module problems in their course work. Fifty-two students responded, either fully or partially, out of approximately 60 who received the survey. The survey consisted of 20 questions divided into three groups and included space for students to share written comments regarding their positive and negative experiences with module problems. The partial respondents did not complete the second page of the survey, resulting in a sample size of 45 students for questions 10 through 20. All questions are included with the survey results in Tables 1 through 3, and student comments are summarized in Table 4.

The first group of questions was intended to establish that the students responding to the survey had been enrolled in classes where module problems were used and to define their time allocation to out-of-class work, including time for completing module problems and preparing for traditional tests. The responses to these questions are presented in Table 1.

Question 1 in Table 1 shows that the average student responding to the survey has had module problems assigned in about two classes. In the classes where module problems are used, there are typically four assigned during the semester, so the average respondent has completed about seven to eight module problems. Comparing questions 3 and 4, students spend a little less than twice the amount of time completing a module problem as they do preparing for a test -- 8 to 10 hours to complete a module problem and 4 to 6 hours to prepare for a test. However, module problems are assigned at the beginning of the lecture sequence and the students have about three weeks to complete them, requiring only a few hours per week to work on the module problem, albeit, many students often wait until near the due date to complete the majority of the work. This allocation of time is interesting when considering that essentially all students find module problems to be very challenging, as will be discussed later.

Table 1. Student Module Problem Experience and Time Allocation

	Question	Mean	Mode
1	In how many classes have you been assigned module problems?	1.78 classes	2 classes
2	About how many hours per hour of class time do you typically spend outside of class on class related work?	2.14 hrs	2 hrs
3	What is the typical number of hours you spend completing a module problem set?	8.2 hrs	8-10 hrs
4	What is the typical number of hours you spend preparing for a traditional test?	4.9 hrs	4-6 hrs

The second group of questions was intended to compare student attitudes between tests and module problems with respect to the following five categories: engaging in group work, fairness in assessing student knowledge of the subject matter, effectiveness in contributing to student learning, interaction between students and the professor, and efficient use of student time. Table 2 summarizes the outcome of these questions and a graphical comparison is presented in Figure 1. The agreement between the means for each question pair was evaluated using Student's t-test with a resulting p-value less than 5% indicating significance.

Comparing the means for parts a and b of questions in Table 2 with the resulting p-values, it is apparent that the p-values are highly significant between students engaging in group work (question 5) and interacting with the professor (question 8) when module problems are used instead of tests. That is, module problems increase both group work and interaction with the professor. Students also see module problems as a more effective learning tool when compared to tests (question 7), again the p-value is highly significant. These results are illustrated in Figure 1. The increase in group work and interaction with the professor observed when using module problems would expect the result that students see module problems as a more effective learning tool than tests. These results support a conclusion that students engaged in cooperative learning activities encouraged by module problems see the expected benefit of more effective learning.

Although students do show a slight tendency to agree that module problems provide a fair assessment of their knowledge when compared to tests (question 6, Table 2), the p-value for the t-test comparing the means is not significant at 5.8%. This is an interesting result considering that students feel that learning has increased. Reasons for this may be attributable to the difficulty of module problems, the amount of time students spend completing them, and a student desire for easier grading. Associated with this question is an expressed concern of some students that the students who do not provide a balanced contribution to the group effort somehow cause a lower grade for others. This is an issue that deserves more attention in the future.

Question 9 in Table 2 also reveals that students feel that they use their time relatively effectively regardless of whether they are preparing for tests or working on module problems -- there is no significant difference between the means for the module problems and tests regarding this question at a p-value of 16%. Note also that the means, at near 2.5, tend more toward a disagreement with the question. This suggests that the time students spend engaged in group activities when working on module problems or preparing for tests is time that they feel is well used.

Table 2. Student Comparison Between Module Problems and Tests

Question		Mean	Std Dev	Mode	t-Test p-Value
5a	Use group work to complete module problems (never = 1, always = 5)	4.19	1.03	5	0.00%
5b	Use group work to prepare for tests (never = 1, always = 5)	2.46	0.851	2	
6a	Module problems provide fair assessment of knowledge (unfair = 1, fair = 5)	3.71	0.957	4	5.8%
6b	Tests provide fair assessment of knowledge (unfair = 1, fair = 5)	3.35	0.968	4	
7a	Module problems are an effective learning tool (disagree = 1, agree = 5)	4.06	0.958	5	0.014%
7b	Tests are an effective learning tool (disagree = 1, agree = 5)	3.25	0.947	4	
8a	Module problems encourage interaction with professor out of class (disagree = 1, agree = 5)	4.02	0.874	4	0.00%
8b	Tests encourage interaction with professor out of class (disagree = 1, agree = 5)	2.63	0.864	2	
9a	Waste time completing module problems (disagree = 1, agree = 5)	2.54	1.09	2	16%
9b	Waste time preparing for tests (disagree = 1, agree = 5)	2.69	1.08	2	

The third group of questions was intended to understand the students' agreement that desired favorable outcomes were occurring from using module problems instead of tests. For all of these questions, the students were asked if they disagreed or agreed with the statement on a scale of from 1 to 5, respectively. The results are summarized in Table 3. The chi-squared test was used to compare the students' responses to a random distribution. To indicate a non-uniform distribution and obvious leaning toward agreement with the question, the p-value for the chi-squared test would need to be less than 5%.

The p-values listed in Table 3 suggest that, in all cases, the students have general agreement with the questions, indicating a very positive overall experience with module problems. These results also indicate that the desired educational outcomes from using module problems are apparently being realized. In every case, the p-value is considerably less than 5%, with a slightly larger p-value being observed for questions 11, 13, and 20, respectively dealing with improving communication skills, encouraging in-class

discussion, and improving student grades. Reviewing the means and the score count for each question shows the strength of the students' agreement with the questions.

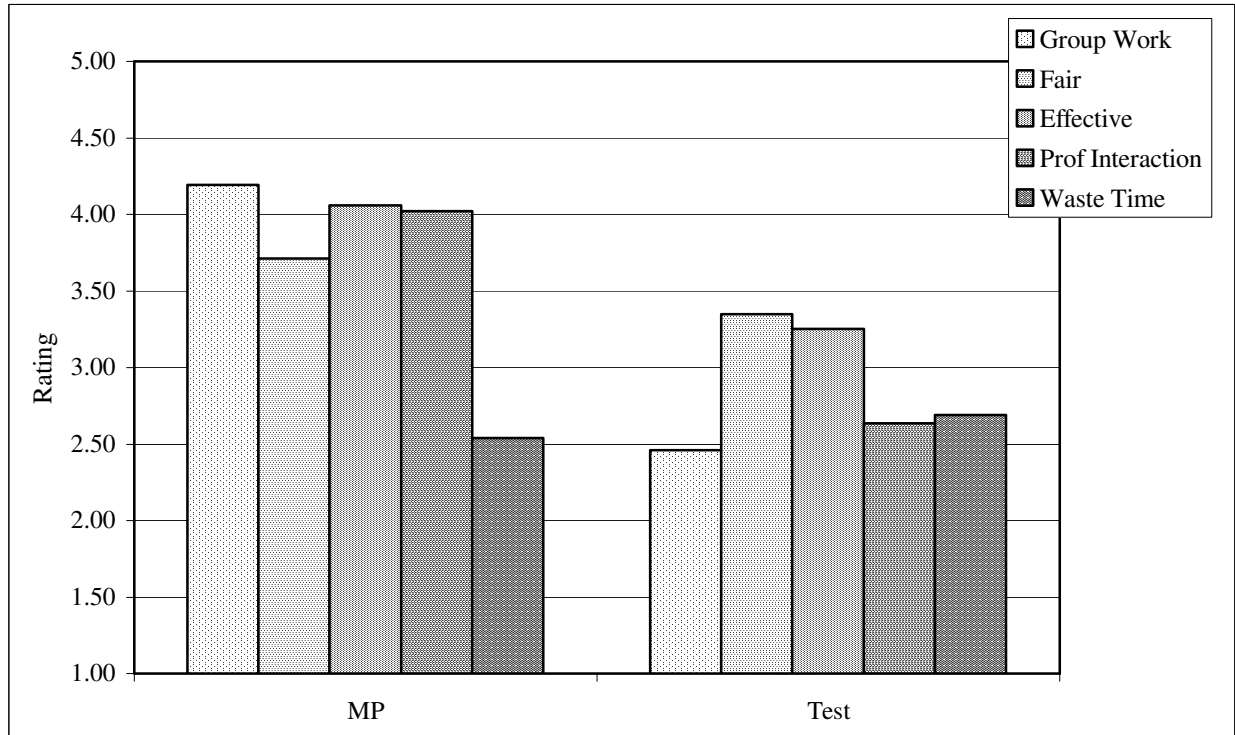


Figure 1. Comparison between Students' Perceptions of Module Problems and Tests

Table 3. Student Assessment of Desired Favorable Module Problem Outcomes

Question	Mean	Std Dev	Mode	Chi Sqd P Value	Score Count*				
					5	4	3	2	1
10 Encourages interaction with other students	4.64	0.570	5	0.000%	30	12	3	0	0
11 Promotes in-class discussion	3.62	1.029	3	0.600%	11	13	14	7	0
12 Improves design skills	4.06	0.785	4	0.000%	13	24	6	2	0
13 Improves communication skills	3.69	0.996	3	0.055%	11	14	16	3	1
14 Improves problem solving skills	4.16	0.767	4	0.000%	15	24	3	2	0
15 Improves skills in finding and using reference materials	4.11	0.982	5	0.000%	19	17	4	5	0
16 Improves critical thinking skills	4.13	0.842	4	0.000%	17	19	7	2	0
17 Promotes learning from other students	4.24	0.679	4	0.000%	16	25	3	1	0
18 Presents a challenge	4.87	0.405	5	0.000%	40	4	1	0	0
19 Help see practical application of class topics	4.22	0.765	4	0.000%	18	20	6	1	0
20 Improves grades	3.30	0.965	3	0.004%	7	10	21	5	1

*Scale: disagree = 1, agree = 5

The students see a particularly strong association with module problems and their interaction with other students, as evidenced in Table 3 (question 10) by the mean close to 5, the relatively small standard deviation of 0.570, the mode of 5, and a score count that includes 30 of 45 responses as 5. Note that a score of 5 shows the strongest agreement with the question. One reason for this strong response may be

in the challenging nature of the module problems that require group work for most students to successfully complete. The response to question 18 illustrates this by showing an almost unanimous agreement that the module problems are challenging. The statistics for this question show 40 of 45 responses are 5 with a mean of 4.87 and standard deviation of 0.405.

Although not quite as pronounced as the results for encouraging group work and the challenging nature of the module problems, Table 3 results show that all students strongly agree that module problems promote and improve many desired favorable educational outcomes. These are evidenced for questions 12, 14, 15, 16, 17, and 19 where the means and modes are above 4 and standard deviations are less than 1.0 (20%). These positive outcomes include improving skills in critical thinking, problem solving, design, and finding and using reference materials, and promoting learning from other students and showing practical applications of class topics.

As part of the survey, students were asked to provide any positive or negative comments about their experiences with module problems. A summary of these comments is presented in Table 4.

Table 4. Summary of Student Comments

<p>"Likes" reflected in student comments:</p> <ul style="list-style-type: none"> • Provide ample time to complete the module problem -- self-paced • Allow access to resources and professor • Improve understanding of class material, allow deeper understanding of topics -- learn more • Require considerable effort -- very challenging • Allow material to "sink in" -- no memorization • Promote working together, discussing solutions and problems in finding solutions, brain storming -- learn from others • Reflect the effort applied -- spending enough time and doing enough work gets a good grade • Cover class topics thoroughly • Reflect real-world engineering • Relieve pressure of tests • Provide picture of overall topic • Improve opportunity to show what has been learned
<p>"Dislikes" reflected in student comments:</p> <ul style="list-style-type: none"> • Require a lot of time • Provide poor final exam preparation • Require effort to find information necessary for solutions • Represent extreme challenge, difficult ("very, very hard"), unable to complete without help • Present open ended problem -- hard to know where to begin • Require effort to develop solutions -- not all information provided in lecture • Encourage sharing with others who do not provide balanced contribution -- poor reflection of student knowledge • Allow multiple correct solutions

In Table 4, in many cases the students both like and dislike the same things about module problems. For example, the students' perception that the module problems are challenging is both liked and disliked, sometimes by the same student. Students like group work, find it to be beneficial, but dislike sharing with those who contribute less. Most of dislikes are positives from the perspective of the professor. Possible exceptions may be that students see module problems as poor preparation for the final exam and, more troublesome, that they experience an imbalance in the workload that results in an inaccurate assessment of student knowledge. These latter two are areas where adjustments in administering the module problems should be considered. However regarding the imbalanced work load, the tendency has been to allow

students to work these issues out among themselves, being somewhat reflective of real world engineering, a circumstance that they seem to value highly.

4. Conclusion

Instead of giving tests periodically throughout a semester as subject matter has been covered, module problems are presented to the students at the beginning of lecture segments, typically four times during a semester. The students see the questions before the material is covered in class and know exactly what will be expected of them as the lecture material is presented. Compared to traditional testing, the module problem allows students access to unlimited resources and ample time. Questions may have several correct solutions, depending on assumptions made by the student and validated by their documentation and justification of those assumptions.

The p-values are highly significant between students engaging in group work and interacting with the professor when module problems are used instead of tests, indicating an increased level of activity brought on by module problems in these two critical areas. Students see module problems as a more effective learning tool when compared to tests. Students engaged in cooperative learning activities encouraged by module problems see the expected benefit of more effective learning. Students indicate a very positive overall experience with module problems, although they admit that the module problems are very challenging. The desired educational outcomes from using module problems are apparently being realized. These positive outcomes include improving skills in critical thinking, problem solving, design, and finding and using reference materials, and promoting learning from other students and showing practical applications of class topics.

Students leave the impression that, among the reasons discussed above, they prefer module problems to tests because the problems allow the students more control over their grades. Module problems remove some of the "chance" that students see associated with tests. The implication is that they have more incentive and opportunity to learn when module problems are used. One student's comment specifically speaks to this issue: "[Module problems] allow you to let the material sink in. This is because for a test you memorize and sometimes forget the material. Modules are not memorization, but a working learning process."

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