

2006-906: THE EFFICACY OF ONGOING COURSE ASSESSMENT FOR ENHANCING STUDENT LEARNING IN STRUCTURAL DESIGN COURSES

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Abstract

A technique was recently developed for the continuous assessment of student learning that involves measuring students' perception of learning of course topics. The assessment instrument is divided into several modules with each module consisting of a detailed listing of course topics. This instrument has been used in the author's on-campus and online structural analysis courses. The results of the data collected from a structural analysis course pointed to enhancement in student learning, with the additional benefit of forcing the students to reflect on and take charge of their own learning.

This assessment technique has been further implemented in structural steel design and reinforced concrete design courses. The data collected is analyzed and compared to students' experiences from the structural analysis course to determine the impact of using this assessment instrument on student learning in structural design courses. The impact of students' perception of learning as measured by the assessment instrument on the final grades obtained in the course, and the influence, if any, of using this ongoing course assessment technique on the end-of-term student course evaluations are also investigated.

Introduction

Most US colleges and universities use some form of end-of-term summative course evaluation - that is an assessment-*of*-learning or after-the-fact assessment technique - where the students rate the instructor, the course delivery method, the textbook, and other aspects of the course. However, under this assessment regime, students cannot benefit from any course correction that may result from their feedback because the assessment is completed by students only at the end of the course. On the other hand, there is a dearth of assessment-*for*-learning techniques in US colleges and universities.¹

An assessment-*for*-learning technique^{2,3} was recently developed and has been successfully implemented in a structural analysis course. The advantages of this technique, when compared to assessment-*of*-learning techniques, include the following:

1. Students are able to reap immediate benefit from their feedback
2. The technique forces students to reflect on and take responsibility for their own learning
3. It helps the instructor identify students who may be struggling with a particular concept or topic.
4. Shy and deaf students are given the opportunity to ask the questions that they may otherwise be reluctant to ask in class. It puts all students in the class on a level playing field so that no student feels left behind.

This assessment technique has now been implemented in two structural design courses, and the impact of the technique on student learning in these design courses is discussed in this paper.

It should be noted that the assessment-*for*-learning (AFL) technique described in this paper is different from the techniques used by other authors that involve the use of clickers or personal response systems.^{4, 5, 6} In AFL, learning takes place inside and outside of the classroom, and student learning is assessed on a weekly basis after the students have had sufficient time to reflect on what they were taught in class and have had the opportunity to apply that knowledge to the homework assignments. The intent of this technique is to ensure that student learning takes place before the students take a test or exam on a particular set of topics. This is in contrast to the techniques which employ clickers or personal response systems where learning is measured immediately after a lecture. In the author's method, because students are given sufficient time to process what they have learned, deep and substantive learning is assessed. It should be noted that the use of clicker or personal response systems in engineering courses has been found by students to be "distracting in terms of the flow of lectures," and there have been mixed reactions to the use of this technology in engineering courses.⁴

The AFL technique also differs from the Classroom Assessment Technique (CATS), a concept developed by Angelo and Cross^{7, 8}. In CATS, the surveys are usually anonymous and are typically completed by the students after every class; the questions are generic and broad, in contrast with the author's technique, which uses a detailed checklist of the course topics. In the AFL technique, students typically complete the non-anonymous surveys outside of class and on a weekly basis. It should be noted that although the module surveys are not anonymous, the identities of the students are not revealed to their peers. The non-anonymity is important to ensure that students in need of individual help can be identified by the instructor.

Different assessment methods are available in the literature for measuring student learning,^{1, 2, 3, 10, 11, 12, 13} and these can be divided into direct (or formal) and indirect assessment methods. Direct assessments include tests, design projects, papers, theses, and written exams. Indirect assessments include self-report surveys at the course, program, or institutional levels. These assessment techniques can be further divided into formative (during the term or ongoing) or summative (end of term) evaluations.^{11, 13} According to Wankat and Oreovicz,¹³ "formative evaluations are obviously more useful for course improvement than summative evaluations – the course is still in session and there is time for improvement." It has also been recommended that assessments be carried out at the individual student level otherwise the effectiveness of assessment diminishes considerably.¹⁴ Nancy Hunt⁹ carried out mid-semester surveys and reported positive impact on student learning. Morgan and Tallman¹⁰ carried out assessment of broad course learning outcomes using student surveys, but these surveys were episodic rather than ongoing. They were administered to students towards the end of the term, and the learning outcomes were rather broad and not broken down into specific course topics.

In an era of continuous improvement mandated by accrediting agencies like the Accreditation Board for Engineering and Technology (ABET) and Middle States, it is important that assessment-*for*-learning tools are developed that can benefit current students and also help the instructor identify students who may be having difficulty with a particular concept or topic.^{1, 2} To achieve this objective, an ongoing formative assessment-*for*-learning tool that measures student understanding of course-specific topics is proposed; to be used in addition to already existing end-of-term summative course evaluations.²

In this paper, the author presents the assessment instrument used, the survey results and impact on student learning in structural steel and reinforced concrete design courses, and students' perception of the effectiveness of these surveys. The analysis of the survey data and the student feedback shows that the assessment technique discussed in this paper enhances student learning and motivates them to take responsibility for their own learning. The use of this assessment technique enriches and deepens student learning and provides ET faculty and programs with a "closed loop" mechanism for continuous improvement that meets the requirements of accrediting agencies.²

Ongoing Assessment-*for*-Learning (AFL) Technique

The assessment tool described in this paper is carried out at the individual student level and involves quantitative as well as qualitative survey of student perceptions about their learning in the course. Students are asked to rate their perception and understanding of course topics using a Likert scale ranging from 1 (not understood at all) to 5 (very well understood). At the end of each module, students also provide qualitative evaluation as they respond to a type of minute essay.^{7, 8} In addition, the last module in the course (module 8 for structural steel design and module 6 for reinforced concrete design) includes the following open-ended questions addressing the effectiveness of the module surveys from the students' perspective:

1. How well did you reflect on the course topics (or intended learning outcomes) in the course modules before completing the module survey?
2. How did the module survey impact your learning in this course?

A typical module survey is shown in the appendix. The module ratings are used by the instructor to assess student learning on a continuous basis, and to make any necessary mid-stream corrections to the course delivery method or courses notes. They are also used to identify students who may be in need of extra tutoring help, and to identify problem topic areas that may need to be revisited in class. If a large number of students indicate a rating of 2 or less on a particular topic, that topic is revisited in class by the instructor. Where a relatively few number of students indicate module ratings of 2 or less on any topic, these students are invited to meet with the instructor privately for extra one-on-one tutoring help.¹

The assessment technique helps the students and the instructor to recognize areas of weaknesses in the students' understanding and helps the instructor "fill in any knowledge gap that can keep a student from progressing."^{3, 11} The assessment instrument was first administered to the 50 students in the fall term 2003 structural analysis course. It was also administered to the 18 students in the winter term 2005 structural steel design class, as well as the 25 students in the spring term 2005 reinforced concrete design class. These classes included both online and oncampus sections.

The structural steel and reinforced concrete design courses are four-credit courses that meet for 50 minutes four times a week for ten weeks. Each course is divided into a minimum of six modules (6 for reinforced concrete design and 8 for structural steel design), with a detailed checklist of all the course topics, in the order they will be covered in class. Course notes were developed for each of these courses, in an addition to the recommended text, that provide the necessary information required in each module survey. The data obtained from the module surveys was analyzed and Table 1 shows a summary of the assessment results for each module from the fall 2004 structural analysis class, the winter 2005 structural steel design class, and the spring 2005 reinforced concrete design class, where N is the number of students enrolled in each course. The fact that the AFL described herein forces the students to go back to their notes or text and reflect on the course topics may be responsible for the high average module ratings (between 3.91 and 4.09). The results did not indicate any significant differences or variations across the various topics, thus pointing to some consistency in the delivery method for each course. The average module ratings and the overall mean final GPA in the course are as follows:

Structural analysis: 4.03; 2.45 (or C+ average)
 Structural Steel Design: 4.09; 2.7 (or B- average)
 Reinforced Concrete design: 3.91; 3.0 (or B average)

Table 1: Summary of Assessment Results for each Module

Module	Mean Module Rating		
	Structural Analysis (N= 51)	Structural Steel Design (N=18)	Reinforced Concrete design (N=25)
1	4.12	4.35	4.26
2	3.96	4.21	3.84
3	4.0	4.14	3.83
4	3.91	3.92	3.81
5	4.10	4.00	3.94
6	3.94	3.73	3.80
7	4.06	4.03	-
8	4.0	4.30	-
Average Module Rating	4.03	4.09	3.91

To evaluate the effectiveness of the ongoing module surveys in the structural design courses, students were also required to answer two additional open-ended questions on the last modules. Their responses are discussed in the next section.

Student Qualitative Feedback

In addition to the quantitative feedback obtained, the assessment technique also provides a means at the bottom of each module for obtaining qualitative feedback from the students. The last module also includes two questions designed to measure student perception with regards to the effectiveness of the assessment-*for*-learning technique described in this paper. Below are some sample student responses to these two questions.

“The modules forced me to review the course material before proceeding to the next course topics”

“[The module surveys] sure helped and I’m looking forward to using them in the other courses that you teach”

“They made me think about what I actually got out of the class”

“Served as a guide for studying and as a source of motivation”

“They are a good learning tool that can help students ask important and burning questions without being recognized by the rest of the class”

“These modules were good in class because they answered some complicated questions that helped everyone”

“They gave me an honest opportunity to be sure I knew what was going on. Furthermore, they allowed me to ask difficult questions. They might be more effective if they were a required submittal with the home work”

“They were a good checklist to make sure I was comprehending what we were expected to”

“They were a great asset to learning. When I had a question on a specific topic, it would be answered within a few days of turning them in”

“Good, you used one of my questions in class and really helped to clarify the problem”

“[The modules helped] very little at first, but a little more now. It’s hard to respond to them sometimes because you think you understood the homework and the material, but then you get it back with a less than satisfactory grade....so then, the modules might not reflect that. I think making them due as an attachment to the homework might be better than just reminding us to turn them in”

“[The modules did] not [help] very much. I figured I needed to learn everything anyways in order to receive good grades”

“”I have a short term memory. Modules actually makes me think when filling it out and makes me think of what all of the topics are trying to explain”

“I reflected a lot to real[ly] mark what I knew and didn’t so that I could get the help I needed. [The modules] made unclear topics clear and understandable”

“The modules are [a] unique feature of this course which provides a media for each individual to ask questions related to the course. From this type of written questionnaire, each student adds to the course material. [As a] result, the learning environment is enhanced”

“It helped a great deal because if I didn’t know something, you would bring it up in class right away. Also, if a lot of people had questions on a topic, I would double-check to make sure I knew the information”

“Overall the module survey helped keep all the students on the same level and same place. No student was left behind if he/she was truly honest”

“They helped me a lot to reflect on what we learned during each section”

“They help to jog my memory to see if I know what you expect we should have learned”

“When I spent time looking at the module questions, it would boost my confidence on the subject matter”

From the more than 35 responses obtained to the two questions in the last module, more than 95% of the students indicated that their learning was positively impacted by the module surveys. Many students pointed to the fact that this assessment-for-learning technique actually helped them prepare for the summative assessments (i.e., tests, exams and projects) in this course. The students’ qualitative responses above demonstrate the effectiveness of the assessment-*for*-learning technique described in this paper. This technique forces the students to reflect on what they have learned, motivates them to go back to their notes or text to restudy those sections or topics that may still be unclear to them, thus motivating them to take charge of their own learning. It also impresses on the students that the instructor cares about their learning and success in the course, thus greatly enhancing the faculty-student partnership.

Effect of the Assessment-for-Learning Technique on End-of-term Course Evaluations

The use of the AFL technique described in this paper has led to improvement in the instructors’ ratings when compared to the department and college instructor average ratings. In the reinforced concrete design course, the instructor received an overall average rating of 4.85 (out of a maximum score of 5) compared with a department

average of 4.37 and a college average of 4.34. For the structural steel design course, the instructor received an overall average rating of 4.67 compared with the department and college instructor average ratings of 4.37. These ratings are slightly higher than the average ratings from the course evaluations from previous years prior to the introduction of this assessment tool. Some students have also indicated in the course evaluations that the assessment tool helped them learn better. It is the author's belief that the use of this effective assessment technique not only enhances student learning, but also results in higher course evaluations for the instructor. When students know that the instructor demonstrates genuine interest in their learning on an ongoing basis, and they see that s/he is willing to spend the extra time to ensure that they fully understand the concepts taught in class, they will be more motivated to learn, and are more likely to rate the instructor highly in the course evaluations.

For instructors interested in adopting this technique in their courses, the first step is to develop a detailed listing of the course topics in the order they will be covered in the course. Use an easy-to-read textbook or provide a set of concise course notes so that the students can readily map the various course topics in the module surveys to appropriate sections in the textbook or course notes. The author has found it advantageous to develop a set of notes for the courses included in this study that are handed out to the students at the beginning of the term, and also used in the lectures as slides on an overhead projector. This helps the instructor from losing time in class with students copying board notes, since there will be a number of occasions when there will be a need to go back to revisit a topic or concept in class. From the author's experience, it takes approximately 4 to 6 hours on average per week to analyze the module surveys and attend to the students who may need individual help.

Though some extra effort is required on the part of the instructor to implement this assessment-*for*-learning technique, the rewards far outweigh the effort and the extra time spent. A further testimony of the advantages of using this assessment-*for*-learning tool is the fact that an instructor who uses this AFL technique in his courses recently won RIT's prestigious Eisenhower Award for Outstanding Teaching.

Conclusion

An effective ongoing assessment-*for*-learning technique has been presented. This technique has been successfully implemented in structural design courses. It has been shown to enhance student learning and could also be used to satisfy the "closed loop" continuous improvement requirement of accrediting agencies like ABET and Middlestates. Throughout the term, students were required to complete weekly surveys that measured their perception and understanding of the course topics on a Likert scale ranging from 1 (not understood at all) to 5 (very well understood). For each module, students were also required to briefly describe the most meaningful concept they learned, and what concept (if any) was still unclear. These surveys and student feedback were used to make any necessary mid-stream corrections to the course, such as revisiting a topic in class and/or posting clarifications on the course website. In cases where only a few students recorded ratings of 2 or less on any particular topic, these students were

invited via email to meet with the instructor for one-on-one tutoring sessions on that particular topic.

The use of the assessment-*for*-learning technique described herein has helped the students focus on what they need to know and what areas they may be deficient in. As a result, there are very few (if any) complaints about not understanding the course material. In addition, students who did not perform to their expectation on the tests and exams in most cases attributed their less-than-adequate performance to test anxiety rather than to a lack of understanding of the course material or inadequate course delivery by the instructor. The qualitative student feedback points to the effectiveness of this ongoing assessment-*for*-learning technique.

The results of this study indicate that student learning was achieved in the structural design courses through the use of the assessment-*for*-learning technique discussed in this paper. The students rate the use of this technique very highly as evidenced by the consistently high and well above department average instructor ratings in the end-of-term course evaluations. The author highly recommends this assessment technique to ET and engineering faculty as a means for enhancing student learning, as well as improving their teaching and course evaluation ratings.

Bibliography

1. Richard J. Stiggins (2002), "Assessment Crisis: The Absence of Assessment FOR Learning," Kappan Professional Journal, <http://www.pdkintl.org/kappan/k0206sti.htm>
2. Abi Aghayere (2005), "The Case for Ongoing Course assessment," ASEE Annual Conference, Portland, Oregon.
3. Abi Aghayere (2004), "Use of Ongoing Assessment of Intended Learning Outcomes to Evaluate Effectiveness of Online and On-campus Delivery of a Structural Analysis Course," ASEE Annual Conference, Salt Lake City.
4. S.E. Silliman et al (2005), "Observations on Benefits/Limitations of an Audience Response System," ASEE Annual Conference, Portland, Oregon
5. Carol Brewer (2004), "Near Real-Time Assessment of Student Learning and Understanding in Biology Courses," BioScience, Vol. 54, No. 1, November, pp. 1034-1039.
6. Lisa Greer and Peter J. Heaney (2004), "Real-Time Analysis of Student Comprehension: An Assessment of Electronic Student Response Technology in an Introductory Earth Science Course," Journal of Geoscience Education, Vol. 52, no. 4, September, pp. 345-351
7. T.P. Angelo and K.P. Cross (1993), "Classroom Assessment Techniques: A Handbook for College Teachers," 2nd edition, Jossey-Bass, San Francisco
8. Karron G. Lewis (1994), "Using On-Going Student Feedback to Increase Teaching Effectiveness and Student Learning," The Teaching Network, Center for Teaching effectiveness, The University of Texas at Austin, Vol. 15, No. 2.
9. Nancy Hunt (2003), "Does Mid-Semester Feedback Make a Difference," The Journal of Scholarship of Teaching and Learning (JoSoTL), Vol 3, Number 2.
10. James N. Morgan and Gary D. Tallman (2002), "Development, Implementation, and assessment of Course Learning Outcomes," Working Paper Series, College of Business Administration, Northern Arizona University, Flagstaff, AZ.
11. Raghu Echempati, Arnaldo Mazzei, and Karim Nasr (2004), "Student Understanding of Program Outcomes through Formative and Summative Course-level Assessment", ASEE Annual Conference, Salt Lake City

12. Arapahoe Community College, "Assessment: An Institution-wide Process to Improve Student Academic Achievement," <http://www.arapahoe.edu/aboutacc/assessment/>
13. Philip Wankat and Frank Oreovicz (2004), "Necessary Evil," Teaching Tool Box, ASEE Prism, November, pg 44
14. Alvin P. Sanoff (2005), "Measure for Measure," ASEE Prism, January, pp. 36-40

Appendix

TYPICAL MODULE SURVEYS

- Please rate each of the course topics on a Likert scale ranging from 1 (least understood) to 5 (very well understood) after each module is completed, by ticking the appropriate box.
Also, for EACH module, describe briefly what was most meaningful to you in terms of what you learned and what was unclear.
- Please submit your surveys to me *at the end of each module*.

Thank you in advance for your participation and cooperation, and for helping me to help you learn better!

Module 1: Reinforced Concrete Design

After completing this module, you should be able to:

	5 = Very well understood	4 = Understood	3 = Somewhat understood	2 = Not well understood	1 = Not understood at all
Identify the basic structural elements reinforced concrete structures.					
Discuss the various properties of concrete and reinforcing steel, and how they affect the properties of reinforced concrete					
Use the Reinforcing steel area tables for slabs/footings and beams/girders and columns					
Identify the concrete cover requirements for reinforcing steel (rebar) and the reasons for providing this cover					
Discuss the structural design principles used in the ACI code					
Describe the meaning of the various limit states.					
Understand the ACI code limit states design method, the strength reduction factors, the load factors, and load combinations.					
Layout the beams and girders in a concrete roof or floor plan using a one-way slab system.					

Differentiate between one-way and two-way slab systems.					
Estimate the roof and floor slab uniform loads. Calculate the service and factored loads, moments and shears on slabs, beams and girders					
Determine SNOW load, ROOF LIVE loads, and WIND loads using the New York State (NYS) 2002 Building Code					
Calculate Axial loads on columns by summing up beam and girder reactions and present the results in a tabular format (i.e. a COLUMN LOAD SUMMATION TABLE)					
Complete homework assignments #1 and #2 (all questions except 1F).					

For this module, describe briefly what was most meaningful to you in terms of what you learned and what is still unclear.

.Module 8: Structural Steel Design

After completing this module, you will be able to

:

	5 = Very well understood	4= Understood	3 = Somewhat understood	2 = Not well understood	1 = Not understood at all
Identify the different types of welds, welding symbols, and welding position					
Calculate the shear, tension, and compression capacity of welds					
Select weld sizes and lengths to resist tension and shear loads					
Identify the different types of bolts and bolted connections					
Carry out the design checks required for the different types of bolted connections under various					

loading conditions: tension, shear, and combined tension plus shear					
Calculate the bolt capacity in shear, bearing, and tension					
Calculate the shear strength of <u>Slip-critical bolted</u> connections					
Analyze <u>Bearing-type</u> connections subject to combined shear plus tension loads using Interaction Equations					
Analyze <u>Slip-critical</u> connections subject to combined shear plus tension loads using Interaction Equations					
Design BOLTED-WELDED, and ALL-WELDED double angle connections for shear loads using the AISC Tables					
Design Single Plate (or Shear Plate) connections for shear loads using the AISC Tables					
Design Beam or Girder-to-Column Moment Connections					
Work through all the Connection design examples provided in Text #1 (Dr. Abi Aghayere's Course Notes).					
Design and detail a simple structural steel building manually					
Use a computer-aided structural steel design software/shareware to design typical beams, girders and columns in a simple structural steel building					

End-of-Term Survey Questions on Effectiveness of Course Modules

1. How well did you reflect on the course topics (or intended learning outcomes) in the course modules before completing the module survey?
2. How did the module survey impact your learning in this course