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Formative and Summative Assessment in Agricultural Engineering and Technology Courses

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Abstract. *Engineering education is undergoing a transformation with a shift in focus to student outcomes. While many efforts to assess student outcomes have been at the curriculum level, assessment must also be done at the course level since this is where much learning and instruction takes place. Multiple summative and formative assessments were employed in a two-year study of student perceptions of their learning and the instructional methods in two related agricultural engineering and agricultural technology courses at Iowa State University. The goal of these efforts was to better understand how students learn so that instructional methods can be changed to better promote learning. Formative assessment tools included a weekly e-mail feedback journal and a midterm electronic survey using WebCT. Summative assessment tools included focus groups and end-of-term student evaluations of instruction (SEI). Based on the e-mail journals and the midterm survey, several adjustments were made to the courses during the course terms; such as bringing more real-world examples into the classroom, providing more example problems in the class, and providing review based on students' electronic questions. The focus groups and SEI were used to better understand the effectiveness of these formative assessment tools and the relationship between student learning and instruction.*

Keywords. Education, fluid power, e-mail journals, focus groups, survey, student evaluation of instruction.

Introduction

Assessment in an educational context is defined differently by various authors. However, common to these definitions is gathering of feedback on the learning process, understanding the meaning of this feedback, and using the feedback to improve the teaching-learning process (Black and Wiliam, 1998; Wiggins, 1993; Huba and Freed, 2000; Palomba and Banta, 1999). Assessment takes place not only at institutional and curriculum levels, but also in the classroom. Classroom assessment involves teachers determining what students are learning and how and to what extent they are learning in the classroom (Angelo and Cross, 1993).

Historically, most classroom assessment has been summative – with end-of-term assessments of learning that has taken place during each term of instruction (Boston, 2002). Summative assessment is often implemented by using final grades and some form of student evaluation of instruction (SEI). End-of-course SEI has been used in North American universities since the mid-1920s (Doyle, 1983). SEI, however, generally provides only limited insights on how to improve instruction. SEI tends to focus on instructors and their performance, rather than on teacher effectiveness in helping students learn (Huba and Freed, 2000). Weimer (1990) argues that SEI generally does not enable instructors to improve their teaching, as previously assumed, because it typically identifies instructional dimensions where students are satisfied or dissatisfied, rather than providing insights on how the teaching-learning process can be made more effective. As such, SEI does have value for evaluating instructors and instructional quality (Greenwald, 1997). With this in mind, it is valuable to think in term of assessments according to their purpose: either evaluating teaching or improving instruction (Weimer, 1990).

In contrast, formative assessment uses feedback to “adapt teaching to meet student needs” (Black and Wiliam, 1998) over the period of instruction. The primary goal of formative assessment is to better understand interaction between instruction and student learning in order to improve the teaching-learning process. With such a goal, formative classroom assessment fosters instructional improvement because it gathers the information needed to make such improvements. In an extensive review of research on the topic, Black and Wiliam found that use of formative assessment results in significant increases in learning – as measured by test scores – and that it helps low-achieving students to a greater degree than other students. Other studies have also demonstrated how formative assessment successfully enhances student learning (Fuchs and Fuchs, 1986; Crooks, 1988). In addition, the shift from a teacher-centered to a learner-centered educational paradigm creates a need for formative classroom assessment (Huba and Freed, 2000). If instructors are truly concerned with student learning, assessment of the quantity and quality of student learning is critical. Teachers must have continuous feedback on the progress of student learning to ascertain if their teaching methods are effective (Stiggins, 1997).

Informal formative assessments of student learning, such as looking for visual cues from students during classroom activities and observing the types of questions asked by students, nearly always occur in the classroom (Angelo and Cross, 1993). However, these informal assessments are generally not reliable or consistent enough to provide instructors with in-depth understanding of student perceptions of their learning or with the opportunity to effectively improve instruction. To remedy this situation, a variety of formative and summative assessment methods can be used to obtain feedback on student learning in the classroom (Stiggins, 1997). For this study, two formative assessments were used: a weekly e-mail journal and a midterm e-survey about the course. Two summative assessments were also used: an end-of-term focus group and an end-of-term SEI form. While such formative and summative assessments generally identify student perceptions about instruction and learning rather than directly

measuring if learning has taken place, Mentkowski (2000) has shown that there is a direct relationship between student perceptions of their learning and actual learning.

E-mail journals consist of written student reflections about their learning in a course and are periodically submitted to the instructor electronically. E-mail journals have been shown to promote communication between students and instructor, with benefits to both. These benefits include providing students with motivation to reflect on course material and opportunities to seek help in a non-threatening forum to improve their understanding of course material. Instructors benefit from e-mail journals by having access to an expanded sample of students' perceptions about course instruction and information about student learning, including misconceptions (Meel, 1999; Wolffe and McMullen, 1995-96). Deal (1995) found that e-mail journaling also helped students develop improved self-assessment skills and better synthesize what they were learning. She found commensurate benefits to instructors through the deeper understanding of student concerns and perceptions provided through the journals. The use of e-mail encourages timely communication concerning course material (Angelo and Cross, 1993). The key component of this type of feedback is the closing of the loop between student questions and instructor responses. It is important for students to perceive that their questions and feedback are considered valuable to the instructor (Spence and Sandmeyer, 1995).

Teacher-designed surveys are another way to receive formative feedback. Using this type of feedback, adjustments can be made during the term. Instructors can solicit feedback on the course in general, or regarding specific projects, testing procedures, or presentation of course concepts. This type of feedback can be used several times throughout the term, but perhaps the most reasonable time for a survey is around midterm. Midterm feedback surveys are usually short, simple, and course specific (Angelo and Cross,1993). When interpreting the feedback, the instructor must determine what changes can be made during the term, those that will have to wait until next term, and those that cannot be implemented based on pedagogical reasons (Davis, 1993). Implementing a web-based midterm feedback survey provides the instructor additional flexibility in survey design and enables rapid collection and analysis of results (Lieberman et al., 2001).

Focus groups can be effective in obtaining specific summative data from event participants. A focus group is "a carefully planned series of discussions designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment" (Krueger and Casey, 2000). According to Christopher (2000), the open and interactive setting of the focus group facilitates deep thinking about a course and uncovers specific suggestions as to how it might be changed. Hendershott and Wright (1993) used student focus groups to explore student attitudes about university general education curriculum requirements and behavior arising from these requirements. They found focus groups uncover "rich data" going beyond information gleaned through surveys. Hamilton et al. (2002) found student focus groups provided specific suggestions for course improvement as well as significant increases in SEI ratings.

Current literature supports the potential for using formative and summative assessment to improve instruction. However, little has been written showing how several assessment methods can be synergistically employed in the courses to promote course improvement. The goal of this research was to investigate the interaction and usefulness of several formative and summative classroom assessments in making course improvements. Specific objectives of the research were to (1) investigate and compare the use of two formative and two summative assessment tools to identify and understand student perceptions of their learning and teaching methods in an engineering course, (2) determine how the formative assessments could successfully be used to make course adjustments during the duration of the course, (3) better understand differences between engineering and technology students.

Methods

The courses

The courses under study were entitled Power and Control Hydraulics, AE 447, and Fluid Power Systems for Agriculture, AST 337, electives offered in the Agricultural Engineering (AE) and Agricultural Systems Technology (AST) curricula, respectively, within the Department of Agricultural and Biosystems Engineering at Iowa State University.

AE 447 provided an introduction to mobile hydraulic design for agricultural and off-road equipment. Students were expected to come into the class with credit or enrollment in fluid dynamics and basic engineering science prerequisites. Each week, the two-credit class met for two one-hour classroom periods. During each period, the instructor discussed course content, solved example problems, and guided the students in active learning exercises such as students interpreting hydraulic schematic diagrams or solving problems in collaboration with their fellow students. Instructional methods include solving example problems on the board, presenting content with overhead projected slides, and using Microsoft PowerPoint presentations – including animations – to demonstrate operation of hydraulic circuits and systems. In addition to the classroom session, students optionally enrolled in a weekly two-hour lab session.

AST 337 provided an introduction to fluid power technology as applied to the agricultural equipment industry. Students were expected to have basic problem solving skills and competency in college algebra and trigonometry before enrolling in the course. The two-credit class met weekly for one-hour in the classroom during which the instructor discussed course content and the students participated in team exercises centered around course topics. Class time was structured around a multimedia presentation consisting of drawings, images, animations, and text which was available on-line to students. Active learning exercises in which the students interpreted hydraulic schematic diagrams through discussions with their neighbors were intermixed with the presentation. The instructor also solved problems and reviewed problems from past quizzes in the class. In addition to the classroom session, there was a weekly two-hour lab session. For both courses, WebCT Campus Edition (WebCT, Inc., Lynnfield, MA), an online course management and content delivery system (Rehberg et al., 2001), provided course content to the students and delivered periodic quizzes, practice exams, and midterm surveys.

The assessments

Classroom assessment data were collected in four classes. These four classes consisted of two AE 447 classes during the falls of 2001 and 2002 and two AST 337 classes during the spring semesters of 2001and 2002. There were 14 and 25 students in the 2001 and 2002 AE 447 classes and 29 and 27 students in the 2001 and 2002 AST 337 classes, respectively. The assessments were (1) a weekly e-mail journal, (2) a midterm feedback e-survey, (3) an end-of-term focus group, and (4) an end-of-term SEI form.

Weekly e-mail journal

Students completed a focused e-mail journal by submitting weekly responses to the following statements and questions that were developed by the course instructor:

1. Summarize three main points discussed in today's class.
2. What was most clear to you in today's class?
3. What topics are you having difficulty understanding and why?
4. What questions remain in your mind about the content of today's class that I could answer?

5. What helped you learn in today's class?

This set was developed to address the objectives of the study and provide a good learning experience for the students. The number of questions was limited so that the students were not unnecessarily burdened by the weekly assignment. The e-mail answers to these questions were to be submitted by midnight of the day following the first classroom period of the week. This time frame was chosen so that the classroom experience was still fresh in the students' minds. In preparation for the next classroom period of that week, the instructor read the student submissions in one block of time. The instructor communicated his responses through (1) e-mail replies to the individual students posing questions, (2) e-mail replies to the entire class, and/or (3) replies incorporated into the following lecture. Five percent of each student's course grade was based on the proportion of possible journal entries that he/she submitted *and* completion of the mid-term survey. Justification for basing a portion of the course grade on these two assessments came from the expectation that students communicating about course content and perceptions of their learning would facilitate further learning.

Midterm feedback e-survey

At mid-term, students were asked to complete a course survey administered through WebCT. While responses to the survey were anonymous, WebCT indicated which students responded to the survey. The survey consisted of the following questions that were developed by the instructor to achieve the objectives of the study:

1. On average, how much time outside of class do you spend on AST 337 (AE 447) per week (please be honest)?
2. What do you have the most difficulty understanding in AST 337 (AE 447)?
3. What can I do to help you learn about hydraulics?
4. What suggestions do you have for improving the class?
5. Please rate the instructor's performance in helping you learn (5 = excellent to 1 = poor).

The instructor examined the responses to identify reoccurring themes. Appropriate course adjustments were made based on this mid-term feedback. Ambiguities and questions arising from the data were used in the development of guiding questions for the subsequent focus groups.

End-of-term focus group

Near the end of each term, focus group participants were selected randomly from those who completed the consent form at the beginning of the semester, although a cross-section of students with various cumulative grade point averages was used to ensure that all the participants were not just high or low achieving students. Ten students were asked each time to participate and were offered a light lunch as an incentive. Their participation was voluntary and not all attended because of conflicts. Guiding questions for the focus group discussions were developed based on e-mail responses and the midterm feedback e-survey. A focus group moderator and recorder, neither of which was the course instructor, guided and recorded focus group discussions which lasted approximately one hour. Discussions were recorded on audio tape, and the recorder made annotations to indicate which student was speaking. The audio tape was transcribed by a departmental secretary. In the focus group transcript, the anonymity of the participant was protected by changing the names of the students before it was released to the instructor. The instructor read and analyzed the transcript only after the course was finished. The transcripts were analyzed using the long table method to find potential answers to questions that were raised by data from the other assessments (Krueger and Casey, 2000). To help ensure that the students would respond honestly and accurately, they were told that the

instructor would not know their identity and the instructor would not be involved in conducting the focus group.

End-of-term SEI

At the end of each course term, students completed a departmental SEI form. The SEI form, developed by the departmental curriculum committee, presented a series of statements about the instructor (n = 14), the course (n = 8), and the room (n = 2). For each statement, the student was asked to provide a ranking from 1 to 5 indicating “poor,” “marginally satisfactory,” “satisfactory,” “good,” or "excellent," rating, respectively. Additional written comments were invited "to aid the instructor in making personal and course improvement." Anonymity was maintained. The instructor was not informed of the SEI results until several weeks after course grades had been submitted.

RESULTS AND DISCUSSION

Weekly e-mail journals

The weekly e-mail journals provided timely updates on how students perceived their learning to be progressing. The instructor used this feedback in preparation for the subsequent class period. He presented responses to student questions, reviewed confusing course content from the previous class, and used student questions to bridge the content from the previous class to new topics in the current class. In addition, the e-mail journals provided regular feedback enabling the instructor to understand how the class generally comprehended the material and to make appropriate adjustments in the following class period. For example, the students provided responses identifying what topics were or which topics they were having difficulty understanding. These statements provided the instructor with current information on the student’s perceived understanding which was used to plan the next class.

The questions that the students raised also provided insight into the learning process and the differences between the students in the two curricula. The instructor was particularly attentive to student questions during the rapid weekly review of e-mail journals because they provided opportunities for direct responses to student concerns or misunderstandings in the next class. Across the two years, 632 student questions from the AST 337 students were collected from the e-mail journals. The largest number of questions (31%) were clarifying course content (Figure 1). The second and third largest categories consisted of those asking how specific course content could be applied in the real world (21%) and those asking about course business (16%). About 12% of responses indicated students did not have a question. From AE 447 students, 433 questions were collected across the two years. The largest category of responses (30%) consisted of students indicating that they did not have any questions. The second and third largest categories were made up of clarifying questions about specific course content (24%) and questions about course business (19%). Questions asking how course concepts could be applied practically made up 16% of the total number of questions. The differences in the distribution of questions points to some differences in the two student populations. The AST students seemed to be more comfortable with the qualitative nature of this assignment and with the practical nature of the course. The AE students tended to have more difficulty coming up with questions and seemed to be more concerned about the business of the class often asking such questions as “Where does the lab meet?” or “Are you going to post the solutions to the exam?” Overall, many questions dealt with course content and provided the instructor with helpful information on student learning.

Similar differences in the two student populations were detected through later focus group discussions. AE 447 Students indicated that the instructor's response to student questions at the beginning of the next class made them feel their feedback was shaping the direction of the course. These students had, however, mixed reactions to the process of writing e-mail journal entries each week. Some students did not like the process of weekly writing e-mail journal entries. AST 337 students generally had positive responses to the e-mail journal because of similar reasons to those indicated by the AE 447 students. In addition, these students indicated that answering a question of one student helps other students as well since other students often have the same question but are not able to articulate it. One student commented that answering questions "makes you a little more attentive in class too . . . because you are covering stuff that you have asked, or there's a pretty good chance that your peers have asked, and there's a pretty good chance that you are interested in it too." Another student said, ". . . there's a lot of questions that I've had which I really haven't been able to put into words on the journal . . . he has them in next week's notes. . . that part is real good." The weekly e-mail feedback journal also allowed the instructor to gauge student perceptions about their learning and his teaching methods in a timely manner. The instructor was thus enabled to make well-informed judgments about how to guide the course to optimize student learning.

The response rates for the four different classes of students were similar (Figure 2). During the first half of the term, the response rate was typically between 80% and 90%. After midterm, the response rate tends to drift downward to around 60% to 70% during the last few week of the term. Reasons for this may include fatigue in repeating the assignment every week and general increases in assignment and project deadlines in multiple courses at the end of the semester.

The responses to the learning methods question were categorized according to the type of teaching method that students felt best helped learning in particular classes. Across the two courses, the category multimedia, received the most responses, 26% for AST 337 and a similar percentage, 29%, for AE 447 (Figure 3). AE 447 students responded most frequently (35%) that working problems was the learning method that most helped them learn. With the other learning method categories receiving responses, differences existed across the two classes. The AST 337 students found utility in the active learning exercises (14%), seeing problems solved (13%), and seeing physical components (10%). The AE 447 students indicated that explanations about concepts were useful (10%).

Two possible reasons may explain why particular methods received high numbers of responses. First, particular methods were perceived as being useful in students' learning. Computer animations were often cited as helping learning – as the students found that animations helped to crystallize particular concepts. One student wrote that computer animations were "really helpful to see these complex systems in motion to truly understand what is happening." Second, some methods were used more frequently than others. The instructor explained course concepts and worked problems, for example, in practically every class period. It is thus expected that this category would receive high response rates.

Midterm feedback e-survey

Over the four classes surveyed, the response rate was high, ranging from 100 % to 86%. The responses for specific questions requiring short answers ranged from no answers provided in a few cases, to one or two word answers, to a response that consisted of 100 words. These responses provided formative assessment of student perceptions of the first-half of the course. They provided a more global perspective of the course, as compared to the weekly e-mail journals – which provided perspective on individual classes. The midterm feedback e-survey helped the instructor better understand student learning difficulties by providing feedback that could be easily summarized and interpreted.

When the students were asked what they found to be the most difficult to understand, the largest proportion of responses (24%, overall classes) indicated that unit conversions were causing difficulty (Figure 4). These responses led the instructor to provide more example problems with unit conversions and to point out where students typically have difficulties with units in particular equations. The second largest category of responses (21%) were those related to the fluid property of viscosity. Problems with viscosity may have been in part a unit conversions problem, because students in the course are required to convert from one set of viscosity units to another and to apply the concept of viscosity to fluid power system problems. However, students may also have had difficulty connecting the concept of viscosity with prior knowledge and experience. Thus after the first year, the instructor related viscosity to common fluids (e.g. water, honey, alcohol) with which the students would be familiar. Another largest category of responses were those that indicated that no problems existed or no particular "most difficult" concept could be ascertained (13%).

Similarly, responses to the question about how the instructor could help student learning also provided greater insight into student learning preferences than the responses in the weekly e-mail journal about learning methods used in individual classes. Two themes emerged from the student responses. One theme – as indicated by 50% of the responses across all classes – was that having "real world examples," "more hands on stuff," "more practical stuff," and "case study examples" would enhance their learning (Figure 5). Another theme that emerged – 13% of the responses – was that the students thought more examples, as indicated by responses such as: ". . . more examples . . .," and ". . . do more problems/examples," would help learning was that the students thought more "hands-on" exercises would help learning.

When asked a more general question about what students would consider as an improvement for the class, the students provided many differing responses. These suggestions were generally understandable and often provided specific information on how the course could be improved. In addition to these suggestions, a theme similar to those identified above emerged: Many responses indicated that giving the course a more practical, hands-on orientation and working more problems could improve the course.

In general, from the responses to the e-survey is was difficult to discern differences between the AE and AST students.

End-of-term focus groups

For the AE 447 classes, in 2001, eight out of 14 students participated (57%); while in 2002, four out of 25 students participated (16%). For the AST 337 classes, in 2001, seven out of 29 students participated (24%); while in 2002, three out of 27 students participated (11%).

In general, focus group discussions consisted of honest, open and frank opinions of what the students thought about the class. They seemed to be uninhibited in speaking their mind and free in providing critical comments. Because of the small percentage of students involved in the focus group, results may not be representative of the entire class; however, the results were not in conflict with the other assessments which collected data from the entire class. The focus group assessment of the course had value because of the in-depth insights into student thoughts about the course, students' perceptions of their learning, and students' observations on how the instruction and the other assessments were helpful to their learning. The focus group was summative and as such did not lead to instructional improvements during the same term. Nevertheless, the deeper understanding into (1) student learning preferences and (2) perceptions of teaching methods derived from the focus group discussion was beneficial and applicable to subsequent terms.

Student learning preferences

Focus group discussions clarified feedback from other assessments leading to a deeper understanding of how student learning was taking place. The focus group discussions clarified what it meant for the class to be more "real-world" or "practical" – themes that arose from the midterm e-survey. Through the focus group discussion, we came to understand a difference between the AE and AST students in what they mean by being "real-world." The AE students mean they can see the connection between the course content and where they might use a concept in their future careers as fluid power engineers. One student praised this building of connections when describing the instructor, "He relates to industry … that really helps me." However, when the AST students referred to something being "real-world," they meant they can see the connection between the course content and their past practical experience with hydraulics either from growing up on a farm or from work experiences.

In addition, a visual over a verbal learning preference was identified from the discussions. For example, one student said, "I need to see what is there and see how it works," or another replied, "I just think it's good to see how things work visually instead of just reading [about] it." They also found animations of circuits and systems that were shown in class helpful to their learning. One student said, ". . . you can visually see it on a screen and see things moving. I guess that's one thing that helps me learn is to be able to see it." Another expressed appreciation for figures and illustrations, "I think that's part of good teaching – to have lots of good visuals." On the other hand, students indicated that they had difficulties reading the textbook to gain an understanding of how things work. A student said, "I just can't read about it and learn about it very well." Or another, "I know myself I just can't stick my nose in a textbook and learn everything I need to know." Another student remarked, "I could read every manual on hydraulics, and it just wouldn't get it done for me. I wouldn't know anymore than I know right now."

Perceptions of instructional methods

The focus group discussions also provided summative reflections on the methods that helped learning across the entire course, in contrast to the weekly e-mail journal, which provided class dependent feedback, or the midterm feedback e-survey in which the students were asked formatively what could be done in class to help their learning throughout the rest of the course. In these discussions, the use of animations and active learning team exercises were mentioned as being helpful. Students also indicated that quizzes and cource content on WebCT, starting off each class period with answers to journal questions, visualization, solving example problems, and making connections with real-world experiences and concrete examples in industry were teaching methods that helped their learning.

End-of-term SEI

The departmental SEI form reflected a teacher-centered paradigm of education. The first sentence on the SEI form was, "Your frank and honest answers to each question in this evaluation will help your instructor improve this course and teaching procedures used in it." This statement set the tone for the entire SEI form, that is, the quality of a course is primarily a matter of the instructor's performance. The questions related to the instructor and course solicited ratings based on how well the instructor had performed or met the expectations of the students. The instructor, for example, was rated on how well he "knew the subject matter," "presented legible board work," or "was well-prepared for class." The third group of questions addressed the adequacy of the physical classroom environment. Students are asked directly about their learning in only two questions: (1) "The course assignments helped students learn subject material," and (2) "The course increased student knowledge of the subject."

Across all classes, 84 out of 95 students (88%) completed SEI forms and the mean scores ranged from 4.65 to 3.24 except a much lower score on two occasions for the statement, “The text material was well-written and easily understood.” When the AE 447 students were asked if the course assignments helped them learn subject material, in 2001, the mean score was 3.42 and the standard deviation was 0.79. On the same question in 2002, the mean score was 3.77 and the standard deviation was 0.68. In 2001, the AST 337 students responded in a manner that yielded a mean score of 3.72 and a standard deviation of 0.94, and in 2002, the mean score was 4.08 and the standard deviation was 0.70. When asked if the course increased student knowledge of the subject, in 2001 for the AE 447 students, the mean score was 3.33 and the standard deviation was 0.98, and in 2002, the mean score was 4.00 and the standard deviation was 0.67. The AST 337students responded in a manner that resulted in a mean score of 3.67 and a standard deviation of 1.05 in 2001, and in 2002, the mean score was 4.36 and the standard deviation was 0.57.Using the ratings, it appears the students perceived that their learning was between “satisfactory” and “good” in most classes with between “good” and “excellent” in a few cases.

Of the 84 forms, 36 (43 %) had written comments on them. Students often composed their written comments with multiple phrases that were often distinct suggestions, criticisms, or praise. Some of these phrases were positive statements such as: “The course was good,” or “Instructor did an excellent job trying to improve the class.” Other phrases were neutral statements or suggestions such as: “more examples in class” or “be more clear on everything.” Many phrases (63%) were negative statements such as: “hated the grading system” or “book didn’t help much.” It was difficult to categorize the phrases because so many different topics were addressed.

While the SEI form provided a low effort means of instructor evaluation, it tended to provide less feedback to instructors on how to improve learning. In particular, the quantitative measures reveal some measure of student satisfaction, and some basic guidance on course improvement could be derived from them. Generally, however, the scores did not depart from the range corresponding to satisfactory to excellent ratings so not much meaning could be derived from these measures. In addition, the scores are difficult to interpret to gain understanding of how the course could be changed to affect improvements in student learning. The written comments, if provided, have potential to provide suggestions for course improvement though they usually are so brief that they lack the context for useful interpretation.

Synergism of assessments

Through this research, we found a synergistic effect when using multiple formative and summative classroom assessments techniques for a course. Part of the reason for the synergistic effect of the multiple assessments was that the assessments differed in repetition, focus, and type of questions. Because of these differences, each of the assessments was probing at different points of information about teaching and learning, making it difficult to rank the value of one relative to another. In addition, the differences led to the combination of assessments providing a fuller view of teaching and learning than if each assessment was used in isolation.

Through careful analysis of the data from each of the assessments and use of questions arising from one assessment to design or guide the analysis in another assessment, the interaction between student learning and instruction was more fully understood. Clearly, adequate assessment of student learning is both formative and summative and will require more than a traditional SEI. Formative assessment promotes student reflection on learning, provides the instructor with information that can be used to change the course during the term, and thus provides students with evidence that their feedback is critical in the learning process and is

taken seriously by the instructor. As shown in other studies, while SEI may be a valid indicator of instructional quality (Greenwald, 1997), SEI tends to provide less information useful for improving instruction. Having the other assessments available for the same course reveal how much more insight can be gained.

CONCLUSIONS

Multiple assessments were helpful for understanding how students learned and what methods were perceived as helpful for learning. Formative assessment helped the instructor also quickly understand where students had difficulties learning and enabled improvements during the courses. The use of multiple classroom assessments did not lead the authors to conclude that one or more assessments were better than the others. In fact, because the assessments were probing different aspects of student perceptions of their learning, the multiple assessment approach led to synergism that resulted in deeper insight about the teaching–learning process.

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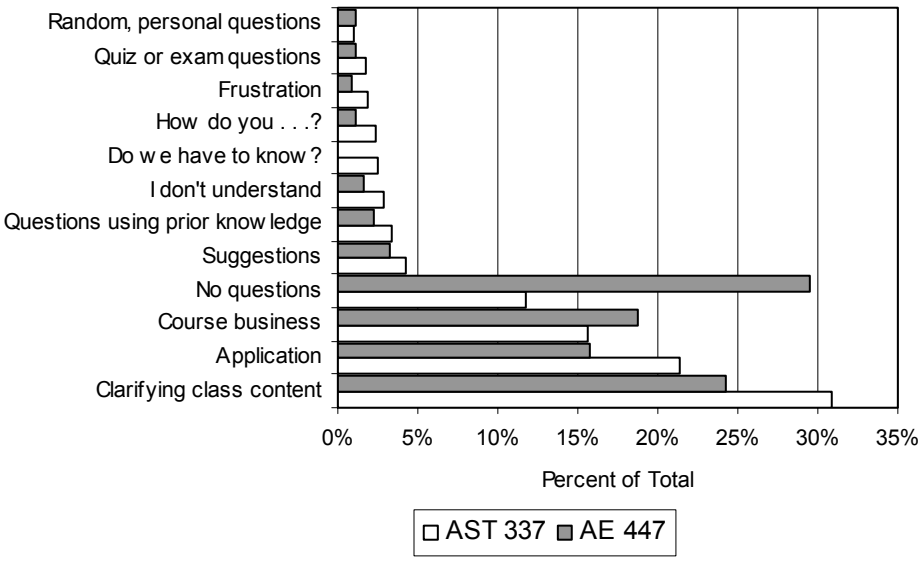

Figure 1. Percentages of student question type by category from the weekly e-mail journals (AST 337, N = 632; AE 447, N = 433).

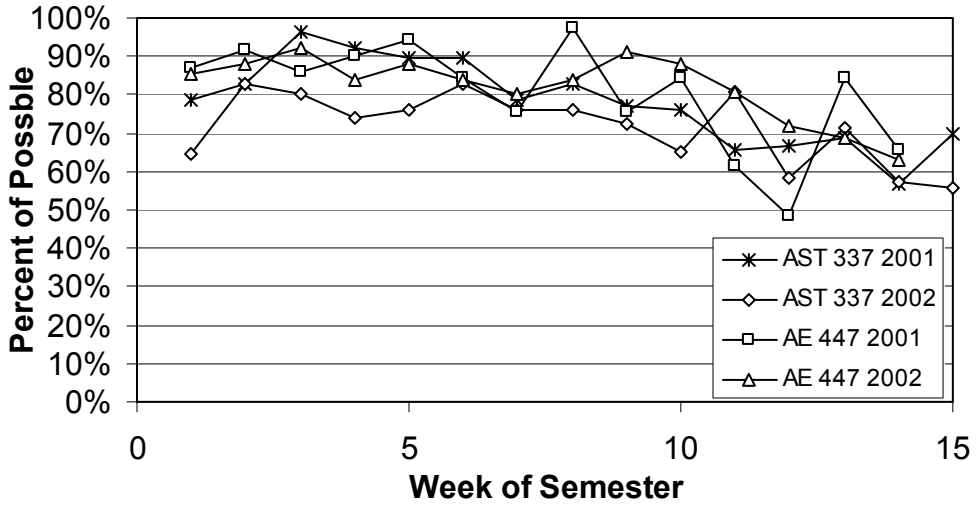

Figure 2. Percentage of possible number of e-mail feedback responses per week in the semester (AST 337 2001, N = 29; AST 337 2002, N = 27; AE 447 2001, N=14; AE 447 2002, N=25).

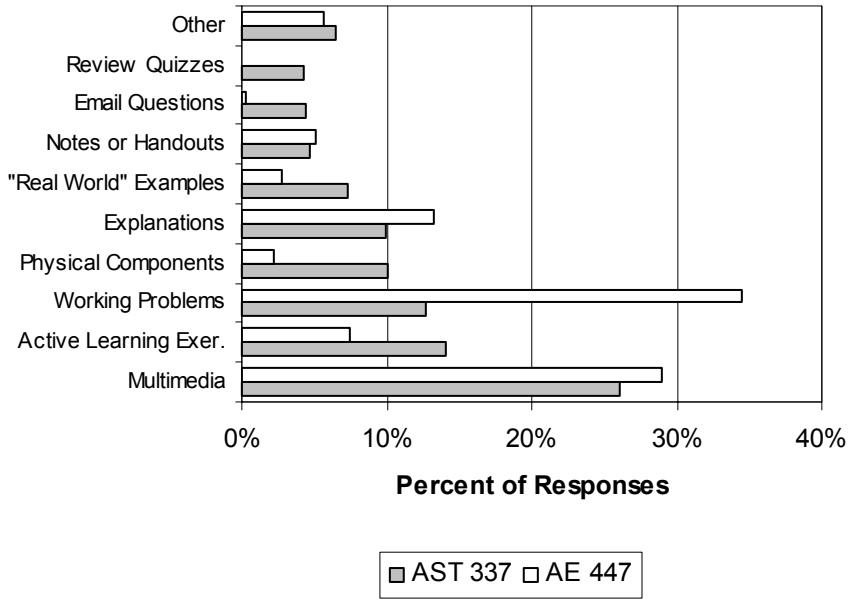

Figure 3. Percentages of responses to the weekly e-mail journal question, "What helped you learn in today's class?" categorized by type of instructional method (AST 337, N = 616; AE 447, N = 446).

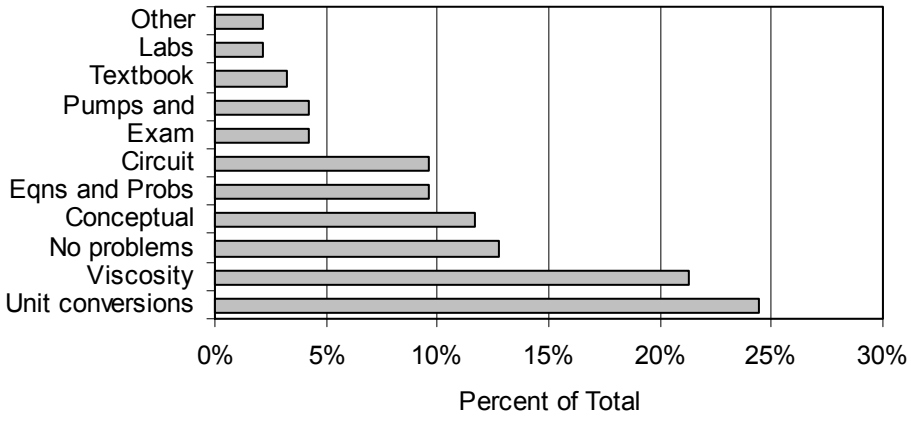

Figure 4. Percentages of responses to the most difficult to understand course areas from the midterm e-survey (all classes combined; N = 94).

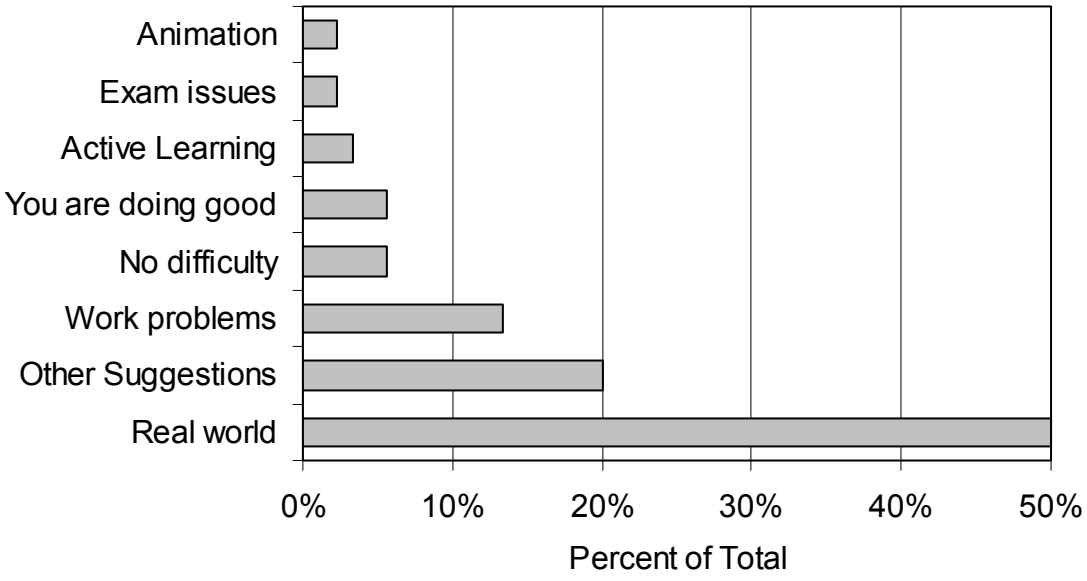

Figure 5. Percentages of responses to what helped students learn best from the midterm e-survey (2001 and 2002 classes combined; N = 90).