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Continuous Engineering Course Improvement through Synergistic use of Multiple Assessment

Brian L. Steward
Iowa State University, bsteward@iastate.edu

Steven K. Mickelson
Iowa State University, estaben@iastate.edu

Thomas J. Brumm
Iowa State University, tbrumm@iastate.edu

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Abstract
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Continuous Engineering Course Improvement through Synergistic use of Multiple Assessment*

B. L. STEWARD, S. K. MICKELSON and T. J. BRUMM
Agricultural and Biosystems Engineering Department, Iowa State University, Ames, IA 50011, USA.
E-mail: bsteward@iastate.edu

During two terms of a fluid power engineering course, four formative and summative course assessments, weekly e-mail feedback journals, midterm e-surveys, focus groups, and departmental student evaluation of instruction (SEI) forms, were used to assess student perceptions of their learning and the instruction methods used. The weekly e-mail feedback journals and midterm e-surveys enabled several course adjustments during each course term. Focus groups were used to explore students' perceptions of both the course and the formative assessments. The SEI provided quantitative measures of student satisfaction that correlated with the focus group discussions. Using multiple formative and summative course assessments techniques had a synergistic effect on gaining insights into the teaching-learning process.

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 [1–4]. 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 [5].

Historically, most classroom assessment has been summative—with end-of-term assessments of learning that has taken place during each term of instruction [6]. 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 [7]. 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 [3]. Weimer 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 [8]. As such, SEI does have value for evaluating instructors and instructional quality [9]. With this in mind, it is valuable to think in term of assessments according to their purpose: either *evaluating teaching* or *improving* instruction [8].

In contrast, formative assessment uses feedback to 'adapt teaching to meet student needs' [1] over the period of instruction. Formative assessment's primary goal 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 [1]. Other studies have also demonstrated how formative assessment successfully enhances student learning [10, 11]. In addition, the shift from a teacher-centered to a learner-centered educational paradigm creates a need for formative classroom assessment [3]. 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 [12].

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 [5]. 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

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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 [12]. 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 has shown that there is a direct relationship between student perceptions of their learning and actual learning [13].

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 [14, 15]. Deal found that e-mail journaling also helped students develop improved self-assessment skills and better synthesize what they were learning [16]. 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 [5, 17]. 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 [17].

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 [5]. 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 [18]. Implementing a web-based midterm feedback survey provides the instructor additional flexibility in survey design and enables rapid collection and analysis of results [19].

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' [20]. According to Christopher, 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 [21]. Hendershott and Wright used student focus groups to explore student attitudes about university general education curriculum requirements and behavior arising from these requirements [22]. They found focus groups uncover 'rich data' going beyond information gleaned through surveys. Hamilton *et al.* found student focus groups provided specific suggestions for course improvement as well as significant increases in SEI ratings [23].

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 same course 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 and (2) determine how the formative assessments could successfully be used to make course adjustments during the duration of the course.

METHODS

The course under study was entitled Power and Control Hydraulics, an elective offered in the Agricultural Engineering curriculum within the Department of Agricultural and Biosystems Engineering at Iowa State University. The course 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 in which the instructor discussed course content, solved example problems, and guided the students in active learning exercises. The latter involved 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. WebCT Campus Edition (WebCT Inc., Lynnfield,

MA), an online course management and content delivery system [24], provided course content to students and administered periodic quizzes, practice exams, and a midterm survey.

Four classroom assessments were implemented during the fall semesters of 2001and 2002. There were 14 and 25 students in the 2001 and 2002 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. Each of these assessment tools will be described in more detail in the following section.

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:

- Summarize three main points discussed in today's class.
- What was most clear to you in today's class?
- What topics are you having difficulty understanding and why?
- What questions remain in your mind about the content of today's class that I could answer?
- 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 in number 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 second 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. The responses to the questions were also used in developing questions for the focus group sessions.

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:

- On average, how much time outside of class do you spend on AE 447 per week (please be honest)?
- What do you have the most difficulty understanding in AE 447?
- What can I do to help you learn about hydraulics?
- What suggestions do you have for improving the class?
- 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, a pool of students was selected from each class to represent a cross section of past academic performance. These students were asked to participate in the focus group and were offered a light lunch as an incentive. Their participation was voluntary, and some students were unable to participate because of time conflicts. 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, but 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 [20]. 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. In 2001, eight out of 14 students participated (57%); while in 2002, four out of 25 students participated (16%).

End-of-term SEI

At the end of each 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 much insight into the learning process. 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. In 2001, 148 student questions were collected from the e-mail journals. The largest category of responses (51%) consisted of students indicating that they did not have any questions (Fig. 1). The second and third largest categories were made up of clarifying questions about specific course content (16%) and questions asking how course concepts could be applied practically (11%). In 2002, the students submitted 285 questions. The largest category contained questions clarifying course content (29%) The next largest categories were questions about course business (26%) and responses indicating no questions (18%). In 2001, the instructor did not provide feedback to the students regarding the large number of 'no question' responses. However, in 2002, he did indicate that 'no question' was not the best response, likely leading to decreased 'no question' responses in 2002. Nevertheless, many questions dealt with course content and provided the instructor with a large quantity of helpful information on student learning.

Feedback about the e-mail journals was obtained in later focus group discussions. 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. Students had, however, mixed reactions to the process of writing e-mail journal entries each week. When asked in the focus groups how the journals affected their learning, students recognized the value of journals in helping them learn. One student replied, 'Yes, it definitely forces you to maybe pound it in your brain one more time.' Nevertheless, some students did not like the process of weekly writing e-mail journal

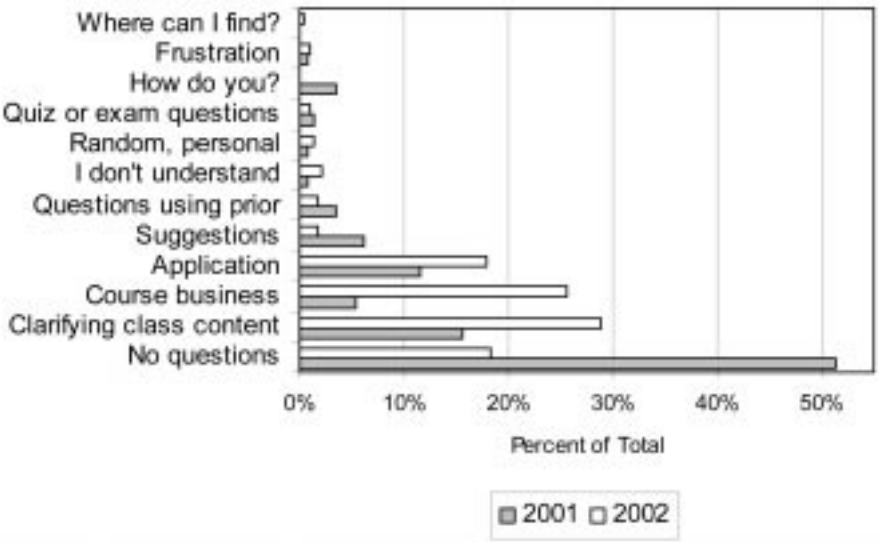

Fig. 1. Percentages of student question type by category from the weekly e-mail journals (2001, N = 148; 2002, N = 285).

entries. One student replied when asked how the e-mail journals helped learning, 'You have to answer the same questions each week and if you don't have any questions then it's just a pain.' In addition, requiring students to write about course topics in the journal forced them to interact with and think more deeply about course content. One student illustrated this interaction when he/she wrote, 'The question that I have on the above topic deals with the example that we did in class . . . never mind the question, as I tried to figure out how to word it, I solved the question on my own.' 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 better-informed judgments about how to guide the course to optimize student learning.

While the e-mail journal was effective, it was limited by two constraints. First, the quality of feedback depended on students providing feedback that truly represented their experience. Enthusiasm for responding to the e-mail journal tended to wane in the last half of the course as indicated by the decrease in the number of responses as the semester progressed (Fig. 2). Second, reading through all of the student responses each week required a substantial amount of instructor time, and would have required even more if all responses were categorized and reflected upon throughout the course. Typically, the instructor read through the responses when preparing for the next class, looking for questions to address to provide new opportunities for learning. The instructor also tried to gain an understanding of the difficulties students were encountering to provide a review of content in the next class to help learning. In incorporating this feedback into the subsequent class, he made modifications to the presentation and lecture notes. While a general understanding of student perceptions of learning came through the quick during-course analysis, more insight came after working with the data in the post-course analysis which had value for subsequent classes. During each course term, for example, the instructor read student responses to the questions dealing with learning methods that the students felt helpful. But often, it was difficult to gain much understanding from these individual responses. Part of the reason was that the responses were class session dependent, and the mix of teaching methods in different classes varied. In post-course analysis, however, more understanding was derived from these responses by examining aggregated data.

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 years, the percentages of responses were highest for working problems, multimedia, and instructor explanations, respectively. In 2001, 158 responses were collected. The category multimedia, received the most responses (35%), while instructor explanations and working problems were the next highest capturing 23% and 20% of the total number of responses respectively. In 2002, 288 responses were collected and the working problems category received the most responses (42%), with multimedia (25%) and active learning (10%) receiving the next highest numbers of responses (Fig. 3).

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

In 2001, 12 out of 14 students (86%) responded to the midterm feedback e-survey, and in 2002, 24 out of 25 students (96%) responded. The responses for specific questions requiring short answers ranged from no answers provided in a few cases,

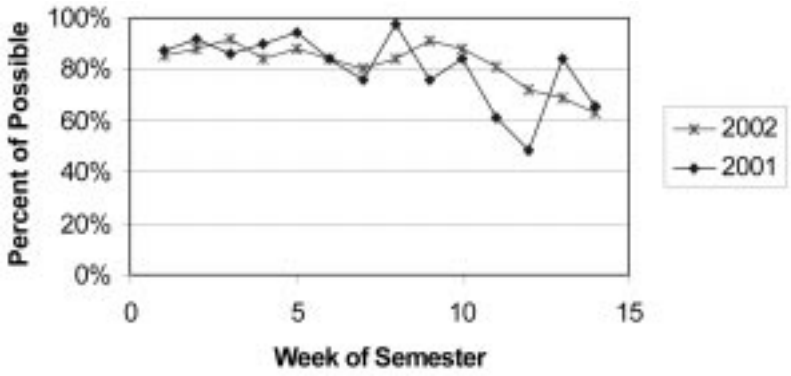

Fig. 2. Percentage of possible number of e-mail feedback responses per week in the semester (2001, N = 14; 2002, N = 25).

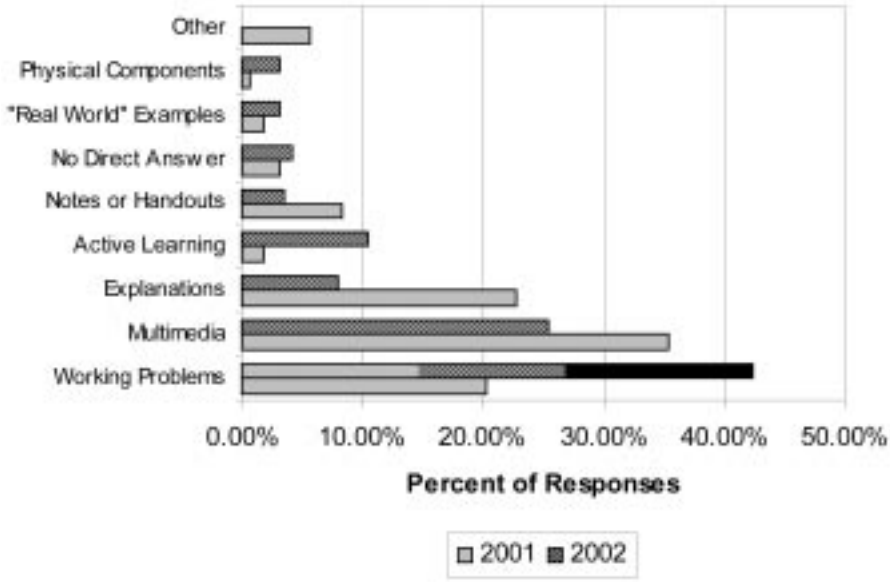

Fig. 3. Percentages of responses to the weekly e-mail journal question, 'What helped you learn in today's class?' categorized by type of instructional method (2001, N = 158; 2002, N = 288).

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.

Nevertheless, when the students were asked what they found to be the most difficult to understand, the largest number of responses across both years (31%) indicated that no problems existed or no particular 'most difficult' concept could be ascertained (Fig. 4). However, of particular concepts that students considered difficult, 25% of the responses were related to the interpretation of circuit diagrams. For example, one student wrote, 'Sometimes it's difficult to look at a schematic and know WHY it is laid out that way . . . it's relatively easy to see what the circuit does, but not always easy to understand why.' The third highest number of responses (17%) involved difficulties with unit conversions. Competency as a fluid power engineer requires skill in converting units in both English and S.I. measurement systems. 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.

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 28% of the responses across both years—was that

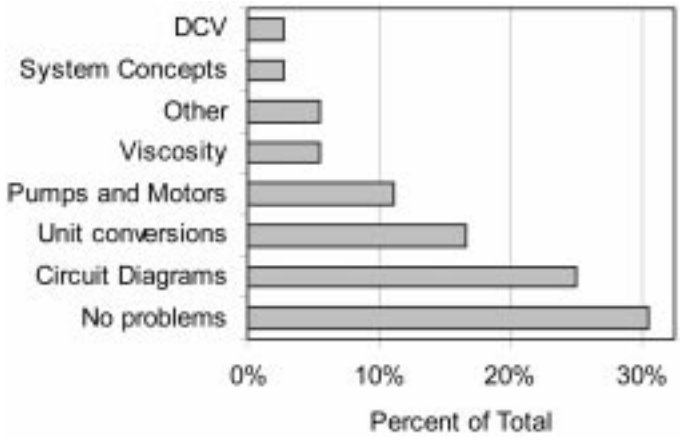

Fig. 4. Percentages of responses to the most difficult to understand course areas from the midterm e-survey (2001 and 2002 classes combined; N = 36).

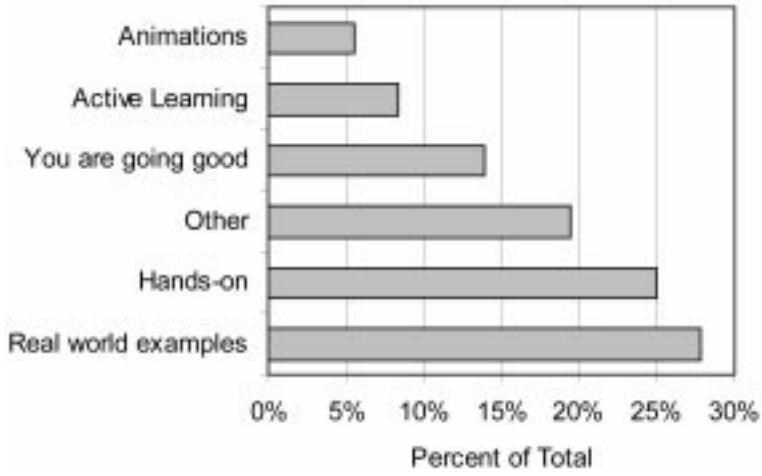

Fig. 5. Percentages of responses to what helped students learn best from the midterm e-survey (2001 and 2002 classes combined; N = 36).

having 'real world examples,' 'more examples that apply to real life,' and 'case study examples' would enhance their learning. The second theme that emerged—25% of the responses—was that the students thought more 'hands-on' exercises would help learning (Fig. 5). These two response categories clearly indicate student preferences for visual, sensory, and active learning. With this knowledge, the instructor has continued to introduce improvements to the course that better address these learning preferences.

When asked a more general question about what students would consider as an improvement for the class, the students provided many differing responses such as, 'scale back the amount of work just a little,' or 'have class in a room where PowerPoint is available.' 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.

End-of-term focus groups

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 negative comments.

Because of the small percentage (31%) 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 discussions in 2001 and 2002 were quite different in character. In 2001, the focus group was larger, and the discussion tended to quickly drift away from the guiding question posed by the moderator. The answers provided by individual participants were terse, and the tone tended to be quite negative about the course. In 2002, the focus group was much smaller because of student time conflicts, and the participants provided longer, more thoughtful responses to the guiding questions. The tone of this discussion was more positive and suggestions were more constructive in nature. These differences between the focus groups, illustrate a potential drawback of focus groups. While the open-ended interaction of the participants in focus groups—stimulated by the moderator's guiding questions—leads to useful data, it also can make the process of inquiry more difficult to control [22]. This lack of control can complicate drawing of meaningful conclusions.

Nevertheless, the focus group assessment of the course had value because of the in-depth insights into students' 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 that when students refer to something being 'real-world,' they 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'.

The idea of something presented in a real-world fashion may also be connected to student learning

preferences. The focus group discussions gave substantial insight into the how students prefer to learn. In particular, focus group discussions showed clearly students' preference for visual over verbal learning. Visualization is very important to students. They thus 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.'

This preference for the visual is easily contrasted with the students' dislike of reading textbooks to learn course concepts. Students indicated, for example, that they had difficulties reading the textbook to gain an understanding of how things work. A 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.' When asked about the textbook, one student said, 'Get rid of it'.

Similarly, the students expressed a preference to learn actively through hands-on lab experiences. One student stated this preference well, 'Once you've had hands-on experience and go back to the classroom, it makes it a lot easier. When you see it on paper, it means a lot more.' In reference to a demonstration of pumps in the lab, a student spoke up, 'That was great. Everyone remembered what a geroter pump looked like because he showed us.'

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 the 2001 focus group discussion, the use of animations and active learning team exercises were briefly mentioned as being helpful. In 2002, the focus group discussion that followed from this question was considerably longer and included discussion of the usefulness of e-mail journals, example problems, concrete examples in industry, visualization, course notes, and course content on WebCT.

The two focus group discussions about particular instructional methods were substantially different. These differences can be illustrated by discussions about the use of WebCT. In 2001 focus group discussions, the students seemed irritated and felt that using WebCT added additional work. Some students expressed displeasure for the additional information that the instructor made available on WebCT. One student expressed frustration about the course being based on information from multiple sources, not only traditional sources, like a textbook and course notes, as well as online information. They didn't appreciate the need for them to go to WebCT to get information. 'When you are a professor, just don't put it on the web and expect us to just go get it,' remarked one student. New information was posted to WebCT during the duration of the course and led to another student saying, 'It's like you just have to be checking all the time. It's not a web-based course and so I don't feel the need to go there.' In 2002, however, the focus group discussion about WebCT was very positive and the students seemed to view WebCT as a tool. This group of students preferred to have information available on-line: 'It's just a lot easier to get at stuff.' Another student said, 'I like . . . the availability of all the slides . . . on WebCT.' These students also appreciated the on-line quizzing feature of WebCT, '[WebCT is] very valuable. He usually has a practice test on there before the exam and you basically print that off and work through it, and it really helps.'

These differing focus group discussions illustrate several considerations about the use of focus groups. First, it is important to keep in mind that focus groups are only a sample that may not be representative of the entire class. In related research, we have observed that smaller focus groups, while being a smaller sample, often produce the most insightful discussions. As such, even though differences between the focus groups exist, those differences reveal the diversity of perceptions and attitudes about instructional methods. Second, it is important to consider information from other assessments when drawing conclusions from focus group discussions. Since most of the students were involved in the other assessments, those assessments are more representative of the entire class while not providing the depth of insight that came from the focus groups. In addition, the student responses from the other assessments were more independent from one another than the responses in the focus groups. While some of the deep insights derived from focus group discussions came from the interactions of the participants, this interaction may also be a weakness as the tone or attitude of a few persons can have a strong effect on the direction of the conversation.

One unexpected insight that became clear through the focus group discussions was that students faced perceived large demands on their time as they tried to juggle multiple projects included in upper level engineering classes. For example, one student said, 'It happens in a lot of the engineering classes that I've had. It all comes down to the final design project right at the end. In these last final three or four semesters, and they all come due about the same time so you have some difficulty in managing your schedule.' Thus given this time pressure, the students expressed frustration about the open-ended design project assigned in this course.

As a result of time pressure, it appears many

students just meet basic course requirements. This is not necessarily a sign of laziness, but could be their method of managing the demands of multiple courses. In addition, students appreciate instructional methods that help them save time in finishing an assignment and tend to dislike methods that require additional time or are perceived as busy work. This may be the reason for the mixed reactions to the e-mail journals and WebCT. Along these lines, the students preferred the instructor to work problems in the classroom.

These insights from the focus group discussions have led to conversations among faculty about course and capstone design projects and how we might accommodate these student concerns. Discussions have taken place about adjusting major assignment deadlines and possible integration of projects with other courses. Insights from the focus groups have led the instructor of this course to continually improve the course by integrating more of those methods that the students find helpful into the course.

End-of-term SEI

A critical analysis of the departmental SEI form revealed that it 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.'

In 2001, 12 out of 14 students (86%) completed SEI forms; while in 2002, 22 out of 25 students (88%) completed the forms. In 2001, the mean scores ranged from 4.25 to 3.25, with the exception of a mean score of 2.83 for the statement, 'The text material was well-written and easily understood.' In 2002, the mean scores ranged from 4.45 to 3.24 with the question about the text drawing the lowest score. When 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. When asked if the course increased student knowledge of the subject, in 2001, the mean score was 3.33 and the standard deviation was 0.98. On the same question, in 2002, the mean score was 4.00 and the standard deviation was 0.67. Using the ratings, it appears the students perceived that their learning was between 'satisfactory' and 'good' in both years.

Of the 34 forms from the two years, 19 (56 %) had written comments on them. Students often composed their written comments with multiple phrases that were often distinct suggestions, criticisms, or praise. From the written comments, 24 distinct phrases were found. Three of these phrases (13%) were positive statements such as: 'excellent, well presented class' or 'the course was good'. Six of the phrases (25%) were neutral statements or suggestions such as: 'more examples in class' or 'be more clear on everything'. The remaining 15 phrases (63%) were negative statements such as: 'too much work for two credits' or 'book didn't help much'. It was difficult to categorize the phrases because so many different topics were addressed. Of the categories drawing the largest number responses, however, there were eight negative statements about the amount of work associated with the class. There were also three negative statements about the textbook.

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. For example, the low scores regarding the course text indicate consistent student dissatisfaction with the text, but they do not indicate how to make an improvement in the text. The written comments, if provided, have potential to provide suggestions of how the course could be improved, but they tended to be dominated by negative comments.

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.

The resources required to implement multiple classroom assessments may be a point of concern, particularly for larger classes. Scaling multiple classrooms assessments to larger class sizes, however, may not necessarily lead to prohibitively large increases in time and effort required to administer the assessments. E-mail journals are the only assessment of those examined, where instructor time to review and respond to the questions is expected to scale linearly with class size. For the size of classes described in the paper, typically only about one hour per week was required to process this feedback. The mid-term feedback survey and the SEI were automated, and larger class sizes should not add much additional time for review, but will result in a larger dataset. Focus groups may benefit from a larger class size which would provide a larger pool from which a focus group may be formed. Since there is not a clear advantage of a larger focus group and the resources required per focus group discussion are fixed in terms of faculty and staff time, a larger class should not lead to additional resource requirements.

CONCLUSIONS

Multiple assessments were helpful for a course instructor to gain understanding of how students learned and what instructional methods were perceived as helpful for learning in a fluid power engineering course. Formative assessments helped the instructor quickly understand where students had difficulties learning and enabled the instructor to make improvements during the courses and from course to course. The following conclusions can be drawn from this study:

The combination of assessments was helpful in understanding which instructional methods students preferred.

The weekly e-mail feedback journal helped the instructor immediately understand where students were experiencing difficulty in learning particular concepts. This feedback allowed the instructor to make timely course adjustments to help students overcome these difficulties. Furthermore, students felt encouraged that their feedback was affecting how the course was taught. The students tended to dislike the weekly task of completing the journal entries, but some students found educational value in this assignment.

The mid-term e-survey provided a more global perspective of student learning. While some specific suggestions were easily understood, other responses were somewhat difficult to interpret due to lack of explanation.

Focus group discussions provided insight into perceptions of student learning and instructional methods, as well as how demands on students' time affected their perceptions of instructional methods. Depending on the characteristics of the focus group, discussions can sometimes go in seemingly divergent directions and are affected by the attitude and tone of the participants.

The SEI required a low effort evaluation of student perceptions of the course, particularly their preferences and overall satisfaction with the instructor. It provided less useful information for course improvement than the other assessments.

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 they were probing different aspects of student perceptions of their learning, it was difficult to rank the value of one relative to another. The multiple assessment approach led to the synergism that resulted in deeper insight about the teaching–learning process.

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Brian L. Steward is Assistant Professor of Agricultural and Biosystems Engineering at Iowa State University. Dr. Steward teaches in the areas of fluid power engineering and technology and dynamic systems modeling and controls. He is actively involved in teaching and learning research on the assessment of student learning at the course level. His research areas include machine vision and image processing for agricultural sensing, precision agriculture, and agricultural vehicle modeling and controls. He is a member of ASEE and ASAE. He received his BS and MS in Electrical Engineering from South Dakota State University and his Ph.D. in Agricultural Engineering from the University of Illinois at Urbana-Champaign.

Steven K. Mickelson is Associate Professor of Agricultural and Biosystems Engineering at Iowa State University. Dr. Mickelson is the teaching/advising coordinator for the ABE department. His teaching specialties include computer-aided graphics, engineering design, soil and water conservation engineering, and land surveying. His research areas include soil quality evaluation using x-ray tomography, evaluation of best management practices for reducing surface and groundwater contamination, and manure management evaluation for environmental protection of water resources. Dr. Mickelson has been actively involved in the American Society for Engineering Education for the past 17 years. He received his Agricultural Engineering Degrees from Iowa State University in 1982, 1984, and 1991.

Thomas J. Brumm is Assistant Professor of Agricultural and Biosystems Engineering at Iowa State University. Before joining the ISU faculty in 2000, he worked in the seed industry for 10 years. He leads the Agricultural Systems Technology curriculum in the ABE department. His technical expertise includes: near-infrared analysis technology; grain processing; grain and seed quality; and the evaluation of grains and oilseeds for food and feed use. He received Bachelor's degree from Iowa State University, and his Master's degree from Purdue University, both in Agricultural Engineering. In 1990, he received his Ph.D. in Agricultural Engineering with a minor in Chemical Engineering from Iowa State University.