METHODS FOR OUTCOMES ASSESSMENT BY FACULTY

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Abstract *— Capstone experiences such as design projects, laboratory projects, projects with industry, and research projects are excellent opportunities for program assessment. One method for using capstone experiences for program assessment is to develop rubrics to allow qualitative assessment information to be quantified in a consistent manner. The summative results of the assessment process can be used to improve the program, thereby completing the feedback loop to the curriculum. The formative results of the assessment process can be used to develop students' skills over time and make certain that their knowledge and skill base is as desired. Another method for assessment of capstone experiences by faculty involves questioning students during an oral presentation of the results of a capstone experience. Through questioning and follow-up questions, detailed information on students' level of understanding can be revealed. Students get immediate feedback on their work, closing one portion of the assessment feedback loop. Class time devoted to detailed project review and follow-up assignments also contribute to closing the feedback loop with students. The faculty is provided feedback on students' performance, closing the feedback loop with respect to faculty instruction.*

Classroom assessment is another method of assessment by faculty and is conducted for the specific purpose of improving teaching and learning within a specific class. It completes a short-term feedback loop in which the measure and feedback occur almost continuously. The result of using classroom assessment is improved teaching, improved learning, and a higher-quality graduate.

Index Terms ¾ capstone experiences, outcomes assessment, rubrics.

INTRODUCTION

Outcomes assessment information can be obtained from surveys and from direct assessment by faculty. Too often, there is an over-reliance on alumni and exit surveys and an insufficient amount of direct assessment by faculty. An assessment plan cannot rely exclusively on self-assessment instruments.

Capstone experiences are an excellent opportunity for summative faculty assessment of learning outcomes. All engineering programs have some type of capstone experience. Therefore, assessment can be done using something that already exists. Furthermore, since the capstone experience is where knowledge gained earlier in the curriculum is applied to the solution of a comprehensive problem or where phenomena learned in class are illustrated in a laboratory experiment, the opportunity exists for assessment of most, if not all, aspects of the curriculum. Finally, since, in many programs, capstone experiences involve multiple instructors, the participation of multiple faculty members in the assessment process can be achieved.

Classroom assessment, a method of formative assessment, is a teaching technique that allows the instructor to assess the effectiveness of instruction and student learning in one particular class meeting or in a series of class meetings. Classroom assessment alone is not sufficient to fuel an assessment plan; however, it is an excellent complement to an existing plan.

In this paper, methods for using capstone experiences both for summative program assessment results and for formative assessment to develop skills over time are described. Additionally, one formative classroom assessment method is discussed.

ASSESSMENT USING CAPSTONE EXPERIENCES

In the discussion that follows, the term "capstone experience" is used in a broad sense. Capstone experiences include the senior-year (fourth-year) design projects common to most curricula as well as laboratory experiences, which are often in the junior year (third year) and/or senior year in chemical engineering programs. While design projects are usually exercises done within the university environment, for programs that assign projects in conjunction with industry, these experiences are also excellent opportunities for obtaining program assessment results. There is the additional advantage of having practitioners of the profession involved in the assessment process.

In a broader sense, there can also be a capstone experience for a course, for a semester, or for a year. Many courses require a project, in which course material learned during the semester or year is applied to the solution of a comprehensive problem. Some departments also use projects throughout the curriculum covering material in multiple courses taken simultaneously [1,2]. These experiences are also excellent opportunities for summative assessment results.

Why are capstone experiences a good choice for obtaining program assessment results? Some of the advantages were discussed above. They are at the location in the curriculum where knowledge learned previously is applied, and several faculty members can be involved in the process. However, one of the key advantages to capstone

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experiences is that they already exist. Given the existing pressures on faculty time and the difficulty in achieving the necessary faculty buy-in for outcomes assessment, it is much easier to implement an assessment plan that involves incremental work rather than entirely new tasks. Since capstone experiences already exist, all that is needed is a method to obtain assessment results.

One method for obtaining assessment information from capstone experiences is the use of a rubric. In the context of assessment, a rubric refers to a set of procedures or guidelines used to ensure uniformity in obtaining quantitative assessment results from what is inherently a qualitative assessment. For example, consider the four-point scale: (1) not acceptable, (2) below standards, (3) meets standards, and (4) exceeds standards. Now, consider the attribute for a the technical content of a design report "apply economic, physical constraints and optimization methods to obtain solution." In the absence of clearly defined guidelines, *i.e.*, a rubric, different evaluators might have different opinions regarding the level a report's format deserved or the exact definition of the term "apply economic, physical constraints and optimization methods to obtain solution." Now, consider the rubric illustrated in Figure 1. Here, different characteristics of the attribute "apply economic, physical constraints and optimization methods to obtain solution" are defined, and a description of each level is given. Using this rubric, multiple evaluators should be able to evaluate the same report consistently. In our application of this rubric, we assign one overall score for the "apply economic, physical constraints and optimization methods to obtain solution" attribute, but it is also possible to assign scores for each characteristic under the attribute. We use the former method because, after trying the latter method, our faculty expressed a preference fewer entries. The complete rubric for design projects (technical aspects) as well as similar rubrics for oral presentations, written reports, and laboratory experiments (technical aspects) used in the Chemical Engineering Department at West Virginia University are available on the web [3].

When rubrics are developed, care must be taken to avoid ambiguous wording. It may take several iterations of developing a rubric, using the rubric, and modifying the rubric before an entirely satisfactory rubric is obtained. Some suggestions for developing rubrics are available [4]. An example of another rubric developed for portfolio assessment, but used for assessing a laboratory experience, is also available [5].

Another method for obtaining summative assessment results from capstone experiences is from the question-and-answer session that usually follows presentation of a project solution. Using questions and follow-up questions, the depth of student understanding can be revealed. This is analogous to a thesis or dissertation defense. At times, a student solution might look good on the surface and in the

Attribute	**1-Not acceptable**	**2-Below expectations**	**3-Meets expectations**	**4-Exceeds expectations**	**Score**
Apply economic, physical constraints and optimization methods to obtain solution					
Show ability to use economics to drive solution to problem and focus on important parameters	economics not used to drive solution or to define key parameters	economics sparingly used to drive solution and to define key parameters	economics used to drive solution and to define key parameters	superior solution obtained by unique use of economics	
Define appropriate objective function	appropriate objective function not used	poorly-defined objective function used	correct objective function used	unique objective function used to obtain unique solution	
Define appropriate decision variables	inappropriate or no decision variables used	not all key decision variables used	correct decision variables used	unique decision variables used to obtain unique solution	
Correct use of optimization techniques	correct optimization techniques not used	errors in optimization methodology	correct/reasonable optimization methodology	superior optimization strategy yields unique solution	

FIGURE 1
PORTION OF A RUBRIC FOR ASSESSMENT OF A DESIGN PROJECT. THE FULL RUBRIC AS WELL AS OTHER RUBRICS ARE AVAILABLE AT HTTP://WWW.CEMR.WVU.EDU/~WWWCHE/OUTCOME/INDEX.HTML

presentation, but questioning can reveal results obtained by faulty logic; from multiple, offsetting errors; or by accident. Asking "why" or "what if" questions can reveal the true depth of student understanding. This method of obtaining assessment results has been described in detail elsewhere [6]. This method must be used with care, since it can be perceived by students as being tantamount to an oral exam. Oral exams have many advantages as an assessment tool; however, the pressure students face during such an exam is a disadvantage [7].

To close the feedback loop on the assessment process, the results obtained from assessment of capstone experiences must be used for program improvement. The loop must be closed with feedback to faculty as well as feedback to students. The former permits faculty to improve their teaching and may suggest curriculum improvements, while the latter permits students to develop their skills over time, and correct errors and gaps in their knowledge.

Feedback to students is essential. The American Association for Higher Education has developed principles of outcomes assessment [8], and they include: (1) Assessment requires attention to outcomes, but also and equally to the experiences that lead to these outcomes, (2) Assessment works best when it is ongoing, not episodic. These principles suggest that if students are to develop, for example, communication skills, design skills, and/or laboratory skills, they should have multiple experiences within a course or throughout the curriculum from which they can obtain feedback and further develop these skills. For assessment of technical knowledge, it should be documented, in a capstone experience, if a significant number of students make the same error, have the same misconception, or have not yet developed a skill they should have mastered prior to the capstone experience. If this occurs, then it is likely that the material was not learned properly at the appropriate point in the curriculum, and feedback to both faculty and students is essential. Results from the rubrics provide a guide to the topics on which feedback is needed. When student misconceptions or gaps in their learning are revealed, class time should be found to address the problem in the capstone class, completing the feedback loop to the students. Therefore, it is recommended that time be built into the schedule or syllabus for this process. When there are multiple experiences in a class, as is often the case in a capstone laboratory, students should get feedback after each experience. This requires rapid turnaround of graded reports so students can obtain feedback from one experience before beginning the next experience.

Feedback to faculty must be done cautiously, since faculty members do not necessarily want to hear that students did not learn what they were supposed to learn in an earlier class. A common response is "I covered that in my class, so it is not my fault." Faculty members need to become comfortable with the concept that, in an outcomes-assessment-based environment, the issue is what was learned, not what was covered. A written assessment report circulated to faculty outlining strengths of student work, weaknesses, and recommended methods used to correct any problems is one method for providing this feedback [6]. A follow-up faculty meeting, during which the results of a single assignment are discussed, is a possibility. An annual faculty meeting where all assessment results are discussed is essential. Over time, a culture can develop where faculty members are more interested in the results of student learning and feel less threatened by assessment results.

AN EXAMPLE OF IMPLEMENTATION OF THIS PROCESS

In the Chemical Engineering Department at West Virginia University, design projects are assigned each semester for all chemical engineering classes taken simultaneously [1]. The same chemical process is used for the project for the sophomore year (second year) and the junior year (third year). Students begin to develop their design skills over the two-year period of these projects, and their design skills are developed more fully in the capstone design class. In the formative assessment component in the sophomore and junior years, students receive feedback each semester to help them improve their skills.

In the senior (fourth) year, there is a sequence of design projects and laboratory experiments. Since this is the "true" capstone experience, this is summative assessment, and the results of evaluation of the design projects provide feedback to faculty and students. Feedback to faculty is in the form of a report discussing the issues involved in the project and how well students did in addressing these issues. These issues are also discussed in a faculty meeting, if it is deemed necessary. All assessment results are discussed at the annual faculty "retreat" devoted to outcomes assessment. In the design class, if there is an aspect of the project that students do not do particularly well, a follow up assignment is given so that students can correct their errors after the project is reviewed. By doing this, formative and summative assessment are done simultaneously. In the laboratory class, both communication skills and the technical aspects of the laboratory are evaluated, and feedback is provided to students and, if necessary, faculty. The result of this assessment process is that students develop design and communication skills over time. They receive feedback at every step of this process (formative assessment) to ensure that their skills improve with each experience. The faculty also receives feedback with each experience, and the summative assessment in the senior (fourth) year allows the assessment loop to be closed by providing information on how well students learned the material required to complete the capstone project.

CLASSROOM ASSESSMENT

Classroom assessment is not new, and the definitive work on the subject contains 50 classroom assessment techniques [9]. These include methods for assessing recall and understanding, critical thinking skills, problem-solving skills, synthesis and creativity skills, and student attitudes. The purpose of classroom assessment is to obtain information on the success of the learning process, and classroom assessment exercises are not used in the grading process.

Perhaps the most widely known classroom assessment technique is the "minute paper," in which students take the last minute of a lecture to write down what they learned in that class, and the instructor uses this informal feedback to assess the success of that lecture period [10]. A variation of this is the "muddiest point," in which students write down the item they found the most confusing in a given lecture [11]. Another variation of these, called the "attention quiz," has been developed and tested in an engineering context [12,13]. Here, the class ends with a short, multiple-choice quiz on material discussed in the just completed lecture. If the goal of a class period is for students to learn something instead of only being note takers, these classroom assessment techniques allow the instructor to evaluate what was learned.

One classroom assessment technique used successfully by this author is coaching students while they attempt example problems. Since engineering students are being trained to solve problems, students can learn from example problems shown in class. The issue is that students learn more by doing examples than by seeing them done for them. While students work on these problems, the instructor circulates around the room so students can ask questions. The instructor becomes a coach rather than a lecturer. By looking over students' shoulders while they work the examples, the opportunity exists to identify misconceptions and typical errors and to correct them individually and/or for the entire class. Students are encouraged to work in groups, but are not forced to do so.

There are pedagogical explanations for the success of this technique. Part of it is the cooperative learning aspect [14], because some students work in groups and ask each other if they get stuck, and the ones who understand how to solve the problem explain to their neighbors how they obtained the solution. Another reason for the success of this method is it serves both active and reflective learners [15]. Active learners learn best in groups and by trying different ideas until they are successful. Reflective learners learn best alone so they can contemplate what they are doing. Traditional lectures serve neither group, since merely taking notes neither allows active learners to be active nor allows reflective learners to reflect. Having students work on problems in class serves both categories since active learners can be active and reflective learners have time to reflect, and all students have the opportunity to interact with the instructor while learning. The only apparent disadvantage to this method is that fewer example problems can be done, so examples must be chosen much more carefully.

Other classroom assessment methods used successfully by the author are described elsewhere [16].

CONCLUSIONS

Capstone experiences are excellent tools for assessment by faculty because they are already a part of the curriculum and because several faculty members often participate in them. A good method for using capstone experiences for program assessment is to develop rubrics describing the attributes desired in these experiences. These rubrics allow qualitative assessment results to be quantified. If the summative results of the assessment process are used to improve the program, the feedback loop to the curriculum is completed. If the formative results of the assessment process are used to develop students' skills over time and make certain that their knowledge base is as desired, then the feedback loop to students is completed. An oral presentation is also an excellent format for assessment by faculty. Asking "why" and "what if" type questions probes students' understanding of fundamental principles. The oral presentation format provides students with immediate feedback, closing one feedback loop.

Classroom assessment techniques improve teaching and hence student learning. Both instructors and students receive feedback, the former on what students are learning and the latter on how well they are learning. This feedback is on a very short time scale. The advantage of classroom assessment is that faculty members become better teachers and students learn more.

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