Utilizing Senior Capstone Design as an Instrument for Student and Faculty Assessment of Program Outcomes

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Abstract – The Mercer University School of Engineering (MUSE) in Macon, Georgia offers an ABET, Inc. accredited General Engineering Degree in six engineering specializations. MUSE has established eight program outcomes that characterize the knowledge and skills to be gained by students by the time of their graduation. Under Criterion 3, Program Outcomes, ABET lists eleven outcomes (a through k) that engineering programs must demonstrate that their students attain. MUSE's program outcomes are bundled together and directly related to the a-k criteria. The focus of this paper is to describe the process and instrument used to assess four program outcomes using data collected from the two-semester senior capstone design course. The course is required of all engineering and industrial management students. The four outcomes of interest include:

- Program Outcome 2: Identify, formulate, and solve engineering problems.
- Program Outcome 3:Apply appropriate breadth and depth of skills in engineering design to meet desired needs with realistic constraints using the techniques, skills, and modern engineering tools necessary for engineering practice.
- Program Outcome 5:Function on interdisciplinary teams.
- Program Outcome 6:Communicate to both specialized and public audiences in a variety of modes, i.e. writing, presentation, etc.

Two means were used to assess each outcome. Based on data for the 2007-08 academic year, preliminary conclusions are:

1. Both the first and second means of assessment for Outcome 2 and the criterion for success were met.
2. Both the first and second means of assessment for Outcome 3 and the criteria for success were met.
3. The first means of assessment for Outcome 5 and the criterion for success was met; however, the second means of assessment and criterion for success was not met.
4. Both the first and second means of assessment for Outcome 6 and the criteria for success were met.

In this paper we describe an efficient and effective process used to assess achievement of educational objectives; assessment results are beneficial for internal evaluation of instructional quality and results can provide useful insights required for accreditation.

Keywords: Assessment, Capstone Design

INTRODUCTION

As a result of EC 2000, engineering accreditation through ABET, Inc. has morphed from a process with a quantitative emphasis to a process that encourages reflection, feedback, and improvement. Under Criterion 3, Program Outcomes, engineering programs must demonstrate that their students attain eleven outcomes (a through k) listed by ABET. The engineering programs are free to develop and specify their own set of criterion by which to assess these outcomes. One such instrument which can be used to evaluate multiple outcomes is the senior capstone design course.

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Capstone courses have become a prominent feature in higher education over the past decade. Such courses provide senior engineering students with open-ended projects much like they will encounter in "the real world" practice. By design, students deal with an open-ended problem statement that requires them to first properly identify the problem and then evaluate alternative solutions. Possibly for the first time, students are faced with many possible solutions—this is in drastic contrast to the unique solutions presented for most exercises typical of textbook "end of chapter" exercises. In addition, students are also, for the first time, faced with not only technical constraints, but also non-technical constraints such as the environmental impacts and the economics of their design solution. Another unique aspect is that many capstone courses typically require students to work in teams. This presents students with the opportunities and challenges similar to what they will face in engineering practice. These situations include learning how to adapt to co-workers and the need for open and constant communications.

COURSE DESCRIPTION

The Mercer University School of Engineering (MUSE) has a two semester capstone design course. All engineering students as well as those students seeking a degree in industrial management are required to take this course during their senior year. Students self-select their team members and their project; they are encouraged to form three to four-person interdisciplinary teams and to identify a project having an industrial sponsor. Although often an onerous task, students typically form teams having suitable discipline talent to appropriately focus on their identified project. Faculty guidance and approval of the projects ensures that teams and projects are appropriate.

Communication between student teams, client, technical advisors (discipline specific faculty member for each student) and course instructor is forced through periodic meetings and written oral and written progress reports. Each student is required to conduct a peer-review literature and patent review in areas related to their projects. Student peer reviews of the final document submitted at the conclusion of each semester activities is encouraged.

And a "just in time" lecture series provides a review in team building, brainstorming, design process review, engineering analysis, engineering ethics, intellectual property, communication skills, future of engineering design, and project management during the first semester. The lectures serve to help the student through the various stages of their design, from proposal to design review.

During the first semester of the capstone design course, students write a proposal within the first two weeks of the semester and with the remainder of the semester used to develop a solution culminating in a report, the preliminary design review (PDR). The PDR is both written and orally presented to an audience that includes the instructor (acting as management), client, technical advisors, and their peers. During the second semester, students build and test their designs as prescribed in their PDR. The process concludes with the written and oral deliveries of their respective critical design reviews (CDR) where the build and test phases with final results are detailed. Parents, friends, additional engineering faculty and students are often in attendance during the oral presentations. Students enrolled in the freshmen engineering design course are required to attend a selected number of PDR and CDR presentations each term.

ASSESSMENT IN CAPSTONE COURSES

Capstone design is explicitly mentioned in Criterion 5 and arguably is also explicit in Criterion 3 of ABET EC 2000:

> Criterion 3: …*"Outcome c: an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability."*
>
> Criterion 5. … *Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints*.

And according to ABET, Inc., engineering programs must also show Continuous Improvement:

Criterion 4: … *each program must show evidence of actions to improve the program. These actions should be based on available information, such as results from Criteria 2 and 3 processes.*

The capstone senior design course provides a convenient avenue to assess student performance for a variety of MUSE outcomes. This idea is not a new one (Shaeiwitz, 2002; Saad, 2007; McKenzie, 2004; Wang and Pai, 2006). A variety of engineering programs have successfully used their capstone course to facilitate assessment. Assessment results have been mined from capstone courses by using a variety of techniques (Shaeiwitz, 2002) including rubrics, a question-and-answer session (Shaeiwitz and Turton, 1999), by student journaling, and by videotaping students working on a project to gain insight to how they problem solve (DiBiassio, 2000).

The 2004 study by McKenzie et at., summarized the results from a national survey that summarized the assessment and evaluation practices incorporated into engineering capstone design courses. Surveys were mailed to all deans of accredited engineering programs listed in the ASEE Profiles of Engineering and Engineering Technology (ASEE 2000). Results from 119 respondents of the 274 institutions were included. The study revealed that 80% of the respondents indicated that it was appropriate and possible to assess each of the competencies outlined in Criterion 3 (*a-k*) through their capstone design course. Figure 1 shows the percentage breakdown of respondents that assessed Criterion 3 outcomes (*a-k*) in their capstone course. Criterion 2, outcome *g*, focused on effective communication, was assessed in capstone courses from 95%t of the respondents. Thirty seven percent of the respondents also indicated that they assessed outcome *i*, focused on life-long learning, within the framework of the capstone experience. These results highlight that faculty agree that the capstone design course is ideal for assessing student learning and program outcomes.

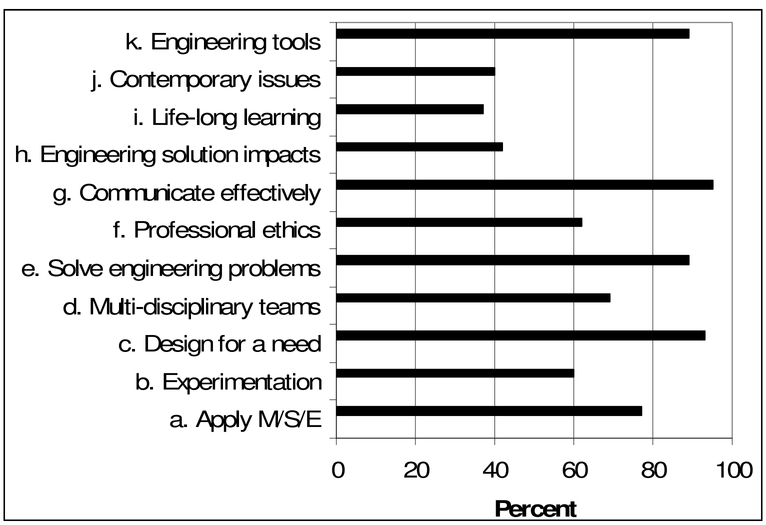

Figure 1. Percent of Assessment of Criterion 3 Outcomes. (Adapted from McKenzie, et al., 2004).

METHODS

The program outcomes for the Bachelor of Science in Engineering program at MUSE are as follows. Students at the time of graduation will know and be able to: (1) apply mathematics and science principles to the solution of engineering problems; (2) apply appropriate breadth and depth of skills in identification of engineering problems; (3) apply appropriate breadth and depth of skills in engineering design and analysis of engineering problems; (4) design and conduct experiments and analyze data; (5) function on interdisciplinary teams; (6) communicate to both specialized and public audiences in a variety of modes, i.e., writing, presentation, etc.; (7) relate the practice of engineering to global contemporary issues, to professional ethics, and to the need for lifelong learning; and (8) contribute to sustaining and improving community. Each of the Mercer University BSE Program Outcomes is mapped into one or more of the eleven outcomes required by EAC Criterion 3. The mapping is shown in Table 1.

Table 1. Relating Eight BSE Outcomes to Eleven EAC Criterion 3 Outcomes

BSE	EAC
1. Apply mathematics and science principles to the solution of engineering problems.	a) ability to apply knowledge of mathematics, science, and engineering
2. Apply appropriate breadth and depth of skills in identification and analysis of engineering problems designed with realistic constraints.	c) ability to design a system, component, or process to meet desired needs within realistic constraints e) ability to identify, formulate, and solve engineering problems k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
3. Apply appropriate breadth and depth of skills in engineering design and analysis of engineering problems designed with realistic constraints..	c) ability to design a system, component, or process to meet desired needs within realistic constraints k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
4. Design and conduct experiments and analyze data.	b) ability to design and conduct experiments as well as to analyze and interpret data k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
5. Function effectively on interdisciplinary teams.	d) ability to function on multi-disciplinary teams
6. Communicate effectively to both specialized and public audiences in a variety of modes.	g) ability to communicate effectively
7. Relate the practice of engineering to global contemporary issues, to professional ethics, and to the need for lifelong learning.	f) understanding of professional and ethical responsibility h) broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context i) recognition of the need for and ability to engage in lifelong learning j) knowledge of contemporary issues
8. Contribute to sustaining and improving community.	h) broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context j) knowledge of contemporary issues

Four of the Program Outcomes are evaluated for appropriateness and achievement every year using a process which includes the following steps:

1. At the beginning of every academic year, four outcomes are identified for the assessment cycle. Two or more means of assessment are used for each outcome examined, with at least one means utilizing a “direct” measure of performance. The criteria for success are determined for each means.
2. Throughout the academic year data are collected.
3. At the end of the year, data are summarized and archived.
4. Data are reviewed by all MUSE faculty during a 1.5 day workshop held in August just prior to the start of the Fall term.

This process enable faculty to make assessment-evaluations of all BSE Program Outcomes on a two-year cycle (making the Program Outcomes assessment-evaluation cycle coincide with the four year cycle of assessment-evaluation of Program Educational Objectives appropriateness and achievement). The faculty also chose means (measures) of program assessment with respect to each selected Program Outcome and the faculty identified criteria for success (indicators of outcome achievement).

In the senior year, students enroll in a sequence of two Senior Design Exhibit courses. Each of the two credit hour courses is accomplished with teams of approximately three students. Each project operates within a prescribed framework that simulates a real-world design experience. Each project has a client; approximately one-half of the clients are outside the University. While all teams cannot have two or more specializations represented because of the different enrollment in each specialization, each team is configured so that the students can play the roles of specialists. The first of these courses introduces the students to their clients’ needs. The students end the first semester with a written report and presentation to the faculty and their client that proposes to build and test a solution to their clients’ needs. During the second senior design course the students build and test a device or system and present it to their client and the faculty with final reports and presentations. It is important to note that a significant number of clients are from industry. Industry funding has been provided as high as $200,000. Examples of recent external project clients include Armstrong, Boeing, Blue Bird, Forsyth Street Orthopedic Surgery and Rehabilitation Center, Macon Power, Macon Water Authority, MetoKote Corporation, Precision Pipe, Rheem Manufacturing, Robins U. S. Air Force Base, Warner Robins Air Logistics Command, Yamaha, and YKK-USA

The proposals submitted at the end of the first course are expected to address economic, health and safety, manufacturability, sustainability, and ethical and aesthetic considerations; as well as social, political, and environmental impact. Each project is required to have engineering test plans and results that as a minimum must have performance tests, quality assurance tests, life, endurance and safety tests, human acceptance tests, and environmental tests. Engineering standards must be considered and applied where appropriate.

The senior design sequence is designed to address each of the eight BSE program outcomes to provide a truly integrative experience as summarized in Table 2 relative to each outcome (Self-Study Questionnaire, 2007). Note, in Table 2, XXX 487 and XXX 488 refer to the first and second semester senior design courses respectively.

Table 2. BSE Program Outcomes Relative to Capstone Design Course Experiences.

Outcome 1. Apply mathematics and science principles to the solution of engineering problems. In XXX 487, all design teams must "analyze" their design to "predict" the performance of the design. In XXX 488, all design teams must measure the performance of their system to compare its performance to the predictions from XXX 487.
Outcome 2. Apply appropriate breadth and depth of skills in identification of engineering problems designed with realistic constraints. Identification of engineering problems is an integral component of the design and analysis phase of XXX 487 and the testing phase of XXX 488.
Outcome 3. Apply appropriate breadth and depth of skills in engineering design and analysis of engineering problems designed with realistic constraints. Engineering design and analysis are integral components of the design and analysis phase of XXX 487 and the testing phase of XXX 488.
Outcome 4. Design and conduct experiments and analyze data. The Test Plan document is formally submitted in XXX 487, before the system is built. In XXX 488, each team is required to carry out the experiments they designed in their test plan and report on the results.
Outcome 5. Function effectively on interdisciplinary teams Many of the teams are truly interdisciplinary, and all have different responsibilities for each team member. All teams are part of an interdisciplinary design class in that they are present for progress reports from other teams, many of which are from other disciplines.
Outcome 6. Communicate effectively to both specialized and public audiences in a variety of modes, i.e., writing, presentation, etc. Design teams submit written proposals, Preliminary Design Reviews (PDRs), Test Plans, Progress Reports, and Critical Design Reviews (CDRs). The teams do an oral presentation of their PDR, Progress Report, and CDR. Team members communicate orally with their technical advisor, faculty grader, client, and fellow team members on a regularly scheduled basis throughout the year.
Outcome 7. Relate the practice of engineering to global contemporary issues, to professional ethics, and to the need for lifelong learning Students are required to design using modern chips, materials, and methods as system components. They must also take safety and reliability into consideration. These issues are specifically part of the required test plan. The act of performing design causes students to identify things they do not know, and therefore reminds them that they do not yet know everything. This may be thought of as a soft, but real, byproduct of the design process in place in XXX 487 and XXX 488.
Outcome 8. Contribute to sustaining and improving community Achieving Outcome 8 is a real byproduct of this course. As team members, students must carry out their responsibilities or face the consequences of letting down their fellow students. Some of the projects directly benefit Mercer labs or community natural resources (ponds, rivers, etc.). Some team members blossom into leaders, and others simply function as responsible citizens of their teams.

All faculty serving as clients and technical advisors complete an evaluation form at the conclusion of each term. A portion of the assessment instrument is shown in Table 3. Note: The use of the five-point rubric scale.

Table 3. Example Portion of CDR Evaluation Form Completed by Technical Advisors and Client. Question used for Outcome 4 Assessment.

Please rate the overall oral Critical Design Review on the students' ability to communicate to a specialized audience (technical personnel in their field).

Unacceptable		Acceptable		Excellent
	2		4	
1		3		5

Please rate the overall written Critical Design Review on the students' ability to communicate to a specialized audience (technical personnel in their field).

Unacceptable		Acceptable		Excellent
	2		4	
1		3		5

Please rate the executive summary of Critical Design Review on the students' ability to communicate to a generalized audience (general public).

Unacceptable		Acceptable		Excellent
	2		4	
1		3		5

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A third assessment tool is the student Self/Peer Team Assessment, [10]. This form is completed by each student at the end of each semester, and requests feedback on student perception of team interaction and distribution of work load.

RESULTS AND DISCUSSION

During the academic years of 2005-2006 and 2007-2008, the BSE program assessment actions focused on MUSE Program Outcomes 2, 3, 5, and 6.

Program Outcome 2 – Students will be able to apply appropriate breadth and depth of skills in identification of engineering problems with realistic constraints. The second means used Senior Design as the assessment instrument. The second means is as follows:

> Second Means: At least 75% of the senior design projects would be rated as acceptable, strong, or excellent in their demonstration of breadth and depth of skills in identification and analysis of engineering problems within realistic constraints by technical advisor(s) and client using a common (1-5) rubric.

The second means was assessed using Question 1.e on the PDR Instructor/Client/Technical Advisor Team Assessment Form. In Fall 2005, faculty rated the senior design projects of 7 design teams for breath and depth of skills in identification of engineering problems. All seven projects were rated as acceptable, strong, or excellent in their demonstration of depth. Similarly in the Spring 2006, faculty serving as client and technical advisors for the 24 design teams rated each as acceptable, strong, or excellent in their demonstration of both breadth and depth. In Fall 2005 and Spring 2006, a total of 25 preliminary design team projects were evaluated by the client and technical advisors to determine if the identification and analysis of engineering problems were done within realistic constraints. All of the teams met the criteria. Using results from the second means of assessment clearly confirm that Outcome 2 was met. After faculty reviewed these findings, it was recommended that in the next cycle of assessment of this outcome, the Senior Design Faculty Team consider a rewording of the success criterion to focus on rating students and not projects. In the subsequent assessment of Outcome 2 that occurred in 2007 and 2008, results from the PDR Team Assessment Form showed that 95% of the 19 design teams received an average score of 3 or more on the five point scale. Thus, the criterion was met.

Program Outcome 3 – Apply appropriate breadth and depth of skills in engineering design and analysis of engineering problems within realistic constraints. The first and second means were as follows:

> First Means: At least 75% of senior design projects will be rated as acceptable, strong, or excellent for demonstration of breadth of skills in engineering design and analysis by a team of instructor, technical advisor(s), and client using a common (1 to 5 scale) rubric.
>
> Second Means: At least 75% of senior design projects will be rated as acceptable, strong, or excellent for demonstration of depth of skills in engineering design and analysis within realistic constraints by a team of instructor, technical advisor(s), and client using a common (1 to 5 scale) rubric.

The first means was assessed using Question 1.f on the PDR Instructor/Client/Tech Advisor Team Assessment Form. In the Fall 2005-2006 academic year, the instructor, technical advisors and clients rated the Senior Design projects of 31 design teams for demonstration of breath of skills in engineering design and analysis. All 31 (100%) projects were rated as acceptable, strong, or excellent in their demonstration of breadth of skills in engineering design and analysis. The First Means of Assessment findings clearly confirm that Outcome 3 was met. In their review of these findings during an August 2006 MUSE workshop, the faculty identified no additional action to take with respect to this outcome. In Fall 2007 there were 13 teams and in Spring 2008 there were 6 teams. 17 (89%) of the teams received a score of 3 or more on the five point scale. Thus, the criterion was met.

The second means was assessed using Question 1.d on the PDR Team Assessment Form. In Fall 2005 and Spring 2006, the instructor, technical advisors and clients rated the Senior Design projects of 24 design teams for demonstration of depth of skills in engineering design and analysis. All 24 (100%) projects were rated as acceptable, strong, or excellent in their demonstration of depth of skills in engineering design and analysis. In Fall 2005, 23 preliminary design team projects and in Spring 2006, two preliminary design team projects were evaluated by the client and technical advisors to determine if the projects were designed and analyzed within realistic constraints. All (100%) of the teams met the criteria. In summary, these findings from the Second Means of Assessment indicate that Outcome 3 was met. No additional action was taken with respect to this outcome.

During the Fall 2007 workshop, Outcome 3 was modified. It currently reads as follows: Apply appropriate breadth and depth of skills in engineering design to meet desired needs with realistic constraints using the techniques, skills, and modern engineering tools necessary for engineering practice. As a result of this change, Question 1.d on the PDR Instructor/Client/Tech Advisor Team Assessment Form was used for measuring the first means of assessment and Question 1.d on the CDR Instructor/Client/Tech Advisor Team Assessment Form was used for assessing the second means. In the Fall 2007 and Spring 2008 all of the teams received a score of 3 or more on the both five point scale for questions relating to both means. Thus, the criteria were met.

Program Outcome 5 - Students will be able to function on interdisciplinary teams. Both the first and second means of assessment for this program outcome are linked to the capstone design course. The first and second means were as follows:

> First Means: At least 75% of senior design teams will be rated as "effective" or "very effective" by clients and technical advisors using a team evaluation rubric.
>
> Second Means: At least 75% of students completing their Senior Design Projects will rate no team member less than 20% below an equal share of effort.

The first means was assessed using Question 6 (4-point Likert scale) on the CDR Team Assessment Form. In the Fall 2005-2006 academic year, 26 of 31 (84%) were rated as effective or very effective by clients and technical advisors. The First Means of Assessment findings clearly confirm that Outcome 5 was met. In the faculty's consideration of these findings at the August 2006 Workshop, the faculty was concerned about the roles played by student design team members. The faculty agreed to emphasize that student design teams be made up of students from two or more specializations and/or insure that students assume specialist's roles in the conduct of their design projects. In Fall 2007 there were 7 teams and in Spring 2008 there were 13 teams. 17 (85%) of the teams received a score of 3 or more on the four point scale. The outcome was achieved. The faculty confirmed this assessment at the Fall 2008 Workshop. The faculty recommended a careful consideration of the decision to round evaluation scores of 2.5 to either 2 or 3 in advance of the next use of this means for assessing Outcome 5.

The second means was assessed using Question 4 from the student Self/Peer Team Assessment Form. Data from the second means indicated that for the academic year, 76 of 93 (82%) students were rated as providing no less than 20% below an equal share of effort. The aggregate Second Means of Assessment findings from the Fall 2005 and Spring 2006 semesters confirm that Outcome 5 was met. During the following August faculty workshop, the faculty again concluded that assessment findings would be improved by insuring that students assume specialist roles in the conduct of their design projects. In Fall 2007 and Spring 2008 terms only 32 out of the 52 students rated no team member less than 20% below an equal share of effort. This is 62% which is less than the required 75%. The criterion was not met. The outcome was achieved although this measure for assessing the outcome was not met (note to Hodge, I don't understand this statement, do you?). At the Fall 2008 Workshop, the faculty recommended adopting a consistent definition of "ability to function on an interdisciplinary team," and providing increased instruction on interdisciplinary teaming in the senior design sequence.

Program Outcome 6 - Communicate to both specialized and public audiences in a variety of modes, i.e., writing, presentation, etc. Both the first and second means were assessed through the senior design capstone course.

> First Means: The written and oral reports of at least 75% of senior design team Critical Design Reviews will be rated as acceptable, strong or excellent for a specialized audience when evaluated by a team of instructor, technical advisor(s), and client using a common (1 to 5 scale) rubric.
>
> Second Means: The executive summaries of at least 75% of senior design team Critical Design Review written reports will be rated as acceptable, strong or excellent for a public audience when evaluated by a team of instructor, technical advisor(s), and client using a common (1 to 5 scale) rubric.

The first means was assessed using Questions 6 and 7 on the CDR Instructor/Client/Tech Advisor Team Assessment Form. In Fall 2005, the instructor, technical advisors, and clients evaluated the Critical Design Review written reports and oral presentations prepared by 7 Senior Design project teams. The written reports for all seven (100%) project teams were rated as acceptable, strong, or excellent for a specialized audience. In addition, all 7 (100%) oral presentations were rated as acceptable, strong, or excellent for a specialized audience. Similarly, in Spring 2006, the instructor, technical advisors and clients evaluated the written reports and oral presentations prepared by the 24 Senior Design project teams. For the written reports, 23 of 24 (96%) project teams were rated as acceptable, strong, or excellent for a specialized audience. In addition, 23 of 24 (96%) oral presentations were rated as acceptable, strong, or excellent for a specialized audience. The First Means of Assessment findings clearly confirm that Outcome 6 was met. In their review of these findings at the August 2006 Workshop, the faculty identified no additional action to take with respect to this outcome. The faculty did request that, in the next cycle of assessment, the report of findings be partitioned into number of teams rated acceptable, number rated strong, and number rated excellent so that a more discriminating evaluation of quality of performance could be made. In Fall 2007 there were 7 teams and in Spring 2008 there were 13 teams. Question 6 addressed the oral reports. For Question 6, 20 (100%) of the teams received a score of 3 or more on the five point scale. Question 7 addressed the written reports. For Question 7, 19 (95%) of the teams received a score of 3 or more on the five point scale. The outcome was met. The faculty confirmed this assessment at the Fall 2008 Workshop.

The second means was assessed using Questions 8 and 9 on the CDR Instructor/Client/Tech Advisor Team Assessment Form. Question 8 addressed the team's ability to communicate to a generalized audience – general public and Question 9 addressed their ability to communicate to a generalized audience – non-technical management. In Fall 2005, the instructor, technical advisors, and clients evaluated the executive summaries for the Critical Design Review written reports prepared by 7 Senior Design project teams. The executive summaries for 6 of 7 (86%) project reports were rated as acceptable, strong, or excellent for a public audience. Similarly, in Spring 2006, the instructor, technical advisors and clients evaluated the executive summaries for the Critical Design Review written reports prepared by the 24 Senior Design project teams. The executive summaries of 22 of 24 (92%) project reports were rated as acceptable, strong, or excellent for a public audience. The Second Means of Assessment findings clearly confirm that Outcome 6 was met. In their review of these findings at the August 2006 Workshop, the faculty identified no additional action to take with respect to this outcome. The faculty did request that, in the next cycle of assessment, the report of findings be partitioned into number of teams rated acceptable, number rated strong, and number rated excellent so that a more discriminating evaluation of quality of performance could be made. In Fall 2007 there were 7 teams and in Spring 2008 there were 13 teams. Eighteen (90%) of the teams received a score of 3 or more on the five point scale on their ability to communicate to both the generalized public and to non-technical management. The criterion for this means was successfully met and the outcome was achieved. The faculty confirmed this assessment at the Fall 2008 Workshop. In the next assessment of Outcome 6, the faculty recommended the following rewording of both the First Means and Second Means to better explain what is actually done: "The written and oral reports of at least 75% of senior design team Critical Design Reviews will receive an average score of acceptable, strong, or excellent (e.g., >3) ."

Implementation of a quality assessment program within a school of engineering can increase workloads for both faculty and staff. In this paper we describe an efficient and effective assessment approach, and provide results of process implementation at MUSE. We have demonstrated that through the use of one simple numerical assessment tool, when applied to a single class, it can provide useful insights required for accreditation agencies, for internal evaluation of instruction quality, and of achievement of educational objectives. The use of data collected from the two-semester senior capstone design course in a BSE program were successfully used to assess four program outcomes.

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