AC 2007-1556: ASSESSING ABET OUTCOMES USING CAPSTONE DESIGN COURSES

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Assessing ABET Outcomes Using Capstone Design Courses

Abstract

This paper presents a methodology for using capstone design project courses for assessing a number of ABET outcomes. In the advent of EC 2000, Engineering programs have grappled with methods for assessing some of the ABET outcomes, especially those skills which are not taught in the traditional engineering programs.

Senior Design and Professionalism I and II are two capstone design courses taken by seniors in the College of Engineering over a two semester period. Each course is team-taught by professors in all the engineering departments consisting of Civil, Chemical, Electrical and Mechanical. Depending on the type of projects selected, student teams could be interdisciplinary, or discipline specific. The capstone design courses are used to assess eight of the eleven ABET a-k outcomes consisting of the ability to: design a system, function on multi-disciplinary teams, adhere to professional and ethical responsibilities, communicate, understand global and local impact of engineering solutions on society, engage in lifelong learning, have knowledge of contemporary issues, and use modern engineering tools for engineering practice. Students' abilities in these outcomes are quantitatively measured using outcome specific project related lectures and assignments given throughout the semester.

The methodology discussed in the paper has made it possible to identify problems encountered by students in these outcome skills, thereby, facilitating adjustment in course content and delivery, and formulation of plans to assist students to improve on these skills. The methodology also makes it possible to document students' performance in these outcomes. The documentation is used to generate outcome specific binders of students' work that are vital for ABET accreditation.

Importance of Senior Design

This course is important because it provides the student, an opportunity to practice design in a way that parallels what will be encountered in professional practice. Students are required to apply a systematic design process, incorporate engineering codes, standards, and realistic constraints that include economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political considerations in solving the design problem. In addition, Senior Design Project is the primary course used to satisfy ABET criterion 4 which requires students to be prepared for engineering practice through the curriculum culminating in a major design experience. The latter should be based on the knowledge and skills acquired in earlier course work and should incorporate appropriate engineering standards and multiple realistic constraints. Senior design is also used to satisfy outcome C of criterion 3. This outcome requires students to have the 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.

Course Objectives and Anticipated Outcomes

The goal of the two semester capstone design courses are to ensure the students have the necessary exposure to engineering design that broadens their abilities in eight of the eleven ABET "a" to "k" outcomes. The eight ABET outcomes taught and assessed in the course are:

"c" an ability to design a system, component, or process to meet desired needs.
"d" an ability to function on multi-disciplinary teams.
"f" an understanding of professional and ethical responsibility.
"g" an ability to communicate effectively.
"h" the broad education necessary to understand the impact of engineering solutions in a global and societal context.
"i" a recognition of the need for, and an ability to engage in life-long learning.
"j" a recognition of contemporary issues.
"k" an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The courses have eight main objectives, with each objective related to one of the eight "a" to "k" outcomes measured in the course, and having a number of anticipated outcomes. The first course objective is to teach students to design systems, components, and processes to meet a desired need by following a well defined design process. The anticipated outcomes for this objective are that students will (1) demonstrate the ability to apply the design process systematically in any design environment, (2) conduct research on the economical, global impact, ethical and technical aspects of the engineering design, and (3) have the knowledge to optimize engineering solutions and designs in accordance with technical and contemporary constraints.

The second course objective is to teach students to function in a multidisciplinary design team. The anticipated outcomes for this objective are that students will (1) demonstrate team work through regular formal team meetings, project management, class presentations and a final design presentation, (2) gain appreciation of interdisciplinary projects involving students from other engineering disciplines.

The third course objective is to teach students to understand professional and ethical responsibilities of the engineer. The anticipated outcomes for this objective are that students will be able to differentiate between ethical and legal issues and how these are related to their design projects.

The fourth course objective is teach students to become proficient in written, oral, and technical communication. The anticipated outcomes for this objective are that students will be able to write a standard formal technical report with particular attention to the proper conventions for formatting, labeling of figures and tables, reference citation and listing, proper presentation of the technical content of the report, and techniques for oral presentation.

The fifth course objective is teach students the broad education necessary to understand the impact of engineering solution in a global and societal context. The anticipated outcomes for this

objective are that students will be able to analyze the impact of the their design and engineering solutions in general on society, both locally and globally.

The sixth course objective is teach students to recognize the need for, and the ability to engage in life long learning. The anticipated outcomes for this objective are that students will be able to review the literature for concepts not covered in the curriculum but needed for the successful design of their projects and be self learners.

The seventh course objective is teach students to be abreast with contemporary issues. The anticipated outcomes for this objective are that students will be in the habit of reading engineering magazines, journals, and other national magazines such as Newsweek to be appraised of contemporary issues.

The eighth course objective is teach students the use of techniques, skills, and modern engineering tools to complete a final design project. The anticipated outcomes are that students are able to use a systematic design process and modern engineering tools such as solid modeling, ANSYS, TRYNSIS, ADAMS, Microsoft Projects, and other Engineering Equation Solvers and software in their design.

Project Selection Criteria

The senior design courses are intended to provide capstone design experience. The courses draw on the students' skills and knowledge gained from previous years of coursework in mathematics, sciences, engineering science and design. The senior design project should be sufficient in scope and technical content to demonstrate the students' technical competence in their major area of study. The successful completion of senior design project is indicative of the students' preparedness to pursue professional practice of engineering. The following guidelines are provided in the Senior Design Projects Manual[1] to help faculty and project sponsors identify suitable senior project topics:

- The project should emphasize design, experimentation and/or hands-on skills.
- The project should offer opportunity for creativity.
- The project should allow teamwork among seniors in one or more majors.
- The project should be of sufficient complexity to allow each team member to contribute about 150 hours in class time and 150 hours outside class.
- The project should draw on the students' skills and knowledge gained from previous years of coursework.
- The project should incorporate engineering standards and realistic constraints that include most of the following: economic; environmental; sustainability; manufacturability; ethical; health and safety; social; and political.
- The project schedule should be limited to eight months (Early September to End of April)
- The project should have concrete and measurable goals.

Projects involving only collection of published materials are unacceptable and projects involving classified materials should be avoided.

Generic Timetable for Major Project Milestones

The senior design project sequence begins in the Fall semester and ends by the end of April the following Spring semester. A guideline is, therefore, needed to ensure that the various sections of the project design sequence are on schedule. Table 1 is a generic time table for major milestones in the senior design project sequence contained in the Project Manual[1]. Separate schedules are provided for projects that begin in the Fall semester and in the Spring semester. The course instructors are strongly advised to ensure that the schedule is followed as closely as possible to ensure successful timely completion of the projects.

Table 1 Generic Timetable for Senior Design Project

ITEM NUMBER	MONTH	8-MONTH SCHEDULE FOR PROJECTS THAT BEGIN IN FALL SEMESTER (tentative)	8-MONTH SCHEDULE FOR PROJECTS THAT BEGIN IN SPRING SEMESTER (tentative)	BEGINNING SPRING MAJOR PROJECT EVENT
0	0			Project Identification
1	1	9/7	1/14	Project Selection and Team Formation
2	1	9/30	1/30	Project Definitions and Specifications and Background Research
3	2	10/15	2/15	Project Planning and Task Definition
4	2	10/31	2/28	Literature Review
5	3	11/21	3/21	Preliminary Design and Oral Presentations
6	4	12/1	4/30	Project Report
7	6	2/15	9/15	Detailed Design Development and Parts Acquisition
8	7	3/1	10/15	Mid-semester Design Review and Presentations
9	8	4/8	11/8	System Simulation & Optimization; Design Iteration; and Construction & Testing
10	8	4/15	11/15	Final Design Review (Oral Presentations and Draft Final Report)
11	8	4/30	11/30	Final Senior Design Report

Senior Design Project Manual

The purpose of this manual is to inform students and faculty of the importance of senior design project and to clearly present the level of details required in the preparation and presentation of homework assignments, design, analysis, experimentation, presentations, intermediate reports, final oral presentation and final project report that may be required. Table 2 is a summary of the content of the Senior Design Projects manual. The project manual provides a detailed review of the acceptable standards for technical writing including the preparation of the table of content, list of tables and figures, the major required chapters of the senior project report, citation and listing of references, format and placement of titles of figures and tables.

In addition to providing the formatting standards, the project manual provides information on the required contents of the senior design project report. A sample required table of contents page for project reports contained in manual is provided in Table 3. Table 3 shows the required parts of the senior project report. In addition to these major sections, each project report is required to have relevant appropriate sub-sections under Literature Review, Preliminary Design and the Detailed Design sections of the report. The manual also contains a detailed rubrics for evaluating the final project report and presentation. The manual is distributed to students at no cost and discussed in detail in the course.

Table 2 Summary of the Content of the Senior Design Project Manual

TABLE OF CONTENTS

Figure 1 Required Table of Content for Senior Design Reports

TABLE OF CONTENTS

Course Organization
The senior design project classes for chemical, civil, electrical, and mechanical engineering programs are scheduled from 4:00 PM – 4:50 PM on Wednesdays and from 2:00 PM to 5:50 PM on Fridays. In the beginning of the semester, the instructors select projects for the various disciplines in accord with the project selection guideline. Depending on the scope of the projects, a particular project may be interdisciplinary and thus require students from other engineering disciplines or the project may be specific to a discipline, in which case students from another major may not be needed.

In the first semester, the four instructors from the four programs team teach the course on Fridays. The class on Fridays has two sessions. The first session from 2:00 PM – 3:50 is a joint class attended by students from the four engineering departments. Common lectures based on PowerPoint presentations are given on one of the following topics each week: (1) introduction to the engineering design process and project teams, (2) written and oral communication and the senior project requirements from project manual, (3) problem formulation and initial project specifications, constraints, and standards (4) project planning, (5) literature review & lifelong learning, (6) conceptual design and creativity, (7) modern engineering tools and practices used in engineering design, (8) Engineering ethics and professional responsibilities, (9) preliminary design and analysis, (10) contemporary engineering issues, (11) detailed design and final project specifications, constraints and standards. Project specific assignments are given at the end of each lecture, requiring students to apply what they learned to their project. These assignment are formulated to test students' abilities in the outcome areas discussed during the lecture. The graded assignments are used to assess the students' abilities in the outcome areas. During the period from 4:00 PM to 5:50 PM on Fridays, and 4:00 – 4:50 PM on Wednesdays, students in the four engineering departments meet separately with their individual instructors to discuss the assignments and work on their specific projects.

In the second semester, students continue to work on the same design project. Still the four instructors from the four programs team teach the course on Fridays. The class on Friday has two sessions every other week. The first session from 2:00 PM – 3:50 is a joint class attended by students from the four engineering departments. Common lectures based on PowerPoint presentations are given on one of the following topics each other week: (1) project planning, (2) detailed specifications for equipment and parts to be purchased and fabricated, (3) product realization process, (4) written and oral communication and the senior project requirements from project manual, (5) modern engineering tools and practices used in engineering design, (6) product testing and final modifications. During the period from 4:00 PM to 5:50 PM on Fridays and entire periods for alternate Fridays, and 4:00 – 4:50 PM on Wednesdays, students in the four engineering departments meet separately with their individual instructors to build the design hardware or simulation or model.

Group formation and project distribution
To ensure that each group has a fair chance of success, members in a group are not selected randomly. Rather, the instructor selects the members in a group based on overall GPA. Group members are selected to ensure even distribution of students with above average, average and nominal GPAs within a group. Once the groups are formed, a list of projects is distributed and each group is made to select a project of their choice. If two or more groups select the same

project, they are requested to negotiate until each group has a different project. On the few occasions where negotiations fail, projects are assigned by lots.

If a project requires students from other disciplines, then the four faculty members meet to discuss the possible scope of work needed for each discipline, and students from the requested disciplines are assigned to the projects depending on interest of the students in the projects.

Group Meeting Agreement and Ability to work in Teams

The first assignment after the formation of a team is the drafting and signing of group meeting agreement that is binding for the entire semester. The assignment states: *"Each group should meet and select a group leader, and decide on common times for group meetings. Then write up a simple meeting time agreement that each member should sign. Each group should meet* ***at least*** *3 hours per week to work on the project. The agreement should include at least the times and location of each meeting. The agreement signed is binding on each student until the end of the semester, and violating the agreement may require you to drop the course".*

The course instructor monitors the group meetings and assesses team work within the group by requiring each group to complete a meetings deliberation proceeding form for each meeting. A sample of the group meeting deliberations forms are shown in Tables 4 and 5.

Table 4 Required Minutes form for Group Meetings

SENIOR DESIGN & PROFESSIONALISM II
FALL 2006 SEMESTER
REPORT ON GROUP DYNAMICS

MINUTES OF GROUP MEETINGS

Meeting Date: _____ Meeting Time:_____

Meeting Location:_____

Members Present: _____

Agenda for Meeting (Items to be discussed or discussed at the meeting)

Detailed Minutes: (should include name of speaker and summary of what he/she suggested)

Table 5 Meeting Task Assignment and Deliverables

Use this table to document task assigned and deliverables
completed/submitted by each group member at this meeting
If deliverables were not completed, indicate the actions taken by the group on this individual.

Name	Task Assigned to team members at this meeting	Deliverables completed & submitted from tasks assigned in previous meeting(s)	Actions taken by group on non-performing member

The Assessment Process for ABET Outcomes

In the advent of EC 2000, several assessment methods have been published in the literature[2, 3, 4, 5]. The senior design course uses one of the eight steps in a process for assessing program outcomes developed in the College of Engineering and detailed in a paper[6] presented at the 2005 ASEE conference in Portland, Oregon. The step implemented in the senior design course is the implementation of outcome competencies in courses, and direct outcome assessment at course level using direct measurement of student performance in each outcome measured in the course.

Assignments Used to Assess Outcomes

As part of the assessment process, the instructors of senior design project are required to use outcome specific assignments to assess students performance in each of the eight outcomes measured in the course. In addition, samples of graded student work on the assignments are collected for each outcome and used to build outcomes based binders. A brief summary of some of the specific assignments used to measure each of the eight outcomes is discussed below.

Assignments and student's work used to assess student's ability to design a system, component, or process to meet desired needs.

Assignments given after lectures on (1) introduction to the engineering design process and project teams, (2) problem formulation and initial project specifications, constraints, and

standards (3) project planning, (4) literature review, (6) conceptual design and creativity, (7) preliminary design and analysis, (8) detailed design and final project specifications, constraints and standards are used to assess this outcome. The major design document used to demonstrate student's ability in this outcome is the complete final senior project reports.

Assignments and student's work used to assess student's ability to function on multi-disciplinary teams.

Assignment on lectures on (1) introduction to the engineering design process and project teams, and (2) project planning are used in addition to the meeting minutes and task assignments to assess this outcome. The major design document used to demonstrate student's ability in this outcome is the graded homework assignments and group meeting minutes.

Assignments and student's work used to assess student's understanding of professional and ethical responsibility.

Assignments given after a lecture on engineering ethics & professional responsibilities, and a one page report on (a) ethical issues related to the design considered by the group and (b) ethical issues that came up within the group members and how they were resolved. are used to assess this outcome. The graded student responses to these assignments are used as documentation on the students' abilities in this outcome.

Assignments and student's work used to assess student's ability to communicate effectively.

Assignment given to students after the lecture on written and oral communication and the senior project requirements from project manual, the graded final report components consisting of (a) the front end of report to the end of chapter 1, the last chapter and the list of References and (b) the final oral presentation and graded copies of final presentation slides are used to assess this outcome. The graded student responses and soft copies to these assignments are used as documentation on the students' abilities in this outcome.

Assignments and student's work used to assess student's understanding of the impact of engineering solutions in a global and societal context.

This outcome is assessed using assignments given to the students after the lecture on impact of engineering solutions on local and global communities. In addition students are required to discuss both the positive and negative impact of their design and solution on either the local or global society. Graded student work on these assignments are used as documented evidence for their abilities in this outcome.

Assignments and student's work used to assess student's recognition of the need for, and an ability to engage in life-long learning.

This outcome is measured using assignments that test students ability to independently study to understand concepts needed for their design that might not have been completely covered in the curriculum or data needed that were not provided in the project statement. The literature review chapter, list of references used, project scheduling and project tracking, relevant codes and standards identified and used in the design are graded and used to assess the students ability in this outcome. Portions of the project report on these topics and other assignments in these areas are used to assess this outcome and also for documentation on students' abilities in this outcome.

Assignments and student's work used to assess student's recognition of contemporary issues.

Throughout the semester, students are made to read current articles in selected engineering magazines, journals, national news magazines such as Newsweek to learn some of the current and contemporary issues facing engineering, the nation, and the world. Each student is required to read three of such publications to identify and summarize three different issues during the semester. A typical assignment reads: "Provide at least a two page essay on any selected current news related to your project and or discipline. You cannot just copy an article from a book, newspaper, magazine, or a website, you may however discuss an article from a book, newspaper, magazine or website, but references should be cited and listed at the end of the essay".

Assignments and student's work used to assess student's ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Throughout the two semesters of the senior project courses, students are made aware of design techniques through comprehensive lectures on all the major stages of the design process. In addition, students are required to use modern engineering tools in their design. Such tools include (1) the use of solid modeling software such as UGS for generating solids models of parts, for generating working and production drawings, and for generating assembly drawings of the subsystems, (2) the use of project management software such as Microsoft project for scheduling, monitoring and tracking tasks, (3) the use of analysis software such as ANSYS, Engineering Equation Solver, Trynsis, ADAMS, and others for design analysis and parametric studies to find the effects of major variables on the design. Students are assessed on the application of the design process, and the use of these engineering tools. A typical assignment for this outcome reads: "Provide (a) a project schedule and project tracking using a project management software such as Microsoft Project, and (b) describe the modern engineering software or hardware used in the project, what specifically you used it for, the results you obtained, and how this enhanced your design".

Assignment Types

To ensure active participation of individual members to the group effort, most assignments are first given as individual assignments. After grading the individual contributions, the assignment is then assigned as a group assignment. Table 6 is used as the cover page of the group

assignments. This table is used to document the level of participation of individual group members to the group assignment.

Table 6 Cover Page for the Group Assignments

SENIOR DESIGN & PROFESSIONALISM II
FALL 2006
PROJECT ASSIGNMENT COVER SHEET 1

GROUP NUMBER _____

ASSIGNMENT# _____

Assignment Title_____Due Date:_____

No	Group Member Name Group Member signature	Brief Description of Work Assigned to Member	% Completed by Member*	Your Score
1				
2				
3				
4				
5				

*100% means the member completed his/her assigned work.

By signing this assignment cover sheet, I agree that the percentages stated in the % completed column reflect the contribution made by me and the other members of the group.

Rubric for Grading Project Report and Demonstration

The senior design final report and project demonstration is graded on a 1000 point system. The rubric shown in Table 7 contains detailed breakdown of the components of the final report, the points assigned to the various sections, and the outcome that the individual sections of the report assess. To facilitate easy tabulation of the score in the various outcomes, a spreadsheet version of the rubric is used in the grading. Table 8 is a summary of the project score by outcomes, automatically generated from Table 7 by a spreadsheet.

Table 7 Rubric for Grading Senior design project Reports

Report Item	Relevant to ABET Criterion	Not Acceptable (0-59.9%)	Below Expectations (60-69.9%)	Average Barely meets expectations 70-79	Very Good Meets Expectations (80-89%)	Excellent Exceeds Expectations (90-100%)	Points Assigned	Points Received
TECHNICAL WRITING SKILL							120	101.5
Title Page, Abstract, Table of Content	(g)						10	10
Figures (Figure # & Titles, provided, Figure discussed/ referenced in text)	(g)						25	20
Tables (Table # & Titles provided, Table discussed/referenced in text)	(g)						25	20
References (Properly cited, referenced in text, listed in List of References)	(g)					*	25	17.5
Appropriate sub-headings under each section	(g)						10	10
Writing Skill	(g)						25	24
PROJECT SCOPE							80	77.5
Introduction	(i)						20	20
Problem Statement	(i)						10	10
Client Identification & Recognition of need	(i)						20	20
Recognition of & Knowledge of Relevant Contemporary Issues	(j)						20	17.5
Goals and Objectives	(c)						10	10
PROJECT PLANNING AND TASK DEFINITION							65	65
Task identification	(c)						20	17.5
Timeline	(d)						15	17.5
Gantt Chart	(d)						15	15
Modern Project Planning Tool Used	(d)						15	15
LITERATURE REVIEW							100	75
Relevant topics identified for literature review	(i)						10	10
Review of Previous Design or related materials, Extent and relevance of materials reviewed to project.	(i)						60	50
References used for literature review properly cited	(i)						20	10
Summary of how literature reviewed helped in project	(i)						10	5
PRELIMINARY DESIGN							100	72.5
Concept Generation, Evaluation & Selection	(c)						40	32.5
Engineering Specifications	(c)						20	15
Preliminary Design Analysis	(c)						40	25
IDENTIFICATION OF CONSTRAINTS & OTHER ISSUES							8	8
Regulations & Design Constraints considered in design	(c)						20	19
Economic, Environmental, Health, manufacturability & Safety constraints considered in design	(c)						20	19
Professional and Ethical Issues considered in Design	(f)						20	19
Social & Political Issues considered in design	(h)						20	19
DETAILED SYSTEM DESIGN/TECHNICAL DETAILS		(Instructor decides the remaining point distribution of this section)					20	20
Use of Modern Engineering tools in analysis, design drawings/schematics/ solid models, report preparation, project management, and communication.	(k)						40	32.5

Table 8 Summary of project Score by Outcomes

Summary of Scores in Outcomes			
outcome	**Score**	**Out of**	**% Score**
c	**483**	**550**	**87.82**
d	**62.5**	**65**	**96.15**
f	**19**	**20**	**95.00**
g	**101.5**	**120.00**	**84.58**
h	**19**	**20.00**	**95.00**
i	**144**	**170.00**	**84.71**
j	**17.5**	**20.00**	**87.50**
k	**32.5**	**40.00**	**81.25**

Outcome Assessment Spreadsheet

The spreadsheet shown in Figure 10 is used to capture student and class performance in each of the eight outcomes assessed and measured in the design project course. The semester class average for each outcome is computed as shown in the Table. These normalized weighted averages are used to determine whether students mastered the proficiencies in the outcomes.

Table 10 Spreadsheet for Computing Student and Class Averages in Outcomes

Outcomes	c Design									d Team				f Ethics			g Communication					
Assignment	HW1	Hwk3	HW4	Hwk2	MTRPT	FRPT	Prototyp		Total	Hwk1	MTRPT	FRPT		MTRPT	FRPT	Total	MTRPT	MTPRES	FPRES	FRPT		Total
Maximum	50.0	100.0	60.0	100.0	29.5	55.0	100.0		100.0	10.0	6	6	100	2	2	100	12	100	100	12		100
Weight																						
NAMES																						
	35.0	75.0	58.0	40.0	22.8	28.0	75		64.0	10.0	2.7	4.25	62.5	1.6	1.5	76.7	8.3	67.2	85	8.8		74.1
	35.0	75.0	58.0	40.0	22.8	28.0	75		64.0	10.0	2.7	4.25	62.5	1.6	1.5	76.7	8.3	67.2	85	8.8		74.1
	48.0	98.0	56.0	90.0	24.3	49.3	95		89.9	10.0	3.75	5.75	84.8	1.4	1.9	86.7	9.2	92.3	94	10.2		86.0
	35.0	80.0	58.0	40.0	22.8	28.0	75		64.3	10.0	2.7	4.25	62.5	1.6	1.5	76.7	8.3	67.2	85	8.8		74.1
	35.0	70.0	50.4	70.0	24.3	49.3	95		86.8	10.0	3.75	5.75	84.8	1.4	1.9	86.7	9.2	83.1	79.9	10.2		81.7
	35.0	98.0	47.6	90.0	24.3	49.3	95		88.9	10.0	3.75	5.75	84.8	1.4	1.9	86.7	9.2	87.7	75.2	10.2		81.3
	35.0	98.0	50.4	80.0	24.3	49.3	95		88.6	10.0	3.75	5.75	84.8	1.4	1.9	86.7	9.2	78.5	84.6	10.2		82.0
	35.0	90.0	50.4	70.0	24.3	49.3	95		87.7	10.0	3.75	5.75	84.8	1.4	1.9	86.7	9.2	64.6	84.6	10.2		80.0
	35.0	70.0	58.0	40.0	22.8	28.0	75		63.8	10.0	2.7	4.25	62.5	1.6	1.5	76.7	8.3	67.2	85	8.8		74.1
	72.889	83.778	90.148	62.222	80.113	135.03	156.57	0	77.6	100	54.722	84.722	75	74.444	86.111	82.2	73.333	75	84.256	79.583	0	78.6

h Global & Society				i Lifelong learning					j Contemporary Issues					k Modern Engineering skills & tools				
MTRPT	FRPT		Total	HWK4	HWK5	MTRPT	FRPT	Total	MTRPT	FRPT	FASSIGN		Total	MTRPT	FRPT			Total
2	2		100.0	40.0	100.0	17	17	100.0	2	2			100.0	4	4			100
1.4	1.5		73.3	37.0	51.0	11.3	10.2	62.2	1.4	1.4			70.0	2.8	2.2			60
1.4	1.5		73.3	37.0	51.0	11.3	10.2	62.2	1.4	1.4			70.0	2.8	2.2			60
1.4	1.9		86.7	39.0	99.0	14.1	14.4	85.4	1.8	1.75			88.3	2.8	3.25			77.5
1.4	1.5		73.3	37.0	51.0	11.3	10.2	62.2	1.4	1.4			70.0	2.8	2.2			60
1.4	1.9		86.7	35.1	95.0	14.1	14.4	84.9	1.8	1.75			88.3	2.8	3.25			77.5
1.4	1.9		86.7	33.2	90.0	14.1	14.4	84.5	1.8	1.75			88.3	2.8	3.25			77.5
1.4	1.9		86.7	35.1	95.0	14.1	14.4	84.9	1.8	1.75			88.3	2.8	3.25			77.5
1.4	1.9		86.7	35.1	99.0	14.1	14.4	85.2	1.8	1.75			88.3	2.8	3.25			77.5
1.4	1.5		73.3		51.0	11.3	10.2	59.8	1.4	1.4			70.0	2.8	2.2			60
								74.6					80.2					70
70	86.111	0	80.7	90.156	75.778	75.621	73.725	74.6	81.111	79.722	0	0	80.2	70	69.583	0	0	70

End of Semester Outcomes Assessment Report

At the end of the semester, the outcomes assessment report is prepared and included in a comprehensive Course Assessment Report for the department. The end of semester outcomes assessment report contains the following information

1. Performance Statistics
   - Total number of students in class
   - The class average performance (stated as %) in each course outcome assessed in this class and the two previous times course was assessed.
   - The acceptable class average for the class in each outcome area as set by each Department.
   - Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary
   - Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems
   - Instructor's critical evaluation of perceived problems that affected students' performance. Realistic problems are identified throughout the semester and summarized in this section of the report.

4. New Plans for Addressing Problems
   - Instructor's plans for addressing the perceived problems the next time the class is taught. These are specific enough for another instructor to implement. Most of these are things that the instructor can implement to help students to improve the next time the course is taught.

5. Overall Trend over last three assessment periods
   - Instructor's summary of overall performance trend for each outcome measured over the last three periods.

Table 12 contains the end of semester assessment report for the eight outcomes measured in senior project class in the Fall 2006 semester.

Table 11 End of Semester Course Outcomes Assessment Report

MCEG 4483-SENIOR DESIGN & PROFESSIONALISM II

FALL 2006 SEMESTER

Report Prepared by: _____

Report Date: December 19, 2006

Semester	Analysis Type	Number of Students	**Outcome c** Ability to design a system, a component, or a process to meet desired need			**Outcome d** Ability to function in a multidisciplinary team			**Outcome f** An understanding of professional & ethical responsibilities			**Outcome g** Ability to communicate (Oral & Written)		
			Expected Average	Class Average	% Students below Expected Average	Expected Average	Class Average	% Students below Expected Average	Expected Average %	Class Average %	% Students below Expected Average	Expected Average	Class Average	% Students below Expected Average
FALL 2006	**Direct**	**9**	**75**	**77.6**	**44**	**75**	**74.9**	**44**	**75**	**82.2**	**0**	**75**	**78.6**	**44**
Spring 2006	**Direct**	**10**	**75**	**86**	**0**	**75**	**75**	**0**	**75**	**86**	**10**	**75**	**71**	**80**
Fall 2005	**Direct**	**9**	**75**	**85**	**0**	**75**	**86.5**	**0**	**75**	**86.5**	**0**	**75**	**85.6**	**0**
Implementation Summary			Senior project manual was distributed and discussed in class. The various stages of the design process were reviewed, and the design requirements explained.			Senior project manual was distributed and discussed in class. The section on teaming and group dynamics was presented and stressed.			A presentation of ethical and professional responsibility was made to students in class, and a report on ethical issues that could arise from their project was required from students.			The various stages of the design process was presented, with emphasis on the requirements for report and oral presentation format and preparation .		
Perceived Problems			Given an open ended problem, students found it difficult to identify the various mechanical subject areas and relevant design equations needed for the design. Design specification was a major problem			Few good students appear to do most of the work. Responsibilities of each team member were not clearly defined.			Students found it difficult to find the connection between their project and professional & ethical responsibilities.			**Students do not begin to compile their work into a report early enough. Presentations are not planned in advance until the last minute.** **Presentations did not have video clips.**		
Plans for Addressing Problems			The following is recommended for implementation. Students should be made to break the project into tasks and identify the subject area needed for each task and relevant design equations required. A lecture on design specifications should be given, followed by an assignment.			The following is recommended for implementation the next time the course is offered. Group leaders will be required to break up assignments among individual members. Instructor should first make individuals turn in key assignments for grading before submission to group. Instructor should grade assignments and award grades to individual members based on how well each performed in his/her respective sub-assignment			The instructor should: Present case studies on professional & ethical responsibilities of engineers. Invite a guest lecture on this topic. Individual assignment and test on this topic. Assign students to read the ASME and PE Code of ethics and students should be tested on these.			The instructor should Require students to begin preparing their report and presentation from the first week of class. Require students to make an outline of their report and presentation right after discussing the senior project manual. Each assignment will then be inserted into appropriate portions of this outlined report and presentation. Require students to embed video clips in their presentations.		
Overall Trend over Periods			There is slight fluctuations in students performance from semester to semester, but on the whole the average has been above the expected value the past three periods			There is a slight decreasing trend over the last three semesters. Not much change between the Spring and Fall 2006 semesters.			The class average has been in the mid 80% over the last three semesters with a slight decreasing trend. There has been gradual improvement in student performance over the last three periods. The average has been over the expected since fall 2005.			There was a decrease in the Spring 2006, but a slight increase in Fall 2006 and expected average exceeded in two of the last three semesters.		

Table 11 Continued

Semester	Analysis Type	Number of Students	Outcome h: Impact of engineering solutions in a global and societal context			Outcome (i): A recognition of the need for and the ability to engage in lifelong learning			Outcome j.: Knowledge of contemporary issues			Outcome k: Ability to use the techniques, skills, & modern engineering tools necessary for engineering		
			Expected Average	Class Average	% Students below Expected Average	Expected Average	Class Average	% Students below Expected Average	Expected Average %	Class Average %	% Students below Expected Average	Expected Average	Class Average	% Students below Expected Average
FALL 2006	Direct	9	75	80.7	44	75	74.6	44	75	80.2	44	75	70	44
Spring 2006	Direct	10	75	79	30	75	70	70	75	80	30	75	93	0
Fall 2005	Direct	9	75	84	11.1	75	84	11.1	75	84	11.1	75	84	11.1
Implementation Summary			Students were made aware of the importance of ascertaining the impact of their project on either the local or global society			Senior project manual was distributed and discussed in class. The importance of life-long learning demonstrated by a detailed literature review and gathering of relevant information needed for the design was stressed.			The importance of reading current issues in mechanical engineering was stressed.			Solid modeling, tools such as Unigraphics, analysis tools such as EES, project management tools such as Microsoft projects were recommended for use in the project.		
Perceived Problems			This was a tough issue for students to address. Students found it difficult to identify the impact of their design in a global and societal context			Students overly depend on the internet for information needed for the project. Students do not have the habit of learning new areas themselves through literature research			Students were not very clear on what they need to do in this area			Some students have problems using some of the tools needed for the design such as EES, Unigraphics, and project management tools.		
Plans for Addressing Problems			Instructor should provide a special lecture on this topic and assign homework in a general area and another homework related to the projects students are working on.			Instructor should provide a listing of selected journals, conference proceedings, and other publications relevant to the projects and require students to read these for additional information on the projects.			Instructor should give a brief lecture on contemporary issues. A disciplinary specific homework on contemporary issues should be given Should give homework on global issues related to and or addressed by the design			Instructor should give homework assignments that help student to practice on the use of these tools early in the semester .		
Overall Trend over Periods			The average has consistently been above the expected average since Fall 2005 semester.			The average has been below the expected average over the list and the last semester, even though there was a slight improvement over the Spring 2006 semester			The average has consistently been above the expected average and in the low 80%.			There was a dramatic decrease in this average from 93% in Spring 2006 to 70% in Fall 2006.		

Conclusion

A process and methodology for using capstone design projects in assessing eight of the eleven ABET a-k outcomes developed at the College of Engineering, Prairie View A&M University have been described. The process includes (1) identifying the importance of capstone design, (2) defining course objectives and anticipated outcomes, (3) defining a criteria for selecting projects, (4) generating a generic time table for major project milestones, (5) having a manual that details the format and requirements for the capstone design project, the reports, and presentations, (6) systematic organization of the course, (7) method for group formation and group meeting requirements, (8) designing outcome specific assignments for the course, (9) assessing of outcomes using outcome specific assignments, project reports, and project presentations and product testing, (10) the use of various spreadsheets for capturing student and class performance in the outcomes, and (11) a final end of semester assessment report that summarizes the performance in outcomes, identifies problem areas, and formulated plans to address the problems the next time the course is taught. The methodology discussed in the paper has made it possible to identify problems encountered by students in these outcome skills, thereby, facilitating adjustment in course content and delivery, and formulation of plans to assist students to improve on these skills. The methodology also makes it possible to document students' performance in these outcomes. The documentation is used to generate outcome specific binders of students' work that are vital for ABET accreditation.

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