AC 2007-266: USING INDUSTRIAL ADVISORY BOARDS TO ASSESS CAPSTONE DESIGN COURSES

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Using Industrial Advisory Boards to Assess Capstone Design Courses

Abstract

The electrical engineering program at Western Kentucky University (WKU) was created in 2001 with a focus on project-based education. Faculty have developed a series of experiences throughout the curriculum to support this mission which culminates in a year long design sequence. In this sequence, students must plan, design, and execute an industrial project. The industrial advisory board is used as a resource for projects and to assess the students at then completion of the project.

This paper will describe the design sequence, explain the role of the advisory board in the assessment, present the assessment tool used, show how the assessment tool relates to ABET Criteria 3 A-K, and describe the results obtained from past assessment cycles.

Introduction

The focus of the WKU Department of Engineering is project-based engineering education. An excerpt from the departmental mission statement exemplifies the focus clearly[1]:

> "The mission of the Department of Engineering is to produce, as its graduates, competent engineering practitioners. An engineering practitioner is one who has a foundation of basic science, mathematics, and engineering knowledge, combined with practical knowledge and experience in applying existing technology to contemporary problems. "

The mission of the Electrical Engineering (EE) Program is to build a foundation of knowledge in electrical engineering by integrating a variety of project experiences at every level throughout the curriculum. The program is to be relevant to the region and to produce graduates who can immediately contribute to the profitability of their employer. The roles of the student as learner, observer, assistant, and practitioner have been clearly defined and articulated for this environment[2].

The EE program at WKU is an ABET accredited program. A variety of methods are used to assess the outcomes of the program. The purpose of this paper is to present the use of an industrial advisory board (IAB) to assess students in the capstone design course.

Design Sequence

The Electrical Engineering Program at WKU has a series of four design sequences throughout the curriculum. The purpose of these courses is to develop problem solving and project skills in the students. Also, these courses interspersed throughout the curriculum reinforce the project-based mission of the department. The four design courses are designated as follows:

- EE 101: Electrical Engineering Design I, 1 credit hour (2 contact hours), first semester;

- EE 200: Electrical Engineering Design II, 1 credit hour (2 contact hours), third or fourth semester;
- EE 300: Electrical Engineering Design III, 1 credit hour (2 contact hours), sixth semester;
- EE 400: Electrical Engineering Design IV, 1 credit hour (2 contact hours), seventh semester;
- EE 401: Capstone Design Experience, 3 credit hours (3 contact hours), eighth semester.

The first design course, EE 101, was created to introduce the student to the university and the electrical engineering program. During this course, students learn to solder and to use the departmental prototyping facilities such as the machine shop. In this course, students begin using typical software packages such as MATLAB and HTML. Also, the issue of ethics is presented for the first time to the EE students. The culmination of this course is the completion of a robotic bug and competing against fellow students for best design and performance[3].

The second design course, EE 200, further builds on the project-based mission. During this course, students learn to construct circuits using the departmental print circuit board prototype facilities. Circuit simulation with PSPICE software is also presented for this first time. The topics of ethics, MATLAB, and technical writing are continued from the previous course. This design course has been designed as a co-requisite for the first circuits and networks course. Students reinforce their knowledge of circuit theory through hands-on exercises in this course.

EE 300, the third design course for electrical engineering students, is the first exposure of students to the engineering design process. During this one semester course, students are placed on teams. Each team must solve and implement a design problem throughout the semester. Professional issues and a variety of ethical issues are presented in this course. This course is taken the spring semester before the senior design sequence and is an important foundation to the senior project experience.

The first course of the senior year experience is EE 400, EE Design IV. The objectives of this course are to

1) further develop design skills,
2) develop teamwork skills,
3) learn to deal with situations in an ethical manner, and
4) design and write the senior project proposal.

The official course description of this course is:

> Design methodology and decision-making. Design of individual projects culminating with oral and written reports, ethics, and professional issues.

During this course, students thoroughly plan their capstone project. At the beginning of the semester, students are placed on teams. The teams are then assigned their projects. All of these projects have a sponsor external to the EE faculty. Some of the projects are industry projects and other projects are grant funded projects. The students interact with the faculty as technical sponsors for their projects and also interact with the industry liaisons. During this semester, the following topics are presented: teamwork skills, steps in effective design (understanding the problem, brainstorming, research, preliminary design, Gantt charts/project planning),

manufacturability, assemble, affordability, reliability, and sustainability. Students spend a significant amount of time developing their proposal. By the end of the semester, the students have completed the project proposal which contains the following information:

- Detailed description of the proposed design/solution;
- Appropriate schematics and diagrams;
- List of components and spec sheets;
- Proposed budget:
- Explanation of design:
- Statement about compliance with safety codes;
- Evaluation plan;
- Action plan;
- Background research; and
- ABET document.

The second course in the senior capstone experience is EE 401. The course description for this course is:

> A course designed for the student to assume the primary responsibility for the completion of an electronic or electrical project.

The course objective for the course states that

> At the end of this course, students will have completed a major capstone design experience. Students will demonstrate their ability to design, build, and test a system to meet specified criteria. Also, students will demonstrate their ability to communicate their project design and results in a written format and in an oral presentation.

During the semester, the class spends very little time meeting as a group. However, the teams meet weekly with the faculty advisors and with the industry advisors as often as necessary. The entire semester is spent implementing the capstone project. The end of the semester culminates with presentations and demonstrations to the faculty, industrial advisory board, and fellow students. These presentations are assessed by all three groups. The teams also present their results at their sponsoring industries.

Role of the Advisory Board in Capstone Design Course Assessment

The EE industrial advisory board (IAB) is composed of faculty, students, alumni, and representatives from various industries. Each spring the IAB is approached as a source for potential capstone projects. During the following summer, faculty consult with the industry partners to determine the projects that are appropriate for capstone experiences. The industry members who agree to sponsor senior projects work with the students throughout the year as they develop and ultimately implement their projects. Each spring during finals week, the IAB has their annual meeting. A substantial part of the agenda of the meeting is the presentations demonstrations by the senior project teams. These presentations usually take thirty to forty-five minutes. At the end of the presentations, the board, faculty, and students assess the communication skills of the teams.

Assessment Tool for Capstone Design Course

The assessment tools used for evaluation of communication skills are shown below. These rubrics assess Outcome 7 of the WKU Electrical Engineering Assessment Plan which directly relates to ABET Criteria 3 G:

Outcome 7: Our graduates have the ability to communicate effectively.

The students are evaluated during their final senior project presentation on the use of multimedia, body language, personal appearance, delivery style, and the manner in which they responded during the question and answer session. These rubrics have been refined through annual use and were originally created from a variety of sources.

Table 1: Rubric Scoring for Use of Multimedia

Numerical Score	Characteristics
4	**Exemplary** • Multimedia clearly enhances presentation • Concepts made clearer • Most information easy to see and follow • Details minimized • Main points stand out
3	**Proficient** • Multimedia contributes to the quality of the presentation. • Most concepts made clearer • Most information generally easy to read and follow • Main points stand out • A few details difficult to follow
2	**Apprentice** • Multimedia poorly prepared or used inappropriately • Generally do not enhance concepts • Sometimes confusing, hard to see, read, and/or follow
1	**Novice** • Multimedia not used or so poor they are distracting • Does not contribute to presentation

Table 2: Rubric Scoring for Body Language

Numerical Score	Characteristics
4	**Exemplary** • Speaks to the audience • Movements not distracting • Comfortable • May add to the presentation
3	**Proficient** • Generally speaks to audience • Only minor distracting movements • Does not distract from presentation
2	**Apprentice** • Tends to speak away from audience (at floor, screen, etc.) • Movements becoming distracting
1	**Novice** • Speaks mostly at screen or at floor • Movements distracting • Hard to concentrate or gain much from presentation

Table 3: Rubric Scoring for Personal Appearance

Numerical Score	Characteristics
4	**Exemplary** • Completely appropriate for the occasion
3	**Proficient** • Generally appropriate for the occasion
2	**Apprentice** • Somewhat inappropriate for the occasion
1	**Novice** • Inappropriate for the occasion

Table 4: Rubric Scoring for Delivery Style

Numerical Score	Characteristics
4	**Exemplary** • Grammar is good • Pace is smooth • Rehearsed with only 1 or 2 flaws • Memorized • Projects voice • Transitions from slide to slide or person to person generally seamless
3	**Proficient** • Grammar is good • Pace is good with a few breaks • Rehearsed with only a few flaws • Mostly memorized • Can be heard almost always • Transitions for the most part good
2	**Apprentice** • Grammatical mistakes becoming noticeable • Several breaks in the pace • Not well memorized • Some key information difficult to hear, • Transitions cumbersome
1	**Novice** • Many grammatical mistakes • No real pace at all • Mostly read • Key information difficult to hear • Transitions very distracting

Table 5: Rubric Scoring for Question and Answer Portion of the Presentation

Numerical Score	Characteristics
4	**Exemplary** • Answers confidently and adequately with no hesitation or stumbling over words
3	**Proficient** • Answers adequately with some hesitation • May stumble over a few words • Some slight lack of confidence • Overall good at answering questions
2	**Apprentice** • Answers not always adequate • Shows uncertainty • Pauses more obvious and somewhat distracting
1	**Novice** • Questions either not answered or done so with great difficulty • Significant uncomfortable pauses • Little to no confidence

Results from Past Assessment Cycles

The EE program at WKU has produced graduates since May 2004. Approximately 20 students have graduated from the EE program to date. The IAB was used to assess the senior students in May 2005 and May 2006. These results are presented below in Figures 1 and 2. Figure 1 shows the rubric scoring averages in each of the five assessment categories for the industrial advisory board and the faculty. In general, the IAB assessed the students higher than the faculty but the averages were very close.

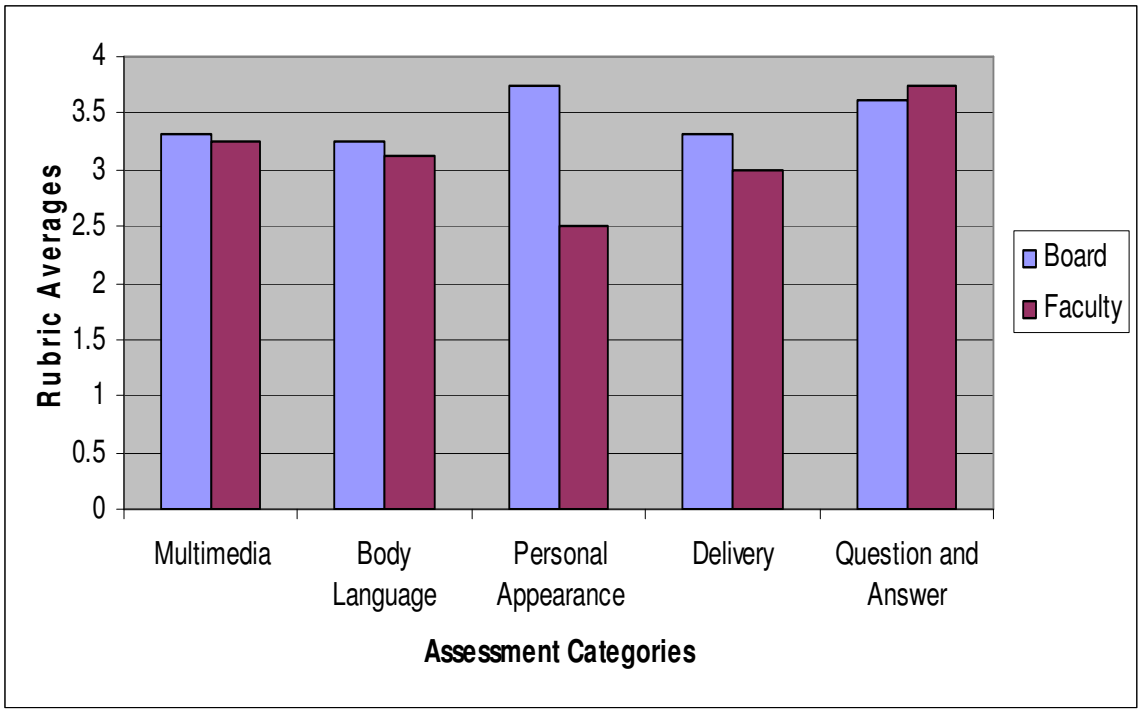

Figure 1: May 2005 Assessment Results

In May 2006, students also participated in the assessment of their colleagues. Figure 2 presents a comparison of student, faculty, and advisory board assessment rubric averages.

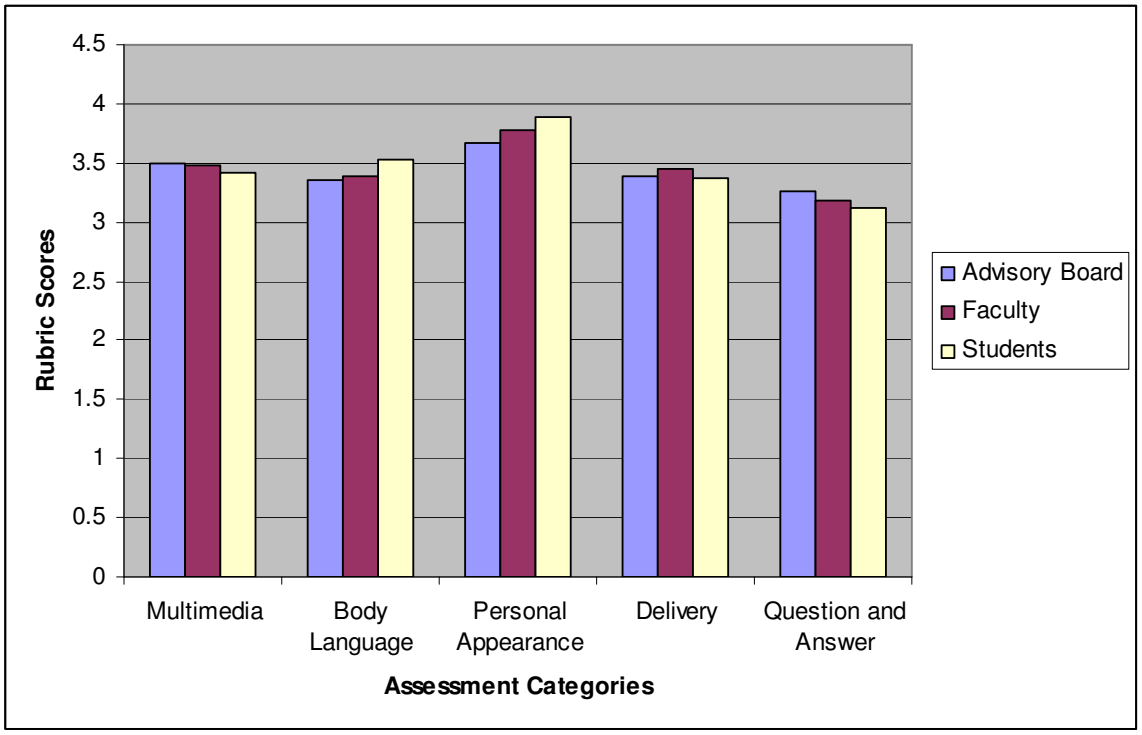

Figure 2: May 2006 Assessment Results

In order the demonstrate the difference in rubric scoring of the three groups, the percent differences in the average rubric scores between the faculty and IAB and faculty and students are listed in Table 6 below. There is a smaller percent difference between faculty and IAB scores and faculty and student scores. In general, the advisory board rubric average scores were closer to the faculty average scores than the student assessment average scores.

Table 6: Percent difference in averages graphed in Figure 1

	Multimedia Score	Body Language Score	Personal Appearance Score	Delivery Score	Question and Answer Score
Percent difference between faculty and IAB averages	0.65%	0.86%	2.80%	2.10%	2.50%
Percent difference between faculty and student averages	1.74%	3.97%	3.26%	2.60%	2.11%

Conclusion

The Electrical Engineering Program at Western Kentucky University is a project-based program built upon a five course design sequence. During these courses, students engage in a variety of project experience that reinforces the mission of the department. The two semester capstone experience is the highlight of the curriculum. The EE industrial advisory board serves as a resource for both projects and assessment. The assessment of the advisory board is an important data point for the assessment plan of the EE program particularly since the advisory board is a constituency of the program. Incorporation of the industrial advisory board into the senior capstone project experience provides an enriching senior project experience for EE students at WKU and relevant assessment data for the ABET assessment process. In the future, the WKU EE faculty will investigate methods for incorporating advisory board members into the assessment of the design process and project success.

Bibliographic Information
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