Assessment of the electrical and computer engineering senior design projects at Old Dominion University

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Abstract

The senior capstone design experience for computer engineering and electrical engineering majors at Old Dominion University (ODU) is a two-semester course. The projects are multidisciplinary, with some projects involving collaboration with industry and federal labs. In the first semester, the students mainly focus on proposal development, acquiring components needed, and conducting preliminary designs. In the second semester, the students implement the design proposal developed in the first semester, write their final report, and present their results in oral and poster formats. The Electrical and Computer Engineering Department at ODU uses a set of rubrics to evaluate the outcome of the senior design projects. A committee of three faculty plus the faculty project adviser complete the assessment rubric and the results are summarized and used to assure that the design projects fulfill the Accreditation Board for Engineering and Technology (ABET) outcomes and to continue to improve the students' learning. In, this paper, we discuss the course structure, requirements, and the grading rubrics.

Keywords

Engineering senior design projects, ABET, student outcomes, assessment

Introduction

The senior design projects aim at developing engineering design skills of a computer/electrical system. The senior design project is divided into two courses that the students take over two semesters. The first course, ECE486, focuses on engineering proposal development, while in the second course, ECE487, the students implement their proposal. The projects vary in scope and include collaboration with local industries and federal labs. Elements of developing a successful design proposal are emphasized in lectures along with written and oral communication skills, engineering professional development, technical presentation skills, developing an understanding of the societal impact of the project, and developing realistic constraints on the design, conforming with engineering standards applicable to the project, and recognizing and adhering to engineering codes of ethics.

ABET is the recognized U.S. accreditor of college and university programs in applied science, computing, engineering, and technology. Accreditation ensures the quality of the postsecondary education students receive. ABET has provided a list of student outcomes requirement for both electrical and computer engineering [1]. The capstone senior design course provides data to assess many of the ABET student learning outcomes (SLO) and, therefore, has been suggested for use in conjunction with other senior core design courses for accurate assessment of students' learning outcomes [2]. We discuss the use of grading rubrics to obtain students' outcomes assessment. The rubrics map into the SLO. These rubrics are used to assess different

interdisciplinary projects that vary significantly in scope and areas of concentration. The students are provided with these rubric at the start of their senior capstone course and are guided to incorporate engineering design skills with broader impact awareness of their design.

Method

Based on the student class roster, the students are identified as majoring in computer engineering, electrical engineering, or double majoring in electrical and computer engineering. The grading rubrics for both classes are provided at the beginning of each semester. Grading for each group is based on rubrics provided to the faculty project adviser and a committee of three faculties. Table I gives the grading policy for the first course (proposal development).

Table I. Grading policy for ECE486 (Engineering Design Proposal Development) and ECE487 (Design Implementation) courses.

First Semester ECE486	**Percentage**	**Second Semester ECE487**	**Percentage**
Class Participation	11%	Mid-term preliminary group report (graded by advisor)	15%
Mid-term preliminary group report (graded by Advisor)	24%	Mid-term oral group presentation (graded by course instructor)	5%
Mid-term group presentation (graded by course instructor)	5%	Final group report graded by Faculty advisor	24%
Final proposal graded by faculty advisor	30%	Final group report graded by committee	24%
Final proposal graded by committee	30%	Final poster presentation graded by Committee	5%
		Final oral presentation graded by Committee	27%
Total	100 %	Total	100 %

Grading rubrics are used to assign a numerical score to the assignments in Table I. For ABET outcome assessments, both final proposals graded by the faculty adviser and by the committee are used for assessment. Grades assigned by the adviser and each member of the committee are given equal weight. This approach is applied for ECE486 (proposal development) and ECE487 (design implementation). Computer engineering and electrical engineering students are grouped separately. Electrical and computer engineering double major students are counted in both categories. The aim of using a committee plus the faculty adviser for grading is to make the grading and assessment standards more uniform than if the adviser's grading is used alone. The final grade is evaluated by a weighted formula provided in Table I. The ABET outcome assessment is embedded into the final proposal and report rubrics. For example, for ECE486, ABET outcome 1, 2, 4, 5, 6, and 7 are assessed. Each outcome contains performance

indicators. The detailed list of assessed performance indicators description for both courses is shown in Table II.

The student outcomes assessment are based on final proposal graded by advisor and each of the three-committee members. The faculty adviser may grade each student in the team individually. Each committee member assigns one grade for the whole team.

We are currently modifying the rubrics so that they can be used to assess the ABET criteria developed in 2016. A modified sample grading rubric is shown in Table III. We utilized the concept/category evaluated in the course mapping with the most relevant Student Outcome Performance Index (SO-PI). The grading rubrics for ECE486 (proposal development) and ECE487 (design implantation) are slightly different. Student outcomes and its performance indexes 1, 2, 6 and 7 are the same. In Outcome 4, there is only one PI in ECE486, however, there are three PIs in ECE487. In Outcome 5, there is only one PI in ECE486 and two PIs in ECE487.

Since the grading rubric are designed for mapping student outcomes, and after collecting the final grades from the advisor and the three committee members, a Microsoft Excel table is generated with students' name in a row and the outcomes in columns. This Excel file is used for generating student outcome assessment report. The students' average grade corresponding to SLO assessed is plotted in bar graphs, which are used to identify the fraction of the students that have met the SLO based on their score and those that have not met that outcome.

This approach provides data that shows any deficiency in SLO by major (computer engineering and electrical engineering). The projects vary significantly in topics and include industrial projects, research-oriented projects, and projects aimed for regional and national competitions. Detailed analysis of the outcome of each project are used to assess which type of projects achieves the best SLO outcome. Generally, projects aimed at competing at a regional or national level tend to have better outcomes. An example of these projects is the SoutheastCon Student Hardware Competition. Industrial projects and those involving federal labs often perform very well, but care must be taken in defining the projects so that the design aspect is well defined since some of these projects are part of a larger research effort.

Faculty Resources

The faculty resources involved in the senior design projects are the course coordinator, faculty adviser for each project, an evaluation committee consisting of three faculties. Some of the projects are joint with other engineering departments. In this case two faculty advisers supervise the project. The project adviser works with the same group throughout the two semesters. The evaluating committee evaluates the final proposal, final project report, and the oral poster presentations. Each semester there are about 6-12 projects in each of the two courses (ECE486 and ECE487). The supervisory responsibility of the faculty adviser and the committee-grading responsibilities are factored in their teaching load.

Table II. List of ABET student outcome assessed performance indicators (SO-PI).

ECE486 (Proposal Development)	ECE487 (Design Implementation)
Student Outcome 1: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	
SO1 – PI1: Capable of identifying and formulating a complex engineering problem	
Student Outcome 2: An ability to apply the engineering design process to produce solutions that meet specified needs with consideration for public health and safety, and global, cultural, social, environmental, economic, and other factors as appropriate to the discipline	
SO2 – PI1: Capable of applying the engineering design process to produce solutions that meet specified needs	
SO2 – PI2: Capable of taking into consideration public health and safety, and global, cultural, social, environmental, economic, and other factors in the engineering design process	
Student Outcome 4: An ability to communicate effectively with a range of audiences	
SO4 – PI1: Capable of communicating effectively in technical writing	SO4 – PI1: Capable of communicating effectively in technical writing SO4 – PI2: Capable of preparing a technical presentation SO4 – PI3: Capable of delivering an effective technical presentation
Student Outcome 5: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
SO5 – PI2: Capable of making informed judgments that consider the impact of engineering solutions in global, economic, environmental, and societal contexts	SO5 – PI1: Capable of recognizing ethical and professional responsibilities in engineering situations SO5 – PI2: Capable of making informed judgments that consider the impact of engineering solutions in global, economic, environmental, and societal contexts
Student Outcome 6: An ability to recognize the ongoing need for additional knowledge, to choose appropriate learning strategies, and to apply this knowledge	
SO6 – PI1: Capable of recognizing the need for life-long learning	
SO6 – PI2: Capable of independently choosing appropriate learning strategies and applying this knowledge to solve an engineering problem	
Student Outcome 7: An ability to function effectively as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and creates a collaborative and inclusive environment	
SO7 – PI1: Capable of contributing to the success of the project	

Table III. Grading rubrics used by project adviser advisor and how these rubrics are used in the assessment of the ABET criteria

ECE 486: Final Proposal Grading Rubric

Graded by Adviser for each Student

Graded by:

Project Title:

Faculty Advisor:

Student: (indicate each student major, EE or CpE)

Concept/Category	Unacceptable (0)	Marginal (1-2)	Acceptable (3-4)	Exceptional (5)	Points
Design Methodology **ABET SO1 – PI1**	Has no understanding of the design problem	Shows understanding of the design problem; Lacks alternative design concepts	Understands the design problem and objective; Have alternative design concepts been addressed	Shows good understanding of the design method; Considers alternative design concepts, and how the problems encountered in the design were solved	
Design Quality **ABET SO2 – PI1**	The design selected is not feasible	The design selected has some problems	The design selected appears adequate	The design is promising	
Realistic Constraints	Lack of realistic constraints in the design	Shows understanding of constraints; Marginal use of realistic constraints in the design	Adequate use of realistic constraints which are reflected in the final design	Design takes into account all realistic constraint and the final design is optimized	
Result and Discussion	Inadequate results and discussion	Unable to make proper connection between results and discussion	Able to validate design	Clearly connects the results together to validate the design	
In Depth Comparison with Alternative Designs **ABET SO6 – PI2**	Inadequate discussion	Some discussion	Adequate discussion	Comprehensive discussion	
Engineering Standards	No mention of engineering standards	Some relevant engineering standards were identified but not utilized	All relevant engineering Standards were identified and some degree of utilization	All relevant engineering standards were identified and utilized in the design	
Team Work **ABET SO7 – PI1**	Did not contribute	Some contribution	Good contribution	Contributed strongly	
Engineering Ethics **ABET SO5 – PI2**	Lack of discussion of relevant engineering ethics and professional responsibilities	Shows some awareness of engineering ethics as it related to the project and professional responsibilities	Adequate discussion of relevant engineering ethics issues and professional responsibilities	Shows strong understanding of engineering ethics and how it related to the project and professional responsibilities	

Continuation of Table III

Written Report Quality **ABET SO4 – PI1**	Poor organization and formatting; Mechanical errors	Some organization; Proper formatting and relatively error free	Well organized and properly formatted and error free	Communicates the key concepts effectively; Well organized and properly formatted and error free	
Broader Impact **ABET SO2 – PI2**	Lack of consideration of economic, environmental, health & safety, social, political, sustainability, and manufacturability constraints	Some consideration of economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints	Adequate consideration of economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints	Comprehensive consideration of economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints	
Lifelong Learning **ABET SO6 – PI1**	No lifelong learning plan discussed	Some discussion on a lifelong learning plan is made	Adequate discussion on a lifelong learning plan is made	A thorough discussion on a lifelong learning plan is made and demonstrates independent learning and use of outside sources.	
Analysis and Testing	Lack of proper analysis and testing	Some analysis and testing	Adequate analysis and testing	Methodical analysis and testing	

Comment on teamwork and performance:

Results of Outcome Assessment and Course Improvements

The implementation of the described assessment method has led to improvements in achieving the senior design goals. For example, some projects are tied to faculty research were identified to lack significant engineering design. This was corrected by requiring the faculty to define the design problem in the project abstract. The multidisciplinary nature of the project was strengthened by requiring that each project include a group member from a different major (e.g., computer engineering, electrical engineering, or mechanical engineering) or that the group interacts with other researchers from different disciplines (e.g., chemistry, materials science, or physics). The assessment has also showed some weakness in the students' awareness and application of engineering standards. This was corrected by including a lecture defining engineering standards and best practices to apply them to project examples. Also, to strengthen awareness of engineering ethics, the students receive instruction on the different engineering ethics codes and examples on how they can apply them to their project. The students are required to refer to the IEEE Code of Ethics in their reports.

At the end of the semester, there are four student outcome assessment reports generated based on the student performance including ECE486 Computer Engineering, ECE486 Electrical

Engineering, ECE487 Computer Engineering and ECE487 Electrical Engineering. The performance categories are shown in Table IV. In each report, a detailed comment and action plan is required to ensure course quality and improvement.

Table IV. Student outcome report performance categories.

		1 Unacceptable (D-/F)[2]	2 Below Expectations (C-/D+/D)	3 Meets Expectations (B/B-/C+/C)	4 Exceeds Expectations (A/A-/B+)							
Assessed Performance Indicator	Assessment Tool (e.g., Question in HW or Exam, Etc.)	Brief Description	Number of Assessed Students	Total Possible Points	Ranges of Points for Performance Categories				Total Number of Students in Each Performance Category			
					1	2	3	4	1	2	3	4
SO1 – PI1												
SO2 – PI1												
SO2 – PI2												
SO2 – PI3												
SO4 – PI1												
SO4 – PI2												
SO4 – PI3												
SO5 – PI1												
SO5 – PI2												
SO6 – PI1												
SO6 – PI2												
SO7 – PI1												

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