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A Junior Level EE Projects Course with ABET Rubrics

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Abstract

All electrical and computer engineering majors at the University of Evansville are required to complete EE 380, a 2-hour projects course at the end of the junior year, prior to enrolling in the senior project sequence. This course requires that all students complete four open-ended projects, one of which must be a team project. The team project is typically completed by all of the students in the class in teams of 3 or 4 students each. The remaining three projects must be done on an individual basis and can be chosen from a list of projects in three different areas such as electronics, linear systems, digital systems, electromagnetics, software, etc.

EE 380 meets once a week in a session where the instructor provides guidance and coordinates the course. The instructor is also available in the lab at arranged times to provide one-on-one assistance with a project.

Students keep a notebook of their work on the projects and turn in a formal report documenting each project. Students must also present a demonstration of each final project to the instructor. As it is structured, this course provides a mechanism to assess ABET outcomes b, d, e, and h. In this paper, we present the logistics of the course, a sample of projects completed, and the course assessment for ABET outcomes.

Introduction

Project based learning is not a new concept and has been shown to be an effective teaching method[1, 2]. EE 380, Junior Projects, is a two-hour course required of all electrical and computer engineering majors which is typically taken the last semester of the junior year. (See [3] and [4] for examples of similar courses elsewhere.) The course originated more than 20 years ago and has always required that students complete a series of open-ended projects related to the required junior level coursework. There is no lecture, other than for organization, and the class meets once a week as a way to more formally answer questions and provide support for students working on projects. Over the years the number of projects and the nature of the projects has varied. Over the past five years the course has been restructured so as to satisfy three objectives:

1. The course provides a mechanism whereby students can complete laboratory exercises that reinforce the theoretical material learned in the junior year. This includes the areas of electronics, linear systems and controls, electromagnetics, microcontrollers, and digital electronics. For the computer engineering students it also includes systems software and real-time programming.
2. The course provides preparation for the year-long senior design project. Students learn how to complete an open-ended project that has little direction other than a list of constraints. They also are introduced to the tools and technologies that are needed to make a project successful such as 3-D printing, circuit board fabrication, packaging, and safety issues.
3. EE 380 provides and efficient way in which to assess several ABET outcomes including:
   ABET (b) an ability to design and conduct an experiment as well as to analyze and interpret data.

ABET (d) an ability to function in multidisciplinary teams.
ABET (e) an ability to identify, formulate, and solve engineering problems.
ABET (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Structure of the Course

EE 380 is a two-credit hour course. The course has no formal lectures and no exams. It meets for one hour a week for coordination, to answer questions, and to keep students on track. Each student has four projects to complete and one of these must be a team project. The team project is chosen by the instructor and typically all of the teams in the class will be doing the same project. For the remaining three projects students must choose from three different areas. Each area, such as electronics or linear systems will have an array of 3 to 7 projects from which to choose. With permission from the instructor, students can create their own projects from one or more of the approved areas as long as the projects are of sufficient complexity.

Each student is assigned a lockable space in one of the project labs. The labs themselves are accessible by students at all hours day or night. Each project lab station has basic lab equipment such as a computer, oscilloscope, function generator, and power supplies.

Each project has a three week deadline; late projects receive a grading penalty for projects. Students must present a formal demonstration of each project to the instructor. Also, students are required to maintain a notebook log of activity for each project and produce a detailed written report which is graded for both content and writing.

The instructor's role is to provide assistance when it is asked for. On occasion, the instructor may do a 15 minute lecture for a subset of students working on a particular project. The instructor is also available at prearranged times in the lab for help. Since this course can require considerable assistance from the instructor, section sizes are limited to just 12 students.

The final grade in the course is based on the grades on each of the four projects.

The Team Project

Students are permitted to form their own teams, three or four students to a team. The instructor will introduce the project in class and suggest a manner in which the project may be separated into distance tasks for assignment to different team members. Each team makes its own assignments of tasks. Team projects are large enough and have enough complexity that they cannot be completed without a team effort in the time allotted.

Team project examples
Two projects which have been used as team projects in previous years are given below:
Remote Sensor Package: Students design and build a sensor package that can monitor and record temperature and air pressure when left in a remote location for up to one week. The typical division of work for four students is: a) develop an algorithm and write the software; b) design and implement the circuit; c) design the power supply and the project packaging; and d) monitor

progress, write all reports, verify design, and provide a testing procedure. All team members consider safety and reliability.

High Altitude Balloon Sensor Package: Students design and build a sensor package to go into a high altitude balloon that will soar to about 100,000 feet and parachute down to be recovered via GPS signal. The sensor package monitors temperature which can be as low as -70^{o} F. The typical division of work for four students is: a) write the software and manage external communications; b) design and implement the hardware and sensors; c) design the power supply and packaging; and d) monitor progress, write all reports, verify design, provide a testing procedure and analysis of the data collected. All team members consider reliability which is critical to the success of this project.

Individual Projects

Individual projects must be chosen from three different areas. EE 380 is a required class for both electrical and computer engineering students. For the electrical engineering students the areas in which projects can be chosen are electronics, linear systems and controls, microcontrollers, and electromagnetics. For the computer engineering majors, the areas are digital electronics, linear systems and controls, microcontrollers, and systems software. The instructor solicits projects from other faculty and provides three to seven projects in each area.

In some cases, students may choose to create their own projects; this is permissible with the instructor's approval.

All of the projects are open-ended – that is, they have a set of specifications and constraints that must be met but the method of completing the project is unspecified. The list below gives sample projects for each area and a complete project specifications for two projects are given in the appendix.

Individual Projects by Area

Electronics

- BJT class A two-stage amplifier design
- DC Switching Power supply
- Analog filter design – typically a third or fourth order Butterworth filter
- Sinusoidal or square-wave oscillator design
- Current switch that turns on when current in an AC line exceeds a set trip-point
- Design of an analog differential thermometer switch that turns on when a temperature difference exceeds a preset trip-point.

Linear Systems and Controls

- PID motor controller for a small dc motor
- Determination of the transfer function for a thermo system
- Analog filter simulation
- Black box transfer function determination
- Design a five-band digital equalizer in MATLAB® and use it to filter a sound file in the .wav format.

Electromagnetics
• Non-contact AC current meter design.
• Design of an experiment to determine the break-down voltage of commercially available capacitors.
• Design of an experiment to determine how capacitance of commercially available parts changes with frequency.
• Construct an inductor by wrapping several hundred turns of wire around a bolt and design an experiment to determine the core loss.

Digital Electronics/Microcontrollers
• FPGA variable speed motor driver
• Digital multi-meter
• How many drinks are left in the fridge?
• Microcontroller based slot machine.
• Digital filter difference equation implementation.

Systems Software
• Strip chart recorder in C#
• Quiz-bowl button/score keeper software
• GUI software that creates analog filter design from specifications
• Spectrum analyzer for wav files written in C#

ABET Assessment

This course has been structured so as to provide an efficient mechanism for the assessment of ABET criteria b, d, e, and h. One or two projects is chosen for assessment of each outcome. A sample rubric used for ABET (b) is in the appendix.

ABET (b) *an ability to design and conduct an experiment as well as to analyze and interpret data.*
The team project is typically used to assess this outcome since it is a large project that usually requires the collection and analysis of data. The rubric looks at the ability to design and conduct and experiment and the ability to collect and analyze data. The rubric is granular enough that if a problem is indicated we know which part of the project to fix.

ABET (d) *an ability to function in multidisciplinary teams*.
This outcome uses only the team project for assessment. We attempted to use peer review for this assessment but found it to be not very effective. Team members now have specific areas of responsibility. The rubric looks at how well individual responsibilities were met.

ABET (e) *an ability to identify, formulate, and solve engineering problems.*
One of the individual projects is used for assessment of this outcome. The rubric looks specifically at three items: Identification of the problem to be solved, formulation and design of an effective solution, and the implemented solution to the problem.

ABET (h) *the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*.
As part of the requirements for this course, students must write a paper which considers the "impact of their project solution in a global, economic, environmental, and societal context". One of the three individual projects is used for assessment of this outcome. The rubric is applied to this paper and the project to which it belongs.

Does this work?

In the fall of 2014 the electrical and computer engineering programs had an ABET visit. The program evaluators found the rubrics we used in this class to be effective. The faculty members who teach EE 380 find the rubrics easy to apply.

The students who take the course are generally enthusiastic and the course has a reputation as a place where "real learning" takes place. We have conducted several student surveys and a small focus group to determine what the students like and don't like about the class. There are some complaints about the deadlines and the amount of writing in the reports, notebooks, and the paper on societal impact. But overall students like the projects. When we do senior exit interviews during the student's last semester, we always ask students to write down the three best courses and the three worst courses they took over the previous four years. Many students consider EE 380 as one of the best courses they have taken.

Conclusions

EE 380 provides and effective learning environment for teaching lab skills and design techniques to electrical and computer engineering students. It also provides an easy to use platform for ABET assessment of outcomes b, d, e, and h.

We have not yet assessed the impact the course has made on the quality of our senior design projects. Anecdotally, we believe students who completed EE 380 are much better prepared to do a year-long open-ended senior design project than those who have completed only the more traditional "canned labs".

Bibliography

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APPENDIX A

Sample Projects

This project is in Linear Systems

Finding Transfer function of Closed System

Obtain a three foot piece of metal pipe ½” diameter, thermistor (temperature dependent resistor), and heat tape. Wrap heat tape around the bottom 10” of the pipe be sure you make good contact with the pipe. On the top of the pipe tape the thermistor also making good contact. Now find the transfer function as related to the heating and cooling of the pipe. Submit: Hardware schematic, a picture of apparatus, Notebook, calculations, measurements, and documentation. Your documentation should include a mathematical representation of the transfer function, a verification sheet signed and dated by your instructor.

This project is in Systems Software

Windows Quiz Bowl Application

For this project you may use either the 8051 or ARM7 processor purchased for use in EE354 and EE454. Your Project should allow for up-to 8 “players” and 1 moderator. Each player should be given a “buzzer” that will be used to signal the application that a user has buzzed in. The moderator should have a “controller” with the following functionality:

1. Start and Restart a Round.
2. Stop or End a Round
3. Signal the correct answer was given or not given

The Microcontroller should:

1. Poll the moderators control for a start of round. (block/ignore player input)
2. Poll the user inputs after a round is started(allow moderator Stop Round)
    a. If timer is being used stop timer in GUI.
3. Poll moderators control for correct/incorrect answer.
4. If correct send user number to Windows Application for scoring (VIA serial port)
5. Else Restart round (Blocking incorrect user/users)
    a. If timer is being used restart timer in GUI.

The C# Application Should:

1. Allow Moderator to select number of players
2. Create appropriate number of Score boxes for Players (AT RUN TIME)
3. Allow Moderator to set time limit for round.
    a. If time limit (send end of round to micro. Via serial port)
    b. Visual indicator of time remaining.
4. Allow Moderator to set number of points for each answer.
5. Auto Score at end of each round.

Submit: Hardware schematic, hard copy of C# Program, Notebook, calculations, and documentation. Your documentation should include a verification sheet signed and dated by your instructor.

APPENDIX B

Sample Rubric

ABET (b) an ability to design and conduct experiments, as well as to analyze and interpret data

Course	% Students	Goal Achieved	Assignment
EE 380	70%	12 or higher	Group project

	5	3	1	0	Score
Design of Experiment	Experiment can fully test hypothesis	Experiment can test portions of the hypothesis	Experiment is irrelevant to the hypothesis	No experiment was designed	
Conduct Experiment	The experiment was successfully conducted	At least half the experiment was successfully conducted	Less than half the experiment was successfully conduct	The experiment was not conducted	
Analyze Data	Data collected during experiment was presented in a useful manner	Data was collected and presented but only partially useful	Data was collected but not useful	Data was not presented	
Interpret Data	Data was interpreted and tied back to hypothesis	Data was interpreted, and was loosely tied back to hypothesis	Data was interpreted, but irrelevant to the hypothesis	Data was not interpreted	