Capstone Project Scheme, Implementation, and Results of an Online BS EET Program

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Introduction

Capstone Design Experience (CDE) exposes students to real-world problem solving, and it is a requirement for ABET accredited engineering and technology programs. Students complete this requirement before graduation usually in their senior year. While CDE is easier to implement in traditional engineering and technology programs, its use in on-line programs is limited. This is because of the asynchronous nature of on-line programs and student demographics.

Per ABET 2016-17 General Criterion 5: Curriculum, Baccalaureate degree programs must provide a capstone or integrating experience that develops student competencies in applying both technical and non-technical skills in solving problems. Thus, CDE is a requirement for ABET accredited engineering and technology programs. The duration and nature of this experience vary between programs. For example, CDE in some programs may span over one semester while others may require two; some may use team projects while others may use group projects. They may use CDE to satisfy ABET requirements on teamwork and written and oral communication by requiring a report and oral presentation. Further, such programs may integrate student portfolios on student outcomes and comprehensive subject area examinations as part of CDE.

In this paper, we will discuss our experiences with the use of CDE in an on-line Electrical Engineering Technology degree program at Excelsior College.

CDE course (Integrated Technology Assessment) at Institution X

Excelsior College, with more than 200 majors, has an ABET accredited B.S. degree program in electrical engineering technology. Most of the students are adult learners, who are already employed and seeking professional advancement. The capstone course enrollment varies between 5 and 20 students in each semester. For their capstone projects, these students are formed into teams of 2-4. Students in each team collaborate in concept and ideation stages, as well as manage the projects using project management techniques. The use of project management techniques is critical, as the team develops preliminary designs for solutions that each team member will implement using hardware circuits or hardware-software systems during the latter half of the term. Each team member then hones into one solution for a problem in his/her area of work, builds the hardware, tests, and documents his/her work. Throughout the build and test stages, students record video evidence of their work. Near the end of the term, each student presents (defends) his/her work through an online seminar to other students and faculty. Each student's capstone project is assessed for integrative learning of the functional areas of electrical engineering technology, mastery of the science and technology fundamentals, experimentation, oral and written technical presentations, engineering ethics in design and practice, self-directed learning, and continuous improvement.

Through this capstone project experience, the student outcomes are geared to:

- Work in a team, brainstorm, research, identify, and analyze a significant problem that is currently lacking socially desirable solutions.
- Design and develop an effective solution to the problem using hardware and software tools and techniques prevalent in the electrical engineering technology field.
- Build, troubleshoot, and test the solution in manners prevalent in the electrical engineering technology field.
- Execute the project using project management techniques for planning, budgeting, reviewing, and successfully completing the project on time.
- Orally and through written reports, present his/her project work in a language suitable for technical as well as non-technical audiences.
- Demonstrate the practice of ethical principles and societal considerations, continuous improvement, and lifelong learning.

Course Activities

The Integrated Technology Course at Institution X consists of the following activities:

Integrated Technology Assessment Report (resume & learning statements)
Integrated Technology Assessment (ITA) report development and submission is an important component of this course, as it engages students in reflecting on their past academic and/or professional experiences, as well as the project developed throughout the course. To assist the student to complete the report in a timely manner, the report is prepared in accordance with the outline listed in the syllabus. Each section of the report is formulated as an assignment posted within the course tools. Students complete their reports using Microsoft Word and submit them in the assignment folder. Any document used as evidence to support a learning statement must be scanned and made a part of the Microsoft Word document. The mentor provides comments via the course embedded mail to the student to revise and/or finalize the assignments. Each assignment (i.e., the ITA report section) is graded in accordance with the grading policy described in the syllabus.

The assignments that are finalized would then become a part of the ITA report. Prior to submitting the final report, students must gather all the assignment documents and put them together as a report document and submit for review as the final assignment. Once the report is finalized after incorporating all comments from the mentor, the report is submitted by the student for final grading and the mentor grades it using rubrics and in accordance with the grading policy described in the syllabus. The final reports are run through "Turnitin" in order to ensure that the reports are original work of the students.

Capstone Project

A hardware centered capstone project is another important component of this course. Through the first three modules, the students work in a team, brainstorm, identify, and analyze significant problems that demand electrical engineering technology solutions. During the first week of each module, students develop and submit individual draft reports of the work carried out and results obtained. The

instructor/mentor gives feedback immediately thereafter. Occasionally the instructor may advise significant changes in the proposed solutions to ensure that they meet the guidelines and complexity of capstone projects. Only upon the instructor's approval, the student takes the next step of revising and submitting his/her module-end report by the end of the second week in each module. Each report should be submitted in Microsoft Word along with narrated video clips of the work performed.

Hardware in this context means electric and electronic components of the type studied and used in the undergraduate curriculum. Examples of these components would include resistors, capacitors, inductors, transformers, small electric motors, diodes, transistors, op-amps, logic elements, microcontrollers, and other integrated circuit devices. Purchasing and using premade circuit cards with these components on them do not count as part of the design. The project can include but not consist solely of software development. From Module 4 through Module 7, each student builds and tests his/her design work. Students are advised to limit the project components' cost to about $50-100. Upon completing the capstone project, students present their work through a webinar and submit the revised ITA portfolio to include this integrative learning experience and its learning outcomes.

Capstone Exam

The capstone examination is delivered directly in the course; it consists of seven mini-exams in Modules 2-7. It includes questions that assess the most common and most important topics and skills within the College's BSEET curriculum, including circuit theory and analysis, analog and digital electronics, microprocessors, digital circuits design, and concentration topics in electronics, power systems, or nanotechnology. Throughout the course, "Capstone exam preparation guide" is made available to the students; this guide contains the topics of the capstone exam, some sample questions, learning resources for the exam, and sample solution schemes.

The capstone assessment is designed to assess mastery of electrical engineering technology concepts, principles, and knowledge expected of the student after a baccalaureate program. In addition to factual knowledge, the tests evaluate student abilities to analyze and solve problems, understand relationships, and interpret material. The tests contain questions that require critical thinking and interpretation of graphs, diagrams, and charts based on material related to the field.

The capstone examination is compulsory; not taking the exam will result **in an incomplete or failing grade**. Additional points awarded to the student's course grade are shown in Table 1 below:

Table 1 – Additional points from Capstone Exam

Examination Score %	**Awarded Points***
Above 90	15
80-89	12
70-79	9
65-69	6
60-64	3
Below 60	0

* Percentage toward final grade. See Table 2 below.

Participation in Weekly Online Discussions

A series of discussion questions are posted during the course. Students are required to participate regularly with their course instructor and other students in online discussions. Each student is expected to use online course tools (**Discussion boards** and **Chat** rooms) to interact with peers and work collaboratively to improve his/her understanding of underlying course ideas and issues.

Table 2 below shows weights assigned to each of the above activities:

Table 2 – Weights assigned to each activity

Activity/Assessment	% of final grade
Integrated Technology Assessment Report (resume & learning statements)	35%
Capstone Project	35%
Capstone Exam	15%
Participation in Weekly Online Discussions	15%
Total	100%

In this paper, we will focus on the hardware component of the CDE at Excelsior College starting from January 2016 term.

Table 3 - Results (Hardware Project Details)

Term Offered	January 2016	May 2016	September 2016
Duration, weeks	15	15	15
Number of students in the class	4	11	16
Number of project teams	2	3	4
Project titles	1. A voltage quadrupling circuit 2. Wireless signal detector 3. A single-phase induction motor with smooth start 4. Dual axis solar tracker	1. Supervisor Control and Data Acquisition (SCADA) system 2. Traffic Lights and Pedestrian Lights 3. Radio frequency (RF) communication 4. Motor control with a Microcontroller	1. Solar powered water pump 2. Automobile Fan Speed Controlled by PWM 3. Refrigerator door alarm 4. Over and Under Voltage Protection Systems 5. Solar powered automatic "set-and-forget" irrigation system 6. Tesla Coil 7. Solar panel that will charge a cell phone

	with microcontroller control	5. Radio frequency signal decoder 6. Utilizing Air Flow to Recharge Li-Ion Batteries 7. Construction of a digital multimeter 8. Cell phone detector 9. Design, build, program, and test an Arduino robot 10. Component validation and testing	8. Cost saving speed sensing replacement technology (optical tachometer) 9. Canine transport cooling system 10. WIFI enabled motor controller w/ Cell phone interface 11. Arduino Uno Thermometer 12. Single-Axis Solar Tracking System 13. WIFI enabled water sprinkler 14. Industrial PID Temperature Control System 15. Grow Chamber Fan Controller 16. Variable power supply/battery charger
Issues/problems faced	Excessive reports 25% projects lacked complexity Project report quality needed improvement	Most projects, except one, had decent complexity Project report quality needed improvement	Several projects went above expectations providing abundant technical development and trouble-shooting, resulting in prototypes of viable new products. Most projects had the expected level of complexity. Two projects did not meet complexity levels which impacted the associated grades. All but one presentations were of professional quality. Reports – Comments on the reports were provided by the EET faculty. All but one report were graded as good with most providing project block diagrams, adequate citations, and references.

Team Task during Weeks 1 – 7

Team members worked together to select individual projects for each member. Tasks included Problem Selection, Problem Analysis, Project Planning using Project Management Techniques, Circuit Diagram, and component selection. Each team member submitted weekly progress reports to the instructor and updated their reports based on instructor feedback.

Individual Task during Weeks 8 – 15

Each member performed the following for his/her project:

- Component procurement
- Constructing the circuit
- Testing and debugging the circuit
- Making a video presentation of demonstration of various steps in the project
- Writing a project report
- Submitting the project and presentation to instructor
- Presenting the video demonstration in a webinar to other students and program faculty
- Evaluating other students' presentations

Project Review Findings

EET faculty at Excelsior College participated in presentation webinar. Here is a summary of findings:

1. Project Complexity – 25% of the projects in the January 2016 term lacked complexity (very few components were used). The project complexity increased in the following two terms.
2. Presentations – All presentations were graded using a rubric and they were assessed to be of professional quality.
3. Reports – Comments on the reports were provided by the EET faculty. All reports were graded as "good" but the faculty felt the quality of the reports could be further enhanced by including block diagram of the problem, additional citations, and references.

Addressing the findings

1. The project report template was modified to include block diagram requirement.
2. Students were strongly encouraged to include sufficient appropriate citations and references.
3. Course instructors were encouraged to share the project topics selected by students with other EET faculty to get their input on complexity levels.
4. The reporting requirement was reduced by 50% for the succeeding two terms.

Summary and Conclusions

The inclusion of a hardware design component to the existing capstone course titled Integrated Technology Assessment (ITA) at Excelsior College was a result of (a) student evaluations of the course and (b) suggestions from an ABET-ETAC reaccreditation visiting team. The EET faculty, EET faculty advisory committee, and industrial advisory council members deliberated on the suitability of this hardware component in an online program. These deliberations resulted in the inclusion of a hardware component to the ITA course in the January 2016 term. The team also developed appropriate rubrics to grade the hardware project component.

Feedback from both faculty and students about the addition of the hands-on hardware component in this on-line capstone course has been positive. Findings from each term are shared with the program director and the EET faculty advisory team, and are continually used to make appropriate changes for the subsequent semester. The Hardware Project component helped the program by (a) providing the students with practical experience and a sense of accomplishment; (b) enhancing students' written and oral presentation skills; and (c) contributing to meeting the ABET-ETAC requirements on Hardware Capstone Project, Team Work, Written and Oral Communications, Project Management, and Ethics. In particular, it helped the program to meet ABET General Criterion 6: "Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints."

Overall, student performance has been satisfactory. Students have commented that they like the incorporation of hands-on projects into the online capstone course. Students have expressed that the entire course should be project based.

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