Student Learning Outcomes through Senior Capstone Experience

Prof. Adel Salama P.E., Austin Peay State University

Prof. Adel Salama, M.S., P.E. Adel Salama is a Professor and Graduate Program Coordinator of Engineering Technology and coordinator for BS of Electrical Engineering technology and AAS Electronics Engineering Technology at Austin Peay State University where he has taught since 1990. Prior to this he taught for seven years at different institutions and sixteen years service in Air Force and seven years in petroleum industry. He is a registered Professional Engineer and Member of National Society of Professional Engineers and Member of IEEE since 1990. Also he is a fellow of Tennessee Academy of Science. He served as Department Chair from 2005 to 2015. He and the department faculty had extensive curriculum revisions for the Engineering Technology Department which has led to TAC of ABET accreditation 2008 and to ETAC of ABET 2014.

Dr. Chin-Zue Chen, Austin Peay State University

Dr. Chin-Zue Chen is a Professor in the Engineering Technology Department at Austin Peay State University in Clarksville, Tennessee, where he has taught and has been in charge of the robotics program since 1985. He initiated PLC, CAM, CIM, and Sensors & Vision Systems courses in earlier years of his teaching tenure. He became involved in Additive Manufacturing (AM) in 2006, initiated AM option under the Manufacturing curriculum and set up the AM Lab in 2014. Because of his background Dr. Chen has been involved in many student capstone projects. Prof. Chen is a Fellow of the Tennessee Academy of Science.

©American Society for Engineering Education, 2020

Student Learning Outcomes through Senior Capstone Experience

Abstract

Over several years of advising graduate and undergraduate Electrical Engineering Technology students at Austin Peay State University, students have been required to solve open-ended real world problems in their respective engineering disciplines prior to graduation by way of a Capstone Experience. To achieve this, we have focused on this Student Learning Outcome (SLO): "*Students graduating with an Engineering Technology degree will demonstrate an ability to design systems independently, or modified needs for engineering problems through a case study."* Our focus is also on a team-oriented design project in electrical engineering technology that incorporates technology standards and realistic design constraints which cover the SLO: *"ability to design systems, components or processes meeting specified needs for engineering problems."* Furthermore, the project requires formal reports and oral presentations which cover the SLO *"ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature.*" Such experiences are typically expected to take place during the culminating year of the undergraduate curriculum.

Background/Introduction

There is the need to introduce Electrical Engineering Technology students to project / experience engineering and professional practice prior to graduation. The aim is to involve the students in topics that are relevant to graduates when they enter the workforce. These topics are issues for professional practice, which include: teamwork, communication - written, oral, and graphical, licensure, standards, and effects of non-engineering factors, e.g., financial issues. There are also issues for project management and engineering, which include: formal product design techniques, realistic constraints on product design - manufacturability, reliability … etc., applying statistics to the analysis of engineering problems, and interpersonal skills to function in a complex organization. [1]

Capstone project experiences, also known as senior design projects or senior capstone projects, are critical to undergraduate engineering and engineering technology education. They are required to provide undergraduate students with the opportunity to solve open-ended real world problems in their respective engineering disciplines prior to graduation. They are also requisite by the Accreditation Board for Engineering and Technology (ABET) for accreditation of undergraduate engineering technology programs. Such experiences are typically expected to take place during the final year of the undergraduate curriculum. They can range in duration from one semester to a whole academic year. Consequently, the senior design course is typically the last bridge for students between the undergraduate engineering technology curriculum and the engineering profession. However, the senior design course differs in fundamental ways from lectures and laboratory-based courses in the engineering technology curriculum.

Capstone Design vs. Regular Courses

The Capstone Design is based on many years of experiences and observations through working with technological education programs. The Capstone Project course differs fundamentally from other undergraduate engineering courses, principally in the following ways:

a. **Close-Ended versus Open-Ended Problems:**
   The capstone experience should by design be structured so that students deal with an open-ended design problem.
b. **Unique Answers versus Multiple Solutions:**
   Solutions to problems in core courses of the engineering curriculum are unique, i.e., permitting a single correct answer, with the solution typically found in the instructor manual. In contrast, by its natural variance, the design process of the Capstone admits multiple possible solutions.
c. Individual Work versus Teamwork:
   Core courses typically require individual effort by students on all assignments, laboratory projects, and exams. In contrast, students must work in teams for the whole semester on their senior capstone projects.

Project Selection

a. Individual Project Idea
   During the initial stage of the project, each student is required to propose an individual project with a feasible idea, e.g., a personal dream machine or device, improving or adding to the functionality of existing devices, or through a case study. The student needs to turn in an Individual Project Proposal to the instructor to demonstrate an ability to design systems, and to contribute to the Capstone Project pool. The proposal shall include a statement of the purpose of the project, description of the expected product, specific functions, and the design/solution.
b. Building the Pool of Potential Projects
   For the next step, every student presents his/her proposal to share individual ideas. Critiques are strongly encouraged in order for the class to get more project candidates into the pool.
c. The Project Selection
   Through the joint work, the class then reviews the project pool and may combine, modify, or expand processes to finalize the projects to be worked on (depends on the size of class). Each project will have between 3-4 students and they will select a team leader.
d. **Capstone Project proposal**
   The team will present a Capstone Project proposal and project timeline. See Figures 1 and 2.

Figure 1 Capstone Project Proposal Form

CAPSTONE PROJECT PROPOSAL

Capstone Project is supervised by a Faculty Advisor (usually in the student's major discipline) who is joined for purposes of final evaluation by a Second Faculty Reader. The project may be completed in two semesters (sixteen weeks) of the senior year which will be taken as a project work independent study with two consecutive courses in electronics option including ENGT 4250 Linear Electronics course. The projects will take the traditional form of the senior report, presentation and defense for faculty and students.
This form must be completed and approved prior to start the project
Please print or type the following information:

STUDENT ID NUMBER_____STUDENT_____

STUDENT ID NUMBER_____STUDENT_____

STUDENT ID NUMBER_____STUDENT_____

STUDENT ID NUMBER_____STUDENT_____

FACULTY ADVISOR _____

SECOND FACULTY READER _____

PROJECT TITLE _____

Semester (s) to be enrolled _____ Semester credit hours _____

Complete the project timeline on reverse and attach a 100-200 word abstract and a preliminary bibliography.

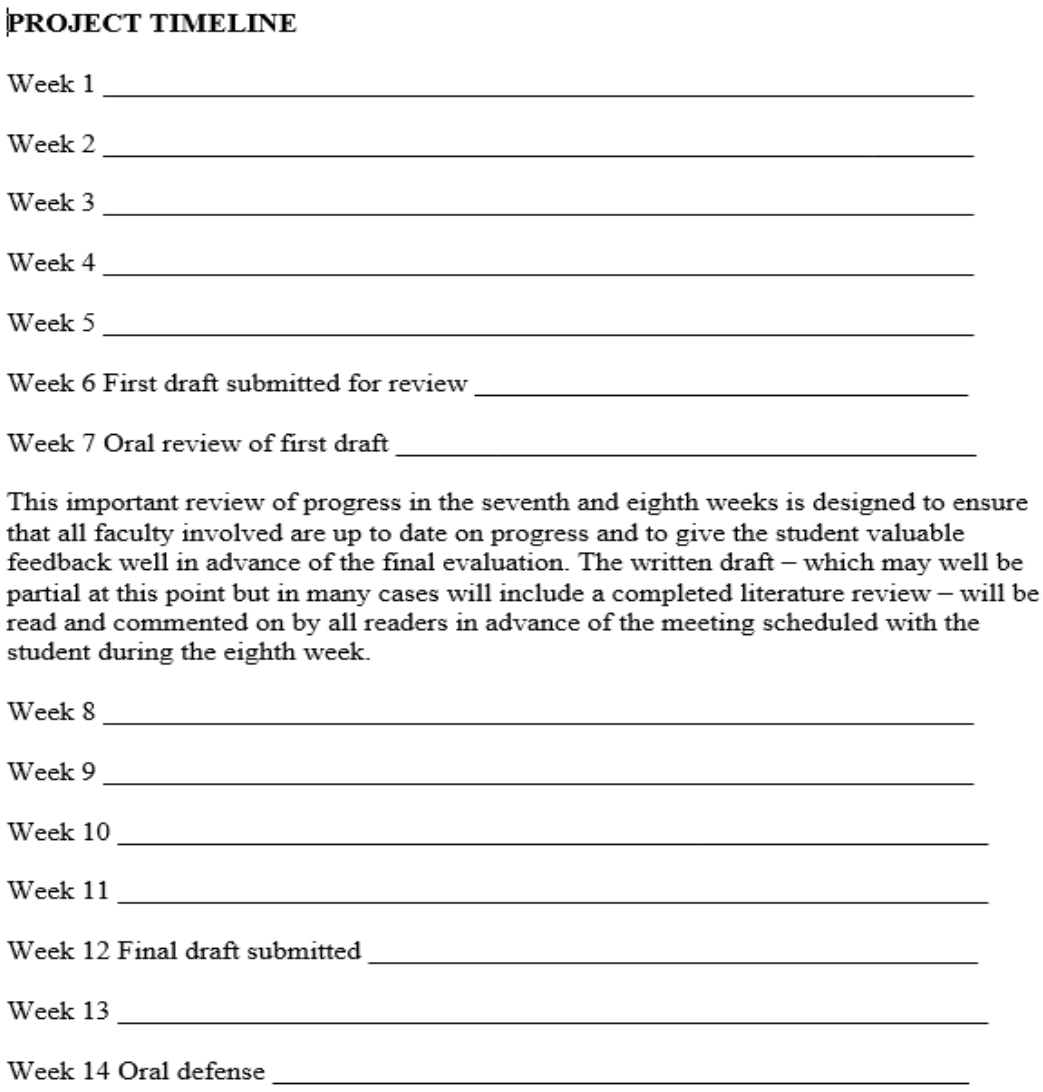
APPROVAL OF PROPOSAL **DATE**

STUDENT _____ _____

FACULTY ADVISOR_____ _____

SECOND READER _____ _____

Figure 2: Capstone Project Timeline



PROJECT TIMELINE

Week 1 _____

Week 2 _____

Week 3 _____

Week 4 _____

Week 5 _____

Week 6 First draft submitted for review _____

Week 7 Oral review of first draft _____

This important review of progress in the seventh and eighth weeks is designed to ensure that all faculty involved are up to date on progress and to give the student valuable feedback well in advance of the final evaluation. The written draft – which may well be partial at this point but in many cases will include a completed literature review – will be read and commented on by all readers in advance of the meeting scheduled with the student during the eighth week.

Week 8 _____

Week 9 _____

Week 10 _____

Week 11 _____

Week 12 Final draft submitted _____

Week 13 _____

Week 14 Oral defense _____

Project Deliverables

Deliverables for the capstone project are comprised of the following:

a. **Project Proposal:** specifies user/problem requirements and specifications, proposed solution(s), and relevant industry standards, such as IEEE standards.
b. **Project Management Plan**: a Gantt chart that lists all tasks, deliverables, and milestones, as well as the breakdown of duties and responsibilities by team member.
c. **Hardware and Software Acquisition:** corresponding to the adopted design.
d. **Weekly Presentations and Progress Reports.**
e. Interim and Final Reports.
f. **Documentation:** developing documentation in the form of [separate] user and developer manuals: the user manual provides a turnkey explanation of how to operate

the project deliverable while the developer manual provides details about the technical aspects of all hardware and software used and developed for the project.

g. **Final Presentation and Demonstration:** of the completed project to the whole class.

Student Learning Outcome (SLO)

Students graduating with a BS in Engineering Technology degree will demonstrate competency through working on their Capstone Project based on ETAC of ABET Guidelines:

a. "Students graduating with an Engineering Technology degree will demonstrate an ability to design systems independently, or modified needs for engineering problems through a case study."

b. "Ability to design systems, components or processes meeting specified needs for engineering problems."

c. "Ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature."

Assessment

SLOs	Assessment Methods
a. "Students graduating with an Engineering Technology degree will demonstrate an ability to design systems independently, or modified needs for engineering problems through a case study."	**Independent System Design** - Students in this course will be assessed based on their Individual Project Proposal ideas and proposed design / solution, as well as the contributions to the Capstone Project pool.
b. "Ability to design systems, components or processes meeting specified needs for engineering problems."	**Team Work** - Students in this course will be assessed on their demonstration of Teamwork. **Project Prototype** - Students in this course will be assessed on their proficiency of their design circuits, components needed, and how they solve the problems through their design work.
c. "Ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature."	**Presentation/Performance -** All Engineering Technology students are required to take the Capstone project course. Students in this course will be assessed on their proficiency in effectively conveying a culminating technical oral presentation as assessed by the American Association of Universities and Colleges (AACU) Oral Presentation Value rubric. [2] **Capstone Documentation -** All Engineering Technology students are required to complete a Capstone Project with supporting documentation. Students completing the Capstone Project with supporting documentation will be assessed on their proficiency in effectively conveying a culminating technical oral presentation as assessed by the American Association of Universities and Colleges (AACU) [2]

	Written Assignment - All Engineering Technology students are required to be assessed on their proficiency in effectively conveying a culminating technical document as assessed by the American Association of Universities and Colleges (AACU) Written Communication Value rubric. [3]

Student Assessment and Program Evaluation

Student assessment is in three modes:

- **a.** Individual project proposal assessment,
- **b.** Team work assessment, and
- **c.** Self and peer assessment.

Authentic assessment, based on real performance as well as traditional assessment methods, is used. Continuous capstone project assessment is conducted to improve content and methodology.

Students are encouraged to present the capstone projects at related conferences, e.g. the University Annual Symposium and the Annual Meetings of Tennessee Academy of Science (TAS). The two capstone projects presented at TAS [4], [5] are considered as examples for this paper. The capstone project we have implemented is successful in our Electrical Engineering Technology program. The result may not be generalizable to other programs.

Conclusion

Real world experiences are invaluable to graduates with newly earned degrees, yet colleges and universities do not always provide opportunities for students to engage in collaboration on open-ended problem-solving without definite answers. At Austin Peay State University, the requirement of a Senior Capstone Project for graduate and undergraduate Electrical Engineering Technology students presents the perfect opportunity to work on open-ended problems. Students are required to work individually to present a proposed real-world issue and a viable solution to classmates. Then, small teams of students decide on one project from the class idea pool to pursue. Finally, using knowledge and practical skills gained from the Electrical Engineering Technology program of study, the team of students is expected to move through and successfully complete all of the steps of project documentation, from project proposal to the final report, with a culminating team presentation of their experience.

Throughout the Capstone Project, students work in teams to learn concepts, solve problems, and make discoveries to gain practical experience in workplace related environment. Students also acquire valuable engineering skills, software development skills, as well as enhance their soft skills and project management skills (teamwork, making presentations, project management etc.). While the goal is for students to fulfill the Student Learning Objectives requirements for a successful graduation as well as becoming more prepared for entering the workforce, they are also highly encouraged to present the results of their projects at relevant conferences.

References

[1] ABET: Criterion 3. Student Outcomes
https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-technology-programs-2019-2020/#GC3

[2] Association of American Colleges & Universities – Oral Communication Value Rubrics
https://www.aacu.org/value/rubrics/oral-communication

[3] Association of American Colleges & Universities – Written Communication Value Rubrics
https://www.aacu.org/value/rubrics/written-communication

[4] E. Friend and C. Chen, "Capstone to Career," *Journal of the Tennessee Academy of Science*, vol. 94, no. 1-2, p. 19, June 2019.

[5] M. J. Purdy, M. Sproul, M. Mercer and A. Salama, "Home Keyless Entry Capstone project experience," presented at the 129th Annual Meeting of the Tennessee Academy of Science. Columbia, Tennessee. November 22, 2019. (*Journal of the Tennessee Academy of Science* publish date to be received)