

## Capstone Design for a Growing Program

**Beth A. Todd and Nima Mahmoodi**

*The University of Alabama*

### Abstract

For a number of years, the Mechanical Engineering program at the University of Alabama completed industry-based Capstone Design projects. A plan was developed to accommodate 72 students per semester which seemed adequate to meet future needs. However in the past ten years, enrollment has quadrupled. The need for adequate resources to advance these students to graduation has led to new ideas for Capstone Design. These include increasing the size of the teams and having multiple teams address the same problem. The previous Capstone Design program will be described from project assignment, design conception, through execution and delivery to the industrial client. Then the current adjustments will be addressed.

### Keywords

Capstone Design, experiential learning, teaming, industrial collaboration

### Headings-Introduction

In 2003 the University of Alabama began a period of unprecedented growth. In 2003 the University had 20,333 students enrolled. In 2016 the enrollment is 37,665 students. However after the Recession, more and more students wanted to become mechanical engineers.<sup>1</sup> In that program, enrollment grew from approximately 300 students in 2003 to 560 in 2010 to 1710 students in 2016.

Capstone design courses provide senior-standing engineering students with experience solving “real world,” open-ended engineering problems where students synthesize knowledge from earlier courses. Typically mechanical engineering programs have problems that require design and manufacture of a solution.<sup>2</sup> This requires financial, infrastructure, and space resources to accommodate these projects. While this enrollment growth affects all courses in the mechanical engineering program, it has a unique and significant impact on the Capstone design sequence.

### Modifications to Capstone Design in 2010

Seeing that enrollment had almost doubled in seven years in 2010 and was continuing to grow, modifications were made to the structure of the course sequence.

Capstone design was traditionally a two semester course sequence, and that overall framework was maintained. The first semester course contained topics such as intellectual property, ethics, lifelong learning, careers, engineering economics, as well as an explanation of the steps of the design process. The design process was realized through a practice project completed in three-person teams which was a competitive design/build. In the final weeks of the semester,

industrial projects were assigned to the teams. The industrial projects were completed during the second semester course.

Modifications in 2010 were to address projected resource shortfalls due to growing enrollment as well as to increase the time that students had to work on their industrial projects. A four-member Capstone Design committee was formed. One committee member taught the first course, and the other three committee members shared the duties of the second course. The lecture topics were retained in the first course, but the practice project became a conceptual design on paper project. The industrial projects were introduced about mid-semester in the first course to give students more time to complete their projects. Team size could be increased to six students. With four teams per faculty member, this arrangement could accommodate 72 students per semester. In 2010 it seemed like a long time before that enrollment would be exceeded if ever.

Based on senior exit interviews, the students did not see value in doing the conceptual design on paper practice project. It was difficult to find an adequate number of industrial sponsored projects for six-person teams. As the semesters went on, student competition projects were included as part of Capstone design so that there would be enough projects available.

Enrollment in the first capstone course in fall 2013 was 78 students.

### **Modifications due to Continued Enrollment Growth**

A number of institutions with large mechanical engineering departments were contacted to request information on how they structure their senior design course(s). The replies that were received were characterized in the results of the survey by R.H. Todd et al.<sup>2</sup>

To address these concerns, a pilot section was conducted in fall 2015. The four projects were introduced during the first few weeks of the semester, and they were competition projects instead of industrial projects. These projects were an EcoCar Subteam, a small Hyperloop team, and two NASA Micro-g NExT teams. All of the students who participated in the pilot section were volunteers. The students still received instruction in intellectual property, ethics, and the other softer topics including just-in-time design process instruction. Each of the teams had almost two semesters to work on their Capstone project, and they were all successful.

Following the success of the fall 2015 pilot section, Capstone projects were assigned in the second week of the semester in the first Capstone course starting in spring 2016. There continues to be difficulty in finding enough projects for the students. In spring 2016 and summer 2016, the enrollment was small enough, 61 and 25 students, respectively, that each team was able to have a unique project. In fall 2016, 195 students enrolled in the first semester of Capstone design. The students were divided into 39 project teams, and one student is doing his Capstone design with electrical engineering. However, there were not 39 unique projects available, and 18 projects were divided among the student teams. Projects selected for multiple teams were based on their appropriateness. With this large number of teams, six faculty will be working with the students on their second semester of Capstone design.

### **Summary**

The University of Alabama is faced with an enrollment increase of a factor of six in its Capstone design sequence. The increased number of students has minimal effect on the way that soft skills

are taught in the course. However assignment of “real world,” open-ended engineering problems to student design teams is in flux. The number of students per project team has been expanded. The projects are no longer unique to one team. Is there a better solution?

### References

- 1 Yoder, Brian L., College Profiles, Engineering by the Numbers, ASEE, 2012.
- 2 Todd, Robert H., Spencer P. Magleby, Carl D. Sorensen, Bret R. Swan, and David K. Anthony, “A Survey of Capstone Engineering Courses in North America,” *Journal of Engineering Education*, 1995, pp. 165-173.

### Beth A. Todd

Beth A. Todd is an Associate Professor of Mechanical Engineering at the University of Alabama. She has been teaching design for over 15 years.

### Nima Mahmoodi

Nima Mahmoodi is an Associate Professor of Mechanical Engineering at the University of Alabama. He has been teaching design for four years. His interests are mechatronics and smart materials.