

AC 2007-1755: CHARACTERISTICS OF CAPSTONE DESIGN PROJECTS AT UNIVERSITIES IN US AND CHINA: AN ANALYSIS

Tianrui Bai, Southwest Jiaotong University

Jinwen Zhu, Missouri Western State University

Virendra Varma, Missouri Western State University

Characteristics of Capstone Design Projects at Universities in US and China: An Analysis

Abstract

The objectives of the capstone or other integrating experiences in the engineering and technology curriculums are to: 1. Pull together the various diverse elements of the curriculum, and 2. Develop student competencies in problem-solving utilizing both technical and soft skills, such as communications and working in teams, etc. A capstone design project or other integrating experience is a major design component in engineering and technology curricula. The Technology and Engineering criteria (TAC and EAC) of the Accreditation Board for Engineering and Technology (ABET) emphasize the importance of a capstone experience in the curriculum. The capstone design projects require students to use fundamental scientific concepts and basic technical skills learned in the classroom to solve 'real-world' problems instead of answering end-of-the chapter questions from the textbook. The capstone projects provide an opportunity for students to demonstrate critical thinking skills. It prepares them better to assume the professional roles in the engineering and technology community. In addition, the capstone projects are widely regarded as an excellent mechanism for assessing the outcomes of engineering and technology programs. They are a direct measure of the quality of graduates of a program. Since we are living in a global economy, and graduates from universities from different countries are communicating and working on multi-national teams and projects, it is essential to investigate educational methodologies of different countries, especially the fast developing countries, like China and India. There is an increased evidence of collaborations and cooperation among universities in the world to meet the engineering work force needs in the light of rapid development of technology. Firstly, this paper discusses the different aspects of the capstone design projects in universities in China. Secondly, it addresses some of the characteristics of the capstone design projects in universities in the United States. Thirdly, differences and similarities of capstone project courses between universities in China and US are analyzed, and strengths and weaknesses of these two systems are addressed. Finally, suggestions for improving the effectiveness and quality of capstone design project courses are presented.

Introduction

The capstone project course is an intrinsic part of the undergraduate education. The capstone projects are widely regarded as an excellent mechanism for assessing the outcomes of engineering and technology programs. They are a direct measure of the quality of graduates from engineering and technology programs. The capstone design projects require students to use fundamental scientific concepts and basic technical skills learned in the classroom to solve 'real-world' problems instead of answering end-of-the chapter questions from the textbook. The capstone course focuses on planning, development, and implementation of an engineering design project which often includes project documentation, project demonstrations, and presentations. It provides an opportunity for students to demonstrate critical thinking skills, communication skills, and

time and project management skills. The capstone course prepares students better to assume the professional roles in the engineering and technology community.

The following sections first describe the characteristics of capstone design projects in universities in China. Also are discussed some of the characteristics of the capstone design projects in universities in the United States. The analysis of the distinctiveness of capstone project courses between universities in China and US is provided. Finally, suggestions for improving the effectiveness and quality of capstone design project courses are discussed.

Capstone design projects in universities in China

Recognizing the importance of capstone design projects in the undergraduate education, universities in China pay acute attention to content and assessment of the capstone design projects. The overall quality of the capstone projects speaks of the academic rigor and demonstrates the commitment to quality of education of a university. The capstone design project is considered the most important phase in undergraduate education in the Chinese universities. The capstone project is more commonly called the graduation project or thesis in China. The Ministry of Education of China provides a general rule for capstone design projects. Each university has its own rules based on the above general rule and has a special organization to monitor the whole process of the capstone project. The organization is comprised of different level committees as shown in Fig. 1. An institutional examination committee supervises the university wide examination of the capstone projects. Different level committees are responsible for achieving specific objectives. The oral exam group, the lowest level committee, consists of a faculty member from the same academic field directly conducting the oral examination for the students involved in the projects in that field.

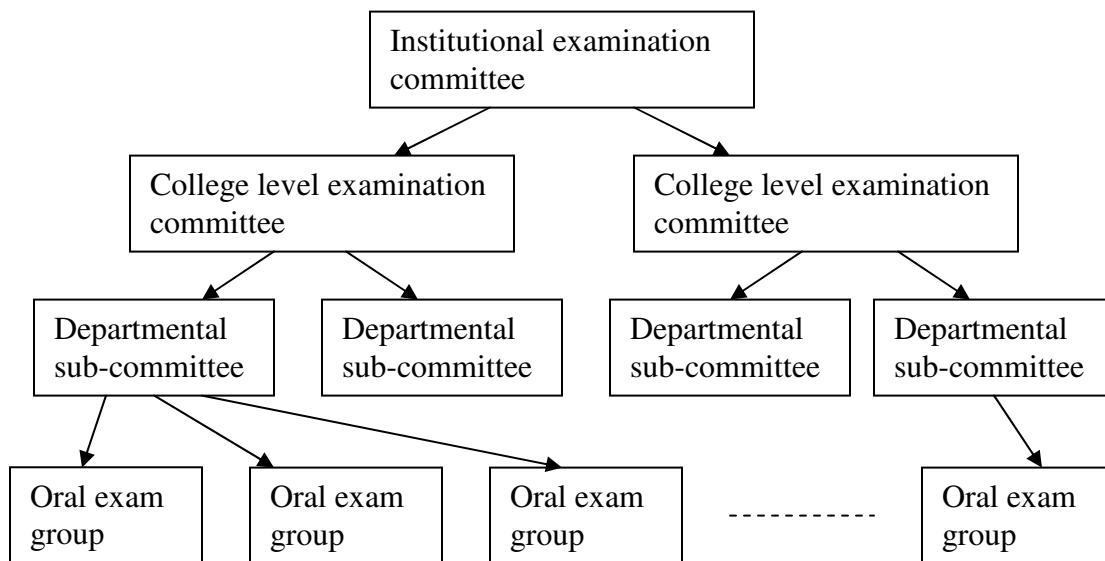


Figure 1 Examination organization for capstone project in a university in China

Each university also has a general regulation and each college has its own rules for the capstone project. The rules include different documents with respect to the different aspects of the design project, as illustrated in Table I. The standards for thesis writing specify the project process methods and the detailed thesis requirements, such as the format, length of the paper, the drawing standards, etc¹. The faculty member fills the project task sheet and time schedule before the beginning of the design project. With the growth of industrial clients, more and more business-sponsored projects are being introduced into the inventory of available capstone design projects. This leads to collaboration and development of cooperating design project management teams which detail the application process, project and funding management, etc². The students are required to spend a complete semester, which is the eighth semester in their undergraduate study, to complete their thesis. They must get a passing grade for graduation and for qualifying for a baccalaureate degree.

Table I: Documents and Forms for capstone design projects in universities in China

Document	Contents
Design project management	Detailed project process management and assessment standards
Standard for thesis writing	Detailed thesis writing requirement
Project task sheet	Project title and design requirement
Time schedule	Detailed time table of the project
Cooperating design project management	Detailed application and management for industrial cooperating project

Capstone design projects in universities in the United States

With the increased emphasis on real-world applications in design as per accreditation criteria of the Accreditation Board for Engineering and Technology (ABET)³, more and more engineering and technology schools are requiring some kind of a capstone or a senior design project. Many programs added their capstone courses during last decade according to a 2005 national survey⁴. These courses also are designed to meet the needs of the industrial customers, who require that graduates demonstrate ability for system design, integration, and syntheses. The structure of capstone design courses varies significantly among different engineering and technology departments and greatly depends on the requirements of participating faculty members, such as department traditions, goals of individual instructors, degree of faculty release time, and availability of resources for capstone courses⁵. Capstone design courses usually include lectures and hands-on learning activities including the design and implementation of a particular product or process. Many courses comprise team oriented capstone projects, which provide a better simulation of industrial environment, to better train today's engineers⁶. However the team project increases the difficulty of the assessment of the individual achievement. Extensive funding for projects is generally sponsored by industrial client, which include the support in the form of equipment, materials, and technical consulting. Most industrial sponsors have a liaison engineer who assists the students during the project period⁷. One of the most important factors leading to the success of industry-sponsored projects is the involvement of the liaison engineer.

From the above discussion we can find the following major differences in characteristics of capstone design projects between universities in China and the United States, as shown in Table II. There are four categories differing significantly from each other. In China, first, the time allotted to the capstone project is longer which allows the students to investigate deeper. Second, it pertains to standard requirements of a project. This standard gives more relevance to application of project management principles and allows for distinctive assessment of student performance. Third, in addition to emphasis on individual ability, team skills may also be emphasized. Fourth, all students are required to take an oral examination whereas in the United States, an oral presentation may suffice.

Table II: Major differences in capstone design courses between China and the U.S.

Category	China	The United States
Time duration	One dedicated semester	One or two semester single course
Formal standard requirement	Yes	No
Team project	No (most time)	Yes (most time)
Oral examination	Yes	Not required

The capstone design project or a senior design course is a universal requirement at the undergraduate education level around the world in the schools of engineering and technology. The capstone or other integrating experiences in the engineering and technology curriculums are required to pull together various diverse elements of the curriculum. This experience helps develop student competencies in a focused problem-solving situation, and utilizes both technical and soft skills, such as communications and working in teams, etc. In some respects the US practice in capstone projects may be better while in other instances may be lacking such as developing more comprehensive and in-depth analytical skills. In order to insure that US practices in the capstone courses in the realm of engineering and technology education are equal or better than those of other countries, the following recommendations are made to improve the quality of student capstone projects in the US.

- First, a formal standard at departmental level should be set up for capstone courses.
- Second, increase the time involved in the project which would allow students to accomplish a more comprehensive project. Thus, students get more training with a real-life engineering design experience.
- Finally, a formal oral examination committee should be organized for each different field, which gives a distinctive assessment of student projects and lessens the subjective assessment of an individual faculty. The oral examinations develop poise and enhance student's communication skills and confidence.

The US students are highly capable, and are capable of performing at even higher level if some adjustments are made to fine-tune the way capstone projects are structured and

delivered. In a global-setting, and in multi-national team environment, students who outperform the others are the ones that have been trained in an educational system that has integrated the best practices of educational delivery. In the final analysis, capstone design experiences provide integrative experiences to students, and give faculty and the program directors a sense of accomplishment of their program outcomes.

Conclusion

The characteristics of capstone courses at universities in the US and China have broadly been discussed. Some recommendations have been made to improve the quality of capstone project experiences of students in the US to allow for development of in-depth analytical skills of students. Although more and more universities in the US are adding capstone courses or senior design projects to their curriculums, it is not yet a mandatory requirement for graduation; it is recommended that capstone courses be made mandatory for graduation from engineering and technology baccalaureate-level programs. The US universities are highly competitive and play a leadership role in the world. Not only do the US universities excel in their educational system but also incorporate the continuous improvement process to improve the quality of their educational programs. In a global economy, US graduates are leading the way, and they can do better if their education is improved further through recommendations made in this paper. It will be one more step in the process of continuous improvement.

Bibliography

- [1] Graduation thesis management and requirement (in Chinese), Southwest Jiaotong University, 2006.
- [2] Rules for cooperating project designs (in Chinese), College of Information Science and Technology, Southwest Jiaotong University, 2006.
- [3] ABET Engineering Accreditation Criteria and Technology Accreditation Criteria, <http://www.abet.org/forms.shtml>
- [4] Howe, Susannah and Wilbarger, Jessica, "2005 National survey of engineering capstone design courses", Proc. of 2006 ASEE Annual Conference, Chicago, IL, June 18-21, 2006.
- [5] Uhl, V. W., "Development and critique of the contemporary senior design course," Chemical Engineering Education, Vol. 16, No. 1, 1982, pp. 30.
- [6] Dutson, Alan J., etc. "A review of literature on teaching engineering design through project-oriented capstone courses," J. of Engineering Education, Jan. 1997, pp. 17.
- [7] Todd, R.H., etc., "Designing a senior capstone course to satisfy industrial customers," J. of Engineering Education, Vol. 82, No. 2, 1993, pp. 92.