The Unrecognized Side of Senior Capstone Design

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Abstract

An innovative approach to the interdisciplinary, senior capstone design course at Grand Valley State University is outlined. During the first semester students select a project and are assigned to a project team. The teams then prepare design proposals for review by the sponsor companies. The second semester encompasses student teams refining designs, purchasing materials, building, and testing a device or product. Projects are predominantly sponsored by area manufacturers. This past year a professional development seminar approach was implemented during the first semester of the course. Rather than the traditional review of subjects taught in many capstone courses, professional development training modules were used. Such modules are currently being offered in a variety of corporations to promote collaborative work environments. Each week a different topic is introduced during the lecture portion, followed by a subsequent lab period devoted to practice-oriented, hands-on team exercises. Topics covered during the course include team building, conflict resolution, time and stress management, resource availability, communication skills, and leadership. Additionally project and budget management techniques are presented. The remainder of the semester is used for student teams to prepare their design proposals and obtain sponsor approval for project implementation. Discussion of the professional development modules and exercises developed are presented.

Introduction

Engineering employers are demanding more and more of current and future engineering graduates. One concern is the lack of soft skills new engineering graduates possess, which is supported by the Society of Manufacturing Engineers Manufacturing Education Plan (MEP)[1]. Several skills have been identified as competency gaps in today's engineering education. The ability to communicate effectively, working in interdisciplinary teams, and management skills are examples cited. One driving force behind the demand is today's engineering graduate will most likely assume a management position within five years of graduation.

Several universities have initiated a two-semester industry-sponsored capstone design course. The implementation of interdisciplinary senior capstone courses provides an avenue to address the absence of such skills in modern curriculums. The ABET EC 2000 criteria[2] also requires attainment of certain minimal abilities including:

- The ability to design a system, component, or process
- Functioning on multidisciplinary teams
- Identifying, formulating, and solving engineering problems
- Communicate effectively
- Use modern engineering tools and techniques.

In addition to the above criteria, the Padnos School of Engineering (PSE) at Grand Valley State University (GVSU) has developed several additional outcomes for its graduates. They include being able to:

- Create physical realizations of their designs in a team environment
- Function in an industrial environment

The objective of this paper is to outline the PSE's senior capstone design course and display its role in addressing the above deficiencies in engineering education. First, the course objectives are presented to address the above competency gaps and engineering graduate outcome expectations. Next, a description of the current course structure and content is presented. Finally, future work in development of the course will be addressed.

Course Objectives

Every senior engineering student at GVSU must successfully complete a senior capstone design project. Many universities have implemented similar courses in their curriculums. The majority of these courses focuses on the design process and involves only a single engineering discipline. Due to the mandatory co-op and hands-on laboratory-based structure of the engineering program in the PSE, the two-semester capstone course is permitted the freedom to include professional development modules. The nature of the industry-sponsored projects demands a commitment to interdisciplinary team approaches. The purpose of the capstone course in the PSE is to expose student's to a complete engineering design project, which includes the ideation-to-product realization process. Participation in the course also increases the student's experience with industry projects and personnel, including engineers, managers, purchasing, maintenance, and factory floor employees.

During the past two years, the capstone course in PSE has been restructured to include multiple experiences in professional development modules. The modules have been developed to include skills identified above and were designed to accomplish the following objectives:

- Understand the interdependence of teams
- Handle difficult situations in executing design projects
- Further develop written and oral communication skills
- Develop leadership skills necessary for successful projects
- Efficient time management practice
- Introduction of project management techniques

The above objectives were achieved by implementing the modular approach discussed previously. In addition to meeting the needs of today's engineering graduates, this approach

fulfills additional needs addressed by several professional societies, including ASME. Specifically, lifelong learning by engineers is established early in the graduates minds. Due to the fast-changing environment that our graduates will experience in their careers, lifelong learning is essential for career success. The methodology also reinforces prior knowledge students have experienced during prerequisite courses and during their co-op experiences.

Course Description

The format of EGR 485/486 – Senior Engineering Project I and II is composed of one fifty-minute lecture period and a three-hour laboratory session per week. Lecture and lab sessions meet in a teambuilding classroom environment furnished with workgroup tables. The layout aids in the facilitation of group exercises and discussions during both sessions. The lecture session is dedicated to presenting the underlying principles and discussion of the modules. The lab session is devoted to hands-on group exercises focused on the module covered during that particular week.

The modular technique was developed to fit the allowed time for the course. A different module is presented each week during the lecture period followed by hands-on exercises in the laboratory. A detailed description and example exercises of the individual modules developed is included below. The modules developed to date are listed in Table 1.

Table 1. Module Topics

Module Number	***Topic***
1	Teambuilding
2	Conflict Resolution
3	Communication Skills
4	Leadership
5	Effective Meeting Management
6	Time Management and Delegation
7	Resource Availability
8	Project Management

The remainder of the first semester is utilized for student teams to prepare a design proposal for their assigned project. In addition, teams must present their design choice, budget, and project schedule to the sponsor for approval. The second semester course is utilized for design and construction of the project. A description of each module developed follows.

Teambuilding – The module is designed to assist students in the fundamental knowledge of leading a team, including strategies for developing, maintaining, and building a successful team. The goal of the module is train students to develop skills, which will allow them to function on interdisciplinary teams and build working relationships with team members. Proficiency developed during this module directly affects the student's ability to not only participate as a team player, but also lead a design team.

Conflict Resolution – The design of this module is directed towards understanding the principles of resolving conflicts. Most student design teams fail to acknowledge conflicts within their team and members are unsure how to resolve them. The methods introduced teach students methods of identifying conflicts and how to handle such situations. The skills acquired allow students to improve the effectiveness of their design teams and the knowledge that not all conflicts are harmful to the success of the project. Several case studies are used as exercises to facilitate the students experience and handling of difficult work situations.

Communication Skills – This module is designed to improve communication skills for effective team operations. Listening and speaking skills are reviewed. Various techniques are covered to improve communications within a team and outside management. The methods introduced include those pertinent to written and oral communications, including writing effective meeting minutes and agendas. A personal survey is used to allow students to identify deficiencies in their communication skills. Several exercises are implemented, to enhance both writing and listening skills.

Leadership –A discussion of leadership principles and different styles used to enable project team leaders to manage projects more effectively is presented. Exercises are used to introduce students to techniques for management and motivation of team members and an understanding of various personality types. The goal is to improve the design teams chance for success.

Meeting Management – Concepts for conducting effective meetings with interdisciplinary design teams is presented. Techniques are introduced in holding effective and more productive meetings. Skills are introduced in handling common group and individual situations for successful meetings. The knowledge gained allows student team leaders to conduct efficient meetings and achieve meeting goals.

Project Management – An introduction to project management principles is presented including performance, cost, and time goals. The module includes information on Gantt and PERT charts and Work Breakdown Structures. A focus on the four key tasks of project management is discussed to include planning, coordinating, monitoring, and project closure. Hands-on exercises emphasize the methods learned to mock engineering design project cases.

Time Management and Delegation – Accomplishing more with the same amount of resources while managing both individual and team time constraints is the focus of the module. Discussions include organization, time management skills, and identifying available time by analyzing where an individual and a team's time is spent and wasted. Next, methods of delegation are presented and discussed. A self-inventory, used to determine an individual's strengths and weaknesses in delegation, is used identifies areas of improvement for the students.

Resource Availability – The availability of local, regional, and international design resources is the goal. Use of the Internet is discussed for effective utilization of resources.

In addition, the resources available within the university are presented. A scavenger hunt exercise is performed to emphasize the use of accessible resources. Typical questions include use of the Thomas Register Online, product manufacturer catalogs, and availability of staff and shop resources.

Conclusions

The employer and project sponsor response to implementing the modular professional development approach has been well received. Several employers have requested certain modules be offered for their current employees, including communication skills and teambuilding. The success of offering this approach is evidenced by several factors. First, more mature industry-sponsored design projects are being undertaken by the student teams, including complete manufacturing systems and advanced testing systems. Second, student success rates in receiving sponsor approval for project completion ahead of time has increased significantly.

Future work is currently being conducted to develop additional modules and in-class exercises, based on this approach. Use of the Internet to offer the modules is also being considered. In addition, a new engineering lab building is under construction at GVSU. A portion of the structure has been designed to include a senior capstone design area. The design bay, for use in building projects, is surrounded by a mezzanine containing design team areas equipped with networked PC's containing all of the interdisciplinary design and analysis software used in the PSE. The work areas have been designed to enhance the interdisciplinary team approach used in the courses. In addition, a teambuilding area is being constructed to include room for further implementation of the course.

References

[1] *Manufacturing Education Plan*, Society of Manufacturing Engineers, Dearborn, Michigan, 1997.
[2] ABET EC2000 Criteria, Accreditation Board of Engineering and Technology.

Biographical Information

Jeff Ray, Ph.D., is an Assistant Professor of Engineering in the Padnos School of Engineering at Grand Valley State University. Dr. Ray holds a BS and MS in Mechanical Engineering from Tennessee Technological University and a Ph.D. from Vanderbilt University. His primary teaching responsibilities are First-year engineering courses and coordinating the Senior Capstone Design sequence. Research interests include engineering education pedagogy and use of computer-aided engineering applications in design.