

AC 2008-1908: ENGINEERING TECHNOLOGY'S DESIGN ACROSS THE DISCIPLINES

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Engineering Technology's Design Across the Disciplines

Abstract

Students completing an engineering technology degree, such as Youngstown State University's Civil & Construction Engineering Technology (CCET) bachelor's degree program are expected to be productive in design offices and in engineering departments of construction firms. Accordingly, the curriculum has evolved over the past thirty years to include design projects of varying complexity in many courses. This philosophy has now been expanded to provide a multidisciplinary design experience for engineering technology (ET) majors.

This paper describes the planning and implementation of a pair of courses required to be taken concurrently by the Civil & Construction Engineering Technology (CCET) and Electrical Engineering Technology (EET) baccalaureate students during their senior year. Mechanical Engineering Technology (MET) may elect to take one or both courses as well. These courses serve as a capstone experience that incorporates both individual and team interdisciplinary design projects. *CCET 4884 – Civil and Structural Facilities Design* is an interdisciplinary capstone course that provides an overview of the requirements and design procedures for civil and structural systems including site development, utilities, foundation, wall systems, framing systems and floor system design as well as specifications & estimating. This course has a major interdisciplinary group project. *EET 4880 - Electrical and Mechanical Facilities Design* is a multidisciplinary course that acquaints the student with physical processes involved in heating, ventilating and air conditioning; plumbing; electrical power distribution; lighting; and communication systems. Several small group labs and studies that are focused on system design are required by this class. These two courses must be taken concurrently. They lay the groundwork for overall facilities design and the assignment of projects in each class that incorporate elements from the other.

Introduction

Research suggests that there will be significant environmental challenges in the engineering and engineering technology profession in the future. Meeting these challenges will require a holistic understanding of economic growth and development in terms of the principles of sustainability. The solutions to societal problems will require that technologies be applied not only in innovative ways but with consideration of cultural differences, historical perspectives, as well as legal and economical constraints^[1]. Preparing today's students for the qualities that the future engineering professionals will need to possess, further emphasizes the need for multidisciplinary design experience in undergraduate education.

Students completing an engineering technology degree in Youngstown State University's College Science, Technology, Engineering and Mathematics (CSTEM) in Civil & Construction Engineering Technology (CCET) associate and bachelor's degree programs are expected to be productive in consultant and governmental agency offices, and in engineering departments of

industrial and construction firms. Accordingly, the CCET curriculum has evolved to include analysis and design applications of varying complexity in many courses.

To address these needs, the School of Engineering Technology faculty developed and implemented a two course sequence (taken concurrently) to enhance the undergraduate engineering technology students' skills in: identifying, evaluating, and using appropriate learning sources; student interaction concerning technical problems; stimulates creative thinking by posing open-ended real world design problems; requires application of technical skills and concepts; and provides training and practice of writing and oral presentation skills ^[2]. In addition, inclusion of an open-ended design experience prepares our graduates to implement the best engineering and management practices and technologies in the engineering design industry.

Capstone Course Process

The Youngstown State University School of Engineering Technology philosophy is to create an academic environment that resembles the work environment into which the graduate is expected to be employed. The capstone course sequence (CCET 4884 – Civil/Structural Facilities Design and EET 4880 Electrical/Mechanical Facilities Design) provides opportunities for student interaction concerning technical problems; stimulates creative thinking by posing open-ended design problems; requires application of technical skills and concepts; and provides training and practice of writing and oral presentation skills ^[3]. By fostering the development of partnerships with the design community, the programs can draw upon the expertise of design professionals to provide review of curriculum and instructional needs; develop open-ended design exercises; and provide ideas for senior capstone projects.

EET 4880 - Electrical and Mechanical Facilities Design is a multidisciplinary course that acquaints the student with physical processes involved in heating, ventilating and air conditioning; plumbing; electrical power distribution; lighting; and communication systems. Instruction is provided in heat transfer as it relates to HVAC loads; and fundamentals of plumbing and electrical power distribution. Students learn to use manufacturers' information to compare and select equipment and fixtures appropriate for specific building requirements. Cost and performance comparisons are made among the viable alternatives. Several small group labs and studies that are focused on system design are required throughout the semester culminating with the analysis, design, selection and presentation of construction documents for the electrical and mechanical systems of the multidisciplinary project assigned in the companion CCET 4884 course.

CCET 4884 – Civil and Structural Facilities Design is an interdisciplinary capstone course that provides an overview of the requirements and design procedures for civil and structural systems. Because the course is interdisciplinary, the technical instruction provided is intended to acquaint all engineering technology majors with a basic understanding of the vocabulary and design concepts for site development and the layout and design of utilities, foundations, wall systems, structural framing systems, floor systems and roof systems. Students are instructed in the use of design tables, graphs, and charts along with computer-aided design tools. Additional instruction is provided in the development of construction specifications and preparation of construction plans. After development of construction plans and details for site,

architectural, foundation, structural, electrical, HVAC, and plumbing using AutoCAD students must prepare material and construction cost estimates.

The final product for this is a major interdisciplinary group project. It requires the development of construction documents for all aspects of a building design project identified by the instructor. Each design team of three or four students is provided information about a common site and functional requirements for the building that is to be constructed. Beginning with the decision on where to locate the structure on the site, the teams must develop plans and details for grading, site utilities, foundations, wall systems, structural systems, HVAC, plumbing, lighting, and electrical distribution. As indicated above, a complete set of plans, specifications and estimates (PS&E) must be prepared by each group. The design packages are submitted to a panel of professionals for review prior to the final multimedia presentation by each group. The course is designed to simulate an actual design project that graduates might encounter after completion of the program ^[4]. The review board serves as the owner's review of the final project. Professionals are selected to provide a variety of perspectives typically including one or more structural engineer, architect, and contractor.

Project Team Dynamics

The capstone course sequence provides a unique opportunity for students to work collaboratively in small groups to complete an assigned task. Each group is assigned a team leader or "Project Manager". His/her responsibility is to coordinate the efforts of the team so that all of the tasks are completed in a timely and technically accurate manner ^[5]. An attempt is made to formulate the groups to provide technical expertise from each of the three disciplines (CCET, EET & MET). Therefore, the detailed technical calculations are generally, but not always, performed by a student with more academic preparation than can be provided within the limited time allocated to the capstone courses themselves. Expectations are calibrated to the background of the individuals performing the respective tasks. Because of the course composition, the site development, structural design and electrical design components are typically more developed than the mechanical and plumbing components.

Although all students have previously completed group projects throughout their academic careers, the scope of dependency on others for project completion and the potential impact on their course grade makes this collaboration unique for most of them. Peer pressure and the general desire to do a good job are generally sufficient motivators for the completion of very good projects by each group. The quality of the final project is most often determined by the real-world experience of the group members ^[6]. Often one or more of the participants has worked or is concurrently working for an engineering or architectural firm. That experience virtually always shines through in the finished project. Occasionally, one or more members of the project team do not perform in accordance with the course and team members' expectations. That is when the assigned Project Manager and other team members learn their greatest lesson about teamwork. As might be expected, several different responses have been observed by students placed in this stressful situation. Each time this has occurred (in varying degrees) the team members first tried to apply additional peer pressure on the underperforming member. Most often the solution has been that other team members "take up the slack" and complete additional work so that the project can be completed. Infrequently, the team members have

isolated the work to be performed by the “slacker” and presented the project with components missing or substantially incomplete. The latter solution results in a substantial penalty to the entire team. Consistent with the course philosophy, students are forced to understand that engineering design is not an individual completion of specific tasks, but rather the compilation of a complete project to achieve the initial scope of work^[7].

Assessment

An outcomes-based assessment process, including the use of student self-assessment and the use of an outside panel of professionals identifies both the strengths and weaknesses of our students as they complete the pair of courses^[8]. The instrument shown as Attachment A provides each student the opportunity for self-assessment as well as assessment of each of their project team members. A panel of outside design professionals’ use a rubric similar to the one shown in Attachment B) to assess the outcomes that the students are expected to demonstrate throughout the semester. The panel of outside design professionals provides a perspective from the practical design side in addition to the academic perspective provided by the course instructors. This assessment information is reviewed by the ET faculty and shared with the students and members of the outside panel of design professional and the Industrial Advisory Boards of each program for additional feedback. Based upon these assessments and feedback, changes to the courses are incorporated as part of the School of Engineering Technology's continuous improvement process.

Summary

Through active and cooperative learning, our ET students gain valuable experience in project planning and coordination; development of technical skills; an understanding of the relationship between engineering technology disciplines in project design; and effective oral and written communication skills. The development of the multidiscipline engineering technology design experience has provided an open-ended design experience prepare for our graduates to implement the best engineering and management practices and technologies in the engineering design industry

References:

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- 4) Guevara, Jose, F. Maldonado-Fortunet, I. Pagan-Trinidad, M. Pando, E. Pesantes, and D. Valdes-Diaz (2006). *"Incorporation of a Comprehensive Design Experience in the Integrated Engineering Project Design Model"*, Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition, Chicago, IL, June 18 – 21, 2006.
- 5) Homer, Jeanne (2006). *"The Architectural Engineering Student Experience of Comprehensive Design Studio"*, Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition, Chicago, IL, June 18 – 21, 2006.
- 6) Hanus, Joseph and Jeffrey S. Russell (2007). *"Integrating the Development of Teamwork, Diversity, Leadership, and Communications Skills into a Capstone Design Course"*, Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition, Honolulu, Hawaii, June 24 – 27, 2007.
- 7) Dunn, Phillip and Bryan Pearce (2006). *"Introducing Project Management to Senior Civil Engineering Students"*, Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition, Chicago, IL, June 18 – 21, 2006.
- 8) Earley, Ronald and Mysore Narayanan (2007). *"Assessment Results of a Senior Design Capstone Course"*, Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition, Honolulu, Hawaii, June 24 – 27, 2007.

Attachment A

TEAM PROJECT ASSESSMENT FORM

date: _____

Design Team _____

Course _____

PROJECT DESCRIPTION: _____

MY PRIMARY RESPONSIBILITIES: _____

MY SECONDARY RESPONSIBILITIES: _____

Individual Evaluations	Technical Contribution				Leadership Contribution			
	none	minimal	average	exceptional	none	minimal	average	exceptional
rater's name :								
Team Member No. 2 :								
Team Member No. 3 :								
Team Member No.4 :								
Team Member No. 5 :								

Attachment B

Outcome a. – An appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines

Metric & Weight (W)	Unacceptable (Score, S=1)	Marginal (Score, S=2)	Acceptable (Score, S=3)	Exceptional (Score, S=4)	Points (P) P = W*S
1. Conduct testing and Selection of CCET materials (W=1)	Fair in limited areas of materials selection and testing.	Good in a few areas of materials selection and testing	Very good at most areas of materials selection and testing.	Excellent in all areas of materials selection and testing.	
2 Apply Modern Surveying Methods for CCET projects (W=1)	Poor at applying surveying methods to CCET projects.	Good at applying surveying methods and Fair at the interpretation of results and appl. to CCET project.	Very Good at applying surveying methods and Good at interpretation of results and appl. To CCET project.	Excellent at applying surveying methods and Very Good at the interpretation of results and appl. To CCET project.	
3 Determine Forces, Stresses, and Perform Structural Analysis (W=1)	Fair at determining forces and stresses in structural elements and Fair at performing structural analysis.	Good at determining forces and stresses in structural elements and Good at performing structural analysis.	Very good at determining forces and stresses in structural elements and Very Good at performing structural analysis..	Excellent at determining forces and stresses in structural elements and Excellent at performing structural analysis.	
4 Software Appl. To perform Analysis and Design on CCET projects (W=1)	Poor in applying SPC, design of experiments, acceptance sampling, and standards	Good at applying SPC, design of experiments, acceptance sampling, and standards	Very good at applying SPC, design of experiments, acceptance sampling, and standards	Excels in applying SPC, design of experiments, acceptance sampling, and standards	
5 Proj. Planning & Scheduling (W=1)	Fair at applying project planning and scheduling for CCET projects.	Good at applying project planning and scheduling for CCET projects.	Very good at applying project planning and scheduling for CCET projects..	Excellent at applying project planning and scheduling for CCET projects.	
6 Prepare P.S. & E Packages for CCET Projects (W=1)	Fair at preparing Plans, Specifications, and Estimate Pks for CCET Projects.	Good at preparing Plans, Specifications, and Estimate Pks for CCET Projects	Very good at preparing Plans, Specifications, and Estimate Pks for CCET Projects.	Excellent at preparing Plans, Specifications, and Estimate Pks for CCET Projects	
7 Facilities Design (W=1)	Fair at applying ET knowledge of design	Good at applying ET knowledge of design	Very good at applying ET knowledge of design .	Excellent at applying ET knowledge of design	
8 Problem Def., Soln. Strategy (W=1)	Fair at ET problem definition and solution strategies	Good at ET problem definition and solution strategies	Very good at ET problem definition and solution strategies .	Excellent at ET problem definition and solution strategies	
9 Team Skills , Pres. & Comm. (W=1)	Fair at utilizing interpersonal skills Pres., and oral & written comm.	Good at utilizing interpersonal skills , Pres. and oral & written comm..	Very good at utilizing interpersonal skills, Pres. and oral & written comm..	Excellent at utilizing interpersonal skills, Pres. and oral & written communications.	
Total Points (TP=ΣP)					