Session 1793

Culminating Team Design Project Reinforces Multiple Problem-solving Principles and Skill Sets of an Introduction to Engineering Technology Course

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Abstract

Central Connecticut State University offers an "Introduction to Engineering Technology" course aimed at providing an overview of the engineering profession, reviewing basic engineering fundamentals, and developing problem-solving skills and practices so that these techniques may be applied to general engineering subject matter. Open to the entire university and void of any prerequisites, the introductory course has been very popular and often serves as a valuable vehicle for recruitment of students with an interest in science and technology into our program. Classroom lectures and activities focus on various topics: the engineering profession; the design process; engineering solutions and problem-solving format; dimensional unit conversions; statistics; mechanics; electrical theory; mass balance; and energy concepts.

To reinforce all the baseline topics listed through experiential learning, a team design project is introduced towards the end of the semester. In order to promote positive team interaction, an instructional workshop on the Myers-Briggs Type Indicator (MBTI) is given to assist with the make-up of the team mix. Following team formation, design projects are completed using the previously learned steps of the engineering design process. The project requires conceptual understanding and the use of mechanical, mass balance, and energy formulae. Given project information is provided in both customary and SI units necessitating numerous dimensional unit conversions. The communication stage of the design process is completed through oral presentations and written reports.

Projects are evaluated by the team's use of all design process steps and the application of basic engineering concepts and formulas to the design analysis. Students rank the team design projects and evaluate the contributions of self and others within their team. Most of the course learning outcomes are substantiated by this culminating team design project with conclusions based upon a review of results from class surveys and project assessment.

I. Introduction

The "Introduction to Engineering Technology" course (ET 150) at Central Connecticut State University (CCSU) seeks to provide students with an overview of the engineering profession and to develop problem-solving skills for application of those techniques to general engineering subject matter through set practices. This is a popular introductory course without prerequisites open to the entire university and serves as a valuable vehicle for recruitment into our program. As previously reported[1], it often incorporates first-year experience (FYE) activities as an added enrichment.

Instructors base course lectures and classroom activities around a text by Eide et al. [5] covering the engineering profession, the design process, engineering solutions and problem-solving format, dimensional unit conversions, statistics, mechanics, electrical theory, mass balance, and energy concepts. Learning outcomes chosen for syllabi, i.e., the resultant capabilities for students upon completion of this class are listed as follows:

- To distinguish between engineering disciplines
- To make judgments consistent with expected engineering professionalism and ethics
- To use engineering method and format for problem solving and solution presentation
- To collect and record data, represent data graphically, and analyze data statistically
- To forecast elementary engineering related phenomena
- To properly express dimensions in customary and international (SI) units of measure
- To apply basic engineering concepts and formulae to machine and process design
- To work in teams

The typical class size is twenty students with two FYE sections offered each fall semester. Other sections are offered during the fall and spring semesters but do not include FYE activities or the team design project. The class format provides a structured sequence of engineering lecture topics with homework assignments that prepare the students for a typical design project involving student team interactions.

The literature reveals various institutions with similar goals for engineering and engineering technology programs. Some use first-year seminars for orientation advising and provide a brief introduction to the engineering disciplines. [4, 8, 9, 11, 12, 13, 14, 16, 17, 21, 25] Like CCSU, many engineering and engineering technology program curricula are initiated by an “Introduction to” course. [3, 6, 7, 13, 16, 22, 23, 24, 26] Improved variations of the introductory course have been suggested which place design in the initial year to maintain interest [9, 10, 15, 17, 22, 32, 8, 9, 13, 15, 18, 26], or which are laboratory-based [2, 4, 7, 12], or finally those which emphasize the development of problem-solving skills. [1, 4, 8, 9, 10, 15, 16, 22, 23, 24] Baylor University uses self-paced mastery of subject material as an interesting further refinement for a problem-solving course.[24] During presentation of previous work[1], interest was expressed in the team design project used in the introductory course at CCSU to reinforce several learned problem-solving principles and skill sets and to culminate the course with an experiential learning experience. This team project effort is similar in many respects to the Building Engineering Student Team Effectiveness and Management System (BESTEAMS) approach [19, 20] which incorporates personal knowledge, interpersonal effectiveness, and project management. According to Schmidt et al. [20], the BESTEAMS project strategy uses a team skill training manual with “discussions of team formation, member roles, responsibility sharing, and peer evaluation” together with the use of learning styles to focus on the positive aspects of membership diversity on project teams. Schmidt, Fines, and Pertmer[19], in addition to learning styles, list other common attribute filters including the Myers-Briggs Type Indicator (MBTI). We chose to use the MBTI filter at CCSU due to its widespread use in industry for teamwork activities and it is this seemingly more intricate tool which certainly differentiates our effort from the BESTEAMS model.

II. Culminating Team Design Project

a. Team Building

The text chosen for the CCSU course introduces the importance of the design team in professional problem solving. The team roles of sponsor, leader, facilitator, recorder, and member can be reviewed prior to the establishment of student design teams which most often consist of four to eight students. Eide et al. [5] also consider the applicability of the popular Myers-Briggs Type Indicator (MBTI) for establishing personal styles inventory (or preferences) and its relationship to design team mix. Prior to team formation, MBTI questionnaires are completed by class participants and confidentially evaluated by our University's Advising Center that customarily facilitates this instrument upon request. In addition to providing each student with an understanding of their personal preferences, the review process instills a realization of the strengths of other styles, and provides an appreciation for membership diversity in a team effort. This tool fosters positive team dynamics to ease the progression through the forming, storming, norming, and performing stages of an engineering design team project.

b. Assigned Design Project

Fig.1 provides details of the recently assigned design project. The required format for the written and oral reports reinforces the learned 10-step design process and satisfies the final communication phase. For project completion, conceptual understandings of three major engineering areas, mechanics, mass balance, and energy (power) are required along with the use of their associated formulae. Solution is attained when the mass balance portion is resolved initially followed by cable sizing and motor horse-power selection. Although the problem has constraints, students have sufficient freedom in bucket design and may choose a large or small bucket making few or numerous runs, which influences cable size and motor selection and ultimately overall project costs. Since given project information is provided in both customary and SI units, numerous dimensional unit conversions are required, which reinforces these computational abilities.

c. Project Report Rankings and Evaluation of Team Member Contribution

Team reports ensure that each step of the design process is addressed. At the conclusion of oral reports, students rank the presented team projects. Instructors average these rankings for grade distribution to the teams. Students also provide the instructor feedback on the degree of project contribution made by each member of the respective design team. The feedback yields data for additional grade refinement as warranted with cases of poor distribution regarding student effort.

III. Assessment

a. Area Reinforced and Student Benefit

An assessment survey is given to students in the "Introduction to Engineering Technology" course to evaluate the effectiveness of a culminating team design project and the helpfulness of

GROUP PROJECT FOR ET 150 (FY1) Fall 2004

Team specification: (1) Project Groups of about 4 to 8 persons.
(2) Written report due according to syllabus.
(3) Oral reports due last class meeting.
(4) Assessment of group members due last class meeting.
(5) Each group decides who will do what part of project and report.

Task: Design a mass transport system.

Task specifications:

(1) System supplies an iron processing plant with iron ore from an adjacent mine 100 m to the east and 500 m below. The processing plant produces 100% pure iron at a rate of 20,000 kg / h and a certain amount of residue made up of 5% iron and 95% dirt. The original mined ore consists of 40% iron and 60% dirt and has a density of 4.46 g / cm^3.
(2) Mass transport system consists of a bucket carried by a high strength steel cable (100,000 psi yield strength) moved by a motor.
(3) Bucket must not be more than 80% full to ensure no loss of ore.
(4) Design the bucket size and shape.
(5) It is safe to assume that the bucket mass is negligible and due to the severe angle of incline it is also safe to consider only tension stresses and assume that all of the weight of the filled bucket acts to create tension stress in the cable.
(6) Selection of a safety factor for the cable (SF = 3 on yield strength) is set by company policy.
(7) Calculate forces and stresses in the cable.
(8) Motor should be run at 75% of rated capacity.
(9) Determine the required motor horsepower rating.
(10) Minimize costs to the company (by minimizing bucket costs, minimizing the diameter of cable, using the minimal horsepower motor available and performing actual member cost research).

Final report should contain:

(1) Problem definition
(2) Search
(3) Constraints
(4) Criteria
(5) Alternative solutions
(6) Analysis / synthesis
(7) Decision
(8) Graphical representation of system per Text Appendix C requirements
(9) Cost analysis

Fig. 1. Culminating team design project details.

elements included for reinforcement. Two questions are posed for each element assessed as shown in Fig. 2. The first question dealt with whether the element is actually reinforced through the team design project. Students rate the degree of reinforcement on a scale consistent with the Engineering Technology Department's typical accreditation and university assessment rubrics. Fig. 3 reports the average rating obtained for each element. The data indicates that most items are ranked as being reinforced through the team design project, with the development of teamwork skills receiving an exceptionally high rating. The second question assessed the helpfulness of the each element in the project to their understanding. Fig. 4 reports the average rating obtained for each element reinforced. The data indicates that most items are ranked as being helpful to development of understanding. Feedback from students demonstrates that the team design project is helpful in conveying the concepts associated with teamwork skills. The positive results obtained through the assessment survey are further supported quantitatively through an 11% increase in final exam performance for classes of students participating in this problem-solving and skill set reinforcing project.

b. Instructor Perspective

At CCSU the "Introduction to Engineering Technology" course that requires a culminating team design project to reinforce engineering methodology is desirable. Students are challenged by the design task by applying multiple skill sets and engineering solution techniques (and formulae) to fulfill the design requirement. These students develop a sense of accomplishment upon course completion. The initial team experience should also prove beneficial to students when participating in future classroom group activities and ultimately upon entry into the professional workforce. One may question the use of student input for project evaluation because each group tends to rank themselves highest, but data from overall performance evaluations become valid when all second, third, and fourth place votes are numerically tallied. Diligent students indicate that they are grateful to provide instructors with the degree of contribution for team members with anticipation of fairness in the overall evaluation. Incorporating a team design project as a course activity required a substantial class time commitment, but instructors are impressed by the results and consider the team design project a worthwhile valuable student experience.

IV. Conclusions

The team design project as a culminating activity in the introductory engineering technology course has been relatively successful at Central Connecticut State University. Most of the course learning outcomes were evaluated and substantiated through this effort. Instructors realized a substantial increase in final exam scores following this activity. Students found that many of the problem-solving principles and skill sets taught within this course are reinforced by the design project and that the team project is helpful to an overall understanding of the subject matter.

1. Engineering Design Process
    a. Did the culminating team project reinforce the engineering design process?

    Not at all *Yes* *Yes, very much so* *Yes, extremely so*

    b. How helpful was the project to developing your understanding of the engineering design process?

    Not helpful *Helpful* *Very helpful* *Extremely helpful*

Fig. 2. Design project element assessment question.

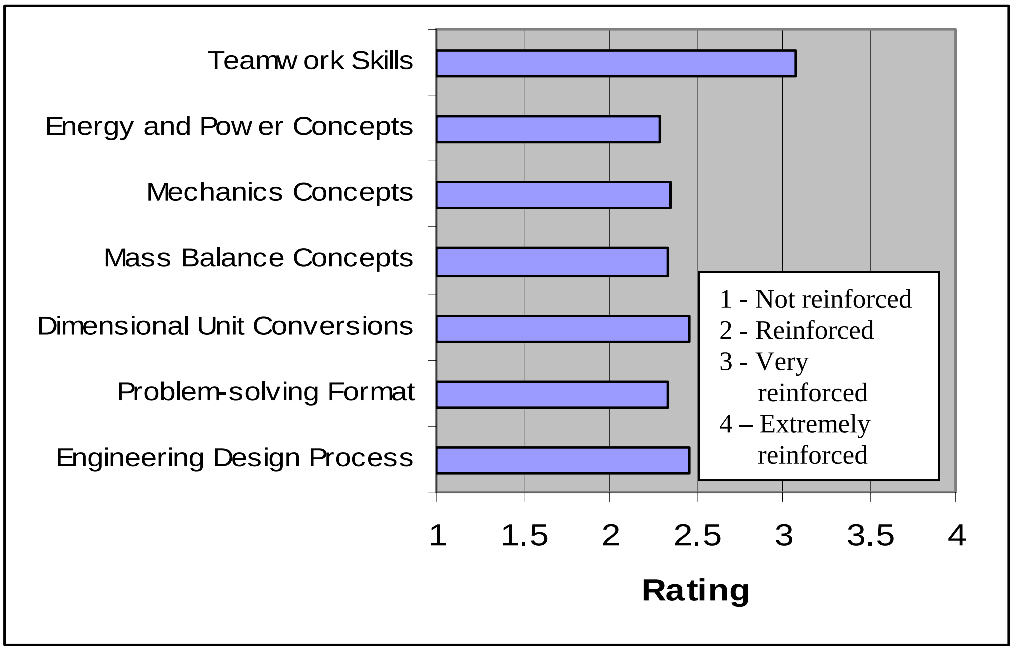

Fig. 3. Student assessment of the reinforcement of each element through the team design project.

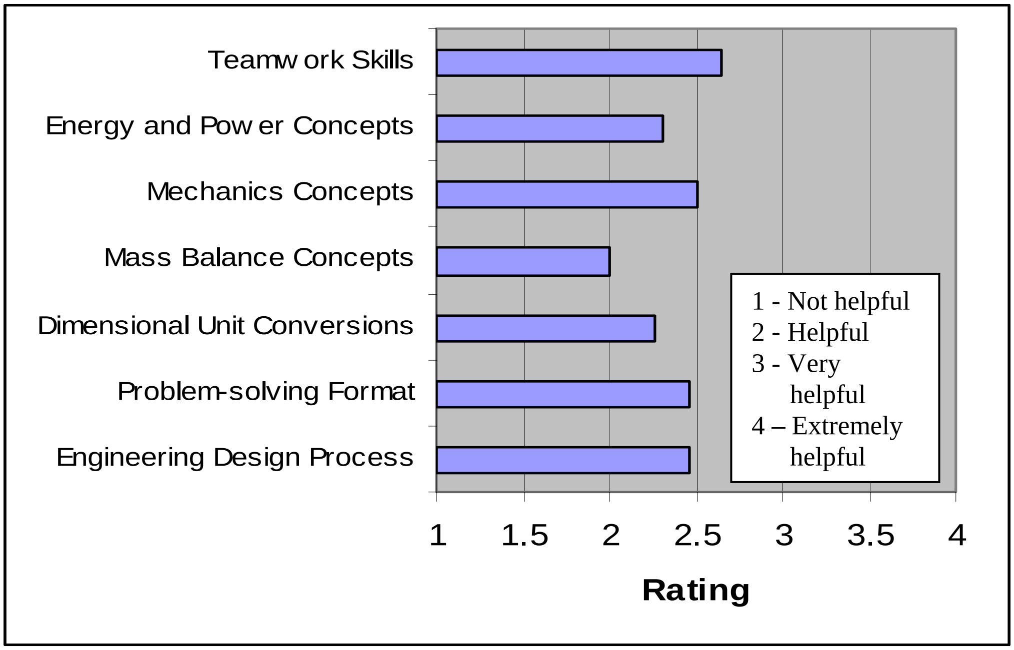

Fig. 4. Assessment of the helpfulness of each reinforced element to student understanding.

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