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Design Education for the 21st Century

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Contents

During senior capstone experiences, student teams are often given a faculty advisor to teach and assist them. Our experience has shown that using the traditional student/faculty teaching model is not an efficient or effective approach to the student learning of design and team processes. The objective of the paper is to show that successful learning experiences for capstone design teams require faculty to shift their role from a traditional lecture or consulting role to a coaching role. Research into key indicators of engineering design team success related to coaching focused on team observations, individual and team interviews, and individual team member and coach surveys. Results shows that a successful coaching role encompasses three main responsibilities: mentor, mediator and manager. Specific expectations and activities that a coach should fulfill to aid in the success of capstone teams can be established.

Team motivation in capstone engineering courses can significantly affect the quality of project outcome. Teams with high motivation often exceed expectations, while less motivated teams at times fail to reach the potential of even a subset of their members. Successful teams typically exhibit a high level of independence in decision making and engineering implementation. However, many components of traditional classroom settings and student projects can hinder team motivation. Moreover, some experiences with student teams have been counterintuitive; groups with slow or rocky starts may end up with higher levels of achievement, while heightened instructor interest in a project topic may result in a detrimental effect on student work. Team motivation is specifically addressed by research in the area of organizational behavior and group processes. This article will apply some lessons derived from group process research to the objective of increasing motivation in student design projects. Relevant input is provided in the areas of project selection, role of instructor, sources of feedback, independence of groups and stages of team development. In addition, familiarity with group processes can increase the quality of the instructor's experience during the inevitable turmoil associated with ambitious student projects. Examples of successful and less successful mechanical engineering capstone design projects are presented to illustrate how team development affects the engineering outcome.

Products and Projects

Many engineering curricula are partitioned into laboratory classes and theory classes. Theoretical lecture courses can cover the largest volume of material, but are often criticized for not engaging students, and, as a result, instilling little retention of the material. This paper contends that we teach engineering more effectively by integrating the theory with hands-on design projects. This contention, of course, is not new, yet the partition remains in all too many subjects. This paper describes an ongoing experiment of adding design laboratories to Harvey Mudd's Computer Engineering class, historically a purely theoretical subject. It then address some of the benefits and challenges that may carry over to integrating theory with laboratories in other courses.

Industry-sponsored team projects have been implemented in design-related project courses. Although many of these courses are capstone-type courses, some may be laboratory project courses linked with more traditional design courses. This paper outlines the implementation of the Product Realization Process (PRP) in team design projects. The major elements addressed are formation of teams, defining specifications, developing conceptual and final designs, written and oral communication, grading of projects and assessment.

SynThesis: Product Design and Business Development for Entrepreneurial Teams is a new curricular offering at Yale University that brings together engineering, computer science, and management students into entrepreneurial teams to create new products and business plans. The evolution of the design of this full-year course is described herein, including the objective of orienting the course deliverables to product-based learning; the use of external validation and peer evaluation; close relationships with industry; privileging a team-based reward systems; reinforcing collaborative learning and problem solving; delivering just-in-time course materials; and aligning projects and self-assembling teams with the concerns of the students. The paper also elaborates on methods of course assessment and student and team self-assessment.

The ***Engage*** *program is a successful new approach to first-year engineering studies that is being implemented at the University of Tennessee. This program develops the desired attributes of engineering graduates that are requested by industrial employers by introducing realistic design problems and approaches in parallel with introductory technical concepts. The resulting program integrates instruction in computer tools, graphics, statics and particle dynamics in two team-taught six-hour courses, each with parallel team design projects.*

In 1991 we began a major change in educating engineering students at the University of Maryland. We reversed the classical sequence of teaching mathematics, science, engineering science, and then finally design. Our teaching methods were changed dramatically from large lecture classes to small classes taught by an instructor who coaches more than lectures. The framework is extremely robust, and it has become an exportable platform for course development across the country. We believed that through re-engineering our educational programs, including the vertical integration of the product realization process throughout the curriculum, we could add sufficient value to our graduates' educational experience that will enable them to compete in the increasingly international engineering marketplace. Among these curriculum changes within the Clark School, we selected four pivotal courses to highlight in this presentation: ENES 100 'Introduction to Engineering Design', ENME 371 'Product Engineering and Manufacturing', ENES 120 'Statics' and ENES 220 'Strength of Materials'.

An innovative interdisciplinary capstone activity is described that integrates theoretical and experiential education in preparing undergraduate students for engineering, science, and business careers. The model uses real projects funded by corporations. The success of the program is in part attributable to the effective use of team building training as well as peer-based and team-based performance reviews. Team building introduces participants to a strategy to increase group cohesiveness and productivity. This training involves the completion, interpretation and discussion of the Myers Briggs Type Indicator (MBTI). The effective use of peer-and team-based performance reviews reinforces the techniques presented during team building. The criteria for client, project and team selection are summarized. A MBTI analysis of a set of teams, and the rationale for peer and team-based performance reviews are included.

J. M. Feland III and **L. J. Leifer** 489–492 Requirement Volatility Metrics as an Assessment Instrument for Design Team Performance Prediction

Predicting and assessing student team performance in design projects presents a host of challenges. Most involve turning qualitative interpretations into quantitative assessments. This challenge is simplified when all student teams are working on the same project. Establishing a relative performance metric based on the top and bottom performers simplifies the task. However, in classes where the projects are diverse and/or sponsored by outside industry representatives the challenge is increased. In classes where formalized requirement documentation exists, requirement volatility (change over time) can be used to simplify student team performance assessment, as well as serving as a predictor of future performance on the project. In an analysis based on project requirement documents from the graduate design class at Stanford, ME210, requirement volatility metrics proved to have surprising power as a predictor of student design team performance. Tracked over time, the metric predicted of team rank-order performance. This document will summarize a method for volatility measurement and the results of our initial analysis.