Implementing a Multidisciplinary System Design and Engineering Course Using Solar Splash '97

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Abstract

In this paper we describe our experience with implementing a multidisciplinary systems design and engineering course by participation in a national student design competition, while simultaneously satisfying the capstone-design requirement within the engineering curriculum. A team of faculty from the departments of mechanical, electrical and industrial engineering acted as consultants to a team of twelve electrical and mechanical engineering senior students whose joint task is to design, construct and test a solar-powered boat. The boat will be entered into the 1997 Solar Splash regatta, to be held in June 1997 in Milwaukee, Wisconsin.

Introduction

In the increasingly competitive global market, government and industry have realized the importance of cohesive, multidisciplinary engineering teams for product design and realization, and for problem solving. The benefits realized result from the wealth of experiences and skills brought to the team by the diversity of its members. In the typical engineering curriculum, however, there is currently a dearth of courses and activities which call on students from various engineering disciplines to collaborate in any way or form.

In recent years, mainly driven by accreditation requirements and industry demands, engineering departments have devoted substantial effort and resources to introduce engineering design into their respective curricula. This trend can be interpreted as a major paradigm shift in undergraduate engineering education from the previous method which relied heavily on repetitive solution of 'closed-ended' problems usually performed individually, without collaboration with one's peers. The wide adoption of 'capstone design' courses across the U.S. is borne out by the great amount of literature documenting such experiences, as reviewed by Todd et al.[1] and by Dutson et al.[2].

Within this body of literature, however, there exists very few documented cases of capstone design courses being implemented across two or more engineering

disciplines. This is surprising given that two recent surveys,[3,4] which included both industry and academia, ranked the ability to work in multidisciplinary teams and a multidisciplinary systems perspective as among the most important traits of emerging engineers. Clearly, there is a need for more frequent use of multidisciplinary engineering design in undergraduate curricula. While the needs for such efforts are obvious, so are the obstacles to wider implementation, such as the administrative difficulties in coordinating such a course, or the issue of how faculty are given credit for participating in a course which requires at least one faculty member from each participating department.

In an effort to prepare engineering graduates for the challenges and the environment they will likely face in industry, we have taken up the challenge and are implementing a multidisciplinary system design and engineering course which focuses on the design of large, complex systems composed of subsystems requiring a variety of engineering skills. The course is being offered as an alternative to the discipline-specific capstone-design courses offered in electrical and mechanical engineering. The overall goal of the course is still in keeping with that for the capstone-design course, namely the synthesis and application of all skills and knowledge gained from previous courses to solve open-ended engineering design problems.

Methodology

For the first project, to be completed during the spring 1997 semester, students will design, construct and test a solar-electric boat, which will then be entered into Solar Splash '97, a regatta sponsored by various private companies and the American Society of Mechanical Engineers. The three-day competition is judged on one written report, one visual display at the competition site, and three phases of physical competition: a qualifying examination of the basic design, a 300 meter sprint, and a two hour endurance contest. The competition will be held in Milwaukee in June; more information regarding Solar Splash can be found on the World Wide Web by browsing to http://www.eng.ncat.edu/~splash/.

In the past few years, A&T Students have competed in a variety of national design competitions, including the SAE Aero Design, Mini-Baja Competition, and Micro-Truck Baja. With these successful experiences, the students were ready to take on the bigger challenge of Solar Splash, as shown by the overwhelming response of students wanting to join the class. In an effort to ensure adequate workload for all students, however, course enrollment was limited to twelve students, eight mechanical and four electrical engineering.

In addition to the disadvantage of being in the competition the first time (Solar Splash has existed for three years), A&T is also handicapped by having only one semester to design and build the boat, compared to the two semesters most other schools devote to the project. To alleviate some of the time pressure, the faculty prepared some groundwork prior to the beginning of the semester.

Sufficient funding was solicited from four sources: the Jet Propulsion Laboratory (JPL), A&T's College of Engineering, and the two participating departments. JPL was attracted to the project because of its goal of training undergraduates in multidisciplinary teamwork, design and engineering, a skill set that JPL seeks in new engineers that it hires. Given that satellites are highly complex systems requiring multidisciplinary design and engineering, JPL's interest is understandable.

In addition to having funding in place prior to the start of the semester, the faculty involved recruited local industries to collaborate on the project. These include local boat builders Hatteras Yachts and Wilderness Systems, and a naval architecture/marine-engineering firm, the Dawson Marine Group. These corporations typically assigned one or two interested parties to act as technical consultants whom the students can call on to answer questions on any aspect of boat building. Additionally, Dawson Marine Group provided a guest lecturer to discuss the fundamentals of boat design.

Given the enthusiasm of the students involved, we decided to allow the students to self-organize into smaller teams focused on the design of subsystems of the boat. Such teams were formed and dissolved during the course of the semester, as their needs arose and waned. The students were encouraged to participate in at least one subsystem which does not fall in their realm of expertise to experience multidisciplinary engineering. The subsystem teams relied on textbooks, consultants, and other mechanical and electrical engineering faculty to complete their tasks. In addition, one team of 'system engineers' was formed, and its responsibilities are to ensure the timely and continual progress of the project and, most importantly, the coordination of all subsystem activities to optimize the *system* design, as opposed to merely an optimization of *subsystem* design. Giving so much responsibility to the students presents some faculty with an uncomfortable situation, but the benefits include a stronger commitment from the students to cooperate with each other to complete their tasks, and a greater feeling of 'ownership' of the project. We feel that it was critical to the success of the course.

Expected Outcome

The project is progressing well at this point, with students hard at work on subsystems to design and specify the hull, the propeller, the electric motors, the solar cell array, and the batteries. We expect the subsystem teams to continually evolve and reform as subsystems design are completed and new tasks arise. Again, we have chosen to let the system engineers decide on new teams, and for the students to volunteer for the teams.

The teams are expected to deliver progress reports weekly, and more substantial 'system reviews' several times during the semester. The semester will culminate in a final design report, which will serve as the report for the competition, and a design presentation and demonstration of the completed product.

Finally, a World Wide Web site http://sunrayce.gmr.com/sea/solar_splash/ is being maintained by the students to inform all involved, as well as interested third parties, on the progress of the project. The Web site also serves as a repository of all subsystem progress reports, so that the team members can get up-to-date information regarding design progress or changes.

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