Introduction to Engineering Program at the University of Wyoming

Charles W. Dolan, David L. Whitman, Thomas V. Edgar

University of Wyoming

Abstract:

The University of Wyoming, College of Engineering developed a one hour introduction to engineering course that integrates teamwork and problem solving into a design challenge. The course is required of all incoming freshmen. This paper explores the pedagogical impetus for the design challenge and explains how the program qualified for the larger Universities Study general education requirements for intellectual community and information literacy.

The design challenge is now in its fifth year. It is one of the more popular aspects of the first semester freshman experience. It has evolved from a "fun activity" to an engineering design endeavor. The paper explores the history of the design challenge and how the challenges are developed. The philosophy of creative problem solving and development of skills associated with engineering design are discussed. There are over a dozen sections of the class and teams are made of students from all disciplines in the college plus non engineering majors. Therefore, students are introduced to multidisciplinary activities early in their career. Assessment activities that are used to judge the effectiveness of the program are presented and the role of undergraduate peer assistants is explained.

Introduction

The College of Engineering, like many other engineering programs, is impacted by the general education requirements of the University. In 2003, the University of Wyoming established a new University Studies Program (USP). The program requires students to not only satisfy general education requirements in humanities, social sciences and the arts, but also students must develop oral communications skills, fundamentals of information literacy and learn to work in team environments, identified as "intellectual communities." These objectives are similar to the continuing ABET a-k requirements as adopted by the departments within the College of Engineering. Therefore, to avoid additional pressure on the number of credit hours required to satisfy the University Studies Program, the college of engineering adopted the University Studies

Requirements into an integrated first year program. This allowed an opportunity to introduce global problem solving skills and introduce design early in the curriculum while meeting the university requirements.

Each fall the college of engineering offers 12 to 14 sections of ES 1000, *Introduction to Engineering*. Each section has 20-22 students and is taught by faculty members that are selected for superior teaching skills and an interest in first year students. Each instructor also has a peer assistant, an upper class engineering student selected based on ability to mentor incoming students. The peer assistant provides additional contact with the first year students and assists in coordination between sections. The course is required of all incoming first year students. In addition, approximately 25 non-engineering majors take the course to satisfy the USP requirements and these students are randomly enrolled within the sections. Classes are multi-disciplinary in that Architectural, Civil, Electrical, Computer, Mechanical, Chemical and Undecided engineering students are intermixed with Computer Science students. Thus, a wide spectrum of intellectual interest is present in each section. Additionally, five sections are "power groups." A power group consists of approximately twenty students who have a blocked schedule, that is, they are all in the common sections of their first semester classes and who may or may not also choose to live together on the engineering dorm floor.

As a one credit course, the amount of material that can be introduced is limited. Therefore, we developed an integrated design challenge to satisfy two levels of educational objectives. The first level objectives were:

- satisfy the University Study requirement for an intellectual community teamwork learning environment,
- introduce oral communication skills,
- address methods of problem solving, and
- provide a design experience early in the curriculum.

To satisfy these objectives, we developed the course around a theme of "The Great Design Challenge," a small design project that incorporates multiple facets of design education.

The Great Design Challenge

The selection of a design challenge is a core element of the course. Examples of first year design projects ranging from detailed engineering design development to reverse engineering to comprehensive design activities to community service learning experiences have been suggested as models.[1-4] Our evaluation of a methodology for introducing design considered these options in detail and also considered the USP intellectual community requirements, the multidisciplinary makeup of our class, budgetary restraints both for the course and for the students, and the skill set of the incoming students. An examination of these options concluded that the experience that best fit our need should be an open ended design project with few rules, one or two fixed resources, a budget constraint and a defined objective. This is felt to maximize creativity in the design process while keeping it within the constraints of one class hour. Finally, the challenge is developed to meet the specified design objective, be moderately difficult, and not to be a

competition with a "first place" winner. Historically, approximately 25-33 percent of the teams succeed in completing the challenge.

The Design Challenge teaming satisfied the first USP requirement of an "intellectual community." By having the students work in teams on a common problem, and introducing formal problem solving methodologies, we satisfied the critical thinking objectives envisioned by colleagues in the college of engineering and in the other colleges on campus. We additionally include a requirement for each student to prepare a short paper on a research question of their choice. The research paper is complemented by a critical assessment of the sources used to develop the paper. The paper may augment information needed to complete the design challenge, but usually is not.

The open ended design challenge offers important opportunities to develop pertinent engineering fundamentals. These fundamentals comprise the second set of objectives and include:

- an overview of the design process,
- an introduction to formal problem solving techniques,
- develop and maintain engineering design records,
- fundamentals of teamwork ,
- introduction to oral communications, and
- the value of failure in developing a refined design.

On the week of the design challenge, all teams must submit their projects for judging two days prior to the challenge. Faculty and peer assistant students review the projects and provide comments on the design approach. Upon submission of the project, the students are given a registration page for their project and draw a time for their participation in the challenge. All teams complete the challenge within a three to four hour period on the appointed day, either a weekend or an evening. This provides all students to observe the range of solutions and the performance of their colleagues.

The design process is introduced in the third week of the semester using a video of "The Deep Dive" prepared by ABC News and narrated by Ted Koppel.[5] Students follow-up this video with an in-class design activity related to the design challenge. The fourth week introduces problem solving in a more formal context. Building on the "Deep Dive" experience, students are given several problem scenarios and asked to develop solutions or failure hypotheses. Students work individually then in small groups. Each student group reports findings to the class. The findings are tabulated and the students learn that group work develops a wider range of solutions than the individual, and the class further develops a wider range of possibilities.

For the design challenge, teams of three to four students are formed. The teams are a combination of self selection and instructor assignment. Each team is required to document the design process by maintenance of a notebook or by submission of progress reports. At approximately mid-term, students submit their notebooks to the instructor during a lecture period with a guest speaker. Notebooks are reviewed and returned at the conclusion of the class period. As reported by others[6], the design notebook is a method to not only organize the design decisions, but also a reference for the final oral presentation. The notebooks must document the

design development and expenses incurred in the project. Typically a $15.00 to $20.00 limit is placed on materials. "Free" material may be used, but must be documented. "Free" is additionally defined by the requirement that any instructor may retain a "free" item at the conclusion of the challenge.

On the challenge day, the students have a set time to complete their mission. This year they were allowed to adjust their vehicles within the time limit to correct for minor problems. Following the completion of all teams, any team could retry the course with unlimited time. The ability to adjust the design proved to be a valuable learning experience and several teams reported what they learned under a pressure condition during their oral presentation.

The students conclude their experience with a formal introduction to public speaking and use of presentation tools. An introductory lecture addresses team presentations, the role of each speaker, hand off among speakers and use of PowerPoint material, including examples of good and poor presentation techniques. The penultimate class in the semester includes an oral presentation by each team. Each team is evaluated by the instructor and their peers. Some instructors have successfully use a classroom response system for the peer evaluation and found that the immediate response is a powerful form of feedback.

Challenge Examples

The following paragraphs describe three design challenges. The first design challenge was developed before a formal evaluation process to assess the results was in place. The last two challenges were conducted under the auspices of the University of Wyoming 2003 USP requirements. Full descriptions of the design challenges are available from the lead author.

- Car Smash – 75 teams
  The "Car Smash" challenge provided the students with a limited amount of foam-core material. The students were to design a small model automobile that would be subjected to a lateral impact load. The objective is to sustain the impact of a sledgehammer such that the driver, a raw egg, survives undamaged. In this challenge, a winner was declared to be the lightest car that survived the impact. Students were directed to USDOT - CAFE rules and web sites to look at actual tradeoffs necessary to get high mileage vehicles fleet efficiency and still maintain safety. Additionally, the students learned the value of careful test setup and monitoring the applied load. Approximately one third of the vehicles survived the impact, Fig. 1 and 2.


Figure 1, Car Smash Challenge

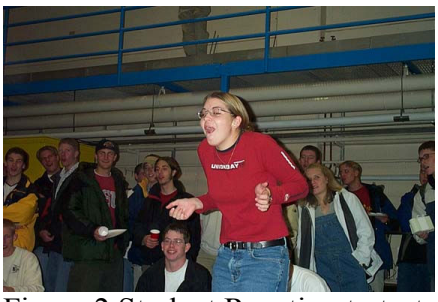
Figure 2 Student Reaction to test

- Mousetrap car – 100 teams
  Many high school students have designed vehicles powered by mousetraps. This challenge provided two mousetraps and a requirement that the vehicle run a slalom course consisting of wood pylons placed four feet on center. Passing two pylons satisfied the basic challenge and more pylons were available for extra credit. The pylon spacing was uniform to allow students to develop simple sinusoidal steering concepts. This challenge proved to be quite difficult because the students were not given advance information on the flooring surface. Consequently, some vehicles lost position due to primary drive wheel slippage. Approximately 20 percent of the teams succeeded. Solutions varied from adapted steering units from radio controlled car sets to sophisticated mechanical linkages tied to the drive axle, Fig 3 and 4.


Figure 3, Mousetrap Car Challenge

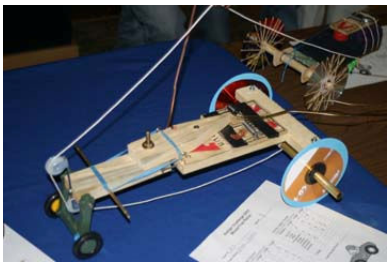
Figure 4 Steering mechanism tied to axle

- Mars Rover – 70 teams
  This challenge provided the students with a 3.5 volt high rpm electric motor, battery box and gear set and asked to design a vehicle to traverse an alluvial field in one of the groundwater hydrology laboratories. The challenge was tied loosely to the current Mars rover activity. The motor assured the vehicle was potentially underpowered to place a premium on light weight design and the students had limited knowledge of the alluvial conditions on the challenge day, since the lab was actively conducting research. Solutions ranged from an aerial vehicle suspended from helium balloons, to a hovercraft, to more conventional designs, Fig. 5-6. Approximately 25 percent of the teams succeeded in crossing the designated field.


Figure 5, Mars Rover Vehicle Inspection


Figure 6, Mars Rover Challenge Course

Assessment

The assessment of the program is ongoing. This senior class is the first group to begin with the design challenge and we will query them on the effectiveness of the challenge during a senior exit survey. We will maintain the survey date for approximately three more years. This will be important since the first two years will predate the formal presentation of the design challenge and the last two will represent students having gone through the formal Design Challenge process. We are specifically querying the student engagement in the challenge to determine if the challenge assists in motivating retention in the engineering program.

The summary of the individual class evaluations indicates a high level of student satisfaction with the challenge. When asked to rank the different activities covered in the semester, a typical result would have 12 – 15 students indicating that the design challenge was the most beneficial activity with the remaining students selecting one of the other issues covered in the course.

The faculty assessment of the Design Challenge is taken at an open forum early in the spring semester. The faculty members have widely supported the challenge concept and many have augmented the challenge with supplemental requirements. For example, one of the authors (Edgar) added a session on vehicle rollover to the class problem solving session and placed a rollover requirement on the vehicles in his section.

Conclusions

The design challenge has met our objective of moving a design activity into the first year curriculum. We found that the college wide design challenge provided a common experience for all the first year students yet maintained an element of academic freedom that spurs success. The student involvement level is high, most students stay to watch the entire challenge.

One component of the USP program is for the students to prepare a short paper on a research question. In future years, we will run a trial section to tie the research question to the design challenge. The objective is to ascertain whether the research activity improves the design solutions. The success will be measured by the number of successful teams in the sections tying the research to the challenge verses those that do not.

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Biographies

Charles W. Dolan, H. T. Person Professor of Engineering is charged with improving the undergraduate engineering program by developing multidisciplinary design projects at the freshman and senior levels. He is a fellow in the American Concrete Institute and a member of ACI 318, Building Code Requirements for Concrete Structures. cdolan@uwyo.edu

David L. Whitman is Associate Dean of Engineering at the University of Wyoming, advisor to the College's Joint Engineering Council and Mortar Board. He is responsible for the coordination and curricula content of the engineering science program. whitman@uwyo.edu

Thomas V. Edgar is the coordinator of the first year Introduction to Engineering program. He is faculty advisor to the ASCE student chapter and coordinator of the Civil and Architectural Engineering curriculum committee. tvedgar@uwyo.edu