

# Supporting a Meaningful Design-Build Challenge for Freshman Engineering Students

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The second semester *Introduction to Engineering* course taught by the Department of Engineering Education (EngE) at Virginia Tech contains a semester-long, design-build, team-based project that constitutes a significant portion of each student's grade in the course. For the past three years, EngE has directed students toward the ASEE Engineering Design Graphics Division (EDGD) freshman design challenge as the required design project and EngE has utilized the ASEE project as a vehicle to teach the engineering design process, project management, and graphics communication to first-year engineering students. In years past, the large number of Virginia Tech engineering students has inhibited our ability to provide students with support and facilities during the build phase of their project. In spring 2004, the EngE department enhanced the student design experience by providing workshops where students have supervised access to a shop-like atmosphere. Students get to borrow/use basic tools in a safe environment to perform project construction work. To help motivate the students, winners of previous freshman design competitions are hired to mentor and supervised the freshman teams during these construction workshops.

This paper describes annual EDGD freshman design challenge, details Virginia Tech's participation and success in the event and encourages more participation by our sister institutions. The role of the ASEE contest within the Virginia Tech first-year engineering program is discussed. Details of the planning, implementation, and costs for the construction workshops are provided and tips for conducting similar workshops requiring only limited facilities and funds are provided. Finally, the success of the workshop is evaluated via a student survey.

## Background

Design projects are commonly used at all levels of undergraduate engineering education to teach engineering design, graphics communication, and teamwork. Projects offer an opportunity to put into practice the principles taught in the classroom. Project work provides a framework for instruction in the art of maintaining design notebooks, running effective meetings, completing a design report, and creating working drawings. In addition, for freshman engineering students, group projects help the students form a support network of friends and study partners. Treating the design project as the "centerpiece" of the course rather than merely an out-of-class assignment significantly enhances the educational value of the design project. The project experience offers a common reference point for discussions of project and time management, engineering economics, technical communications, ethics, and other engineering topics.

Design-build projects, which require a prototype to be built, better demonstrate the engineering design process, necessitate more student teamwork and planning, and tend to make student designs more realistic. Students find the design-build experience even more satisfying when it culminates in a prototype contest or competition. Such course or even better school-wide competitions generate student enthusiasm and allow the truly exceptional student teams to shine in front of their peers. Many freshman project assignments, however, stop short of prototype construction to avoid the problems associated with student construction and prototype evaluation. For institutions that use design-build projects in their freshman-engineering curriculum, it is crucial that students are enabled by the university to meet the project requirements and not just left to *fend for themselves* when in need of tools and building space.

Developing appropriate design-build project assignments for freshman engineering students, that are affordable and present a valid engineering challenge, is often as difficult for instructors as the projects themselves are for the students. The ASEE Engineering Design Graphics Division (EDGD) holds an annual design-build contest targeted to the freshman engineering level. This event provides universities an opportunity to involve their students in a national competition that both provides a significant challenge and showcases student skills and accomplishments. This educational opportunity is currently under utilized by our sister universities and it is hoped that this paper will increase the visibility and participation in the ASEE National Design Competition.

This paper highlights the use of the ASEE EDGD design competition in the freshman engineering curriculum at Virginia Tech and presents our approach to enabling students to meet the project requirements.

### **The approach used at Virginia Tech**

At Virginia Tech, approximately 1250 freshmen are admitted to the College of Engineering each year. The common first-year program for all freshman engineering students is administered by the Department of Engineering Education (EngE). During the second semester of their first year, students take a course in engineering design and graphics communication. A major portion of the students' grade for this design-graphics course is determined by the success of a team design project<sup>1</sup>.

This second semester course is typically delivered in 25-30 sections of 32 students each, by 10 or more instructors. Although the course content is common for all sections, each instructor is individually responsible selecting the design project for his/her sections. Historically not all instructors selected a project that included a build component. However, in the past few years the department has increasingly encouraged that the second semester project be a design-build project, and although the instructor is not required to use the ASEE National Design Competition project as the assigned project, this project is strongly recommended. Unfortunately, although we encourage and prefer to assign a design-build project we do not have machine shops or other facilities that are accessible to the large number students we serve. So while some teams have been able to locate facilities to support the build phase of their project, this situation clearly lead to certain teams being disadvantaged and was unfair.

To remedy this situation, and to make the project work a more integrated and meaningful course component, the EngE department implemented a series of changes and additions to the second semester course. The most significant and difficult change to implement was providing a series of evening workshops where students could use simple tools in a safe environment for the build phase of their project. The Frith Freshman Design Laboratory<sup>2</sup>, which can safely accommodate about 10 teams working at once, was made available four nights a week for several weeks prior to the project due date. A Virginia Tech machinist was hired to supervise the sessions and two undergraduate teaching assistants (UTAs) provided to help during each workshop. The UTAs were recruited from among previous winners of freshman design-build competitions, so the UTAs were able to offer real mentoring and meaningful advice to the freshman design teams. Two 2-hour sessions were offered each evening over a four-week period. To provide fair access to the workshop for teams that needed it, teams were initially restricted to two workshop sessions and were required to pre-register for the workshop time. Once all teams had had the opportunity to sign up for workshop time, the remaining timeslots were made available to all teams on a first-come basis.

The evening workshops were offered for the first time in spring 2004. The workshops were used by 565 of the 900 students participating in the ASEE Design Competition during the spring semester. Every student was required to review the lab safety rules, be familiar with any tools used and sign a liability waiver prior to performing any work. The students performed all of the construction work themselves, but the machinist and UTAs were available to offer help when asked. The workshop sessions provided all student teams an opportunity to construct their project safely and to enhance their knowledge to tools, materials, and construction methods.

The majority of freshman engineering students have limited knowledge of the tools and construction methods that may be useful in project work. A design-built project therefore offers an excellent opportunity for our future engineers to gain first hand knowledge in this area. To enhance the experience, brief supporting lectures were incorporated into the second semester freshman engineering course. These supporting lectures described various building material options (wood, pvc, wire, sheer metal, etc...), fastening systems (screws, adhesives, pop rivets, etc...), and force or work components such as compressed air, springs, motors, bungee cords, etc. These common project elements used in classroom discussions on the engineering design process have immediate meaning to the students.

Additionally many students are unaware of local sources for the desired materials and components for building their design solution. To help students located these local sources, an on-line presentation is made available that describes the locations of area hardware, lumber, electrical supply, and hobby shops. Where applicable, services provided by each retailer are also listed (for example Home Depot will make simple wood cuts for a small fee). This information saves time for the students, the majority of whom are unfamiliar with the community around campus.

The evening project workshops were started with approximately \$1000 worth of purchased tools (funded by the VT Student Engineers Council) and a few items borrowed from engineering department machine shops. A good selection of hand tools, power tools and a few pneumatic tools were provided. The EngE department paid the supervisor and UTA salaries. Students were

notified ahead of time about the tools available and the workshop schedule. The project construction workshops assure that all students participating in the design-build project have ample access to tools. Therefore, excuses for poor workmanship due to a lack of resources are no longer valid and Virginia Tech has *raised the bar* of expectations for the student design-build projects.

### **ASEE National Design Competition Participation**

Although Virginia Tech has had a number of teams participate in the ASEE National Design Competition over the years, Spring 2004 was the first year that essentially all first year engineering students participated in the ASEE National Design Competition. Using the ASEE contest as the class project offers several advantages to course administration. Having all students designing to the same set of goals and being aware of the same set of contest rules allows the instructor to frame classroom discussions of project management, design optimization, teamwork in a context that is applicable directly to the project, and therefore more meaningful to the students. Additionally, as the ASEE contest rules dictate that participating universities may enter only three teams to the national competition, holding an internal contest among student teams is a great way to engage students and generate positive publicity.

We found that the local contest generated a lot of student excitement. Scoring and evaluation were conducted in a single big event so that students had the opportunity to all entries. Most students remained around the contest venue for hours to watch the competition. The UTAs from the project workshops helped with scoring and crowd control. The “winners” of the local competition are selected to represent Virginia Tech at the National Competition and the Dean of the College of Engineering awards certificates of recognition to the students on these teams. To the students, being selected to represent their university in a nationwide contest is an exciting honor and likely more important to them than placing in the ASEE final competition.

### **Student Responses**

To evaluate the success of the evening design workshops students were surveyed about workshop usefulness, weaknesses and asked for general comments. The number of signed waivers collected was used to determine usage of the workshop facility. To evaluate student and satisfaction with the workshops and to make future improvements, student responses were collected to the following survey questions:

1. Did your group use the Frith Lab?
2. Did your group have regular access to tools and workspace outside of the Frith Lab?  
Answer 3, 4, and 5 only if your group used the Frith Lab
3. Were the supervisor and the TAs in the Frith Lab helpful?
4. What other tools or equipment would be useful additions to the Frith Lab facility?
5. Please offer any comments you may have about the evening workshops.

Approximately 65% (565 students) of students used the Frith lab workshops at some point, as determined by the number of waivers collected. These students represented 85% of the teams participating in the design-build project. Virtually all other teams indicated that they had an

alternate source for tools and workspace and so did not need the Frith Lab facilities. Responses indicated that students found the staff and TAs to be helpful and knowledgeable. The most common negative responses indicated that more time and more tools were desired. Overall, student teams were found to use the workshops extensively. All three of the teams chosen to represent Virginia Tech in the 2004 ASEE engineering design challenge indicated that access to the workshops was crucial to their project success.

## **Conclusions and Recommendations**

The Department of Engineering Education at Virginia Tech has made the ASEE Engineering Design Challenge an integral part of its approach to teaching engineering design to first-year engineering students. The use of this design challenge as the semester project engages students in a popular and exciting competition and provides a common thread for discussions of project management, the engineering design process, graphic communications and other engineering topics.

The use of workshops to support student activities on the project has been successful and has enabled students to construct and refine their design prototypes. Most importantly, the workshops have offered students a more level playing field for their design-build project submissions. Use of the workshops will be continued at Virginia Tech, and it is hoped that an expanded selection of tools may be offered in the future.

The ASEE Engineering Design Challenge has about 10 universities that regularly participate, but increased participation can make the contest much more exciting. It is recommended that other universities consider contest participation for their freshman engineering students. More universities will make the contest more successful and promote more prizes and funding for winning teams. Participating universities are also encouraged to help contest coordinators with project development and contest judging. The audience reading this paper is the group of people who have the ability to grow this contest into a truly exciting event. Therefore, it is hoped that this paper sparks discussion and possibly a committee to evaluate and improve the current status of the ASEE Engineering Design Challenge.

### **Bibliography**

1. Department of Engineering Education, Virginia Tech website (<http://www.enge.vt.edu/>)
2. The Frith Freshman Design Laboratory (<http://www.enge.vt.edu/lab.html>)

## Biographies

### STEVEN C. YORK

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