

Ensuring the Success of Competitive Engineering Design Projects Through a Centralized Operation

Tina C. Yuille
Clarkson University

ABSTRACT

In 1997 Clarkson University created the SPEED (Student Projects for Engineering Experience and Design) program to centralize the operations of its competition-based engineering design project teams. This paper describes the benefits of centralizing the operations of competition-based engineering design projects. Benefits of centralization include institutionalizing the activities of the project teams, pooling limited resources, decreasing the administrative responsibilities of the faculty advisers, enhancing the project experiences, increasing the effectiveness at which project activities are used as recruiting and marketing agents, and integrating “extracurricular activities” into the curriculum. Best practices gained during the over four years of SPEED’s existence are also described.

introduction

Many universities provide project-based team opportunities to their undergraduate students via competition engineering design projects. Usually these projects “live” in individual engineering departments; e.g. the Formula SAE Racing Car project is offered through Mechanical Engineering Departments and the Steel Bridge competition project is offered through Civil Engineering Departments. These department-specific projects tend to limit the project opportunities to only those students in the sponsoring departments. Also, having department-specific projects may limit the universities’ ability to provide adequate resources to ensure the success of the students’ experiences.

In 1997 Clarkson University created the SPEED Program (Student Projects for Engineering Experience and Design) to confront the challenges faced by department-specific projects. SPEED promotes and supports team-based engineering design project experiences. It provides an umbrella under which these engineering design projects exist to, among other things, increase the interdisciplinary nature of the projects, ensure adequate resourcing of the projects, and enhance the project experiences of the students involved. SPEED consists of 13 student-run, faculty advised competitive engineering design project teams. Clarkson’s Provost, the SPEED Director and the 13 SPEED faculty advisers received the 2001 Boeing Outstanding Educator Award for this innovative program.

program objectives

In addition to confronting the challenges faced by department-specific projects, SPEED was developed to build upon Clarkson's success in providing team-based project opportunities to its students through engineering design competitions. Design competitions provide a solid foundation of projects that emphasize hands-on, real world, multidisciplinary efforts. In addition, these competitions incorporate many of the training elements critical to the development of engineers ready to meet the challenges of the global market place. The competitive nature of the projects has also proven effective as a motivating factor in driving students' understanding and application of engineering fundamentals in solving real-world problems. This makes for a better student and a more competitive and sought after engineer. Research has also shown that women and students of color seek out and excel in team-oriented environments. Through its team-based approach to engineering design, SPEED aims to increase the number of women and students of color who pursue degrees in engineering at Clarkson University.

In meeting the professional and academic development goals of its participants, SPEED activities are closely in line with the mission of Clarkson University. As articulated in its mission statement, the university provides students with the opportunity to:

1. Solve real-world, open-ended problems that require creativity and risk taking...
2. Develop and refine exceptional communication skills with an awareness of potential cultural differences;
3. Work productively within and lead disciplinary and multidisciplinary teams composed of members with diverse interests and backgrounds;
4. Obtain outstanding capabilities in utilizing computing and other 21st century technologies.

program administration

Tina C. Yuille, Director of the SPEED program, manages the fundraising, purchasing, public relations, travel, professional-development and recruitment activities of the program with the recent help of a full-time administrative assistant. Project teams are generally run by students and advised by faculty, representing the physics department and three of the four engineering departments. SPEED is housed in the School of Engineering and the Director reports directly to the Dean of the School of Engineering.

Clarkson University supports the salaries of SPEED's Director and Program Assistant. External funding provides the bulk of support for the project-related expenses, which include materials for the projects, outsourcing, and competition travel. The SPEED Director collaborates with the Director of Corporate and Foundation Relations, the Dean of Engineering and the Provost to solicit and secure corporate funding to support project and travel activities of the SPEED participants. Companies that regularly hire Clarkson graduates, such as Corning, General Electric, and Kodak, have been consistent supporters. Additional financial support comes from a modest endowment, alumni groups, in-kind gifts from vendors, and team-sponsored fundraising

activities (bottle drives, raffles, car washes). The university is currently working on amassing a significant endowment for the program.

before speed

The SPEED Program was created to address the limitations that many schools are experiencing with the department-supported project model, e.g. limited funding and resources, over burdened faculty advisers, etc. Before the development of the SPEED, Clarkson students had the opportunity to participate in six extracurricular engineering design competition projects, which were housed in the specific engineering academic departments. The Formula SAE, Mini Baja East and Solar Car projects were supported by the Mechanical and Aeronautical Engineering Department. The Environmental Design, Concrete Canoe and Steel Bridge competition projects were housed in Clarkson's Civil and Environmental Engineering Department. Faculty in the departments that supported the projects advised these student-run teams.

Clarkson's department-specific projects provided invaluable professional development for the student participants. The faculty voluntarily advised the teams and ensured the technical competence of team participants. The advisers were also ultimately responsible for all administrative procedures related to the projects. The faculty worked with the teams in addition to instructing their full course loads and attempting to keep up with their research. Though faculty contributions to the projects were vital to the success of the projects, there was no mechanism to reflect this appreciation and value in the tenure process. Thus, it became difficult to keep the faculty as advisers and even more difficult to secure faculty advisers for new projects.

These department-specific projects were often times under-funded, forcing the students to divert attention from the quality of the projects in order to raise funds. Most years, the project accounts were spent in the red, requiring that the school of engineering ultimately cover the deficits.

The department-specific projects were not attractive to wider student population and did not typically attract a diverse or interdisciplinary population of participants. The composition on the teams was homogenous in nature – with few exceptions, white male engineering majors.

While some of the projects were effective recruitment tools for the individual departments that supported them, Clarkson was not able to fully capitalize on the full potential of the projects as a university-wide recruitment tools.

description of projects

Through SPEED, Clarkson offers 13 interdisciplinary team-based project experiences that culminate into entries in design competitions. The teams offer opportunities for extracurricular project-based learning for all students regardless of discipline and major, i.e. a senior Finance major was the team leader for Clarkson's Formula SAE Racing Car team during the 1998-99 academic year and a sophomore Chemical Engineering student was the business administrator for the Mini Baja Team during the 2000-01 academic year.

During the 2001-02 academic year, SPEED supported the following engineering design competition projects:

Concrete Canoe	Mini Baja
Construction Management	NSBE Boeing Flight
Design Build and Fly	Snowmobile
Destination Imagination (formerly Odyssey of the Mind)	Solar Car Racing
Environmental Design	Steel Bridge
FIRST Robotics	Timber Bridge
Formula SAE Racing Car	

The fall semester is dedicated to recruiting members and team building, conceptualizing and designing the projects, as well as developing business plans and budgets. During the spring semester, the teams construct their projects for the competitions using the university's machine shop facilities under the supervision of the machine shop staff and the guidance of the faculty advisers. In an effort to build a well-rounded engineer, most competitions require participants to gain not only experience in problem-solving, engineering design and analysis, but also to demonstrate competencies in communication and business. As in the case of the Formula SAE Racing Car Competition, ~100 teams compete in static and dynamic events, and are judged on their design papers, cost reports and marketing presentations. In 1999, Clarkson's Environmental Design Team won for "Best Paper Presentation" and received accolades for having produced the best paper in the history of the WERC Environmental Design Contest.

description of teams

The SPEED project teams are open to all students regardless of year and discipline. They are formed at the beginning of each school year. Current team members recruit students at Clarkson's fall activities fair and host information sessions. Team members choose team leaders and faculty advisers remain the same each year.

Many of the teams have similar organizational structures. A team leader / project manager oversees all of the activities of the teams. A team administrator / budget manager is responsible for the administrative details of the projects which include preparing and submitting the team's business plan and budget proposal, managing the team's budget and making travel arrangements. There are also sub-team leaders for such subsystems as the frame of the Formula SAE Racing Car, the floatation device for the Mini Baja Car and the lift mechanism for the FIRST Robot.

The teams are open to all students, but are made up of mostly engineering students. The marketing efforts of the SPEED Director and the recruiting efforts of the teams have been crucial in ensuring the interdisciplinary makeup of teams. During the 2000-01 academic year, 34 (17.61%) of the 193 SPEED participants were non-engineers. The fact that the SPEED projects are centered around engineering design projects would otherwise give the overall student body the impression that non-engineering students are not allowed on the teams. The business-related events of the competitions have made it especially important for the teams to solicit non-engineering students. This past year, the Formula SAE Racing Car and Mini Baja teams successfully recruited business managers as the teams' administrators/ business managers. The Snowmobile team was successful at recruiting three business students, all women, as part of its business sub-team. One of the young ladies managed the team's budget, and the other two coordinated the development of the marketing plan for the snowmobile and coached the team members who gave the marketing presentation at the competition.

One of the goals of SPEED is to increase the number of women and students of color who participate on the projects. The Destination Imagination and Environmental Design projects have been most attractive to women. The overall participation rate of women was 21% during the 2000-01 academic year. The fact that students from underrepresented ethnic groups make up less than 3% of the enrollment in the School of Engineering has made it especially difficult to recruit members of this group to the teams. During the 2000-01 academic year, the SPEED Director collaborated with the executive board of Clarkson's chapter of the National Society of Black Engineers to devise a strategy for making the projects more attractive. SPEED's support of a NSBE Boeing Flight team has jumped started the increased involvement of students of color on the teams.

outreach activities

SPEED participants also have the opportunity to polish their communication and interpersonal skills by preparing for the oral presentation components of the competitions, and by being involved in university-related activities. The SPEED projects are highly visible and the participants are often requested to represent the university at recruitment, fundraising and outreach activities both on and off campus. All requests for participation in these activities are directed to the SPEED Director, who then organizes the teams for the various events. SPEED teams have given presentations and showcased their projects at malls, public schools and at the headquarters and factories of its biggest corporate sponsors..

benefits of speed

By virtue of being involved on project teams, student participants gain knowledge and experience. The students learn to apply academic concepts to solving problems, giving them a better appreciation for material taught in classrooms. In building the projects, students learn what is involved in manufacturing, helping them to understand some of the requirements of good designs. Students learn the design process from conceptualization to fabrication, and are exposed

to such real-world practices as working within a budget, finishing a project on time and motivating the team for success. By participating on the project teams, students have the ability to develop and refine leadership skills, communication (oral/written) skills, interpersonal skills, project and budget management, and effective team building. Having real-world experiences also helps students to be competitive in their job search. Companies are recruiting those students who excel academically, and have experience in leadership, working in teams and problem solving. They also look for students with good ideas, and the ability to communicate those ideas effectively.

But SPEED takes the educational benefits of the projects one step further, through enhancements. SPEED aims to ensure that students indeed gain competencies in leadership and teamwork. The Director has collaborated with the Director of Clarkson's Center for Leadership and Entrepreneur Development to develop and facilitate workshops on teamwork and leadership for the SPEED participants. There is a plan to revisit an earlier attempt to assign MBA students to the SPEED teams as coaches/management consultants to further help participants develop their team skills. The SPEED Director has also collaborated with the Director of Clarkson's Center for Excellence in Communication in an effort to provide a resource to ensure high quality oral and written reports for the competitions. Other enhancements, made possible through the SPEED program include coordinated workshops on safety, sexual harassment, diversity and a machine shop certification program.

The SPEED program has been important in raising money to support the individual project teams. It has proven to be easier and more efficient to raise money for all of the SPEED projects than to raise money for each individual project. SPEED has also been integral in leveraging funding from government agencies, corporations and foundations to support other academic and research activities on campus.

best practices

curricular

Recognizing that SPEED projects provide true learning experiences, Clarkson University created the Multidisciplinary Project (MP) program. The MP program enables students to have their project participation formerly documented on their academic transcripts. The faculty advisers create the "course" for which students from across disciplines can register. These MP courses are offered for variable credits with different requirements determined by the advisers. Typically, freshmen receive one credit, sophomores receive two, and juniors and seniors receive up to three credits. For instance, a first year physics student can receive one MP credit for participation on the Concrete Canoe team and a junior civil engineering student can receive three MP credits for the same course. The courses are usually graded Pass/No entry as to not dissuade participation. Generally, these MP credits do not go towards meeting graduation requirements, but in a few cases, the MP project course can be used to satisfy a professional elective requirement. Although students like the extracurricular "fun" nature of the projects, many appreciate that their activities can be documented. Documenting project participation has helped many students successfully compete for jobs upon graduation.

Faculty advisers are proponents for the MP program as well. Offering the projects as “courses” provide the advisers with leverage to ensure that the projects are completed within budget, on schedule and at a high level of quality. There is also a move to make advising a project team part of the tenure process. One day, advising a project will be considered a long with research and instruction in evaluating a professor for tenure. Clarkson’s Civil and Environmental Engineering department has already taken the faculty reward system one step further by making the Environmental Design project a formal course counting as part of the faculty adviser’s work load. The team participants also receive course credits that count toward the graduation requirement.

Senior mechanical engineering students are able to use SPEED projects as their projects in their senior capstone design course. For the past three years, at least one SPEED project has been incorporated in this design course. Examples of the projects include the flotation device for the Mini Baja car, a solar array stand for the solar car and the mechanical subsystems for the FIRST Robotics robot.

fundraising

The SPEED Director works very closely with Institutional Advancement to raise money to support the teams. She authors, co-authors, and edits grant proposals requesting support for SPEED. She travels with the Director of Corporate and Foundation relations to meet with and give presentations to potential sponsors. As the principal investigator on a number of grants, the SPEED director is responsible for managing the grants and producing the annual reports to the grant-making agencies.

Although teams are encouraged to participate in fundraising activities, a policy has been established that such activities are coordinated through the SPEED office. This prevents more than one team from approaching the same company. This also prevents a team from competing against the university for sponsors, for example, ensuring that the solar car does not request \$5,000 from a company that the university has approached for \$500,000 towards the capital campaign.

Streamlining the fundraising activities also ensures adequate record keeping and appropriate follow-up with those companies and individuals that have supported the projects.

safety

The SPEED Director works closely with the university’s machine shop supervisor in designing and implementing safety regulations for machine shop use. Instead of having to speak with thirteen different people, the machine shop supervisor has to only work with the SPEED director in designing and implementing safety policies. The Director distributes information to the teams, taking a lot of the administrative burden off of the faculty advisers and the machine shop staff. One such policy that has grown out of SPEED is the machine shop certification program. Students are trained and certified to use the machine shop equipment by the machine shop staff. Only those team leaders with the appropriate levels of certification have keys to the machine shop, which allow them access to the machine shop after hours. This program is monitored closely by the machine shop supervisor, the faculty advisers and the SPEED Director to ensure that no abuses take place.

budget management

Each fall, SPEED teams must submit a budget proposal to the Director in order to have funds released for the project fabrication and travel to competition. To provide some elements of the real world, student teams have some latitude in the development of the budgets, but ultimately, the advisers and the Director must agree that the teams are requesting an appropriate amount. This process provides the teams with ownership of their budgets as well as an appreciation for working within budgets. As a safeguard, all purchases are streamlined through the SPEED office. This makes it possible to establish checks and balances for purchases, and enables the Director to have a real-time sense of the amount of money that the teams are spending. This streamline approach to purchasing and budget management has also made it easy for the purchasing and accounts payable office to remedy discrepancies.

public relations and recruiting

SPEED is a hallmark program at Clarkson University, and it plays an important role in recruiting and fundraising activities. The Director works closely with the university's communication and freshmen admission offices to organize public relations and recruiting activities. Photo shoots, interviews, tours, and special demonstrations are all coordinated through the SPEED office. Having one place to find out when the Formula SAE Racing Car will compete and how the Environmental Design placed in its competition has made capitalizing on the success of SPEED more efficient. The Director provides information for press releases and news articles. Having an in-house expert who can speak on all of the projects has proved effective.

institutional memory

Students graduate. Faculty advisers move on to different jobs. Maintaining records on student involvement, sponsors and how teams performed has proven very useful in writing grant proposals and in designing public relations tools. Having one place to go to find out how many women participated in SPEED in 1999, and how the Solar Car performed in 1997 has cut down on a lot of research time for a number of offices on campus.

the bottom line

During the 2000-01 academic year, \$161,066 was spent to design, build, and compete the SPEED projects. In analyzing dollars spent per student, one may criticize the resource expenditures for such projects as being highly inefficient when compared to the number of students involved in these activities. However, the dollar per student does not adequately tell the full story of the value of the projects to both the students and to Clarkson.

Team	2000-01 Expenditures (rounded to nearest dollar)	No. of Students	Dollar per Student
Concrete Canoe	\$ 4,827.00	13	\$ 371.31
Construction Management	\$ 4,525.00	13	\$ 348.08
Design Build and Fly	\$ 2,724.00	15	\$ 181.60
Destination Imagination	\$ 13,037.00	21	\$ 620.81
Environmental Design	\$ 9,500.00	12	\$ 791.67
FIRST Robotics	\$ 8,881.00	22	\$ 403.68
Formula SAE Racing Car	\$ 20,689.00	29	\$ 713.41
Mini Baja	\$ 14,255.00	17	\$ 838.53
NSBE Boeing Flight	\$ 1,280.00	5	\$ 256.00
Snowmobile	\$ 14,865.00	14	\$1,061.79
Solar Car Racing	\$ 60,000.00	11	\$5,454.55
Steel Bridge	\$ 5,113.00	14	\$ 365.21
Timber Bridge	\$ 1,370.00	13	\$ 105.38
TOTAL	\$161,066.00		

The SPEED participants are being prepared to become leaders in their respective fields. While working on the projects, the students develop professional and technical competencies enabling them to successfully compete in the global workforce. They learn to apply “abstract” concepts to real world problems, making them stronger students. They learn to effectively work in diverse teams of students, making them team players and better citizens. The projects have made stronger and happier students, students who consider working 20+ hours per week on the project enjoyable and meaningful. The SPEED projects enrich the participants’ college experience, which, in the short existence of SPEED, has made for alumni who are happy to contribute to the program.

SPEED is valuable to Clarkson. These students are eager to help recruit new students, and the SPEED participants and projects are usually the highlights of Open Houses, Parents Weekends, Campus Tours, and Alumni Reunions. Anecdotally, there are a number of SPEED participants who chose to enroll in Clarkson because of the opportunity to help build the next Solar Car, or to continue participating in the Odyssey of the Mind as a college student. The success of SPEED has been used as leverage to successfully compete for grants, including a NSF K-12 grant. The SPEED program has facilitated Clarkson’s involvement with the community. One of the biggest thrusts in education is getting young people excited about science. The SPEED participants have been asked to speak to a number of elementary, middle and high school groups about how fun and interesting science is. The FIRST Robotics program takes the interaction with the community one step further, in that the Clarkson students work very closely with high school students, mentoring them while designing and building the robot. A number of high schoolteachers and parents are involved in FIRST as well.

SPEED has also enabled Clarkson to impact engineering education with this innovative approach to providing and supporting engineering design activities.

what's next?

The success and increased popularity of SPEED has peaked the interest of a number of professors and student groups to form their own "SPEED" Teams. An advisory council has been formed to determine what should constitute a SPEED team and help to formulate the process of how a project becomes a SPEED project. This group will also evaluate the existing SPEED teams to determine eligibility for continued SPEED support.

An alumni survey is in the works to evaluate how SPEED has helped prepare Clarkson graduates for their careers. Clarkson is also interested in surveying corporate recruiters to find out how project participation has factored into the hiring of SPEED participants e.g. the students are more attractive, they have higher starting salaries, they advance quicker.

There is also a discussion to develop an interdisciplinary SPEED course. This course would be required for all SPEED participants. Topics to be presented would include team building, leadership, project management, and presentation skills. A more comprehensive machine shop equipment-training module could also be included in this course.

TINA C. YUILLE, Director of Clarkson University's SPEED Program, assumed her responsibilities in 1997. She holds a Bachelor of Science degree in chemistry from Lincoln University. Prior to her employment at Clarkson, she served as a program assistant for the Ford Foundation Fellowship Program, which is administered by the National Research Council of the National Academy of Sciences.