Projects Day: Completion of the Engineering Capstone Design

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Abstract

Projects Day at the United States Military Academy (USMA) is an annual event to showcase senior design projects. The goal of Projects Day is to "promote academic excellence" [1] by providing senior students "with a public forum in which to present their senior theses or design projects." [1] The students work on these projects all semester and, in some cases, all year. Projects Day allows the students to present their projects, relate their difficulties and successes, and formally complete the project with the customer and faculty advisor. It is also a terrific way for the students and the community to share in the academic richness that exists at any school. A number of academic departments participate in the event to include Civil and Mechanical Engineering, Chemistry, Behavioral Science and Leadership, Mathematics, Electrical Engineering and Computer Science, and Geography and Environmental Engineering.

In May 2001, over 280 students were involved in 72 projects that were showcased. Many of the projects the students were involved in were sponsored by outside agencies. Based on the results of the projects, many outside agencies have implemented the student designs. Some capstone projects are part of national or regional competitions, and some are design and build projects. The quality of work displayed by the students proves that the academic program and capstone experience meet institutional objectives and the expectations of the students and customers. In the Department of Civil and Mechanical Engineering, Projects Day has become an effective way to seek multidisciplinary opportunities, assess the curriculum and program effectiveness through customer feedback, and advertise the projects to future students. This paper focuses on the Department of Civil and Mechanical Engineering's experience in Projects Day, use of it as an assessment tool, and long term benefits of the event. Conclusions and outcomes are substantiated with student surveys and customer feedback.

I. Introduction

Since the spring of 2000, USMA has conducted Projects Day as an initiative to engage all of the academy's students and the local community in engineering design. It is unique since engineering excellence is supported and advertised by the institution rather than one of the engineering departments. This distinction has encouraged its acceptance and promotion throughout the academy.

The Dean's Policy and Operating Memorandum states that Projects Day promotes academic excellence by providing senior students with a public forum to present their senior theses or design projects. [1] Projects Day is scheduled near the end of the Spring Term when most of the senior capstone projects are complete or near conclusion. Freshmen through seniors who have a free hour in their schedules are encouraged to attend Projects Day events, and a large number attend and ask questions. Additionally, the sponsoring departments try to schedule presentations over several instruction periods during the day to encourage student participation. The

department of Civil and Mechanical Engineering requires its sophomore CE/ME majors in Statics and Dynamics and the junior CE/ME majors in Structural Analysis/Intro to Mechanical Design to attend at least one presentation and prepare a journal entry. The departments also invite clients, project sponsors, community leaders, and local school children to attend the presentations as well.

The senior projects usually originate from major capstone or independent study projects that represent the culmination of their four-year educational experience. Students begin their education as freshmen with highly structured courses and detailed requirements in the core program taken by all students. Not later than the junior year, each student begins an in-depth study within one of the majors offered at West Point. The academic experience normally ends with an open-ended, challenging real-life project often providing a service to a real client. This paper will highlight the Department of Civil and Mechanical Engineering's participation and success with USMA's Projects Day. Projects Day, when used as a stimulus in conjunction with teaching design, is a superb experience for those involved, giving students additional experience with teamwork and a real world situation to implement their problem solving skills.

II. Projects

The Department of Civil and Mechanical Engineering is extremely proud of the variety and number of projects it provides for the students. Many continue the research being conducted at Army Labs or by the faculty. However, a large number of capstone projects each year are associated with some type of national competition or provide a needed service to our local community. Projects generally belong to one of these three categories. With an average group size of three to four students, each project requires each student's contribution, cooperation, and expertise, while allowing maximum student, client, and faculty advisor interaction. Student selection for projects depends primarily on student preference. The civil and mechanical engineering directors make every attempt to give students their top selection. Some advisors recruit students for specific skills and project success.

Community service projects have been valuable at educating the community about engineering in society and building ties with local organizations/communities. These local organizations/communities receive a valuable service from the students in the form of a design, professional recommendation, or working device at minimum to no cost. These organizations / communities have, in turn, informed other groups that have sought assistance from the department. Students learn to interact with community sponsors, many who have little technical training, and contribute to the local area in a meaningful way. Recent project sponsors ranged from sports clubs at the academy to the local VA hospital. A description of the Popolopen Brook Float Bridge [2] project follows.

The focus of the Popolopen Brook Float Bridge project was to develop different design alternatives to span 230 feet of Popolopen Brook in order to connect the revolutionary Forts Montgomery and Clinton. This bridge is the most important link in making the Fort Clinton / Fort Montgomery Battlefield Site a complete historical site by allowing visitors easy access to both forts as they are reopened. The desired result was a feasibility study of each alternative. The military historian for the Hudson River Valley and Palisades Interstate Park Commission,

was the primary client and used the feasibility study to spark interest from a multitude of funding sources to include the governor. The team designed/built one full scale float bridge module (Figure 1) that incorporated four design alternatives to assist the clients in deciding on a final design.

Figure 1. Float Bridge Full Scale Module Demonstration on the Hudson River

A list of last year's community service projects and sponsors is in Table 1.

Table 1: Community Service Projects

Community Service Project	Sponsor
West Point Lower Area Recreational Complex	USMA Housing Office
Walden Humane Society Renovation	Walden Humane Society
Popolopen Brook Float Bridge	Fort Montgomery Battlefield Site Ass.
Ground Water Study and Aquifer Model	USGS and Town of Gardiner, NY
Structural Evaluation of Church Bell Tower	St. George's Church, Newburgh, NY
Ice Jam Prediction Investigation	Cold Regions Research & Engineering Lab
Indoor Obstacle Course Load Testing	Department of Physical Education
Mechanical Grabber	Castle Point VA Hospital
Headstick Design for Handicapped Individuals	Special People in the Northeast (SPIN)
Power Plant Study	USMA Dir. Of Housing and Public Works
Oar Design	USMA Crew Team

Competition projects are conducted at regional and national levels. Funding for these projects is primarily through our alumni organization, the Association of Graduates (AOG). These design, build, and compete projects usually involve various technologies and bring out the best effort in the students. Students are very knowledgeable about their project, and the competition design teams are structured and very organized. Competition projects are highly desirable to the students since they are competitive by nature – traveling and winning are high on the list as well. The ability to travel and participate in the competition is always dependent on the quality and progress of their product. Teamwork and project management skills go a long way in these major design projects. A description of the Autonomous Unmanned Ground vehicle competition is below.

Project MAGIC is an annual intercollegiate autonomous unmanned ground vehicle (AUGV) competition held this year at Oakland University, MI, 1 - 4 June 2001. The competition is to design, build, and race autonomous unmanned ground vehicles (Figure 2). The student-designed autonomous vehicles are golf cart sized and utilize various technologies including vision systems to locate lane markings, rangefinders to locate obstacles, and computers to analyze and integrate

Figure 2. USMA Autonomous Unmanned Ground Vehicle

the sensor data and control steering and speed. The AUGV competition offers a design experience that is at the cutting edge of engineering education. It is multidisciplinary, theory-based, hands-on, team implemented, and focused on product realization. It encompasses the very latest technologies impacting industrial development and taps subjects of high interest to engineering students. The subject area is directly applicable to future Army weapon

development. Even though, this project is led by the Department of Civil & Mechanical Engineering, it includes faculty advisors and seniors and juniors from Electrical Engineering, Computer Science, and Systems Engineering.

A complete list of competition projects from 2001 are in Table 2.

Table 2: Competition Projects

Competition Project	Sponsor
AISC Steel Bridge Competition	AOG
ASCE Concrete Canoe Competition	AOG
National Timber Bridge Competition	AOG and PDJ Components
Battlebots	Department of Electrical Engineering and Computer Science
AIAA Aero Design, Build, Fly	AOG
SAE Aero Design, Build, Fly	AOG
IEEE MicroMouse	AOG
MAGIC - Autonomous Unmanned Ground Vehicle Competition	AOG
Baja - SAE Off Road Vehicle Competition	AOG

Research projects give the students an excellent opportunity to further existing research at an Army laboratory or assist a faculty member at USMA with research. Many of these projects allow students to have access to data and computing facilities not available at the institution. Research project sponsors are usually not in the local area, but an initial visit to the laboratory, constant communication, and any necessary follow up visits to/by the sponsor usually provide sufficient direction. These projects allow students to affect a new Army technology they may see after they graduate and enter the Army. A description of the Modal Analysis of Blast Plates project follows.

Simplified structural-response models based on limited parameters are needed to facilitate vulnerability analyses of Army vehicles subjected to blast loading. Towards this end, blast tests using spherical charges have been conducted on flat panels (Figure 3). Parameters in the experimental study include charge weight, panel material and edge constraint. These experiments have been modeled using finite elements to assess the accuracy of finite element predictions by direct comparison with experimental data. Initial comparisons between experiment and prediction indicated errors in the finite element model. Simple analytical models were constructed to verify the operation of the finite element models. Subsequent to this verification, an error in the modeling of boundary conditions in the analytical work was identified. Validated finite element models will ultimately provide a basis for studies to determine the most relevant parameters to be included in simplified response models for vulnerability analyses.

Figure 3. Modal Analysis on Flat Panels

Research projects and sponsors from last year are in Table 3.

Table 3: Research Projects

Research Project	Sponsor
Parafoil Design	Department of Electrical Engineering and Computer Science
Laser Light Show	Department of Electrical Engineering and Computer Science
Wall Crawling Robot	Army Research Laboratory
Marklin Train	Department of Electrical Engineering and Computer Science
PM Soldier	US Army, PM Soldier Systems
Unmanned Ground Vehicle Demo III	Army Research Laboratory
Prioritizing Repair Projects -Locks and Dams	Construction Engineering Research Lab
Carbon Fiber Reinforced Plastics	ARO
Modal Analysis of Blast Plates	Army Research Laboratory
Watershed and Reservoir Study	Waterways Experiment Station
USMA Parking Analysis	Department of Civil and Mechanical Eng
Auger Pilings Design for LAMS	Natick Labs
Mine Vehicle	Army Research Laboratory
Rugby Facility Design	AOG, Army Rugby Team

III. Benefits

One of the indirect advantages of Projects Day is the volume of faculty who become more aware of the department's projects. The visual conveyance and articulation of the projects have prompted many faculty members from other departments to offer solutions. More importantly though, they see opportunities to get their students involved in the projects and assist in community service, competitions, and research in order to solve a stated need. These opportunities for other students to assist in multidisciplinary, engineering design help meet ABET's Criterion 3(c-e):

(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems [3]

Likewise, there has been an offering of civil and mechanical engineering students to projects sponsored by other departments, promoting more cross talk and coordination between all departments.

In addition to the publicity from Projects Day, the number of students attending the presentations has been a benefit. Some students who normally do not take engineering courses suddenly become curious and want to be part of a project in the future. Some want to be part of a research project, a design competition, and many wish to contribute to a community service project. Likewise, sophomore and junior civil and mechanical engineering students who are unsure of what capstone project to pursue have a wealth of information in one location. They can read about the projects, look at static poster board displays which are required for each project, listen to the presentations, question senior students who have worked on the projects, and query faculty advisors about the future of the particular capstone projects.

In the same vein, clients invited to the presentations see new opportunities for projects. Their visit to Projects day is more than a formality. They have a last chance to question the service provided by the students and provide feedback both formally and informally to students and faculty advisors. Many clients decide to continue projects or find new ones for future students when they see their organizations and the students mutually benefit from the experience. By attending Projects Day, their contribution and support to the senior capstone experience gains credibility and meaning.

The seniors involved in Projects Day see it as an opportunity to "strut their stuff" and demonstrate their products to the clients. Most students have no problems presenting and welcome questions and challenges from the audience – part of the communication ABET program outcome. Since Projects Day is scheduled late in the Spring Term, many design competition teams have returned from the competitions with results and lessons learned. Community service and research projects are usually near completion at this point in the semester as well. Some design teams have already given a final report to their clients, but these design teams must still participate in Projects Day to tell their own experience and pass their knowledge on to other students, the clients, and faculty. The seniors are proud of their

accomplishments and have even invited family members in or visiting the local area to attend their presentations during Projects Day.

Projects Day provides a media opportunity for the department and the institution. As the largest department to participate in Projects Day, the Department of Civil and Mechanical Engineering has taken the lead in publishing articles about Projects Day and particular capstone designs in the local newspaper as well as the alumni magazine. These opportunities help the local community understand engineering and what our students can do. In addition, the publicity helps fill the pool of local community service projects for future students.

IV. Challenges

Projects Day is a highly successful approach to combining and synchronizing the various student projects into a single well-coordinated effort similar to any conference in the country. With over 70 presentations by 280 students, Projects Day requires very little overhead and minor external coordination.

Scheduling Projects Day is performed by the Office of the Dean in consultation with the departments that will participate. All departments may not agree on a date, but they do agree that it must be late enough in the spring semester for the students to be complete or nearly complete with their capstone. There are minimal scheduling problems within the department for classroom space and times for the presentations. Since some presentations and question periods exceed the allotted time, and some teams needed extra time to set up, we scheduled a 25 minute break between presentations. Comments indicate that more time may be necessary between presentations to accommodate the follow on discussions and demonstrations.

One goal of the department is to ensure adequate faculty coverage for every presentation. At least three faculty members within the department are there at each presentation to provide comments and objective feedback. These faculty members can help answer visitor questions and ensure that all groups are properly assessed and challenged during their oral presentations. Every instructor and a number of guests use the oral assessment forms provided in each briefing room. Coordinating faculty teaching schedules, faculty priority lists of presentations to attend, and project sponsor visits are factors in scheduling this faculty coverage. The oral assessment forms are collected and used to help evaluate the program outcome on communication (3g)[3].

Once the Projects Day date is established and the schedule of presentations is complete, the department must invite guests and project sponsors. The department chair invites most of the clients and sponsors. However, the Dean and School President will personally invite significant sponsors and heads of large organizations. Determining the list of invitees and delineating responsibility to the department or a higher office are necessary tasks.

V. Assessment

Projects Day is a relatively new event and little objective data exists to measure its effect. Free response survey answers allowed Projects Day participants to comment on the projects and the event, and most comments were favorable. Many comments emphasized how much students

valued being involved with real engineers, customers, and projects. Numerous students benefited from observing what other students were doing for their capstone projects and learned from them. Some students just observing Projects Day decided what discipline and capstone to pursue.

Projects Day provides an opportunity to assess the curriculum. ABET 2000 Criterion 3(g) states that graduates must have an ability to communicate effectively[3]. Clients receive a written product and a formal brief either at Projects Day or at the clients' business. Having spent at least a semester on a project, most design groups were so familiar with entire project that preparation for the presentation was really not a huge burden considering all the required information is in the completed report. Some students enjoyed the free structure of presentations during Projects Day. Table 4 is an objective assessment measuring the students' confidence to present their capstone project:

Table 4: Assessment of Ability to Present Capstone Project

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I can deliver a clear, well-organized oral presentation	62.7%	23.5%	11.8%	0%	1.9%

Faculty advisors also received informal feedback from the clients. Most have reported enjoying Projects Day, working with the students, and receiving a valuable product in return. Most of the sponsors volunteered again and many clients solicited the students' assistance in subsequent years, which is further evidence of their satisfaction with the program to include Projects Day.

The free response surveys also indicate areas for improvement. The presentation schedule must be finalized as early as possible to allow students time to rearrange their schedules and see as many presentations as possible. Often, other departments would change an internal presentation schedule for the benefit of clients and sponsors, affecting students who were presenting more than one project. Additionally, more institutional publicity is necessary for Projects Day to persuade more people to attend the briefings.

VI. Conclusion

The Department of Civil and Mechanical Engineering's participation in USMA's Projects Day has been very positive for students, faculty, and clients. USMA promotes Projects Day as a medium to communicate student capstone projects to peers, clients, and faculty. The Department of Civil and Mechanical Engineering has found Projects Day as a way to seek multidisciplinary design opportunities, assess the curriculum and program effectiveness, and advertise the projects to prospective students. It allows engineering students to formally close out their projects with the sponsors and faculty advisor. The benefits derived from exhibiting the students' talent come at a substantially small effort to coordinate the event. Students graduate from the program with a better understanding of customer focused engineering and are better communicators through the Projects Day experience.

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