Service Learning in Engineering at Cal Poly

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Introduction

The benefits of service learning have been demonstrated in a number of different settings (Jacoby, 1996; Tsang, 2000). By participating in projects with a community-based focus, students gain an appreciation for the role they can play in society by reflecting on a variety of socioeconomic and ethical implications of their experience. Cal Poly has long had a strong design component in its engineering curriculum and stresses "learn by doing," and this emphasis can be used in projects that can help the community. Many instructors have had individual success with service learning design projects, and we hope to expand these valuable learning experiences to an even larger percentage of our students.

Service Learning

Service-learning is a pedagogy in which students achieve academic learning objectives by working on projects that address societal needs. Necessary, and to distinguish itself from community service, is a reflection component (Jacoby, 1996; Tsang, 2000). Students gain an appreciation for the role they can play in society by reflecting on a variety of socioeconomic and ethical implications of their experience.

Reflective judgment (i.e., critical thinking) and associated skills are an important educational outcome for engineering students (Tsang, 2002). The development of these critical thinking skills enables the engineering undergraduate to develop a broader appreciation of concerns facing the engineering profession and the world. Global issues have been proposed as a means to precipitate change in engineering curricula (Vanasupa et al., 2006). Traditionally, reflective judgment within engineering service learning has focused primarily on the social, political, and cultural impact of engineering and technology on society. Engineering Projects In Community Service (EPICS), a vertically-integrated, multidisciplinary service-learning program (Coyle et al., 1997), has expanded the use of critical thinking skills to include reflections on the community partner (called the project partner), team dynamics, the design process, and ethics (Slivovsky et al., 2003, 2004).

This expansion demonstrates ABET program outcomes, including "an understanding of professional and ethical responsibility" and "the broad education necessary to understand the impact of engineering solutions in a global and societal context" as well as such outcomes as "an ability to function on multi-disciplinary teams" and "an ability to identify, formulate, and solve engineering problems" (ABET, 2002). Direct contact on projects with groups such as not-for-profit organizations and K-12 schools and the reflection on the impact a student is making on these groups, rudimentary in service-learning, are aligned with these program outcomes.

It is important to remember that service learning should be used as a tool to meet course objectives. In the Cal Poly engineering departments, this has occurred most frequently in the design courses. There is a push both nationally and at Cal Poly for more substantial design experiences, those that will educate better engineers. Additionally, there is a thrust within the College of Engineering at Cal Poly to increase service learning opportunities as a way to accomplish this goal of educating better engineers with improved societal awareness.

The importance of design in an engineering education has been underscored in communications from industry, government (NAE, 2004), and academia for years and has been seen with a shift from analysis-centered to design-oriented curricula (Evans et al., 1990; Dutson et al., 1997; Dym et al., 2005; Smith et al., 2005). While many assess the impact of design experiences and student understanding and performance, they do not answer the question "*How*?". Dym, Wesner, and Winner (2003) state that "Design is a journey," and some suggest that engineering students are armchair adventurers in design. Only by experiencing design themselves can they begin to understand and learn how to design; only through design can they know design. Senior capstone projects centered around service oriented projects can provide additional motivation for students, increase Cal Poly recognition in the community, create a sense of civic responsibility in our engineers, and provide a meaningful learning experience.

Community Partners

When attempting to incorporate service learning into an engineering curriculum, it is important to find community partners who can help identify projects. Often, engineers and researchers develop new products without sufficient input from the actual users. While this may still be a meaningful learning experience for students, it is important for them to learn the importance of defining user requirements, gaining user trust, and constantly seeking user feedback in the process.

The Central Coast Assistive Technology Center (www.ccatc.org) was created in 1998 to serve individuals with disabilities of all ages in the Ventura, Santa Barbara, and San Luis Obispo counties of California. CCATC provides a comprehensive resource that promotes professional technology evaluations, recommendations, training and follow-up. Assistive technology (AT) is any device that improves quality of life and restores function in the individual's life. To create the CCATC, members from over 25 local agencies (Department of Rehab, California Children's Services, United Cerebral Palsy, Easter Seals, Independent Living Resource Center, Regional Center, Local Hospitals, UCSB, Goodwill, School Districts, etc.) donated their time and were assembled on a monthly convening advisory board for the establishment of CCATC.

The CCATC continues to serve the central coast community by providing health-related occupational therapy services—with an emphasis on assistive technology— to individuals with physical disabilities. The CCATC has also developed an extensive network of local companies and organizations that have partnered with CCATC to create a unique service. The CCATC has also worked closely with neighboring California Polytechnic State University on many engineering and recreational type projects to improve and simplify the lives of individuals with disabilities.

Past Projects

Computer Engineering (CPE), Electrical engineering (EE), Mechanical Engineering (ME), and Industrial and Manufacturing Engineering (IME) have all had a great deal of success with service learning. CPE has a a two-quarter Capstone Design experience that provides teams of students with large, loosely defined projects for real-world customers.

In the first year of the capstone, all projects involved Radio Frequency Identification (RFID) and were designed and implemented for the new RFID Center on campus, a collaborative center between multiple engineering and agriculture disciplines. Example projects include an Active Tag Design, a Smart Shelf System, and an RFID Entry System. The multidisciplinary nature of the projects and the benefit to the customers have prompted the introduction and advancement of service learning as part of the capstone curricula. Students reflect on their experience in dealing with their customer and the socio-economics and ethics associated with the introduction of this technology in the target industry.

More recent service learning in the Capstone include projects for on-campus community partners: the College of Engineering and the CPE/CSC/EE Digital Curriculum of courses. For the College of Engineering, students designed and implemented a GPS-enabled Self-Guided Campus Tour system that runs on a PDA. The system will serve multiple purposes. It will be used to train Engineering Ambassadors, engineering students who give campus tours to visitors and prospective students. It will especially help the ambassadors to learn specifics about the other engineering disciplines in the college. Additionally, the system will be downloadable from the college website for anyone to download and use during their visit to Cal Poly.

The Digital and Analog I/O Board Design Project has students designing a peripheral device board that will be used in the Programmable Logic and Microprocessor Based Systems class, CPE 329. Current peripheral boards available today are either lacking in the variety of I/O on the board or are expensive. This board will feature a number of analog and digital devices with which students will use in their lab experiments and final projects in the class at low cost.

The CPE and EE are currently collaborating with the Mechanical Engineering (ME) Department and CCATC to create an Electronic Travel Aid (ETA). People with impaired vision can use a cane successfully to navigate in a forward direction, but often have difficulties with obstacles at eye level and with detecting openings (such as open doorways) to their sides. A team of one EE and one ME student is developing an ETA using ultrasonic sensors to detect obstacles in front and to the sides of the wearer. Upon sensing an obstacle or a doorway opening, this information is provided to the user by means of a tactile belt (Figure 1). Vibromechanical tactors, which are similar to vibrating batteries in cell phones, can be placed circumferentially around the waist (or at other locations) to provide intuitive directional information. The students have been in close communication with CCATC and with several different persons with visual impairments while developing their design requirements.

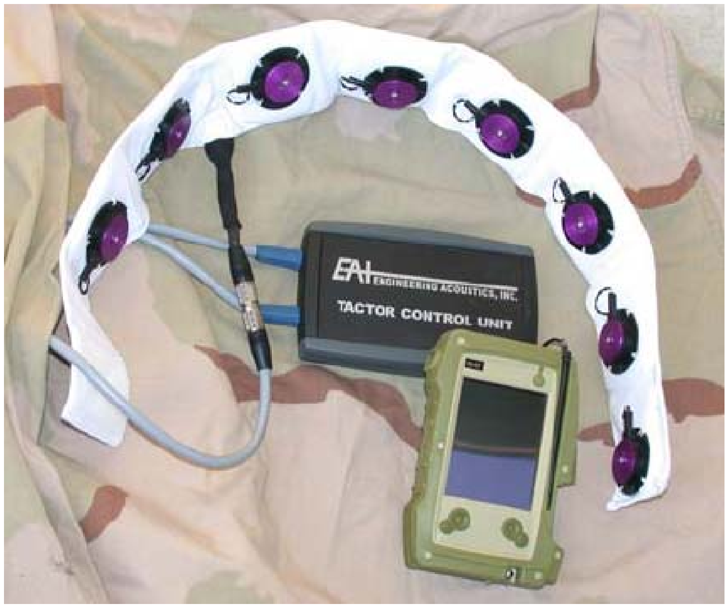

Figure 1. Tactile belt.

The Mechanical Engineering Department has had several senior design projects involving service learning. They include designing rehabilitative devices for children with cerebral palsy to building test fixtures to help design ankle-foot orthoses for those with ambulatory difficulties. The most successful of the projects have involved teaming with faculty in the Kinesiology Department to design and build devices for adapted physical activities.

Currently, modifications to a tandem kayak have been made to enable control via a joystick over a trolling motor attached to the rear of a sea kayak (see Figure 2). Successive teams of Mechanical Engineering students have designed the current system to ultimately allow the option of changing between many different forms of control. At completion we hope to have the option of controlling the vessel with either a joystick or a chin joystick. Initially we increased the stability of the kayak using inflatable sponsons that have now been replaced by a keel. The keel adds more stability, it can not be punctured (it's more durable), and is considerably less visible from a distance. Developing control over the motor took a great deal of time, the speed at which the kayak can travel has been restricted so that it travels at a speed similar to that of a manually propelled boat. Governing the speed ensures the safety of all participants, while creating a sense of comfort and independence for the pilot. A feedback device was initially designed to mount on the front of the kayak allowing the pilot to determine which way the motor is facing.

As ME students proceeded with the design and construction, a team of Kinesiology students developed safety procedures for the use and operation of the finished craft, and established a liaison between the project team and potential pilots, to solicit their input and advice. Based upon input from potential pilots, we are concurrently exploring different transfer possibilities into the kayak. Many participants have commented that transferring into and out of the kayak can be uncomfortable and lead to embarrassment when being lifted from their wheelchairs, by program assistants. We were asked to consider finding a lift that could be user operated to allow paddlers to control their own transfer from chair to boat. As a result of this input, a further group of engineers designed a hoist specifically for use in adapted paddling settings. The most promising design incorporates the hoist into a boat trailer that will also be able to transport kayaks to and from the paddling location. We are currently exploring the possibility of soliciting additional funding to build the hoist. As an alternative now we plan to begin design of a "shuttle vehicle" which would be a joy stick controlled vehicle that the paddler would drive into the water for the kayak to float off.

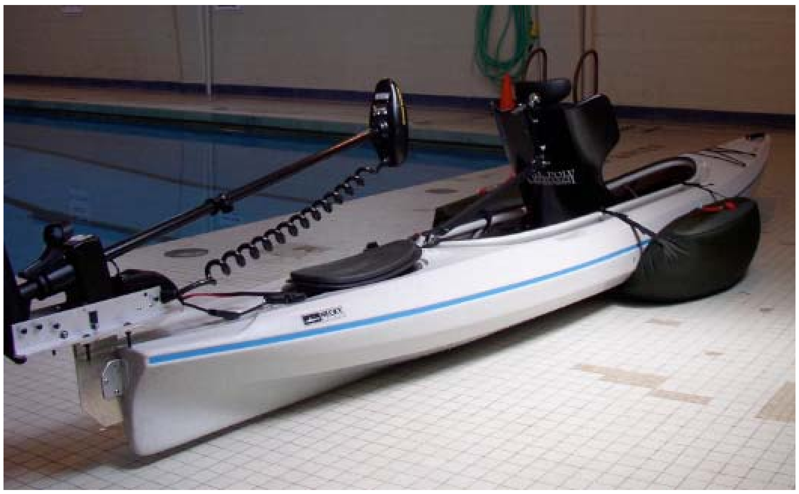

Figure 2. Adapted kayak.

A second project is the Universal Play Frame (UPF), Figure 3. The UPF is used by athletes in wheelchairs and with a limited range of motion to play games in which participation may otherwise be impossible. Having witnessed the power of play in terms of catharsis and a sense of empowerment, Kinesiology students and faculty are working with Mechanical Engineers to design toys for people with quadriplegia. Kinesiology students serve as "Project Managers" and collaborate with Mechanical Engineering students who design and build adaptations that are dreamed up by the Kinesiology students working in the Adapted Physical Activity programs at Cal Poly, San Luis Obispo.

The UPF is similar to the design of a commercial device that was taken off the market, but with many improvements. Different attachments are connected to the UPF to allow participants to engage in different recreational activities such as bowling, baseball, and soccer. Design requirements included being able to attach the frame to any commercially available wheelchair, allowing for different sizes of users, minimizing the force and displacement required to operate the different attachments, and keeping the UPF as light as possible to help with attachment and transport.

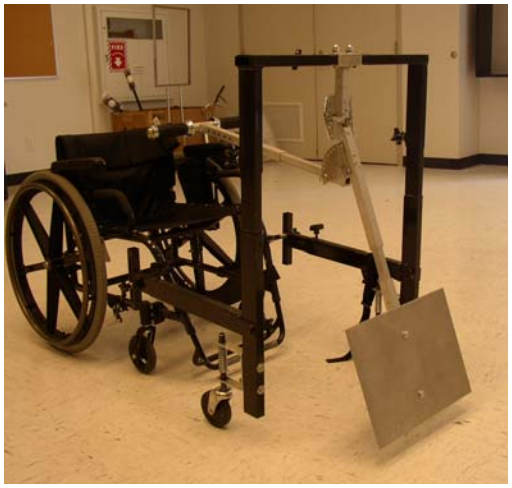

Figure 3. Universal Play Frame

The current version of the UPF can attach to all tested wheelchairs in under a minute using clamps that attach to both left and right sides of the wheelchair. Current design specifications for the latest prototype make it collapsible to a size of 36’’x36”x12”. All attachments are designed to be fully operable by a user with a maximal force output of 5lbs. and a 12” range of motion. Current attachments include softball/baseball, soccer, and golf, with plans for Frisbee golf, bocce ball, archery, basketball, floor hockey and paint ball. Each of these attachments can serve as another senior design project – a bowling attachment is currently being developed concurrently by a team at Cal Poly and a team at the Munich University of Applied Sciences.

Students from the Industrial Manufacturing Engineering have also joined the UPF team to examine the manufacturability and usability of the current UPF. They will also examine the performance, safety, comfort, ease of assembly, and durability of the frame. This further increases the interdisciplinary nature of the team and exposes Cal Poly students to a variety of different majors throughout the university.

One of the most successful service learning projects at Cal Poly is housed in the IME department. PolyHouse is the culmination of a project management course that requires students to apply their new knowledge to renovating the home of someone in the San Luis Obispo community, similar to the popular television show *Extreme Makeover: Home Edition*. Students must raise the funds for the project, make a budget and necessary purchases, create a timeline, and then actually work on the renovations over two separate weekends in May. They must included contingency plans in case of poor weather, organize different skilled volunteers, and assess the needs of the homeowner (Javadpour, 2005).

Conclusions

From anecdotal reports, students in design teams that are focused on service learning projects tend to be extremely motivated. Such projects help students develop ties to the community, realize ethical responsibilities of engineers, and can provide meaningful educational experiences for students. We are currently seeking ways to involve more students at Cal Poly in service learning experiences. The Honors Program is offering funding and student support for faculty engaged in service learning projects, and there is a university-wide effort to develop a service learning strategic plan. It is also imperative that we begin a more formal assessment process to verify that these projects meet educational objectives and determine if they truly affect student motivation.

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