SERVICE-LEARNING IN ENGINEERING

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Abstract — *Service learning is a pedagogy that integrates academic learning with community-based work. Service learning has been widely adopted within higher education nationally in many disciplines and offers engineering a compelling environment to meet many of the EC 2000 criteria that may be difficult to integrate into traditional engineering courses. There is also a growing case that service learning presents opportunities to attract underrepresented groups to engineering through the context of community-based projects. Despite the vast potential for service learning, engineering has lagged behind most other disciplines in the acceptance of this pedagogy. To encourage more widespread adoption of service learning within engineering, a panel session will present several successful models of engineering service learning and discuss the benefits and outcomes of the programs. This paper provides overviews of the participants' service learning programs along with contact information.*

Index Terms ¾community-based projects, design, multi-disciplinary teams, service-learning

INTRODUCTION

Undergraduate students in engineering face a future in which they will need more than just a solid technical background. In setting the goals for any system they are asked to design, they will be expected to interact effectively with people of widely varying social and educational backgrounds. They will then be expected to work with people of many different technical backgrounds to achieve these goals. They thus need educational experiences that can help them develop these skills. To meet these needs, engineering education has seen a significant increase in emphasis on experiential education and on the "soft skills" that engineering students will need when they enter the workplace [1,2].

Many engineering programs have turned to industry as a source of "real-world" projects as a context for such learning environments. This approach has been successful; however, community organizations also have a growing need for engineering solutions. Community service and education agencies face a future in which they must rely to a great extent upon technology for the delivery, coordination, accounting, and improvement of the services they provide. They often possess neither the expertise to use nor the budget to design and acquire a technological solution that is suited to their mission. They thus need the help of people with strong technical backgrounds.

Partnerships with the community have the benefit of incorporating service learning into the design experience. Although service learning has been shown to be an effective means of addressing the needs of engineering curricula [3], engineering has lagged behind many other disciplines in the integration of service learning into the curriculum [4]. This panel session will highlight successful integration of service learning into engineering curricula. Each program represented in this session is briefly described below and includes contact information.

EPICS – ENGINEERING PROJECTS IN COMMUNITY SERVICE

The Engineering Projects in Community Service (EPICS) enables long-term projects in which teams of engineering undergraduates are matched with community service agencies that request technical assistance. Under the guidance of faculty and industry advisors, these EPICS project teams work closely over many years with their partner community organizations to define, design, build, test, deploy, and support the systems the agencies need. The results are systems that have a significant, lasting impact on the community organizations and the people they serve.

Through this service, the EPICS students learn many valuable lessons in engineering, including the role of the partner, or "customer," in defining an engineering project; the necessity of teamwork; the difficulty of managing and leading large projects; the need for skills and knowledge from many different disciplines; and the art of solving technical problems. They also learn many valuable lessons in citizenship, including the role of community service in our society; the significant impact that their engineering skills can have on their community; and that assisting others

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leads to their own substantial growth as individuals, engineers, and citizens.

Each EPICS project involves a team of eight to twenty undergraduates, a not-for-profit community partner – for example, a community service agency, museum or school, or government agency - and a faculty or industry advisor. A pool of graduate teaching assistants provides technical guidance and administrative assistance.

Each team is vertically integrated, consisting of a mix of freshmen, sophomores, juniors, and seniors. Each team is constituted for several years, from initial project definition through final deployment. Each student may earn academic credit for several semesters, registering for the course for 1 or 2 credits each semester. The credit structure is designed to encourage long-term participation, and allows multi-year projects of significant scope and impact to be tackled by the teams.

Each student in the EPICS Program attends a weekly two-hour meeting of his/her team in the EPICS laboratory. During this laboratory time the team members will take care of administrative matters, do project planning and tracking, and work on their project. All students also attend a common one-hour lecture each week. A majority of the lectures are by guest experts, and have covered a wide range of topics related to engineering design, communication, and community service.

EPICS was initiated in the School of Electrical and Computer Engineering at Purdue University in Fall 1995 by Professors Leah Jamieson and Edward Coyle, with 40 students participating on five project teams. The program has grown steadily at Purdue both in size and breadth. In the 2001-02 academic year, 450 students participated on 25 teams, addressing problems ranging from data management for social services to mitigation of agricultural pollution and from designing learning centers for local museums to developing custom play environments for children with disabilities. EPICS spans engineering disciplines at Purdue and includes students from over 20 university departments. By 1997, EPICS programs were under way at the University of Notre Dame and Iowa State University; in 2000-01, programs were initiated at the University of Wisconsin-Madison, the Georgia Institute of Technology, and Case Western Reserve University; and in 2001-02, programs were initiated at Penn State University and Butler University.

Contact Information: for more information on EPICS, see the website http://epics.ecn.purdue.edu/

EPICS AT BUTLER UNIVERSITY

Butler, a small liberal arts University, joined the EPICS (Engineering Projects in Community Service) program during the Fall 2001. The EPICS program at Butler requires student participation in long-term non-for-profit software engineering projects. To-date Epics-at-Butler entails eight students, one faculty member and three affiliate non-for profit organizations. Students are required to participate in the EPICS program in order to receive a BSSE degree. Moreover, EPICS participation makes our students eligible for a four-year NSF scholarship.

Our early experiences with EPICS indicate that it is a perfect fit with our newly crafted software engineering degree. It facilitates the application of classroom knowledge to realistic projects *early* in the curriculum and thus it minimizes the gap between academic exposure and real-life experience. The program extends the benefits of an internship because it involves students at various levels for a long period of time.

Some key challenges during our first year of Epics-at-Butler include: (a) what is the best way to teach Epics (b) how to establish solid team structures (c) how to establish progress evaluation techniques (d) how to establish long-term continuity projects and (e) how to select appropriate software engineering projects for Butler students. Moreover, some of the early feedback we get from our students include: (a) they are excited to participate in something different than a traditional lecture-based course (b) they are not afraid to think "outside the box" (c) they appreciate meeting with actual customers and undertaking a realistic software engineering project and (d) they don't hesitate to take leadership roles in a team. Finally, feedback from our department entails: (a) early signs for promoting internal and external visibility (b) endorsement from our advisory board and (c) support from all faculty.

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THE ROLE OF THE INTERPROFESSIONAL EDUCATION CURRICULUM IN DELIVERING SERVICE LEARNING EXPERIENCES AT ILLINOIS INSTITUTE OF TECHNOLOGY

The IIT Interprofessional Projects (IPRO) Program is an innovative model for collaborative learning in higher education that adds value to the traditional specialized knowledge that students gain through a single discipline by stimulating student and faculty interaction across the boundaries of individual professions and disciplines. IIT's Interprofessional Project extends far beyond the traditional senior capstone or other single-discipline design experience, because the team is cross-functional "by design", focusing on a common goal with a complexity of technical and non-technical issues that are addressed by an integrated mix of students from across the university. This gives engineering and technology-oriented students a greater appreciation for non-technical considerations, while at the same time instilling in students of law, business and other professions greater insight concerning the process of research and technology development. There is a critical characteristic of this process that helps to distinguish the IPRO Program from many other student team project experiences. While the university provides a project team course platform with

associated learning objectives, it is a broad range of faculty members who commit to mentoring a team as lead faculty -- with colleagues often collaborating -- and who represent the full range of disciplines and professional programs at IIT, depending on the nature of the open-ended real-world projects that are proposed by sponsors, faculty or students themselves.

All IIT undergraduates must complete the general education requirement of a two-course, six-credit-hour IPRO project course sequence that organizes students from all disciplines and professional programs, and from sophomore through graduate level, into 60 cross-functional teams each year involving over 60 faculty and 600 students and numerous sponsoring organizations and mentors. Since 1995, the IPRO Program has grown and continuously improved through 259 IPRO team projects involving over 2,000 students, 100 faculty and 50+ organizations sponsoring one or more IPRO teams. Students enroll in IPRO course sections as they would any other course. They come from all disciplines and professional programs (engineering and science, architecture, design, law, business, psychology, and law and financial markets) and all levels (sophomore through graduate school), selecting an IPRO project course section depending on the needs of a project and the background and interests of students.

Many interdisciplinary IPRO teams over the past six years have focused on service learning projects, including opportunities for innovation in assistive technology (entertainment and training game software for those confined to wheelchairs, exercise equipment, guidance systems for the visually-impaired, a digital Braille watch), community economic development, community leadership development services, K-12 computing partnerships, reestablishing the rule of law in Bosnia, war crimes documentation in Kosovo, and improving access to justice for the self-represented litigant. For Fall 2002, IIT has organized two international service learning projects that will each span two semesters -- one is sponsored by the Tang Foundation focusing on China, while the other is sponsored by Rotary International and will focus on Latin America. In both cases, the IPRO teams will collaborate with students in-country.

Other service learning experiences are developing with an entrepreneurial focus. Through IIT's Ed Kaplan Entrepreneurial Studies Program, a new form of IPRO project has been created, the Entrepreneurial IPRO (EnPRO). An EnPRO satisfies all of the requirements of an IPRO, with the added dimension of creating a business plan. At the end of the semester, the EnPRO teams present their business plans and compete for seed funding based on the credibility of their work as presented to a special investor and entrepreneur review panel. As an example, an EnPRO project scheduled for Fall 2002 will provide an interesting service learning experience for our students involving the idea of an independent entrepreneur to create a suite of entertainment and training games for those learning to navigate a wheelchair through various environments.

As an extension of the IPRO Program, IIT is now formalizing its service learning experiences as a "pathway" within a new Pathways to Professional Practice Program, designed to augment students' traditional coursework. Students will have the opportunity to immerse themselves in special combinations of seminars and special IPRO project team coursework with concentrations in entrepreneurship, leadership, project management, research, service learning, teacher education and international experiences.

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SERVICE-LEARNING IN FIRST-YEAR COURSES AT THE UNIVERSITY OF SAN DIEGO (USD)

Service-learning has been incorporated into the first and second semester freshmen engineering classes at the University of San Diego (USD). In the fall of 1998 and 1999, first-semester engineering students worked with students in a science class at a local middle school with an economically disadvantaged and ethnically diverse student body[5]. Middle schools need to keep students interested in science and motivated to go to college, become technically literate, and possibly pursue technical careers. First-year engineering students need to learn about what engineering is, why it is useful to society, as well as skills such as communication and teamwork. The engineering students worked in teams to prepare a hands-on, fun, and educational activity. Their academic learning goals were to effectively communicate to a "real live" nontechnical audience, to creatively design and implement an activity, to complete a project as a team, and to deepen students' understanding of engineering related topics. Although some students were initially resistant to the idea of service-learning in engineering, after working with the middle school students, most college students were excited that they had done something worthwhile.

Since Spring 1999, second-semester freshmen engineers have participated in the e**N**gineering **I**mprovement in a **F**irs**T** **Y**ear (NIFTY) Design Project. In this project, students work in teams to create[6] or improve upon[7] computer-controlled electromechanical models of systems and provide full technical documentation by applying methods used by practicing engineers. Projects that students chose to build included a Ferris wheel, a slot machine, and a drawbridge. At the end of the semester, students present their projects to local high school science classes. The academic goal of this service-learning activity is to communicate effectively to an audience unfamiliar with their project. The high school students benefit by interacting with

college students who could encourage their interest in math, science, and engineering. The engineering students reported that this experience contributed to their learning and the presentation at the high school is often cited by students as one of the highlights of the semester.

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MAINSTREAMING SERVICE LEARNING IN REQUIRED UNDERGRADUATE AND GRADUATE COURSES

Over the last four years service learning has been integrated into nine different courses, eight of which are required for either a BS degree in mechanical engineering or an MS in solar engineering, at U Mass Lowell. The goal is to have every student in the respective degree program have at least some exposure to service learning. The service learning components of the courses range from a miniproject representing 10% of a large sophomore course to 100% of six credit course in design. The projects range from analyzing the kinematics and safety of children on local playground rides in a sophomore dynamics course to designing and installing microhydro systems in remote villages in the Andes of Peru. The course components are summarized in the Table I.

The following observations are made on the matching of service and course work in an attempt at learning on the part of students and the community and the instructors about engineering to help meet community ("customer") needs:

- It is a challenge to integrate both the subject matter objectives and the service objectives in a way that does not compromise course objectives.
- This challenge is also an opportunity for the instructors, the students, and the community to be creative.
- On average there appears to be a diverse (but on average clearly positive) opinion by students as to whether service and learning should be integrated into courses, based on four years of student questionnaires.
- The approaches used in this study are adaptable to other school types and levels, to other subject matter, and to other communities and climates.
- Basic attitude changes on the part of students toward citizenship and service to the community will probably take more courses over a longer period of time with more service-learning projects with more direct interaction with the community than exists in typical engineering programs at the present time.
- Service learning appears to be a viable means of integrating non-technical areas into engineering courses to meet required ABET objectives.

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TABLE I
SERVICE LEARNING COURSE COMPONENTS AT THE UNIVERSITY OF MASSACHUSETTS-LOWELL

Course	Service-learning component	% of course/grade	Hrs. per student	Assessment, reflection
Solar Systems Engineering (22.527)	Mini-projects: insulation, window analysis; house thermal design; PV design for radio communication in Peru	10% (required)	20	Report
Capstone Design (22.424)	Detailed house design; microhydro in Peru; vaccine refrigerators;	100% (voluntarily chose project)	250	Presentations, report
Mechanical Engineering Lab I (22.302)	Measure local river water quality parameters	10% (required)	15	Poster pres., report
Mechanical Engineering Lab II (22.403)	Design projects for thermal and mechanical tests for Habitat for Humanity (HfH) houses	30% (must choose 1 of 5 projects)	45	Presentation, report
Solar Fundamentals (22.521)	Mini-project: solar gain in HfH houses; solar water pasteurizers	10% (required)	20	Report
Manufacturing Systems (22.573) (elective course)	Experiments and analysis for reliability of remote solar systems	+5% (extra credit assignments)	10	Report
Design of Energy Systems (24.504)	Design of solar hot water and crop drying systems	100% (voluntarily choose project)	180	Presentations, report
Dynamic Systems (22.451)	Anal. of thermal response of an aquaculture tank; vaccine refrigerator controllers	10% (required miniproject)	20	Report
Kinematics (22.213)	Analysis of safety of playground rides	10% (required miniproject)	20	Report, class discussions

SERVICE LEARNING AT MIT

Service learning at MIT started in 2001 as a joint enterprise of the MIT Public Service Center and the Edgerton Center, an interdisciplinary center that focuses on hands-on learning. This partnership has enabled us to develop our program quickly and effectively. We are working in several areas simultaneously as we create models for community service learning that fit into MIT's culture and mission.

Public Service Design Seminars (PSDS): The PSDS are dedicated service learning seminars, intended to teach technical subjects in a hands-on, design-and-build manner, using service projects as a tool to improve understanding of community issues and context analysis for engineering projects. The first PSDS was offered last spring; this semester, we are teaching four PSDSs that focus on different technical aspects and community needs, including health technologies for developing countries, electronic learning tools for autistic children, and web-site development for non-profit organizations.

Freshman Advising Seminars (FAS): Since FAS are focused on creating a welcoming environment for incoming freshmen, they typically center on topics of faculty interest that freshmen also may share. A service learning approach seems particularly appropriate for these seminars, and we successfully incorporated service learning into four seminars this past fall. Surveys indicated strong satisfaction with the results, and we intend to expand this approach for next year's incoming class. Establishing service learning in freshman seminars has many potential benefuts, including improved faculty-student communication, a greater sense of community, and familiarity with service learning as a basis for other classes.

Integration into existing classes: So far, MIT faculty have been extremely receptive to the idea of incorporating service learning into their established classes; incentive and materials grants have supported the revision of several classes to include service learning projects. Last year, six service learning writing classes were offered, and this term, four engineering and management classes have been recruited to follow suit.

Service Undergraduate Research Projects (UROPs): We're tapping into MIT's strong undergraduate research tradition as a means to offer additional service opportunities for MIT students and to enable students to complete projects that they start in PSDS and other service learning classes. Students with service UROPs work with their supervisors and with community partners to create or finish projects that address community needs.

IDEAS Competition: The acronym stands for "Innovation, Design, Enterprise, Action, and Service," and the competition was launched at the beginning of the spring semester. The IDEAS competition encourages student teams to develop designs, plans, strategies, materials or products that address community needs while working with

TABLE II
EXAMPLES OF SERVICE LEARNING PROJECTS AT MIT

FRESHMAN ADVISING SEMINARS

Instructor	Seminar	Project
Marty Culpepper Ken Stone	2.A32 Product Design (What It's All About)	Designing and manufacturing toys to be distributed through the Codman Square Health Center
Katie Livingston-Vale	SEM.131 Introduction to Educational Media	Creating web pages to help students at the MATCH school study for the MCAS exams
Robert Redwine	8.A15 Nuclear and Particle Physics: We Still Don't Understand a Lot of Things	Designing and building classroom demonstrations for teachers at Cambridge Rindge and Latin High School
Amy Smith Sally Susnowitz	SP.763 Women Working To Help Women	Designing and building furniture for the Women's Lunch Place shelter

PUBLIC SERVICE DESIGN SEMINARS

Instructor	Subject	Project
Toby Bashaw	SP.774 Welding	Grain mill for the Hopi reservation in northern Arizona and/or villages in rural Kenya. Charcoal kiln for villages in rural Ghana
Jim Bales	SP.771 Practical Electronics	Learning tools for autistic students at the Protestant Guild Learning Center
Andrew Nevins Eric Traub	SP.772 Internet Technology in Local and Global Communities	Web-based tools for community organizations such as T.H.E. Brain Trust and the MATCH School
Amy Smith Amy Banzaert	SP.773 Health Technologies for the Developing World	Low-cost unit for transporting and storing vaccines in developing countries

community partners, locally, nationally or internationally. Competitions thrive in MIT's entrepreneurial culture, and thus a competition is an effective way to focus MIT students' energy, allowing them to complete projects begun in their classes or pursue original ideas that solve community problems. Over one hundred students participated in the competition in its first year.

Service learning support systems: We are beginning to establish information resources in the form of web support, print information resources, and a workshop series for faculty and community partners. In addition, we are creating a project and community partner database to facilitate involvement from MIT faculty and students.

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PROCEED (PROGRAM FOR COMMUNITY ENGAGEMENT IN ENGINEERING DESIGN)

ProCEED is a student organized program (the Mechanical Engineering Honorary Society, Pi Tau Sigma) that brings together community based projects with engineering students through their capstone design courses. Groups of 3 to 5 engineering students work closely with project sponsors and the instructors each semester (for approximately 4 months) on individual projects and take them from concept to physical models (prototypes).

Through the use of community-responsibility lectures in ME450 and through designing a community project, students learn the personal satisfaction that comes from helping the community in a meaningful way. Students also gain knowledge of the civic responsibility they have to "give back" to the community. Our assessment shows a greatly increased appreciation for community service even among students not directly working on ProCEED projects.

ProCEED is also aimed at educating the community about the role of engineers in society. The role of medical and legal professionals in the community is very clear to most individuals. The community understands this type of service through the widespread publication of these professions through popular television programs. The same circumstances are not so for the engineering profession. Rarely, if ever, is the same sort of attention paid to the practicing engineer. Hence, the role of ProCEED was also an engaging, community program aimed at teaching the community about the role of engineers and the work they perform.

The program is unique since volunteer student solicitation and consulting with community organizations impacts a required course in engineering design. It is a program maintained by students for students. This unique implementation of the program allows student to take an active role in contacting the community as well as an active role within the department. Students take the lead in the success of the program and learn to be involved with the department. This activity fosters teamwork as well as the abilities needed to become strong group leaders.

The majority of the students are Mechanical Engineering students and nearly all are seniors. Recent interdisciplinary projects are made possible by faculty from other disciplines through independent study courses and their design courses

Contact information: web site for program: http://www.engin.umich.edu/soc/pts/ProCEED/, William W. Schultz, The University of Michigan, Dept. of Mechanical Engineering, 2027 Auto Lab, Ann Arbor, MI 48109-2121, (734) 936-0351, Email: schultz@umich.edu

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