A Service Learning Program for CSE Students

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Abstract - **We describe a service-learning program within the CSE department at the University of Notre Dame. Started in 1997 as the first affiliate of the Purdue EPICS program, this service-learning program involves volunteer faculty-mentored teams of students applying engineering skills in local, national, and international consulting projects for various community, educational, and not-for-profit organizations. Student-led teams, functioning as small engineering consulting firms, participate in identifying and selecting potential consulting engagements followed by the delivery of solutions to those clients. We describe 1) our unique adaptation of the EPICS model 2) supporting resources, and 3) a review of computer science centric education in multidisciplinary service engineering projects. The practical considerations of real world project management, client interaction, and liability are discussed in correlation with recent service projects undertaken by the students. Advice for interested educational institutions for developing their own engineering service learning program is presented.**

Index Terms – Active-Collaborative Learning, Experiential Learning, Computer Science and Engineering, EPICS, Multi-Disciplinary, Project Management, Service-Learning,

INTRODUCTION

A service-learning program in the Department of Computer Science and Engineering (CSE) at the University of Notre Dame is described. The program started in Fall 1997 as the first university affiliate of the Purdue EPICS program (Engineering Projects in Community Service) [1-6].

Service learning is an educational philosophy in which students learn through active engagement with the community. This concept of learning is not new; it was described by Dewey, an early proponent of learning by reflecting on one's experiences [7]. Kolb extended Dewey's ideas on experiential learning with a learning model known as the Kolb Learning Cycle [8], comprised of four stages: concrete experience, reflective observation, abstract conceptualization, and planning. The first three stages (and occasionally the fourth) are often formally included in service-learning programs (i.e., concrete experience, followed by a structured reflection process, that then leads to learning by abstract conceptualization) [9-11].

EPICS at Notre Dame, was originally centralized within the dean's office of the College of Engineering. Faculty from several engineering departments volunteered, on a teaching overload, to mentor EPICS teams, with the greatest and most consistent level of activity existing in the CSE and Civil Engineering departments. After several years, the college decided to decentralize the program, since the bulk of the activity was in a few departments. The rest of this paper will focus on the service-learning program in CSE, but we note that most of the teams include some students from other engineering departments. In 2005, 4 CSE faculty (2 regular faculty and 2 graduate student instructors) mentored EPICS teams, summing to about 35 students/semester.

The primary technical skills used by students include 1) database design and programming, 2) network design and analysis, 3) design and implementation of web-based information systems, 4) computer system configuration and support, 5) computer-assisted design (CAD), and 6) general principles of engineering design. Skills needed on these projects go beyond those learned in traditional classes and are often acquired through student-led tutorials. Clients include environmental agencies (e.g., water quality databases), service agencies (e.g., homelessness, regional autism center, substance abuse, women's shelters, and low cost housing agencies), not-for-profit corporations (employment for the handicapped, computer recycling for the needy), and schools. In addition to both 1) learning the importance of giving back to society, and 2) learning and applying practical engineering consulting skills, the students are 3) learning skills that may serve them in a global economy where distributed, self-managing engineering teams must deal with diverse cultures and extremes of technology adoption. In addition, some of the projects have spurned interest in entrepreneurship as users and observers convince the students that their solution may be a marketable product or service.

PROGRAM CHARACTERISTICS

I. Program Organization

In order to provide maximum flexibility, the Notre Dame College of Engineering has adopted a decentralized administration structure for the engineering service project courses. Each department is given the opportunity to design and instruct the service-based courses with a simple format for the issue of academic credit. While coordination of credit was simple in a college-based program, the decentralized strategy has led to some minor interdepartmental coordination regarding the application of the course credit toward the degree for a non-CSE student. Students have also chosen to take the course beyond their degree requirements, as they have a strong interest in either community service, or the project itself.

A typical participating CSE student registers for 1 credit hour per semester starting in their sophomore year, and may combine 3 of these academic credits for application toward one engineering elective course and another 3 credit hours toward a CSE elective. The extension of the student's involvement over multiple sequential semesters provides essential project continuity and team memory within the project teams and their client contacts. The students benefit from increased flexibility with respect to their academic course load. One of the goals of the program is to get students involved, and to keep them involved throughout their academic career. Last semester seniors are often disallowed from joining teams for the first time, as a single semester of participation often does not give the student enough time to come up to speed to become productive contributors to the project.

The structure and instruction of individual projects is the primary responsibility of the instructor, and oversight is performed by the departments and college at respectively increasing levels of abstraction. CSE EPICS teams consist of 5 to 25 students. Each team is organized as though it were an engineering consulting firm. The students are responsible for identifying, selecting, and delivering on their "consulting engagements." For the larger teams, several client projects may be served in parallel with team members moving between projects to meet work demand and while some projects have slow periods. Each sub-team that services a particular client has their own project meetings, work sessions, and visits to the client. The entire team meets weekly, providing status reports, plans, presenting problems, new consulting opportunities, and technology tutorials. These "all-hands" meetings enable students on the sub-teams to stay abreast of the status of the other projects should they be needed to move over to meet work demands on other projects. A larger team, working on several service-learning projects, may be organized as shown in Figure 1. The faculty mentor may be assisted by 1) a student coordinator facilitating inter-team activities and 2) a student media-manager responsible for documentation, project web sites and posters.

Individual students are typically expected to keep a semester journal of activities and reflections on those activities. An end of semester report documenting 1) their contribution to the project, 2) their personal learning experiences, and 3) a formal reflection on their service experience is generated by each student. This final report, including the formal reflection, contributes to the learning of their service-learning experience [8-10, 12].

II. Grading

Since the students register for credit (typically 1 credit hour per semester) a grade must be determined and assigned to each student. Much of the work is done independently by the students, so the faculty mentors generally treat the EPICS courses as they would an independent study course, and primarily assign grades to the team based on outcomes. Individual grades are derived from the team grade, peer- and self-evaluation, feedback from the client, evaluation by the student team leaders, and evaluation by the faculty mentor of student's participation (when directly observed). Peer evaluation factors include: work as meeting-manager, technical contribution, task contribution, leadership, teamwork, tutorials and presentations, and an overall evaluation and ranking. In most cases, the public-service agency partner will be asked for their input on student performance. Because the students often work closely with the agency contact personnel, these individuals often have insights into the student's activities that are overlooked by the team faculty advisor.

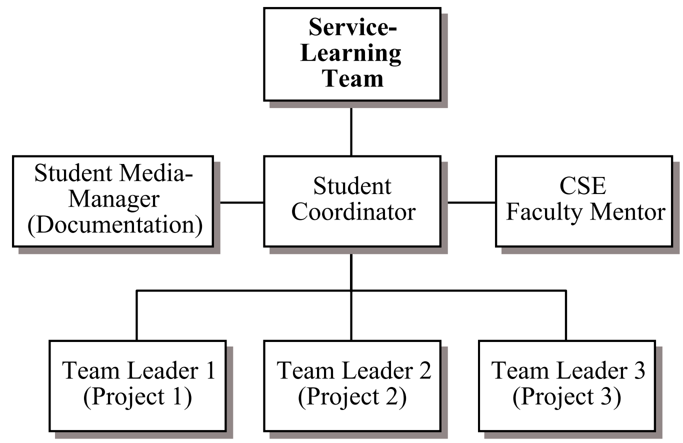

FIGURE 1
A TYPICAL LARGER SERVICE-LEARNING TEAM WITH SEVERAL PROJECTS

III. University and College Resources Supporting Service-Learning Projects

The University of Notre Dame has social service at the center of its foundation. For example, in a section of its mission statement, the University of Notre Dame states: " … *the University seeks to cultivate in its students not only an appreciation for the great achievements of human beings but also a disciplined sensibility to the poverty, injustice, and oppression that burden the lives of so many. The aim is to create a sense of human solidarity and concern for the common good that will bear fruit as learning becomes service to justice*." [13] Reflecting this component of the university mission, over 80 percent of the student body performs some type of social service during their undergraduate studies [14]. An organization serving the entire campus, The Center for Social Concerns, is the "*service and community-based learning center of the University. [It] invites students, faculty, staff and alumni to think critically about today's complex social realities and about their responsibilities within them. The Center does this in collaboration with academic departments throughout the University as it sends students out into various service and experiential learning placements."* [15] This campus resource, the Center for Social Concerns, supports, promotes and publicizes service-learning opportunities on campus, including the CSE EPICS projects. Staff at the Center assist faculty mentors and student team leaders with identifying agencies that may have technology needs and thus be a candidate service-learning site for the CSE EPICS teams. The Center also provides transportation for trips to service sites. As the University actively promotes student service there is also significant infrastructure in place to aid instructors with administrative questions such as policy, safety and liability. The College of Engineering has an "open learning center" with computers, tools, workbenches, and meeting areas for project teams to meet and work. The CSE department provides an EPICS workroom within a laboratory, with computer workstations and servers, software, manuals, and a work area.

COMPUTER SCIENCE CENTRIC

Essential to the success and academic suitability of an engineering service project is a firm basis in engineering fundamentals. Although students can join projects administered by engineering departments other than their own to broaden their technical education, every attempt is made to make sure that the projects are tailored to the expertise of the instructor and academic field of his or her own department. Weekly project design meetings are supplemented with both student and instructor led tutorials such as an overview of the web programming methodologies (e.g., PHP, XML, Cascading Style Sheets) used on a project, or the cost efficient design of an e-technology solution.

Within the authors' department of Computer Science and Engineering, recent projects have ranged from designing web based databases for hydrological test data, to computational infrastructure consultations, to the design of mobile computer training facilities for deployment in impoverished international communities.

One of the EPICS faculty members has mentored teams that have ranged in size from 10 to 25 students. Projects have included a distributed database system for the Homelessness Prevention Network (a joint project with a Purdue EPICS team), Habitat for Humanity of St. Joseph County (databases for tracking inventory, tools, and donors), toys redesign for handicapped community members (for the Logan Center of St. Joseph County), an IT Strategic Plan for the Montessori Academy of Edison Lakes, a web-based information systems for the Michiana Regional Autism Center, and a National Habitat for Humanity survey and database system in conjunction with several other EPICS university teams.

Another faculty member in the CSE department mentors an EPICS team that is currently working on a hydrological database to track the quality of the water of the Saint Joseph's river as it flows through the communities of Elkhart, South Bend, and Mishawaka Indiana. The City of Elkhart's Department of Water Works has been the primary "customer" for this project. The students have worked closely with the City of Elkhart to design, implement, and tune a database application for the municipalities to collect, archive, and analyze chemical and biological agents found in the river.

The initial database solution was presented to the customers in 2003, and the students are currently completing a redesign and re-implementation of the database in order to meet the escalating needs of the partner agencies. The initial version of the application made the assumption that all of the chemical and biological agents would come from point sources. New legislation, as well as agency interest in non-point sources, has the students working on improvements to the application. Current and future work planned for the project includes the addition of interactive mapping and visualization of the data, as well as the addition of code to allow tracking chemical and biological entities that enter the watershed via non point source sources.

A third EPICS team focuses on the design of mobile computer training and Internet access facilities for third world and disaster stricken communities. Team members work with a client who is providing the computer assets and components which will be packaged as a kit for retrofitting locally procured buses. Shipment will be in tandem with food goods already in route via another nonprofit organization with whom we are partnering. The students are evaluating the cost and practicality of varied "kit" designs. It is not difficult to see how this project although computer technology centered requires substantial multidisciplinary support. We discuss this briefly in the following section.

MULTIDISCIPLINARY PROJECTS

Many of the engineering service projects are focused on engineering design as opposed to engineering research and development. As engineers we soon learn that successful designs must integrate with the environment within which they will operate. To provide this integration, however, engineers must be able to identify environmental factors that would often fall within the academic bounds of other engineering disciplines.

The mobile computer-training facility design provides a good case study. Traditional mechanical engineering skills are required with respect to anchoring the workstations, isolating vibrations, and cooling the training space. Traditional electrical engineering skills are in need to evaluate the power consumption requirements and estimate the generator and conduit costs. In addition, students are performing all of the geometrical coordination and drawings via AutoCAD, a skill subset for technical draftsman and designers.

Our nonprofit client does not have the budget to hire additional consultants at this stage in the design phase. Fortunately this multidisciplinary project team includes mechanical and electrical engineering students. The instructor has the ability to consult with other faculty with discipline specific expertise, and in this particular case the team's faculty mentor choose to advise this project team because of his multidisciplinary industry experience and his licensure as a Professional Engineer.

However, even the perfect mix of advisor expertise and student's academic experience does not permit a full production ready design. These practical limitations are discussed in the general case in a later section titled Practical Responses to Liability.

HANDS ON PROJECT MANAGEMENT

One of the additional benefits to engineering service projects is the opportunity for students to experience dynamic project management challenges with respect to an engineering design. Although in a purely academic exercise, an instructor can simulate "surprise" client requests or budget limitations, a simulation does not replace having a real client email or call your team leader and change their design goals due to budget fluctuations, just when the team believed they were nearly complete with the design. During a recent design presentation, students on one of the teams were surprised by recent security changes on the client's systems. The students had planned to deploy a binary installer on the client systems to install their project code. The head of the client's information technology group pointed out that this was not an option. The students had to re-design the application to rely on off-site servers before the final project code could be delivered to the customer.

In addition to the experience of dynamic adaptations, the student team leaders also get the opportunity to manage their team's progress, work schedule, and individual talents and personalities. Team leaders are expected to prepare for their succession, should they be ready to graduate or complete the EPICS program (3 semesters is a natural breakpoint associated with satisfying a technical or CSE elective.),

CHALLENGES TO SERVING CLIENTS

As an instructor it is important to make sure that the needs and behavior of the client do not obstruct or distract from the goal to provide the students with discipline specific engineering skills, i.e., the learning in service-learning should not be secondary to the service aspect. Therefore the instructor must be ready to step in and re-center the relationship with the clients. Although most clients are grateful for the engineering services we are providing, it is human nature to occasionally disregard the professionalism and time investment of consultants that you do not have to pay for. Of course in fairness, the clients may at times feel that the student teams are less responsive due to the fact that they are working for free and producing results on par with a one credit hour commitment.

Another challenge is associated with the fact that many social service agencies (the majority of the service-learning clients) have very low-tech needs. Old donated computers running Windows 95 (in 2005) are often the norm in some of these organizations. Also, the computer literacy of the staff at the service agencies is often limited. On one hand, it is easy for even a sophomore computer science major to contribute assistance to the agency, but on the other hand, the lower technical complexity of the project may raise questions among peer faculty about why credit is being earned and what learning is actually taking place. The service component, the service-learning concepts, the educational theories under pinning service-learning, the principles of Computer Scientists for Social Responsibility, the digital divide, and the mission of the University of Notre Dame help with these concerns.

PRACTICAL RESPONSES TO LIABILITY

Despite one's best intentions to perform a voluntary selfless service in support of their community, there are significant and important practical concerns with respect to liability. An errant calculation could cause material loss or injury not only destroying all original intents to better our community but opening the door for large financial losses in litigation.

As instructors and educators we pay chief attention to these additional concerns which result from engineering in the "real world" as opposed to purely academic exercises. It is important that both the project teams and the clients understand that the work and final products presented by the team may only be taken as design estimates and the client retains full responsibility if he or she was to take steps to implement a design without consultation from a licensed engineer or insured consultation firm.

Under these auspices our teams and instructors provide services such as database design without any license or guarantee. Consultations regarding computational infrastructure are for the client's utilization for initial planning and estimation purposes not for purchasing and implementation. Similarly calculations of computer workstation power requirements used to size the mobile training center's generator are for cost estimation and feasibility analysis only.

Because all of the Notre Dame EPICS projects are encapsulated within the standard for-credit course structure, the students, instructors, and the university receive risk coverage provided by the university's in-place insurance policies. On a few projects (e.g., those that involve AC rewiring on appliances for the handicapped), the university's Office of Risk Management is available to provide training, inspections, and additional liability waivers for both the students and the community agency.

ADAPTING AND INTERNALIZING SERVICE LEARNING

The EPICS program at Notre Dame started as the first affiliate of the EPICS program at Purdue University. As such, the early EPICS program at Notre Dame was strongly patterned after the program at Purdue. Key features included centralized coordination of all EPICS courses in the college of engineering, projects often embedded in 3 credit hour courses, efforts to include existing capstone design courses in EPICS, and exploratory participation from most engineering departments. Due to dissimilarities in the curriculum, sizes of the respective universities and colleges of engineering, and pre-existing service programs, the program at Notre Dame evolved with a different character from the program at Purdue.

Research in the area of organizational studies [16, 17] suggests 1) that programs that grow and prosper in one institution often cannot be easily transplanted into another organization, and 2) the when new ideas, such as the EPICS service learning program, are introduced into other institutions, they will be adapted and modified in ways that are relevant in the new institution. Differences in institutional culture and governance, differences in the student body, and differences in the character of the institution all can influence the nature of a successful service-learning program. Some such differences that make the Notre Dame and Purdue experiments with service learning different include size, role of engineering education in the institution, and pre-existence of service-learning opportunities at the institution. At Purdue, engineering education is a primary focus within a large state land-grant school, while at Notre Dame engineering is taught in one of the smaller colleges of a private mid-sized university where liberal arts education is a primary focus. This has implications for the potential of achieving a critical mass needed for a new service learning initiative to catch on and sustain itself; the pool of engineering faculty and students is much larger at Purdue permitting a critical mass of service-learning engineering faculty and students to emerge in more departments at the university. On the other hand, the EPICS program began at Notre Dame with a smaller pool of engineering faculty and students to draw on and with many pre-existing service and service-learning programs in place. Thus EPICS at Notre Dame had to complete for student and faculty participation with pre-existing more established service-learning programs. This may partly explain the focused character (primarily in the CSE program) at Notre Dame.

While the EPICS teams at Purdue, especially those originating in the ECE and ME departments, generate physical artifacts, this has generally not been the course followed by the EPICS program at the University of Notre Dame, where the critical mass of participating faculty as emerged in the CSE department. The projects taken on by the EPICS teams within the CSE department tend to be software-oriented solutions. The students produce computer software, web-based information systems, or database applications in lieu of physical artifacts.

Another major difference between the program at Purdue, and the program at Notre Dame is the extent of support the programs receive from their respective institutions. At Purdue, the EPICS program has grown from support by a single department, to college-level support, and now to university-wide support. At Purdue, the president of the university is a strong and vocal supporter of the program. Faculty are given teaching credit for their participation, and junior faculty have cited their participation in the program as proof of community involvement in documentation for promotion and award submissions. At Notre Dame, faculty participation is a voluntary teaching overload, and is not encouraged for junior faculty.

Other institutions need to look at service-learning programs such as EPICS, and contemplate how these offerings could be institutionalized at their location. The programs should be allowed to start small, and grow naturally to a sustainable level. Attempts to artificially grow the program, or push it onto unwilling students, faculty, and administrators may doom the program to failure.

RECENT PROJECTS

Some recent CSE service-projects at Notre Dame follow.

Heritage Foundation Database – This database allows room scheduling, invoicing, generation of liability forms, room setup information, room confirmation, and recurring schedules. Tasks accomplished include implementation of a web interface, and network accessible such that multiple users have concurrent access.

Center For the Homeless Volunteer Database – This group created a database to track and log volunteer hours at the Center for the Homeless. The input comes from a barcode reader and touch screen monitor placed in the lobby of the Center.

St. Joseph River Project – This EPICS group works on the creation of a web-based data entry system to serve as a mechanism for the storage and retrieval of measurements and readings used to monitor the changing water quality of the St. Joseph River as it flows through these three cities on its way to Lake Michigan.

Homelessness Prevention Network – Primary task was to establish a database of information that will be shared by the customer agencies: The Life Treatment Center, The Hope Rescue Mission, and the Center for the Homeless. By sharing information, the client agencies can more quickly and conveniently develop a common and coordinated plan to help individuals to see more clearly the causative factors in their lives (or life styles) and to deal with them with courage, and with assistance from the agencies who serve them.

National Habitat for Humanity Project – Students are contributing web-based reporting software for a Habitat for Humanity-National database project. The project will develop tools for the Habitat organization to track donors, and other information related to the mission of Habitat. This is a collaborative project with EPICS students from Purdue and the University of Wisconsin. The Notre Dame EPICS team is using Crystal Reports to generate the web-based reports.

Toys Group – This project involves the redesign and adaptation of toys and other electrical powered items for use by the therapists at the Logan Center. With the modified items, the therapists will be able to work more effectively with the mentally and physically challenged youth.

St. Margaret's House, Women's and Children's Center – This is an architectural design project for open unused space at the center. Project uses AutoCAD design tool and developed cost estimate and material lists. Additional software support projects are anticipated.

Logan Industries – This project includes design tasks for the Logan Industries packaging and assembly facility (non-profit work opportunities for the handicapped). Additional software support projects anticipated.

Computers for All / Feed the Children – Students are generating designs and specifications for a computer training bus modification kit to be sent to Sri Lanka for tsunami aid.

Autism Center of Michiana – Students are designing and developing an interactive website and web-based information system providing resources for parents of autistic children. The web-based information system serves as an informational tool, both locally and nationally, and a search vehicle to identify the population of individuals (estimated to number about 2000) with autism in the Michiana region – North Central Indiana and Southwest Michigan.

Montessori Academy Project – This project provided analysis and design of the school's strategic technology plan. As part of the requirements and analysis activity, students provided technology support for computers, software, and networking.

CONCLUSIONS

This paper describes service-learning courses based in a CSE department. The character of the program is influenced by its association with the Purdue EPICS program (over 8 years at the time of this report), the concerns for social justice promulgated in the mission of the Notre Dame, existing service programs, the size and role of engineering education at the institution, and the fact that a critical mass of participating faculty and students emerged in CSE.

The students develop skills in 1) project management, 2) customer relationship management, 3) database design and programming, 4) network design and analysis, 5) design and implementation of web-based information systems, 6) computer system configuration and support, 7) computer-assisted design (CAD), and 8) general principles of engineering design. Many of the skills needed on their projects go beyond the scope of traditional classes and are often acquired through student-led tutorials. Clients include environmental agencies, service agencies, not-for-profit corporations and schools. Students learn the importance of giving back to society, learn and apply practical engineering consulting skills, and learn skills that may serve them in a global economy.

The challenges of implementing such a CSE service-learning program include: 1) adapting the models described in the literature (e.g., the Purdue EPICS program, the Notre Dame experience) to the local organization, 2) generating a critical mass and momentum of participating faculty mentors and students, 3) acquiring supporting resources (e.g., identification of partner agencies, computing workstations and servers, meeting and work spaces, supporting software), 4) managing the community partners' expectations, 5) managing the legal and liability risks, and 6) measuring, documenting and communicating the *student learning* in the service-learning projects that is taking place to peer faculty and administration.

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