2006-2614: IMPLEMENTING SERVICE LEARNING IN ENGINEERING CURRICULUM

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Implementing Service Learning in Engineering Curriculum

Abstract

Service learning is a pedagogy that provides students with structured opportunities to learn, develop, and reflect through active participation and thoughtfully organized community involvement. It enhances the academic experience of students by relating academic content and course objectives to issues in the community.

Community engagement through service learning has become a well-established education approach in liberal arts and science education. While engineering education seems like a natural fit, community engagement through service learning with very few exceptions is not integrated within the engineering curriculum. To provide hands-on educational experience, traditionally, engineering schools have developed partnership with industry through various programs such as internships, co-operative education and sponsored research. However, implementing a sustainable model of service learning in engineering is very different from industry-based education, and faces serious challenges.

Cal Poly Pomona has recently established an Engineering Service Learning Institute (ESLI) with NSF support to integrate service learning in engineering curriculum. This paper focuses on service learning as an effective pedagogy to provide authentic learning experiences, discusses the projects implemented at Cal Poly Pomona and the engineering service learning course content.

Introduction

Community-based Service learning[1-7] is a pedagogy that provides students with opportunities to learn, develop, and reflect through active participation and thoughtfully organized community involvement. It enhances the academic experience of students by relating academic content and course objectives to issues in the community.

The concept of service learning is not new and it has been in use in various forms especially in liberal arts and education. Traditionally, engineering has been engaged with the community beyond the campus boundaries through technical assistance programs, university extension, and work of individual faculty serving as consultants to local community organizations. However, the community engagement is usually not systematically integrated within the engineering curriculum. Most programs tend to be focusing more on a student's professional development, rather than on their becoming socially responsible engineers who are prepared to address the needs of increasingly complex societies and communities using contemporary technologies in a cost-effective way.

In the recent past there has been a noticeable push to adopt service learning in engineering[8]. Purdue University[9] developed an innovative program that creates partnerships between teams of undergraduate students and local community not-for-profit organizations to solve engineering-based problems in the community. This partnership provides many benefits to the students and the community alike. California State University system has 23 campuses and all CSU are

committed to ensuring that all students have the opportunity to participate in service before they graduate. Currently, more than 185,178 CSU students are providing service in California communities. Cal Poly Pomona, one of the 23 CSU Campuses, and its College of Engineering recently received an NSF grant to establish an *Engineering Service Learning Institute* (ESLI) to develop a plan for college-wide implementation of service learning.

Constructivist Teaching Model and Authentic Learning Experiences

The predominant pedagogical model today is based on a teacher-centered, didactic approach to instruction. This is mostly due to the fact that educators, parents as well as administrators have never encountered a learning experience in which they constructed meaning from the experience.

Authentic learning approach to teaching based on constructivist[10-15] model is very different from the traditional model. Constructivist approach to learning and teaching is based on the notion that learners construct their own knowledge rather than knowledge being transferred into learner's brain. Learner's construction of knowledge is based on their past knowledge, the timeliness of new knowledge, and the learner's ability to understand the connections. This process forces learners to either modify existing knowledge or develop new ones.

Such learning experiences, which occur under actual conditions, while engaging learners is termed as Authentic Learning Experience[16]. Authentic learning as an instructional strategy is based on the principles of constructivism and provides one of the most effective ways to actively engage the students in the learning process.

To implement an effective authentic learning environment based on constructivism, Jonassen's[17] eight general characteristics of Constructivist Learning Environments can be used as a guideline. The summary of these characteristics are:

* Constructivist learning environments provide multiple representations of reality.
* Multiple representations avoid oversimplification and represent the complexity of the real world.
* Constructivist learning environments emphasize knowledge construction instead of knowledge reproduction.
* Constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context.
* Constructivist learning environments provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction.
* Constructivist learning environments encourage thoughtful reflection on experience.
* Constructivist learning environments enable context and content dependent knowledge construction.
* Constructivist learning environments support collaborative construction of knowledge through social negotiation, not competition among learners for recognition.

While teaching approaches may utilize some of the above mentioned characteristics but effectively achieving the integration of all core characteristics is possible only by a well-thought

out and properly implemented instructional strategy. Our experience in service learning reveals that service learning by its nature can provide authentic learning experience.

* Authentic learning strategy invariably involves the learners in activities that deal with a real-life problem.
* Service learning involves real people in real time, and therefore, it contains certain elements of drama and dilemma, just like in real world.
* In service learning projects, content knowledge usually is embedded in the situation in which it is used.
* In service learning, students are not usually given engineering specifications to start with (as opposed to class projects or even industry based projects). This unstructured environment enables the learners to construct new knowledge using their old knowledge and their interaction with community partners.
* Construction of knowledge is accomplished through the completion of the project.
* Clearly service learning projects have value beyond classroom which is an important requirement for authentic learning.
* Service learning projects are personally meaningful and fulfilling.

Thus service learning projects, in general, have the potential to provide authentic learning experience. By carefully planning using the basic premises of constructivism, service learning can be effectively used to provide authentic learning experiences.

Integrating Service-Learning into Engineering Curricula

At Cal Poly Pomona, a central administration hub called the "Engineering Service-Learning Institute" (ESLI) was proposed within the College of Engineering to provide managerial, development, collaborative and logistic support to service-learning based curricular activities. It helps perform a realistic analysis of fiscal impact, resource needs and local constraints.

ESLI works closer with faculty and supports the faculty-led Curriculum Committee to develop an academic infrastructure for service-learning courses. This involves developing a protocol for reviewing and approving service-learning courses including credit units and an offering schedule. A lower-division life-long learning course for all engineering majors is currently under development and is being designed to increase students' awareness of citizenship and social responsibility via service-learning activities. The primary service-learning experiences that students are expected to receive will be from a year-long multidisciplinary engineering project. At Cal Poly Pomona, special sections of the existing Project Design Principles and Applications course have been offered to accommodate service-learning projects in terms of academic credits. An expanded course outline has been developed to clearly address the course objectives, service-learning requirement, multidisciplinary nature and teamwork, course outcomes, reflection, performance evaluation and project assessment with community partners' feedback.

The potential community partnerships can be established with local non-profit organizations, local and state government agencies, K-12 schools, health care providers, environmental protection offices, and many others. ESLI works closely with faculty (through their contacts), the Campus Center for Community Service-Learning, the Engineering Council (made of student

leaders), and industry contacts to identify and develop partnerships. An initial on-site visit to the community partner candidates following phone/electronic contacts is usually made to help assess service need and to develop a mutual understanding of the reciprocity of service-learning. Community partners are required to play a more active role in working with educational institutions and the faculty-and-student teams, in particular, to attain their intended service objectives, as well as to assist mentoring students to be greater citizens. ESLI and community partners shall together identify the learning objectives involved in the services to be rendered. With an emphasis placed on multi-disciplinary teamwork along with effective communication skills and problem solving techniques.

Upon endorsement of the project, a planning meeting should be arranged among the ESLI representative, the faculty advisors and the community partners to draft a collaboration plan. Periodic meetings must be held throughout the duration of the project to ensure the service-learning project is being properly conducted and managed jointly with the community partners. The ESLI will evaluate progress toward the desired goals. A clearly-defined feedback loop and schedule must be maintained in order to channel the outcome assessment back to the students' home departments and the College Curriculum Committee to ensure that academic quality and legitimacy are maintained. With a good mutual understanding, the College of Engineering shall enter a comprehensive agreement with each community partner in regard to the associated service-learning activities and their liabilities and risk management before the project begins. Most engineering service-learning activities require resources that may not be readily available within the College. Industrial partners have always played a significant role in many College of Engineering activities, including financial and technical support of engineering programs as well as assistance in college development. As sincere as educational institutions, many industrial corporations constantly wish to demonstrate their interest in upholding their highest citizenship for a better society, and they may provide needed resources for supporting service-learning activities. At Cal Poly Pomona Engineering, this is initially accomplished through the Industry Action Council, an industry advisory group, at both the college and department levels.

Interdisciplinary Engineering Service-Learning Projects

Several engineering service-learning projects have been accomplished at Cal Poly Pomona. Every one of them requires a common engineering sense built on the fundamental subjects and softer skills developed in general education classes as well as engineering and science classes, particularly the team-oriented laboratory classes. A brief summary of some of the projects are given below:

Robot FIRST

A group of engineering students teamed up to support Robotics Alliance of West Covina, a local robotics community for teaching and assisting local high school students of West Covina High School in designing and constructing a robot for the FIRST Robotics competition. FIRST stands for "For Inspiration and Recognition of Science and Technology" and is an initiative started in 1989 to promote science and technology to high school students, our future workforce. The robotics experience helped high school students explore realms of engineering and technology through intensive hands-on exercises, and many of them chose engineering to be their

educational objective and career path. (This project requires knowledge in robotics, machine design, manufacturing processes, automatic control, fluid power, microcontrollers, and electronic circuits and devices.) Fig. 1 shows the robot built with the help of Cal Poly Pomona students in 2005.

Fig. 1 – FIRST Robot

Voice Controlled Wheelchair

A conventional joy-stick controlled wheelchair has been redesigned and modified with a voice-controlled system to provide quadriplegics and paraplegics who suffer from a high degree of paralysis a more effective control method for maneuvering the wheelchair. A voice recognition module is used to sense the input and then processed to command two motors for steering and movement, respectively, through a motor controller unit. (This project requires knowledge in automatic control, microcontrollers, signal processing with DSP, machine design, and manufacturing processes.)

Devices for Developmentally Disabled:

Cal Poly Pomona has developed a partnership with a local organization that serves the needs of the developmentally disabled. One of the projects under development is a Picture Exchange

Communication System (PECS). PECS is a training package that allows children and adults with autism and other communication deficits to initiate communication. PECS that is currently in use is limited and uses static pictures. Since every child requires his own PECS, it is difficult for care-providers to manage different PECS for different students and organize all the pictures. A new PECS that is easy to use for students and care-providers is currently under development. Another project is spoon holder (Fig. 2).

Fig. 2 – Spoon Holder for Developmentally Disabled

Emergency Evacuation Plan Based on Geographic Information System (GIS)

ArcGIS, a GIS system, was used to design an emergency evacuation plan for community. The Cal Poly Pomona campus was selected for pilot study first due to that its geographical data were readily available and can be transported directly into ArcGIS in digital form. The campus evacuation routes (Fig. 3) were studied and simulated with constraints and local evacuation criteria. (This project requires knowledge in geographic information system, operations research, traffic engineering, and computer applications.)

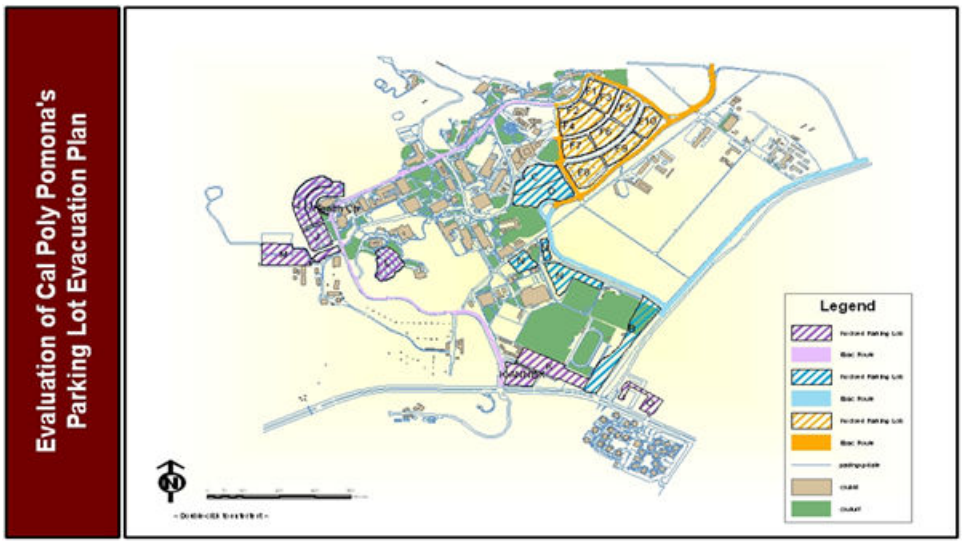

Fig. 3

Strategies and Challenges for Implementation

Faculty and Student Participation: As addressed earlier, faculty is the heart of any educational program. In fact, programs involved engineering service-learning activities depend on faculty far more than a conventional engineering program without a service-learning component does. This is because additional efforts are needed to work closely with community partners and deal with situations that are often not expected in a typical, purely technical project, such as identifying and translating the community service challenges into problem specifications, maintaining reciprocal learning context, organizing and managing reflecting activities, etc. Participating Faculty must share the same belief that service-learning is an effective pedagogy which can help their students achieve a higher level of success. They should be encouraged to participate in service-learning related workshops to continuously explore, assess and expand the service-learning-based pedagogy. Student participants can be recruited from engineering classes. Most faculty members would have little difficulty to assemble a competent student team for service-learning projects. At Cal Poly Pomona Engineering, we also contacted student leaders via Engineering Council, a coordinating unit for all engineering student organizations, for their input as well as help in recruiting students. Open meetings with engineering students were arranged for introducing service-learning activities in engineering, their significance to students' professional and personal development. Genuine feedbacks from students' perspectives were helpful for project planning and student recruiting.

A survey conducted in an engineering service-learning workshop indicated that the vast majority of faculty either agree or strongly agree with the general philosophy of service-learning and wish to explore the possibility of incorporating service-learning in their courses. But, they also wish to know more about engineering/technology-related service-learning activities, resources and support for them, and, in particular, the potential benefits of service-learning for their disciplines in terms of scholarly development. Similar results were also obtained for students. Although the nature of service-learning activities is interdisciplinary, faculty seem to be neutral in participating in interdisciplinary service-learning activities or projects that involve faculty and students across the academic disciplines. This may attribute to that interdisciplinary activities

usually require far more administrative efforts and effective communication for faculty and students across different academic disciplines, but without comparable recognition. On the contrary, students are very interested in participating in interdisciplinary service-learning projects since most of students surveyed were first senior students and they recognized the importance of interdisciplinary project experiences, as they learned from either their part-time jobs or industry visits. To encourage faculty to participate, adequate support and incentives must be provided, such as teaching assistants for faculty's regular teaching assignments.

Community Partnerships: It takes time and efforts to develop and establish service-learning partnerships with community organizations. Immediately after an initial contact of potential community partners, faculty needs to review the community service needs, assess the reciprocal interrelationship between the community partners and engineering service-learners, define service-learning activities and assess resources required for the activities. With a good mutual understanding, the College of Engineering should enter a comprehensive agreement with each community partner in regard to the associated service-learning activities and their liabilities and risk management. Upon endorsement of the project, the faculty advisors and the community partners meet to draft a collaboration plan. Periodic meetings must be held regularly between the service-learning team and the community partners throughout the project to substantiate the collaboration of the project at every single phase. Because the efforts required for solidifying a community partnership and the challenges involved in identifying a project for engineering service-learners to meet their educational objectives, an organization which has more potential to provide students opportunities for long-term projects should be more favorably considered for partnership, such as Environmental Protecting Agency (EPA).

Risk Management: The potential risks embedded in engineering service-learning projects must be carefully assessed before they begin. Otherwise, the embedded liability could restrain the development and frustrate faculty and service-learners with every potential risk. In some cases, legal advices are needed to ensure that all practices are fully compliant with the law as well as the university requirements.

Reflection and Outcomes Assessment: Reflection is the key to service-learning activities permitting students seriously examine the learning they have in the context of the community services they rendered. It is an integral component to make service-learning activities different from simply community services. The most common tools used for reflection are group discussions and journals. Group discussions allow student participants share their views and/or experiences with others and learn from each other. Journal writing helps students constantly express their observations and thoughts and log the progress of development. Faculty advisors and community partners can help enhance reflective experiences by participating in the discussions and providing timely feedbacks on students' inputs. In addition to gage students' level of learning through reflection, faculty advisors can also use reflection to perform program outcomes assessment. All ABET-accredited engineering programs are required to have an on-going assessment system to continuously evaluate their program outcomes and to feedback for improvement. Service-learning activities provide students opportunities to develop their capacity and abilities in meeting the program outcomes. Regular reflection sessions can be designed to include structured measures for faculty to measure students' disciplinary knowledge and other skills related to the list of expected program outcomes.

Proposed New Course

A new lower level 2-unit service learning course titled *Technology for the Community* (EGR 263) is currently being proposed. This course is designed to provide opportunities for new engineering students to explore the societal needs from a holistic perspective, develop technologies for the community, and reflect on their role. This course is designed to encourage Lifelong Learning by stimulating interest and promoting individual involvement in contemporary issues. New developments, sustainable technology, natural capitalism, design for affordability, policies, and practices in technology will be addressed. Students will study a current technical controversy that impacts society (e.g. energy, pollution, transportation, etc.), conduct a research or a service project and present their results. Guest lecturers may present topics in sustainable technologies, management, business, law and professional development. Course may also include field trips and attendance at appropriate community partner sites. The course outline is as follow:

Week	Meetings	Topics
1	1	Introduction, Expectations, Requirements What is Service Learning? How to communicate with non-technical audience?
2	3-4	Case studies: Successful SL Project examples Field Trip: Visit to a local community partner
3	5-6	Needs in the US/Developing Countries Engineers without Borders, International Development Enterprises
4	7-8	Introduction Sustainable Technology Field Trip to CRS: Sustainable Energy Systems
5	9-10	Sustainable Technology Continued. Field Trip to Cal Poly Water Systems. Water Analysis
6	11-12	Design for Affordability
7	13-14	Technical Controversies that impact society (Guest Speaker) Government policies, role of NGOs
8	15-16	Environmental, Social, Cultural and Legal Issues (Business Opportunities) Guest Speaker: Hot Topic
8	17-18	Project/Research Paper Presentation
9	18-19	Project/Research Paper Presentation
10	19-20	Life Long Learning Issues Service Learning Reflection

Conclusions

Service-learning is a pedagogy that provides students structured opportunities to advance their learning as well as to meet community needs. But, as one explores this instructional approach that provides a framework for providing authentic learning experience, a comprehensive and

sustainable plan is needed to ensure a successful, synergistic integration of service-learning in an engineering pedagogical framework. Examples of community-based, interdisciplinary engineering service-learning projects were presented. Strategies and challenges for implementing service-learning coursework were discussed. To further expand the efforts at Cal Poly Pomona Engineering, ESLI is currently developing a lower-division service-learning course designed to reach more underclass engineering students and to raise their sense of social responsibility, while teaching fundamental project management skills so that they can be ready for service-learning projects

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