Institutionalizing Service-Learning into a First-Year Engineering Curriculum

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Introduction

Over the past ten years, engineering has been undergoing a reform of its educational models. We have seen a significant increase in emphasis on design and on the wide range of skills that engineering students need when they enter the workplace[1-6] .Among the most dramatic statements about these skills has been the set of program outcomes at the heart of the engineering accreditation guidelines that went into effect in 2000, dubbed "Engineering Criteria 2000"[7]. These criteria, in addition to "traditional" engineering knowledge of mathematics, science, engineering and experience in engineering problem solving and system design, students are mandated to be able to function on multidisciplinary teams, to communicate effectively, and to understand a wide range of issues in engineering. These issues include: professional and ethical responsibility, the impact of engineering solutions in a global and societal context, and knowledge of contemporary issues. While recognizing the importance of these issues within the engineering curriculum, many departments find it difficult to effectively integrate experiences that include the full spectrum of professional or "soft" skills that simulate current industrial practices[8]. Service-learning integrates community service with academic learning and provides a pedagogy that allows for an easier integration of these professional skills as students learn the academic content.

Service-learning also has the potential to impact other current issues in engineering education which include the declining interest in engineering among pre-college students and the continued under-representation of women and students of color. The service-learning pedagogy is very well matched with the literature on recruitment and retention of women in science and engineering with its social context; emphasis on general educational goals including communication; employment of cooperative and interdisciplinary approaches; and problems with a "holistic, global scope"[9-11]. Matyas and Malcolm[12] and Oakes, Gamoran, and Page[13] suggest that many of the same factors are relevant for attracting and retaining minorities. In a UCLA study of retention of engineers in general, it is suggested that one factor contributing to engineering's low retention rates is the failure of engineering faculty to value such educational goals as teaching personal values, enhancing self-understanding, and supporting emotional development[14]. Service-learning integrates all of these aspects and has proven to be effective in enhancing learning.

There are many challenges and perceived challenges to adopting service-learning, which are some of the reasons that service-learning, while well established in many disciplines in higher education, has been slowly integrated into engineering education[15]. There are successful examples of service-learning in engineering contexts[16], including first-year introductory courses[17], capstone senior design courses[18], multidisciplinary approaches[19,20] and integration of co-curricular activities[21].

The success of engineering service-learning programs including Purdue's own EPICS program[22,23] has motivated the Department of Engineering Education to integrate service-learning into its first-year courses. This paper describes the current status of these efforts as we move to institutionalize the service-learning component and is a follow up to the initial paper[24] which described the program and presented the results of the first year. A companion paper[25] presents qualitative data from student participants from the 2003 academic year. This paper seeks to share lessons learned and the rationale behind the decisions we made and also to provide an example of service-learning that has yielded positive results with first-year engineering students.

Purdue University's First-Year Engineering Program

Purdue University's Department of Engineering Education has responsibility for all of the approximately 1650 first-year engineering students. All engineering students are required to complete a common first year core of classes shown in Table 1 before matriculating to their respective engineering major. Minimum grade levels are established for matriculation to the major of their choice. The department includes seven tenure track faculty and four academic advisors. This department has the responsibility for all of the academic advising for first-year students and primary teaching responsibility for the engineering lectures, seminars, help and assistance courses as well as the first engineering course, ENGR 106 - Engineering Problem Solving and Computer Tools.

Table 1: Purdue University First- Year Engineering Curriculum

Fall Semester	Spring Semester
Calculus I	Calculus II
Chemistry I	Chemistry II
Engineering Lectures (+ seminar option)	Physics (Mechanics)
Engineering Problem Solving and Computer Tools	Computer Programming (C or Fortran)
English or Communications	English or Communications
Optional Electives	

Integration of Service-Learning

A number of options for implementing service-learning into the first year have been considered. The EPICS program at Purdue has demonstrated significant success but only can accommodate approximately 250 students each semester. With over new 1600 first-year

students each year, this is not currently a viable option for a large percentage of the first-year students.

First-Year Seminars - One concept was to integrate service-learning into the first-year seminar courses, which are either taught by faculty or upper level students. First-year students have the option of taking one of these one credit seminar classes. Service-learning was piloted in the faculty led seminar with very mixed results. Projects were assigned but with only part of the one credit available, it was difficult to find enough time to meet the needs of the community and to accomplish something significant from the students' viewpoint. These factors created frustration on both the students and the community partners. These trials did, however, provide valuable experience to gauge the capabilities of the first year students and allow the instructional team to develop materials to support the service-learning projects. These experiences reinforced the fact that reflection was imperative to help students process their experiences in the community. These experiences also showed that the seminar format was an excellent environment for these reflection discussions of the student experiences.

First Engineering Course - An alternative approach was to integrate service-learning with the first engineering course, ENGR 106 - Engineering Problem Solving and Computer Tools. During each step, how the program would be sustained was considered. The course offered a great potential with its inclusion of two large team-based projects and the learning objectives which could be enhanced through service-learning:

- Develop a logical problem solving process which includes sequential structures, conditional structures, and repetition structures for fundamental engineering problems,
- Translate a written problem statement into a mathematical model,
- Solve fundamental engineering problems using computer tools,
- Perform basic file management tasks using an appropriate computer tool,
- Work effectively and ethically as a member of a technical team, and
- Develop a work ethic appropriate for the engineering profession.

We did not want to create a new course with the overhead that would create an additional burden to the faculty. The approach was to integrate service-learning into one of the sections of the course. Other approaches that have been used in large classes are to offer service-learning as an option to another project or assignment. These models have been shown to be effective but run the additional logistical challenge of matching the students who chose that option. The class is taught with a team-based learning environment so it would require that teams were formed around their choice. These challenges were one reason that we chose to have a separate lecture division for the service-learning students. The section was smaller than the traditional sections, but with approximately 1400 students enrolled each fall, we had always had one smaller section. The faculty agreed to allow the smaller section to be the service-learning division, with the understanding that it would increase to a larger size over time.

These decisions meant that the service-learning needed to fit with the other sections of the course with common assignments and exams across all of the divisions. Students attend two lectures and a computer lab each week. The first project is typically a hands-on or design-build

style of project that integrates simple (e.g. spreadsheet) computer tools and analysis. The second project is typically a more intense computer application and programming project. The first project aligned well with the goals of service learning and was chosen. The separate lecture proved to be very valuable. It let us set the stage for their work and to help frame why they were doing these kinds of projects since everyone in the lecture was doing some sort of community-based project. Earlier, with a mixed lecture (some doing traditional project and some doing community-projects) we did not feel comfortable spending lecture time talking to only a part of the class.

First-Year Learning Communities

Selecting one division of the engineering course begged one major question, how would we choose the students to go into that section? Some universities have the ability to designate service-learning courses in registration materials. Our university does not. Our intention was to offer the experience as voluntary, so we had to have a way to identify the students interested. The learning community model served this purpose since students in the learning community were identified before summer registration.

A second obstacle was that the common course schedule and format we were committed to did not allow time for students to meet and discuss their projects with their community partner nor did it allow any significant reflection opportunities. As we have stated earlier, we found that reflection is a key component to service-learning experience. This is consistent with the literature in service-learning[15]. Reflection allows students to make the connection between their project and the academic content of the course, which is a challenge for most students. As presented earlier, the learning objectives were aligned with the service-learning projects, yet we found that many students did not see how their projects were related to them and in some cases engineering more broadly without some reflection. The second reason reflection is so critical is that students exposed to genuine community needs and issues do not always understand the issues and need assistance in processing their experiences. Participants can have their stereotypes actually reinforced rather than challenged. For example, one young man, during the seminar pilots, participated in assessments of substandard housing. He stated that what he had learned from the experience was that he was glad he would be an engineer who could live in the suburbs where housing is not an issue. This was clearly not what we had intended for him to learn but without the reflection discussion, it would have been what he had learned.

The solution, which solved both problems, was to integrate service-learning into the section of the ENGR 106 course that was part of the First-Year Engineering Learning Community. This section was linked with two other classes. For the fall semester of 2003, approximately 140 engineering students were enrolled in the Network or IDEAS learning communities, both of which were directed by the Department of Engineering Education. Each learning community consisted of two or three linked classes where cohorts of students were registered together and also participated in co-curricular activities. Students were offered a residential component where they could live on the same floor of a residence hall with their classmates. Information about the Learning Communities is mailed each spring to incoming students by a central university office and student volunteer to participate. We simply incorporate the descriptions of service-learning into the Network and IDEAS descriptions, which

allowed us to identify who was interested. We used the process and infrastructure of the Learning Communities for the selection of service-learning.

Service-learning also added an important dimension to the Learning Community, a curricular tie. The goal of the learning community is to connect the classes, which can be a challenge with classes such as Communication, English and the seminars. The shared experience of the service-learning project became a common experience that each class could integrate into their curriculum. The project was assigned and the reports graded out of the engineering classes. The seminars allowed the community partners to come and meet the students early in the semester. After the projects were completed, the seminars also allowed discussion around the issues they addressed. The Communication and English classes used the experiences as a basis for assignments and provided the needed reflection to complete the learning experience started in the engineering class.

The integration through service-learning has made the curricular ties easier to manage because we were not coordinating each week of each course. It was very helpful with the service-learning as it provided additional people to help with different aspects of the course. A pitfall of service-learning can be burnout. Whenever students do real projects with real people, problems arise and the linked classes allowed us to share the challenges that the projects presented. With the large number of students involved in this program, it was a key component of the institutionalization plan to have the peer leaders who taught the seminar classes engaged in the progress of the student teams. They were able to identify problems along the way and bring them to my attention before they got out of hand.

Beginning service-learning

The first step to implement the service-learning is to solicit projects from the community before the semester begins. Many campuses have offices of service-learning or at least volunteer bureaus and/or community relations offices. These can be used to distribute materials or even identify potential partners. The people in these offices often know the community very well and can make referrals once they understand what you are looking for.

At Purdue, we used the channels of the university's public relations department, the local volunteer bureau and personal contacts from previous experiences. Each potential community partner or service provider was given a description of the program including the constraints and expectations of the service-learning experience.

We wanted to keep the learning community cohorts together so we sought opportunities where groups of 10 to 14 students could participate at the same community organization. This size was designed to match the size of the seminar courses. Students were assigned to teams of 3 or 4 students, so a seminar class of 10 would have three teams and a seminar class of 14 would have 4 teams. The teams could work on the same projects, different or duplicate projects (e.g. if they were modifying a website, they could each work on different designs and we select one of the products to be implemented).

It is important to be clear from the start what you are looking for and what they can expect, including deliverables and the duration of the project. We let the service providers (why do you use service providers here you don't use it anywhere else in the paper) know that these were first-year students who are involved in this program in their very first semester. The following are examples of what we told the community member the first semester freshmen should be able to do:

- Web page design and implementation .
- Preliminary design, feasibility studies or research (e.g. traffic flow around a facility, computer or networking needs, automation or upgrades). While the students may not have the expertise yet, they are able to do research and find the local resources. Research is something they can (or should) be able to do.
- Setting up computers and/or installing software.
- Setting up data analysis tools (e.g. spreadsheets or simple databases).
- Tutoring (math, science, and computers).
- Participate in programs for k-12 students focusing on engineering, math, science or computers.
- Simple repairs, maintenance or construction (hands on opportunities are great for the students and they are learning how things work and how to design them better).
- Economic analyses for future opportunities.

This ended up to be an accurate assessment of their capabilities.

In all service-learning, students should be receiving academic credit for demonstration of learning objectives, not just for the service. So for each project, they received engineering credit for their work defining the problem and the quality of their report and recommendations at the end of the project. In their English class, they received credit for the quality of their writing assignments based on their service, but not on the service. This is an important distinction to draw and one that is vital to gaining support amongst faculty colleagues. Service-learning is not substituting academic content for service but the enhancement of academic learning through service.

Fitting into the common course

To institutionalize the service-learning, it had to fit into the common course structure, as was highlighted earlier. All of the projects needed to be done on the schedule for the rest of the ENGR 106 divisions so that we could still use the common labs, homework assignments and exams. This eliminated the overhead of creating a completely new course and allowed the instructor to concentrate on optimizing the service-learning components.

This worked well with a few exceptions. A couple of the projects each year needed some follow-up after the final deadline but these were easily handled on an individual basis. At the beginning we explained the timing constraints to our community partners. Our projects started on the second week of classes and ended in the eighth week to meet this schedule.

The reporting and evaluation also mirrored the traditional project. Interim reports were due and evaluated in week 5 and final reports were due in week 8. At each of these reporting times students produced a report with defined deliverables, completed peer evaluations and the community partners were asked to complete a six question evaluation for each team.

Grading created a challenge because each project was a different project. In the engineering course, a TA would typically have three lab divisions. The common project that the other divisions did had a grading rubric, but these projects were more difficult to assess through a common instrument. A constraint placed on the service-learning section was that the TA's could not be expected to do any additional work that would require additional TA's. The compromise was to construct a grading scheme where the TA's graded the structure and components of the reports, similar to the other reports, the community partner's evaluation provided additional points and the instructor read their recommendations and reflections. This was some additional work on the instructor's part but was actually enjoyable seeing the accomplishments of the students. This additional grading could be done with an undergraduate grading assistant.

Sustaining and growing service learning

The service-learning program was expanded to 218 students for the fall semester of 2004 and is planned to grow to 250 in 2005. The learning communities have provided a structure to support this large-scale endeavor. In the 2004 year, a few adjustments were made to facilitate the growth and institutionalization. First, English was dropped as a linked class due to the class sizes. In the 2003 year, our sections were given permission to run with smaller sizes of 20 per lab. This added to the departmental costs so Communications was added which had class sizes of 28, which matched the preferred lab section size. English had provided an excellent class to link with the service-learning, but we could not bear the additional cost for the smaller sections.

The peer mentors were also given additional responsibilities to arrange the community partner visits to their classes and were asked to keep track of the progress of the students in their sections. With two peer mentors for every 14 students, we were able to identify most of the problems early and deal with them before they became a significant problem.

For the 2004 year, we went back to our community partners from 2003 that were successful. This reduced the burden of having to solicit projects on the same scale. It is interesting to note that even with our expansion from 143 to 218; we did not have to distribute a new solicitation to the community. We placed a high value on cultivating and maintaining the relationships in the community. At the conclusion of the projects, all of the partners completed an evaluation. We also hosted a celebration luncheon where we recognized the partners and invited them to participate the next year. We had enough repeat projects and referrals to fill out needs. Table 2 shows the projects from 2003 and 2004. One of the partners that did not repeat, Trinity Mission, will be back in 2005.

Table 2 Community Projects for 2003 and 2004

Organization	Tasks in 2003	Tasks in 2004
Community and Family Resource Center/ Head Start	Tutor head start students and report on how technology can be used to enhance the classrooms	Tutor head start students and report on how technology can be used to enhance the classrooms
Greater Lafayette Recreational Soccer Alliance	Research and recommend improved data management tools for the league	Not repeated, implemented solutions from 2003
Caregiver Companion	Created and installed a website for the organization	Upgraded website and installed additional capabilities
Purdue's Boiler Volunteer Network	Researched and identified ways to improve data management of volunteers	Not repeated, using university support for their needs
Engineering Education	Designed and implemented outreach curriculum for middle school children	Designed and implemented outreach curriculum for middle school children
Trinity Mission	Developed training materials for fixing computers and appliances for thrift store sales.	N/A
Hanna Community Center	Tutored after school children and reported on ways to improve facilities through technology	Tutored after school children and reported on ways to improve facilities through technology
Imagination Station Children's Museum	Designed curriculum modules for science outreach programs	Designed curriculum modules for science outreach programs for young girls
Imagination Station Children's Museum	Created displays for highlighting the technology used in the building's operation	Created displays for highlighting the technology used in the building's operation. Built upon the work started in 2003.
Habitat for Humanity	Surveyed community and developed standards for assessing sub-standard housing	Evaluated homeowner selection process, created an energy efficiency website.
Science Bound	Developed and implemented a project design for Science Bound students and performed a feasibility student on future collaborations with Science Bound	Built upon the work of 2003 to design and deliver a day-long outreach program for Science Bound students, high school sophomores
Historic Centennial Neighborhood Association	N/A	Survey and catalog historic homes for energy analyses
University Place Retirement Center	N/A	Assess the transportation and communication needs for the center and the needs of the residents
Dean of Students	N/A	Take a mobility project developed by upper division students and map the campus using GPS enabled PDA's.
Klondike Elementary School	N/A	Upgrade a spelling quizbowl software game
West Lafayette Schools	N/A	Develop webpages for parent organizations
Family Services	N/A	Feasibility students on converting systems to all digital, threat analysis and compliance with federal regulations

Vertically integrating

Some of the new projects for 2004 came from projects that had been developed by the EPICS Program [22]. These projects were developed by upperdivision students but each needed additional work that were capable of being done by the first-year engineering students. For example, the Dean of Students team had developed software for a PDA that would tell a user how to get to a building from any place on campus using GPS. The EPICS students had developed the prototype and had begun mapping the campus. One division of first-year students was paired with the EPICS team, which put the EPICS students in the role of customer and exposed the first-year students to more senior engineering students. The first-year students did the mapping of larger parts of campus and helped to debug the pilot version of the software. Service-learning can provide an excellent way to integrate first-year and upper division classes and we can use the projects from the upper division classes as the context for the first-year engineering students.

Funding

This initiative was supported by Hewlett-Packard Philanthropy in its first-year. Initiating service-learning with external support can help institutionalization as it provides an external source of credibility with administrators and colleagues. Foundations, corporate and private, are excellent places to look for funding. NSF has two places to fund service-learning, the CCLI program and the EEC Department Level Reform. The Corporation for National and Community Service (www.cns.gov) is another source of startup funds.

In Fall of 2004, the initial grant was gone and the program was supported by institutional funds. The instructors, TA's and peer mentors were all provided as part of the normal teaching assignments, which is why it was so important to fit the program into the traditional course structures. As mentioned earlier, the one concession was that the service-learning division was smaller than the other divisions of ENGR 106.

Some of the additional costs involved the community partners, parking on campus for meetings and the partner luncheon. These were small costs and were covered by discretionary funds. Our Provost has a program where her office will fund small student projects in the community. Many schools have funds that are available for student projects in the community. What we have done is to allow them to be used in the course-based community projects. We used these funds to pay for the cost of the projects, which were small. None of the projects cost more than $250, which was under the $500 limit per project. This a sustainable way to manage the project costs as long as the Provost's program exists. An alternative source of funds is to have corporate sponsors for the projects. Our experience with the EPICS program has shown that the easiest funds to get for this kind of work is something that goes to the teams' projects. Many companies look to invest in programs such as these and the alignment between service-learning and their own objectives make these kinds of programs relatively easy to sell. These types of funds are typically controlled by the recruiters who come to campus for the corporations. The key is to be allowed to talk to them with the development officer's permission. When doing any of these programs, it is a good idea to talk to the development people to get on their list of programs. Many people across the country have found that donors

who are not interested in traditional funding for institutions are very willing to fund service-learning programs. Many, in fact, have secured endowments for these efforts (see www.compact.org).

A final and significant expense is a support person to help manage the logistics of the community projects. We have used part of the time a clerical support person. Many schools have centers for service-learning and/or community service which can manage these aspects. Purdue does not yet have such an office so we have had to add this into the department. This is the final piece to institutionalize for our program that is not yet secured. Companies are not interested in funding people nor are grants in the long term. We are making the case of why this expense is a worthwhile and cost effective expense using the evaluation data[24,25] and by showing how we have leveraged funds from so many other places (e.g. Learning Communities).

Conclusions

Service-learning was successfully implemented on a large scale in a first-year engineering program. It has served as a curricular tie between three clustered courses as part of a learning community and has provided a valuable community-building experience to the learning community. Evaluations of student and community reactions have been very positive and have encouraged the department to continue expanding and institutionalizing the program. To accomplish this, service-learning has been integrated into existing courses and existing retention initiatives and has used these existing infrastructures. To sustain and continue to grow the program, we have continued to imbed aspects of the program into existing course structures and other initiatives. We have learned how to leverage the available resources, such as peer mentors and learning community staff support, to handle the additional logistics that service-learning presents.

An important lesson that we have also learned is to go slow with service-learning and not to be afraid of having it "perfect". The first few times we tried, it was far from perfect. Each time, however, we learned more and improved on the model. The momentum of the current initiative is very promising for growing to a sustainable number of our first year students.

Finally, we have learned how much fun it is to have our students engaged in real issues in our community. Student evaluations showed a very positive reaction from the students. [25]From the professors and TA's, we can attest to how rewarding it has been to see the growth in our students and the results of their work in the local community.

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