Service-Learning Projects in Environmental Engineering Courses: Models of Community Engagement Activities

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***Abstract*—The curriculum for an introductory environmental engineering course was enhanced with the addition of Service-Learning (S-L) based projects in the community. Senior year Civil and Environmental Engineering students worked on four projects, including green roof and biomass energy considerations at a local elementary school (engaging a fifth grade classroom), water quality testing (engaging high school chemistry students), researching the environmental impacts from a proposed biomass plant in the state (engaging local citizens opposed to the project), and a Geographical Information Systems (GIS) based map project for southwest Haiti to locate and display health clinic locations for use by the area health workers. Students interacted with four different community partners, and reflected on their experiences answering questions focused on their interactions with the community partners, impacts on their learning, and personal growth as individuals. The impact of these projects transcends the 20 students who participated in the experience, as various population groups locally and internationally were affected in this process. This paper is a narrative on the development of the projects in collaboration with the community partners, along with detailed notes for faculty wishing to develop similar projects in their communities, and a summation of the lessons learned. A similar course design this academic year involves six projects with four community partners. Students and community partners will take surveys and specific metrics on the test results will be available for presentation and reporting, at the conference.**

***Index Terms*—service-learning, community partners, collaboration, reflections, projects**

I. Introduction

FURCO (1996)[1] explored various definitions and forms of Service-Learning (S-L) by distinguishing S-L programs from volunteerism, internships, community service, and field education. However, Berman (1996)[2] cites the first documented definition of S-L provided by Signon and Ramsey in the sixties, as a value added component in student learning in the context of their positive contributions to their communities. This definition is still the cornerstone of the myriad interpretations of this term in various educational institutions engaged in S-L. For example, the Service Center at the Massachusetts Institute of Technology (MIT) refers to S-L as "a pedagogy that involves the interaction of academically relevant service projects into the academic context.[3]" California State University at Stanislaus regards S-L as being central to both students' academic experiences as well as their social awarenss[4]. Norwich University defines S-L as the incorporation of service into the curriculum[5].

Partnerships such as the Campus Compact, which comprises of over 1,100 colleges and universities, with over 6 million students across over 30 states, have brought the message of service as an integral component of learning to the mainstream of the education reform debate[6]. The Compact's resources abound with examples of faculty across the United States who have researched, and implemented service in various forms within their curricula, and students that have benefited in a variety of ways from such experiences. For example, the longitudinal study conducted by Astin et. al (2000), gathered data from over 20, 000 undergraduate students engaged in various service activities within the California colleges and universities[7]. All 11 outcomes measured qualitatively and quantitatively, and ranging from academic performance such as writing and critical thinking skills, to personal attributes such as self-efficacy, and leadership showed significant positive correlations.

Professional schools, such as engineering are uniquely positioned to create these experiential education opportunities for their students as stated by Bringle and Hatcher (1996)[8]. These opportunities range from those provided to first year undergraduate students in engineering (for example at Northeastern University[9]), to designing senior year capstone design projects to be S-L based, (for example at South Dakota State University[10]), to entire program curricula based on S-L principles (for example at the University of Vermont[11]) to a multi-disciplinary approach to use engineering principles and solve problems in the community (for example the EPICS program founded by Purdue University[12]). Thus, there are a number of studies that provide quantitative research based data on the impacts of such S-L integrations within engineering courses. However, the process of developing small service based experiences within new or existing courses for newer engineering faculty, without much background in the S-L pedagogy and limited community contacts is still insufficiently described. The establishment of

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the Community Engagement division within the American Society of Engineering Education (ASEE) reflects the importance of this pedagogical tool within the engineering discipline. It therefore stands to reason that more and more engineering faculty will look to S-L type experiences for their students.

This paper provides a narrative on how a new faculty member with very limited contacts in the community went through the process of framing and integrating small four-week S-L projects in an introductory environmental engineering classroom. In this regard, this is a qualitative, case-study style of research project, than a typical quantitative, outcome and evaluation data based form.

II. Method

A. S-L Background and Resources

The Vermont Campus Compact (VCC) served as a starting point for the S-L curriculum development experience. I attended a three-day workshop offered by VCC that provided lectures and presentations from experienced faculty in various disciplines within the VCC network. The workshop sessions also allowed for collaborative, and interactive activities with other workshop participants that allowed for a deeper understanding of concepts and paradigms. The workshop's cornerstone was a panel, offering faculty, student, and community partner perspectives, one on each of the three days of the workshop, to really see each side of the equation. VCC also offered a mini-grant through the charitable arm of the TD Bank, for faculty developing S-L based curricula in environmental science and engineering. I was awarded one such grant of $600.

Note: Interested new faculty should seek out their campus S-L coordinating agency or state campus compacts as the first step in obtaining resources to better understand the S-L pedagogy and ways of integrating it into their classrooms. Also, look for small funding sources, which may be used to develop meaningful experiences for students, or alternatively toward community partner needs that are addressed through the student involvement.

B. Understanding if and how S-L fits in your classroom

S-L is not suited to every classroom. Designing these experiences involves a considerable time commitment on the part of the instructor. Therefore, it is imperative that new faculty, who are still developing their courses make an informed decision on which classes would benefit from the S-L pedagogy (entirely or partially). I was assigned to teach senior Civil and Environmental Engineering students a course entitled "Sanitary Engineering". The department chair had approved revamping the course to go beyond the hydraulics and water based focus of the course into a more general overview of the overall field of environmental engineering and encompass air, noise, and waste engineering in addition to the previous water based focus. This is a required course and the class meets thrice a week for a 50-minute classroom session and for a three-hour lab, once a week. Norwich University has strong roots in service, given its nature as a private military college, and the student body is predisposed to the idea of service. Therefore, in addition to the content revisions, it was also determined that this class would serve as an ideal stage to introduce students to mini S-L experiences.

Note: For newer faculty, deciding to develop short-term project based S-L experiences may prove to be a prudent choice, rather than an entire class based on the S-L pedagogy. This allows for opportunities to still avail of all the rewards offered by the S-L experience, without having to have an entire class be derailed in the event that the projects do not work out for one or more groups.

C. Finding the right community partners

Community partners are one of the main pillars of a successful S-L experience. I contacted eight potential community partners, including local schools, non-profit agencies, and state agencies. Initial contact was by email, followed by a telephone call. Of these, four contacts agreed to serve as community contacts and have the Norwich students work on their needs, while ensuring that the students would have an opportunity to apply their classroom learning in the field, and continue the academic piece of this experience. The final community partners were:

1. Elementary School – A fourth grade teacher*
2. High School – A Chemistry teacher*
3. Toxics Action Center – Our contact introduced us to a private citizen who served as our community partner for a community Biomass Project*
4. Haiti relief work: A health relief volunteer*

* All names have been withheld due to privacy reasons and because the Institutional Review Board (IRB) approval was not requested in this effort.

Note: Berman (2006)[2] provides an excellent resource for faculty interested in contacting potential community partners, suggesting questions to ask contacts (including a "script" for interviews) to help find the most appropriate partners for their curricular needs.

D. Prepping for classroom instruction

The early selection of community partners helps in determining the nature and scope of projects that will be assigned to students, based on the needs expressed by the community partners. For example, one of my community partner, a fifth grade elementary school teacher was interested in having my students involve hers in "any" environmental issue to introduce students ways to "engineer" solutions to common environmental challenges faced by society today. As the school was considering a new roof installation, we tentatively agreed to have the engineering students look into a green roof design for the school, while engaging the fifth graders in the design process, as well as the selection of appropriate vegetation for a potential rooftop garden.

However, ensuring that the classroom content is robust enough to support the theoretical and mathematical basis for any design projects that the students would be involved in is just as important. In engineering programs, additional considerations provided by the Accreditation Board for Engineering Technology (ABET) also influence syllabi and course structure. Therefore, all of these factors went into the initial course prep, along with finding the right textbook, developing the syllabus to accurately reflect the role of S-L within the framework of the course, developing course lessons to expand on the S-L aspects within the technical content, designing assignments, exams, and activities to encompass both the S-L within the technical education.

As reflection is a crucial component of S-L, various forms of reflection commonly assigned and used in S-L courses were investigated. Specifically, for this course, I used reflection as defined by Eyler (2001)[12], as a process that helps students connect the dots between their classroom lessons and their observations and experiences in the community. Bringle and Hatcher (1999)[13] provide an excellent compendium of examples of reflections. These and other examples from the Campus Compact collection of resources were used to develop question based reflection prompts for students. As researchers in this field have noted that continuous reflections (over a course of time) are the most meaningful, three reflection pieces were expected from each student. Over a three-week period as students worked on their S-L projects, they reflected on their community partners, their personal growth and experience in the projects, as well as the relation between the projects and their course.

Note: New faculty should begin the process of determining a tentative nature and scope of the S-L experience that their students will be assigned in close discussion with the community partners and their needs. This will help in ensuring that classroom content can offer a strong backdrop against which these projects will evolve. I did have student groups establish their own project scopes with their community partners (see next section), but it was helpful for me to have an initial broad idea of what the community partner expectations were, so as to offer the parallel educational component.

E. Project Design and Logistics

Projects were assigned to students mid semester. Four students with the top mid term grades were offered the chance to serve as project leads and select their own teammates from within the students in their lab sections. This resulted in four teams, with four to six students in each team. The student team leaders were provided contact information for their assigned community partners and asked to determine availability for an initial meeting.

Student teams had the following tasks (Summarized in Table 1):

TABLE I
PROJECT ASSIGNMENTS BY THE WEEK

Week	Task
1	Initial meeting + negotiate project scope
2	Background research, data collection, protocols/procedures for initial design ideas.
3	Initial designs
4	Finalize design and work on final report

1. Week 1 – Meet with the community partners. Determine (negotiate) a project scope, keeping in mind the short nature of the projects, as well as being realistic of their capability to do the tasks that the community partners expected of them.
2. Week 2 – Perform requisite background research on the assigned project scope; develop initial formats for data collection, protocols, and procedures prior to their visits to community partners. Collect necessary data during their visit.
3. Week 3 – Develop initial designs based on the collected data, and interactions with community partners. Present these design ideas to community partners during the visit.
4. Week 4 – Finalize the design based on instructor and community partner feedback. Start working on the final report and presentation.

Students, and community partners also completed online surveys conducted by VCC on their S-L experiences. During the second, third, and fourth weeks of the project, students completed the reflection pieces described in section D above.

Additional logistics that were crucial for the projects included the following:

1. Authorization for students to leave campus: As Norwich University is a primarily residential campus; students have to be authorized to leave the campus for academic work. This permission must be requested a minimum of 72 hours prior to the off campus event.
2. Student transportation and approved student drivers: Unlike many college campuses, Norwich University students are expected to use NU vehicles, for off-campus events, especially academic ones. Moreover, students have to be approved to drive these vehicles. As the approval process may take a few weeks, it is recommended to begin this process early in the semester.

Most of these logistical concerns may be specific to Norwich University or other residential campuses, but are provided to offer a sense of the range of issues that an instructor may have to deal with to set the projects in motion.

Note: S-L based curricula run the gamut from highly detailed (instructor/partner driven) to highly flexible (student/partner driven). New faculty may benefit from using the former model; at least for the first few times they offer a S-L course, especially if it is the students' first experience

with S-L as well.

III. S-L PROJECTS

The four projects completed during this course are described briefly. These are provided as examples of the range of S-L experiences students were exposed to, within very limited resources.

1. Elementary School Project(s): The six students on this team, split up, when the community partner (fifth grade teacher) expressed an interest in exploring energy issues with her fifth graders in addition to the green roof design that was initially planned.

   a. Green Roof Team: A green roof design was provided to the community partner. The green roof option was determined to be more expensive (from a strict monetary perspective), however, it was recommended that the school consider a small section of the roof to be a green roof to promote environmental awareness and education, including concepts of sustainability.

   b. Energy Team: This project group studied the current heating system at the school and its (in)efficiency. They then developed activities, including a crossword puzzle to talk to the fifth graders about conventional and alternative forms of energy and sustainable and non-sustainable options. Their conversations included the proposed wood chip burning plant for the City of Montpelier, including the government offices and buildings in the city (including all the public schools), as well as wind, solar and hydroelectric power.

2. High School Project: The student team worked with a high school Chemistry class teacher and demonstrated how common air pollution measurement meters worked. Then, they measured the air quality of select rooms at the high school along with the high school students. Temperature, humidity, pressure, CO concentration and hydrocarbon concentration of the chemistry classroom, gymnasium, senior lounge, cafeteria and an additional classroom were collected.

   In addition, temperature, pH, turbidity, nitrates, ammonium, salinity, hardness and dissolved oxygen levels of ten water samples were tested. After the data were collected, results were discussed. All samples from the school (water fountain, biology lab, bathroom) met drinking standards. Further, no samples exceeded standards.

3. Biomass Project: The student team worked with a private citizen opposed to an upcoming biomass plant in southern Vermont. They performed a Chronic Daily Intake (CDI) analysis for the various emission pathways that failed to meet the standards of the State in tons per year. The results made it clear that the downwind concentrations were not high enough to elicit any dangerous response, nor put the people at any increased risk of cancer. The team also studied deforestation effects, and the economics of job creation. It was noted that 20,000 acres per year would be required to fuel the Biomass Plant. However, the State has 4.6 million forested acres, of which only a minute portion of the forest allocated for harvest is used annually. Over the past 29 years the State's forest has increased by 2%, which amounts to approximately 92,000 acres of forest. This is partially due to importing some wood fuels from the neighboring states. This leads to the dispelling of a promise: to create more jobs for the State. The construction of plant will create 600 new jobs, temporarily. After the site is created, most of the logging jobs will be created for the neighboring states, from whom we import the majority of the wood fuels. There will only be about 28 jobs created by the plant after construction is complete. The team also looked into noise pollution from truck traffic for a comprehensive look at a myriad of environmental impacts of the project.

4. Haiti GIS Project: This project focused on the creation of a set of Geographical Information Systems (GIS) based map encompassing multiple rural communities in Southwest Haiti. This map was intended for the community health workers to be able to identify the areas the serve in, as well as help their clients find the nearest health clinic. The student team worked with a relief worker based in Vermont, who was involved in volunteer work with the health clinics in southwest Haiti. Two large maps and twelve smaller maps were created and delivered.

A detailed timeline along with the progress made on two of these projects is provided here, as a way for new instructors to see the entire process. The two projects are the Green Roof project that was conducted in the elementary school and the Haiti GIS project, which was for the citizens of an international community. These projects reflect two very different kinds of community partners and engagements, and will help new instructors see the diverse paths that S-L projects may take.

Before week 1: The team leaders were provided contact information for their community partners and asked to make initial contact. Their goal was to introduce themselves and their teams, check for the partners' availability, with a view to discuss and finalize the scope of their projects.

1. Green roof project:

The team leader emailed the elementary school teacher, introduced himself and his team, checked the teacher's availability and confirmed their visit time for next week and determined that he would have to check in at the school's front office before the group went over to the teacher's classroom.

2. Haiti GIS project:

The team leader emailed the Haiti relief worker, introduced himself and his team, checked the partner's availability and provided details on parking and meeting rooms for next week, when the partner indicated that he could meet with the group on the NU campus.

Deliverable: Copies of emails sent out to the community partners.

Week 1: The students met with their partners for the first meeting and developed a scope of work.

1. Green roof project:

The team arrived at the elementary school and met with both the fifth grade teacher and the school custodian. After introductions, they walked through the school campus to determine possible problems that the student team could work on. It was determined during this discussion that there were two possible areas that the school could use help with. With a new roof in the future, the teacher was excited at the idea of getting her students involved in discussions on the possibility of building a green roof. However, the city had approved a plan to build a biomass plant that would also take care of the school's energy needs, so involving students in energy discussions, as a precursor to all the construction that they would soon see was also in consideration. To help out, the student team decided to take on both suggestions made by their partner by breaking off into two sub-groups, with one group focused on the green roof design and the other focused on energy issues.

2. Haiti GIS project:

The community partner visited with the student team on the NU campus. After introductions, the partner provided the students an insight into the life of people in Haiti, specifically after the earthquake. He shared some pictures and explained the work done by his group; i.e. offering health services to those in need through a local organization in Haiti. With the lack of good quality maps, the partner explained that community health workers often face the challenge of not being able to direct people that need the health services to the closest clinics. He had some data points to be able to start developing maps using GIS and wanted the student team to develop these maps.

Deliverable 1 (team): A 2-page report with the meeting date/time, list of participants and the agreed upon scope of the project work.

Deliverable 2 (individual): Reflection on community partners.

Week 2: Students were expected to start working on their projects, return to their community partners for additional visits if need to gather any necessary data.

1. Green roof project:

Prior to their visit, the student team researched green roofs, and developed some slides and pictures to share their understanding of green roofs with the fifth graders. During their visit, they shared their research and got the fifth graders engaged in a conversation on the kinds of plants they would like to see on their green roof, and some design considerations, including loads from the garden, water infiltration and leakage, etc. Students also took measurements to begin their design work.

2. Haiti GIS project:

This group of students had just been introduced to GIS, so the project was a great way for them to reinforce their understanding. They also determined that a map of just the clinic locations was a very narrow scope of work, and wanted to do more. They researched other relevant data sets for that region of Haiti, such as major highways, available street names, and other big landmarks in the area, so as to map these as well.

Deliverable 1 (team): A 2-page progress report, to again include a list of all participants and the work that was performed before, during and after their visits.

Deliverable 2 (individual): Reflection on personal growth.

Weeks 3 and 4: All design work had to completed, as well as the reports and presentation slides. Additional visits were allowed on an as-needed basis.

1. Green roof project: Students developed their design, as well as cost estimates, and submitted a report that documented their findings and recommendations.

2. Haiti GIS project: The final maps were copied into several sets and laminated, so each of the twelve health workers could carry these laminated versions around as they visited the community members. There were also two poster-sized maps that were developed and printed. The grant money was used to cover printing and lamination costs. The community partner travelled with his group to Haiti in December and delivered these maps, and reported that the health workers were very excited and grateful for these.

Deliverables (team): Final report (and maps) and PowerPoint presentations.

Deliverable 3 (individual): Reflection on connections between course content and the S-L project experiences.

IV. Discussion and Lessons Learned

The projects all worked out successfully for the most part. However, it must be noted that the most successful projects included a strong student team as well as a dedicated community partner. The needs of the community partners varied in difficulty levels and amount of work and time involved. Therefore, no two projects were alike.

The Haiti GIS project seemed to offer the students a direct sense of accomplishment. This was because, having just learned the basics of GIS, the team got a chance to develop these simple maps that are making a huge difference in the communities in which they are being used. A number of students in the team reminisced about the Haiti earthquake and the helplessness of not being able to do much. This work seemed to help them make a small but meaningful contribution to those in need.

The Biomass project taught the student team the all-important engineering lesson of staying impartial on controversial social issues and letting their data and calculations do the talking. They also learned the art of discussing their results, which did not affirm their community partner's assertion that the biomass plant would cause a lot of environmental damage to the community.

The student groups that worked with the elementary school students had to find a way to explain complicated or highly technical concepts in layman terms and engage fifth graders in their conversations in an age appropriate context. The student group that worked with the high school students had an opportunity to test their own knowledge and understanding of common environmental measurements by engaging the high school students in similar tests. However, they were also able to provide the high school students an insight into college life and share their own experiences.

Students were assessed for content-based understanding through assignments, and exams. The S-L projects accounted for 20% (200 points /1000 points) of the course grade and were assessed through online discussion forums, reflection pieces, interim and final reports on their projects, and a final presentation to the class on their projects. This breakdown is presented in Table 2 below. Note that the reflections and interim deliverables were considered "lab submissions" and graded as part of the lab component of this course.

TABLE 2
PROJECT GRADING SCHEME

Item	Points
Project report	60
Project presentation	50
Team member review	25
Class peer review	25
Instructor review	20
Community partner feedback	20
Total	200

Finally, I surveyed the students to determine the best use the $600 of the grant money I received for the S-L curriculum implementation. Unanimously, the class decided that all monies should be made available to deserving community partners based on the needs identified during the implementation of the service- learning projects. The grant money was therefore used to purchase classroom kits to learn about various science and engineering phenomena, and printing of laminated maps for the Haiti project.

The overall lessons learned from this experience may be summarized as:

1. Introduce projects and partners early on in the semester, regardless of when the students start working on their projects, so they have time to think about their projects, and scopes and begin working earlier if reasonable.

2. Help students develop a scope: Even though I had a good idea of what the project will involve based on my discussions with the community partners, I expected students to develop their own project scope. Some groups stayed on task, while others could have benefited with my intervention.

3. Develop specific expectations of what should be included in the report. Several teams took pictures, but these were not included in their final reports.

V. CURRENT AND ONGOING RESEARCH

On reading the reflections submitted by students, as well as discussions on their experiences as well as the feedback provided by community partners, I wanted to share the highlights of the experience with the broader community interested in this aspect of engineering education. However, I did not have the foresight to apply for IRB approval and cannot share any of the student reflections or community partners in this paper. This is therefore a paper of process and setting up the S-L projects. After this initial experience, which is qualitative in nature, I now have IRB approval to determine the impact of the six S-L projects that were completed by student teams in the 2013-2014 academic year. These will be used to quantify some of the outcomes and document some of the student reflections, as indicators of their gains from these experiences.

Note: All new faculty developing S-L based courses should think about the scholarship aspect of this form of instruction. To research and write about any innovative forms of delivering this aspect of education or asking unanswered questions, ensure that IRB approval has been applied for and received.

VI. CONCLUSION

As an instructor, developing a new course is challenging in and of itself, without the added layer of also creating these S-L projects. The fact that the students are seniors by the time they are required to take an introductory environmental engineering course posed a unique challenge. Curriculum changes at the University are ongoing to address this issue, however, in the meantime, engaging students in these projects and offering them an opportunity to use their classroom learning to do some real good in the community was appreciated by some if not all students.

Through informal feedback, some students stated that the projects provided them with a taste of a real life work conditions, post graduation. They indicated that in their jobs, they might have to work with dis-organized clients, unaware of their own needs, and those with whom they will have to negotiate the project scope based on time and resources as they did with these S-L projects.

Challenges to instructors may be in the form of multiple projects with multiple community partners that requires a high level of organization, keeping various community partner needs and deadlines in order. Logistical issues included scheduling meetings with community partners, arranging student transportation, making students accountable to provide community partners with their reports, to name a few.

Overall, it should be noted that the projects were successful in engaging senior year college students in a course content effectively, and providing them a taste of a post graduation life working with clients. The community partners were provided with services that met their needs. All community partners expressed willingness to continue collaborating on future S-L projects with next year's student groups. From an instructor perspective, student interest in the course content, along with meeting some community needs made the amount of time and effort spent in developing, and implementing the S-L component of the course worth it

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