An Engineering Perspective on Collaborative Client-Based Service-Learning Projects in an Introductory Environmental Engineering and Science Course

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Abstract
The partnership of client-based course term projects described in this paper is an approach to enhance students’ confidence in researching complex environmental issues and to affect their environmental perspective in the process. This paper presents an adaptable model that can be used in multiple different situations. In this two-year longitudinal study, we partnered an introductory environmental engineering and science course of approximately 250 students per year with an introductory marketing course of approximately 70 students per year. The courses partnered on semester-long, collaborative term projects focused on the adoption of sustainable environmental solutions within the community. Before and after the term project, anonymous surveys were administered to assess changes in respondents’ views on the importance of their findings and how they might contribute to a solution for the community. We conclude that the collaborative term project model described in this paper improves a student’s confidence and environmental perspective while developing solutions to complex environmental issues.

Introduction
Developing sustainable, real-world solutions to energy and environmental problems often requires a holistic approach, meaning that viewpoints from economists, social scientists, and environmentalists must be considered (Mihelcic et al. 2003). However, these wide-ranging viewpoints are difficult to simulate without extricating students from the classroom. Many universities have real-world problems within their communities in areas such as energy efficiency, water efficiency, and solid waste management, but they do not always have the time or resources to examine the problems in depth. If done correctly, collaborative client-based service-learning projects can fill both of the aforementioned gaps. Previously published studies indicate the importance of taking projects outside the classroom and implementing them in the local community to solve a problem for a client who has a measurable need. Several sources (Coyle et al. 2006; Carlson and Sullivan 1999) indicate that implementing course projects in a real-world context not only increases the pride the students take in the results, but also benefits the community. Additionally, providing students the opportunity to develop solutions
to problems they observe concerning energy and the environment can help shape behavior and promote lifelong dedication to sound environmental practices (Hungerford and Volk 1990). Educating students with methods that develop a thirst for lifelong learning at the right time and in the right manner is also important. Students learn in various ways, and this can be particularly true for “millennial” students (born between 1977 and 1998), who are characterized by their ability to multi-task in a rapidly changing environment (Thielfoldt and Scheef 2004). Knight et al. (2007) showed that providing students with a hands-on, team-based project early in their education aids in student retention and long-term interest in that discipline. Further, science and engineering students sometimes exhibit a void in “human” skills, such as communication and teamwork (Mills and Treagust 2003). A collaborative team-based project can enhance such skills by building confidence amongst the students (Hammervoll 2011).

Currently, there are no readily available peer-reviewed articles outlining collaboration between a junior-level environmental engineering and science course and a junior-level marketing course as a means to take a more holistic approach to a client-based service-learning project. Furthermore, while precedent for developing coordination between marketing and engineering courses is available, it is not abundant (McKeage et al. 1999; Lunsford and Henshaw 1992). This paper examines the connection between an introductory environmental engineering and science course and an introductory marketing course as a means to increase students’ confidence in researching a complex environmental issue and to change students’ environmental perspectives through the completion of a client-based service-learning project. It presents a model for collaborative client-based service-learning projects that was assessed using survey results from an introductory environmental engineering and science course and can be adapted to meet the needs of other universities.

**Environmental Engineering and Science Course and Term Project Description**

The purpose of the term project for EV300 and EV301 is to develop solutions to local environmental problems by applying the scientific method. Student groups (three or four students) are asked to develop a hypothesis with data collection procedures to conduct a scientific experiment that supports one of two project types: client-based or knowledge-based. Project sponsors define client-based projects by identifying a problem and providing the scope of their desired outcomes, while personal scientific curiosity and the desire for additional knowledge provide the basis for knowledge-based projects. Students gather scientific data and couple them with social or cultural research to support their final designs. Groups with outstanding projects have the opportunity to present their findings to their respective sponsors.

Our university’s introductory marketing course (MG380) had introduced a “Green Marketing” campaign project, which provided a logical linkage to an environmental engineering and science course with a sustainability-focused term project. Marketing can play a key role in effectively relaying technical engineering or science information to the local community in an understandable and acceptable manner, an area on which our introductory environmental engineering and science course does not focus.
The EV300/301 term project commenced earlier in the semester than that of MG380, allowing for topics, appropriate hypotheses, and experimental methods to be developed and vetted by the instructors. If conducting a client-based project, term project groups were expected to meet with their sponsors to identify the problem and the sponsor’s requirements for a potential solution. During the green marketing campaign project in-brief for MG380, the EV300/301 topics and methods were presented, allowing the marketing student groups to ask questions, develop ideas, and select which project they would like to support (Fig. 1, Collaboration Point 1). Client-based term project groups were expected to maintain communication with their sponsors to keep them apprised of their progress and ensure that their experimental design would not hinder the sponsor’s day-to-day operations. Over the next several weeks, student groups from EV300/301 conducted scientific experiments and gathered data necessary to support their hypotheses. These results and potential conclusions were shared with the MG380 students so that they could begin developing a targeted marketing plan (Fig. 1, Collaboration Point 2). The marketing students typically conducted social change surveys to assess the effectiveness of their desired marketing campaign. These data were shared with the EV300/301 student groups, allowing the environmental engineering and science students to refine the conclusions, solutions, and recommendations in their final report (Fig. 1, Collaboration Point 3). The final point of collaboration occurred when the final reports for both courses were submitted. If applicable, student groups were expected to present their joint findings, solutions, and recommendations concerning the observed environmental problem to their respective project sponsor (Fig. 1, Collaboration Point 4). The collaboration efforts were expected to provide all of the student groups with a more holistic approach to either recommending or marketing a solution to an environmental problem, which could then be conveyed in their final written report.

The model described in Figure 1 is not a linear process. The outputs at the end of the model, such as student surveys, reflections, and client feedback, all serve to refine the next iteration of projects as the inject for the process to restart. The outputs allow for continual improvement and refinement of the process, as well as the exchange of potential new projects or needed improvements to work already conducted and presented.

This model provides a framework that can be applied to introductory environmental engineering and science courses at other universities for the development of a collaborative and client-based service-learning project. The model is adaptable, as the user can add guidelines or more specifically define collaboration to “fit” the framework and better suit the needs of the courses and students involved.
Example Projects at our University
Projects at our university have encompassed a wide range of topics based on locally observed environmental problems, including recycling, energy usage, food waste generation, solid waste reduction, and water quality (Table 1).

Assessment
The instructors administered anonymous surveys to assess how well the term project model enhanced a student’s confidence to research a complex environmental issue within the construct of a client’s needs, as well as his or her change in environmental perspective. The anonymous survey was administered only to the environmental engineering and science students, and these are therefore the only data that are presented. The same survey was given prior to the initiation of the project and again after the final project report was submitted using a 5-point Likert scale to enumerate responses to the six questions (Table 2). Data analysis was conducted in R (R Core Team [2012]). Welch’s t-test was used for comparison purposes due to the potential for unequal variances amongst the survey groups. This test serves as a nonparametric adaptation of the Student’s t-test.

Chi-square tests were performed when the data were not robust enough to support the t-test.

Pre- versus Post-Project Assessment
As a whole, the client-based service-learning project and the collaborative project model enhanced students’ confidence in their research skills, as well as positively changing their environmental perspectives based on personal student ratings (Table 3) when analyzed using Welch’s t-test. Questions 1–4 exhibited statistically significant (α = 0.05) differences between the before and after means of each question, and when student responses prior to and after the term project were compared, a longitudinal improvement in each student’s experience was observed across all questions. Questions 1–4 measure a student’s values, whereas questions 5 and 6 directly analyze a student’s motivation. It is positive and reinforcing that a sustainability-focused, collaborative service-learning project improved students’ environmental values and induced a statistically significant difference between the means of the before and after surveys on questions 1–4. Although the results from questions 5 and 6 were not statistically significant, they do show a slight increase in

<table>
<thead>
<tr>
<th>Project Description</th>
<th>COURSE</th>
<th>TOPIC TYPE</th>
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<tbody>
<tr>
<td>Analysis of energy use by machines left on overnight in a gymnasium.</td>
<td>EV300</td>
<td>✔</td>
</tr>
<tr>
<td>Impact of plastic wrap on laundry bundles.</td>
<td>✔</td>
<td>X</td>
</tr>
<tr>
<td>Food waste generation due to dining style (multiple variations).</td>
<td>✔</td>
<td>X</td>
</tr>
<tr>
<td>Recycling system analysis in the dormitories (multiple variations in both courses).</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Potential for biogas generation using organic food waste from cafeteria.</td>
<td>✔</td>
<td>X</td>
</tr>
<tr>
<td>Impact of different laundry services on water consumption.</td>
<td>✔</td>
<td>X</td>
</tr>
<tr>
<td>Impact of noise on common study areas.</td>
<td>✔</td>
<td>X</td>
</tr>
<tr>
<td>Impact of shower arrangement on water conservation.</td>
<td>✔</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 1. Example environmental term projects. Complete projects have both a “✔” in the “Course” columns coupled with an “X” in the “Topic Type” columns. Adapted from Pfluger et al. (2013).
student motivation. A refinement of the survey questions is warranted to explore this in depth.

The client-based term project model created an educational experience with tangible and relevant results through the connection between the environmental engineering and science course, the marketing course, and the community sponsor's needs. After the project, students felt more confident with their skills to identify, research, and convey information through a report on a complex environmental issue (question 1). All of the students intrinsically felt that it was important to identify and develop solutions to community-based environmental problems (question 2). The real-world context and relevancy of the results interested the students and indicated an increased level of personal pride in the students' individual work and greater potential for lifelong learning. Lastly, we hoped that students would be more motivated when working on service-learning projects that had potential impact in the surrounding communities (question 5); however, there was very little change in students' perceptions over the duration of the project.

**Project Type Assessment**

In addition to the opportunity to select a service-learning project with a definite sponsor in the local community to whom they could then present recommendations or solutions, student groups also had the opportunity to develop their own project based on personal observations and curiosities. The sponsor-driven groups participated in a client-based project while the other student groups participated in a knowledge-based project. Data from both project types were analyzed using a chi-squared distribution after stratifying the surveys first by time period (before or after the project) and by type of project (client- or knowledge-based) (Table 4). In several cases, the student groups had not yet selected their project topic upon the pre-project survey administration, resulting in the difference in sample sizes before and after the project. The survey results of those students who had not selected a specific client-based project were assigned to the knowledge-based project category in determining the pre-project means. During the post-project survey, students then identified their project as either a community- or knowledge-based project and their results were grouped accordingly.

The results of the pre-project survey indicate that a student's response to questions 1–4 is dependent upon the type of project on which he or she is working ($\alpha = 0.05$). This is not the case after the project, with results indicating that a student's response is independent of the type of project on which he or she worked. The shift in dependence of a student's response from being dependent on the type of project to being independent of that same project signifies that the benefit of the collaborative nature of this model is a stronger force on student perception and experience than project type. A factor contributing to the observed regression towards the mean may be that in many cases a clear delineation did not exist between project categories. Some of the projects classified as knowledge-based included aspects of relevance to a client or the community (Table 1). Additionally, students who selected knowledge-based projects scored higher, on average, on questions 1 and 2 prior to the project initiation than those students who selected client-based projects. This may indicate that a knowledge-based project, in which the student personally develops a testable hypothesis from an observation, initially influences personal satisfaction more than a client-based project. Conversely, after the completion of the project students who worked on client-based projects scored higher on questions 1–5 than those students who worked on knowledge-based projects. This term project is
the first experience that many of the students have had with a client-driven project where the sponsor initiated the project and requested specific deliverables and outcomes. To the students, this fact may have transformed what would have been “just another project” into a significantly larger and more rewarding accomplishment, since there was an invested person or organization on the receiving end of the final term project submission. The personal satisfaction associated with such a rewarding experience may have increased the post-project scores of the client-based projects over those of the knowledge-based projects. Further, when comparing each respective question by topic type from pre- to post-project, all of the means increased except for the knowledge-based project on question 5, which decreased from 3.72 to 3.64. Such a widespread increase in student perception indicates the positive effect that the service-learning project model had on the students’ confidence to research a complex environmental issue within the construct of a client’s needs as well as their overall environmental perspective.

**Conclusions**

Our university partners an introductory environmental engineering and science course with an introductory marketing course to study and provide marketable recommendations or solutions to local, real-world environmental problems. This construct provides a vehicle for student-client interaction, benefitting both the students and the community. The collaborative model assessment yielded three main results: students prefer client-based service-learning projects to knowledge-based projects; students’ environmental perspectives were improved regardless of the type of project; and the student experience was positive overall. The opportunity to research and analyze local, real-world environmental problems based either on personal curiosity or driven by a sponsor’s requirements help to provide tangible results that improve students’ views and perceptions of the importance of the environment. The collaboration and interaction with real-world clients allows environmental engineering and science students to increase their confidence in researching a complex environmental issue and has a positive effect on their environmental perspectives.

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References


