Learning through a Community-based Energy Conservation Project

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Director of Sustainability at University of Scranton. Graduated from Wilkes University in Wilkes-Barre Pennsylvania with a BS in Electrical Engineering and a Minor in Physics. A key member of the facilities operations team for the past twenty-two years. I have been involved with nearly $300 million in new construction and renovations over the past twenty years. Originated, planned, specified, bid, and managed many millions of dollars in successful energy saving projects. Enjoy sharing our experiences and knowledge with our students, the University community and the local community. Raising awareness to sustainable practices by being an example, organizing campus events, guest presenting, and student involvement.

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Abstract

A local school district and the electrical engineering department worked together to identify potential school district projects to conserve both fiscal and environmental resources. The service project, "An Engineering Approach to Sustainability: Energy Saving Lighting and School District Energy Data Analysis" included an intense need for the collaboration team to work together, learn together, discover together, and apply classroom knowledge to a real world application. Students were introduced to standards and regulations of the energy industry, energy metering and billing, sustainability, and the environmental impact of power usage. They were given web access to utility data, annual energy costs, and square foot data for eight school district buildings. The district superintendent and business manager presented information to the students and were available to answer student questions on school district energy use, operating schedule, and construction history. Student teams evaluated available data, and developed energy-saving proposals and site survey plans based on their research and discussions with project collaboration members. Teams focused on computers and technology; plumbing and interior lighting; kitchen appliances and lab hoods; and building automation schedules and exterior lighting. They were given weekend access to the high school and worked closely with school district personnel to develop their site plan and to make direct measurements of water usage, power consumption and light intensity. Final reports were submitted that included results of the site survey, recommendations, and expected energy savings. The ultimate success of this community-based learning project resulted from the teamwork and collaboration of students, university and school district staff. Not only was the project an engineering success, but also was a source of career influence for student participants.

Introduction

Problem Statement: How can the university engage engineering students in community-based projects that provide both a relevant technical application of content and a formative experience for career development?

Community-based service-learning is a collaboration of university and community members designed to support student learning outcomes, to serve community interests and to develop career awareness. Lima[1] describes key components of service-learning as: service for the common good, academic content, reciprocity, mutual learning, and reflection. Thus, effective learning can be accomplished through action, interaction, and reflection.

Research has shown that well-designed service-learning experiences have a positive impact on learning and developmental outcomes for students[2,3,4]. Astin et al (2000) provides a comprehensive study that shows participation in service positively impacts student academic performance, self-efficacy, leadership, choice of career, and service participation after graduation[3]. Their report indicates that the positive effects of service-learning are strongly derived from activities that allow students to "process" the experience. Students process their experiences through training that links course content to service, through interactions with

others, and through reflection. Astin reports that choosing a "service-related career is more strongly affected by participating in community service and by service learning than most other student outcomes"[3]. Participation in service-learning affects a student's decision to enter into a career in service. The role of engineering service-learning on technical career selection has not directly been addressed and demands further study.

Fisher writes that "The stage at which students begin consciously, and often frantically, to consider post-graduation choices provides a rich opportunity for personal introspection on the values they have recognized, developed, or lived through their service"[5]. A content-driven service experience designed for engineering students in their junior year may provide an opportunity for students to reflect on their future career path. A content-based experience may affect specific technical career choices in several ways; through increasing student awareness of the field and interest in the specialty, building a student's resume and skills in a particular area, and giving students an authentic engineering project to discuss in detail during an interview. Additionally, the student-faculty relationships fostered during the service-learning experience allow for more personal and in-depth letters of recommendation for student employment in the content area. Service-learning research seeks to identify the interactions between service-learning and career selection, and to develop methodologies to describe and quantify these interactions[6,7]. Researchers often assess the impact of service-learning on career selection through the use of student reflections[6,7]. The report that follows describes a content-based, community service experience that was implemented in a junior-level electrical and computer engineering lab and examines its impact on student career selection based on number of students entering a field directly related to the content area. Although this research is based on a single institution and a small student group, its results are consistent with those found in Astin's studies which show that participation in service impacts choice of service-related career[3]. Students not only benefit from a service-learning experience, but these benefits also continue to impact student choices after graduation.

Course Description

Electronic Circuits I and Electronic Circuits II are required lab-based courses in the electrical engineering and computer engineering programs at The University of Scranton. In the 2012-2013 academic year, all third-year engineering students participated in this energy saving project during three lab periods. The Electronics Circuits lab sequence provides a hands-on, project-based learning experience to develop skills necessary for engineering practice. Student learning outcomes supported by the energy conservation project include:

- utilizing instrumentation and techniques to measure physical quantities
- gathering information, analyze and interpret results, and form conclusions
- communicating effectively
- collaborating in teams to meet project deadlines, report on progress, and submit final report

Project Partnership

This project, "An Engineering Approach to Sustainability: Energy Saving Lighting and School District Energy Data Analysis", was a collaboration between Abington Heights school district administrators and members of The University of Scranton community. School district partners

included the district's Superintendent and Business Manager. School district physical plant workers assisted during the site visit and provided vital information on building services, technology, and infrastructure. Participants from the university included nine junior electrical and computer engineering students, one engineering faculty member, and the Director of Sustainability, who is an electrical engineer with experience in energy audits, energy purchasing, energy savings projects, and sustainability.

Project Description

The superintendent of the school district contacted the university's engineering faculty to develop an educational partnership. This community partnership intended to apply engineering technical knowledge, problem solving skills, and data analysis experience to a real world application. Historical and real time energy data from the school district was reviewed to identify potential projects that would conserve both fiscal and environmental resources.

This community-based service-learning experience was introduced within a junior-level engineering lab course. Emphasis was placed on how understanding and monitoring energy usage can lead to energy savings, pollution reduction, cost savings, and more sustainable operations. Service-learning researchers have stressed the importance of structured activities, such as class discussions, that link the service experience to course objectives[8].

To prepare for the project, a guest lecturer from Exelon Corporation introduced students to North American Electric Reliability Corporation (NERC) standards for security and reliability of electric power generation, transmission and distribution within the electric utility industry. The university's Director of Sustainability provided an overview on power distribution, energy metering and billing, deregulation, energy purchasing, lighting technology, return on investment, environmental stewardship, campus sustainability activities, and electric utility resources on energy savings[9]. Students were given online access to the PPL Electric Energy Analyzer[10] to view data from advanced meters located at several school district facilities. These advanced meters record electricity usage on an hourly basis, and transmit this information to the electric utility over existing power lines. The Energy Analyzer provides graphs of hourly, weekly, or monthly energy use collected from the advanced meters. Using this resource, students were able to analyze energy use data from each individual school district building. The community partners provided historical data on annual electricity costs, annual natural gas costs, year of construction, and square footage for eight school district buildings.

Prior classroom knowledge on energy conservation and sustainability was applied as students analyzed school district data, and prepared preliminary reports that described six areas of potential savings. Preliminary findings were presented to the entire group of engineers and school district personnel. School district partners contributed to the discussion on district facilities, recent capital improvements, and future plans to upgrade facilities. After discussing all areas of potential energy saving, four projects were selected for further investigation. These final projects were selected based on greatest potential return on investment, impact on sustainable operations, and on ease of implementation. The group discussed which of the district buildings would benefit most from the proposals. The high school building was selected for the site visit

because it was the largest of the district buildings, used the most energy, and was found to offer the greatest potential to benefit from the energy conservation projects.

Four student teams were created matching unique student interests to the four final projects. Teams focused on computers and technology; plumbing and interior lighting; kitchen appliances and lab hoods; and building automation schedules, swimming pool facilities, and exterior lighting. A facility survey plan was developed by each group to outline data that would be collected on site, and to specify the engineering tools required to collect the data.

The site visit was scheduled for a Sunday morning in April 2013. School district officials and physical plant workers led student teams through the high school to make observations and collect data. Subsequently, students analyzed data and generated a feasibility study. In total, the students dedicated about 20 hours to this service-learning experience.

The first team focused on computers and technology, which discovered that 38% of the school's computers and monitors were left on over the weekend. Measurements were taken to determine the power used by these systems. School district officials estimated the total number of computers in the district, and from this an estimate was made of the total energy used to power computers left on after school and on weekends. Students recommended software be installed that would schedule an automatic shutdown of computers to reduce annual energy use, with the projected annual savings of nearly $23,000 (143,593 kWh) for the entire district.

The second team looked at plumbing and interior lighting. Current toilets used an estimated three gallons per flush. An upgrade to 1.6 gallon per flush toilets, along with installation of aerators on faucets, could lead to water savings of up to 50%, for an estimated savings of 10,000 gallons of water per year per toilet. Light levels in classrooms and hallways were checked against published Illuminating Engineering Society (IES) recommendations[11]. The types of lighting and use of occupancy sensors throughout the building were noted. It was discovered that the school district had already successfully employed energy saving lighting and light controls. The team found that there may be some opportunity for energy savings through daylight harvesting optical sensors and lighting control in some areas, particularly in classrooms with large north-facing windows. Optical sensors are used measure existing light levels to use as much daylight as possible while maintaining IES recommended lighting levels.

The third team focused on kitchen appliances and lab hoods. The group found that there could be some improvements in equipment locations, and recommend that heating units be placed at a greater distance from refrigeration units. They discovered open refrigeration cases left on when not in use and lab hood sashes left open. Their recommendation was to turn refrigeration units off and close lab hoods to conserve energy when not in use. A refrigerator door's rubber gasket was worn, and not creating a good seal. This caused the refrigerator to turn on more frequently, and use more energy to maintain the desired interior temperature. A simple and inexpensive repair was suggested replace this gasket to reduce energy use.

The fourth team reviewed building automation schedules, exterior lighting, and indoor pool systems. They found that the building automation schedule was being used effectively. A survey of the pool clearly indicated an upgrade was required. School district officials shared

their concerns over issues with the ventilation system. The team also surveyed parking lot lighting and lighting under a large covered walkway. Light-emitting diode (LED) parking lot fixtures could be used to reduce energy consumption by more than 50%, although the initial costs to upgrade these light fixtures are high. Replacing lights under the covered walkway with compact fluorescent or LED lamps would also lead to savings of 50% in energy costs, and would provide a significant increase in lamp life.

Reflections

This student-learning experience was completed as part of a credit-bearing lab course. Project reports were graded and contributed to the student's final semester grade.

The first assessment was based on in-class discussions, assigned readings, and an analysis of school district historical energy data, energy costs, building sizes, and utility data from advanced meters at the school district facilities. Students submitted a written report that used this data to propose six potential projects that would conserve both natural and fiscal resources. Students presented their findings to the group, and participated in discussions and final selection of projects.

The second written report was a facility survey plan that outlined the data to be collected during the site visit to further evaluate project proposals.

Final written reports included project goals, site visit observations, data analysis, recommendations, and conclusions. These reflections contributed to 20% of the student's final semester grade. Additional lab assignments were completed during the semester that were not associated with this service-learning project.

Outcomes

This experience positively impacted all participants; the students, faculty, staff, and community partners. The school district implemented recommendations from the report and continues to reference the document in ongoing conservation efforts. The conservation efforts serve as examples of good financial stewardship and sustainable practices for the district's students, faculty, staff and local community. Any reduction in energy expense could be reinvested into educational programming for students or tax relief for the community.

The electrical engineering department has maintained initial student employment records from 1998 to 2014. Over those years, 93% (72 of 77) of engineering graduates reported details of employment immediately after graduation. To study the impact of this service-learning experience, the number of students who selected a career in the energy industry was determined from employment records. These employers include PSEG, PPL Electric Utilities, PECO Energy, CONSOL Energy, and FTS International. This energy conservation project had a notable impact on the student population involved, where 33% (3 of 9) of the participating students obtained a paid engineering internship in the energy industry in the summer following the completion of the project. Upon graduation in 2014, 44.4% (4 of 9) of the participating students accepted a full time position in the energy industry. This outcome was compared to the

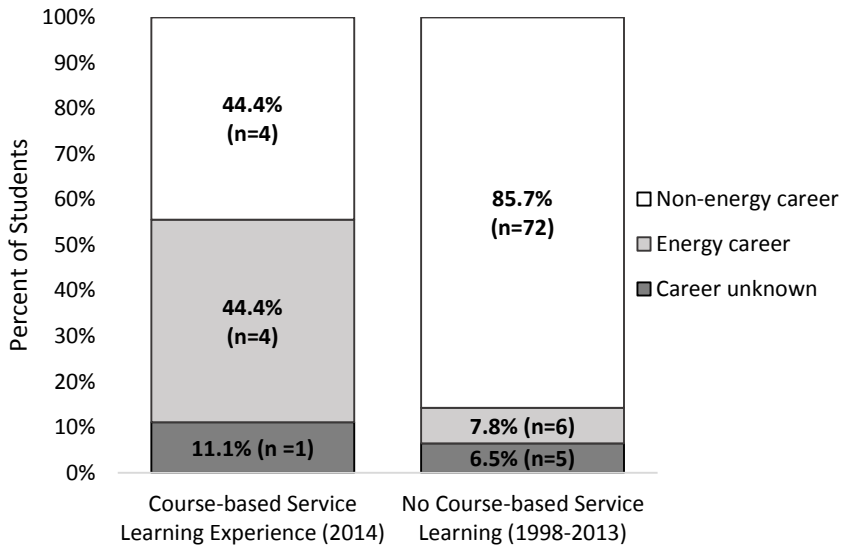

Figure 1. Initial career selection of students who participated in the course-based service learning experience (2014 graduation data) as compared to previous graduates (1998-2013) who did not participate in course-based service learning.

previous fifteen years (1998 – 2013) when students were not involved in any course-based service learning project. Only 7.8% (6 of 77) of engineering graduates in this group reported employment in the energy industry (Fig. 1). The data indicate that participation in a course-based community service project can meaningfully impact a student's formative development. While additional factors affect career choice, the high percentage of student participants entering the energy field supports the ongoing utilization of community based service projects.

Unlike traditional coursework, the relevancy of the material and its practical application engaged students in the learning process. The experiences exposed students to the language of energy, standards, regulatory issues, energy distribution, metering and billing in ways not easily replicated in a traditional laboratory setting. The experience also equipped students to demonstrate real world experience on resumes and job interviews. The increase in energy related career choice is attributable, in substantial part, to the service-learning experience.

Opportunities for Improvement

Several opportunities for improvement presented themselves during the project. The instructor should have asked students to critically reflect on the social implications of sustainability, the effectiveness of the service experience, and the impact of this experience on career selection. Finally, it is best to develop long-term, sustained projects, but the project described has not been sustained. Long-term projects with the goals of fiscal and environmental conservation in partnership with other external partners should be explored.

Future Studies

Similar energy-savings projects could be implemented at other institutions with local community partners. The project did not require extensive travel and did not require special equipment to implement. The goals of this service-learning experience, to act, to interact and to reflect, are not unique to this setting and would benefit other communities.

Conclusions

This community-based energy conservation project has enabled the Abington Heights school district to foster an educational partnership with The University of Scranton that conserves both fiscal and environmental resources through the application of community-based research. Together, the group defined project goals, shared and discussed ideas, planned and implemented selected projects.

Each team member learned from one another, and each benefited from group participation. The community benefited from cost-savings through energy conservation. Engineering students learned to review and analyze energy data, identify potential energy savings opportunities, develop a site survey plan, collect data, generate a feasibility study, predict expected outcome, and provide a recommended course of action to implement change. Following the completion of this project, several students obtained internships and full time employment in energy production and delivery. Based on the outcomes of this small study, it is concluded that a content-driven service-learning experience designed for engineering students in their junior year positively impacted the choice of career specialization.

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