

AC 2009-177: A SERVICE-LEARNING EXPERIENCE IN ENGINEERING AND ITS IMPACT ON STUDENTS

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Abstract

The engineering education literature addressing service learning as a new pedagogy and its assessment and benefits is scarce. This paper describes a concise engineering service-learning experience in the context of a typical heat transfer course for undergraduate mechanical engineering students. The service learning was designed to probe the ability of students to a) explain the societal context of engineering, b) explain the importance of pro-active community service, and demonstrate an inclination to continue such service in the future, c) exhibit an appreciation of communication with non-engineers and finally, d) challenge some of the students' stereotypes regarding others. The service-learning project was executed in collaboration with a local not-for-profit organization. Reflections were conducted by the students by answering a set of carefully-phrased questions after conducting the project. Analysis of students' responses as well as the implications of the trends obtained, are explained in this paper. The recorded benefits of service learning are described and can be expected from similar service learning projects in other engineering courses.

Introduction

The societal context of engineering has been gaining a lot of interest in engineering education forums in the US and around the world. Pascal¹ contended that engineers must work and think technical and human problems through together, without separating these two spheres. Ravesteijn et al.² emphasized the engineers must acquire the ability to understanding social dynamics of technology and to communicate facts, values and emotions on different levels. Santander Gana and Trejo Fuentes³ viewed technology as a human practice and a social activity that develops as a result of various intrinsically-woven socio-cultural circumstances. Engineers Australia⁴ and many new science and technology policies in Europe emphasize the importance of societal values connected to engineering.⁵ In the US, outcome 'h' in the Accreditation Board for Engineering and Technology's (ABET) Engineering Criteria 2000 deals with the broad education necessary to understand the impact of engineering solutions in an environmental and societal context.⁶ The National Academy of Engineers stressed that the years between now and the year 2020 will require that engineers strengthen their leadership role in society.⁷

Traditional engineering programs are usually more focused on technical development, not on preparing socially-responsible engineers with a strong sense of citizenship.⁸ Service learning is a viable solution for addressing this issue. Service learning is a pedagogy that provides students with structured opportunities to learn, develop and reflect through active participation in community projects.⁸ It is an opportunity to learn several non-technical skills.⁹ Service-learning develops students' awareness, cultural sensitivity, empathy and a desire to use technical skills to promote peace and human development.¹⁰⁻¹³ Tsang¹⁴ classifies service learning as experiential education, and says that it as elements of drama and dilemma, just like the real world.

There has been rising interest in service learning in engineering.¹⁵⁻¹⁷ Some of the published articles regarding engineering service learning lack any reflective or pedagogical analysis of service learning impact on students.^{17,18}

This paper gives a brief description of an engineering service-learning activity in a heat transfer class. In addition, it presents, assesses and analyzes the effects of the service experience on students' stereotypes, societal awareness, communication and other opinions and observations.

General Description of the Service-Learning Activity

A service learning assignment has been undertaken by undergraduate mechanical engineering students in their heat transfer course at the University of Detroit Mercy. Similar service-learning assignments have been implemented for the past few years. These service-learning experiences were assessed and analyzed from many angles.^{19,20} Last year (2008) a total of fourteen students participated in this assignment. For this last cohort, a clear outcome-based assessment was conducted and the results and conclusions of the assessment are presented here.

The service-learning activity was conducted by the students with help from Warm Training Center.²¹ This center is a non-profit organization that has been serving the Detroit area for about 20 years. One of the center's programs helps homeowners save on heating fuel and electricity bills by installing plastic storm windows, rope caulk, and door sweeps, which reduce heat loss. There was a need for assistance of some residents in installing the materials, mostly due to a combination of old age, disability, and illness.

Student teams of two went to the homes to install the materials and took window and door measurements, which they used in calculating the reduction in heat loss due to modifications, and the resulting monetary savings on monthly heating bills. There was an incentive of few bonus points towards the final grade in the course. Each team visited two homes- one home for an energy audit and the other for installing the energy saving materials. The students who selected to participate in the service learning experience were all white. The students were prepared by attending a lecture about service learning and another presentation about energy efficiency and how to install the materials and what to expect during their visits. There was a direct and clear link between these calculations and some of the heat transfer course outcomes. More details about the current service learning experience are given in.^{19,20}

Reflection Questions and Assessment of Outcomes

Reflection is key in service learning that differentiates it from simple community service.^{8,22} It promotes learning about larger social issues.¹⁴ The students usually reflect on how issues of race, ethnicity, socioeconomic class, and other social factors might affect an engineering problem.^{12,22} The act of reflection develops evaluative thinking skills¹⁴ and reflective judgment.¹²

Reflection and its analysis are relatively new in engineering education.^{12,22} Sometimes it can become extensive.²³ Efficient, concise and easily-implemented reflective components and

assessment rubrics can be extremely useful for assessing the impact of service-learning on engineering students.

In this project, the students were required to reflect on their experience considering several reflective questions. The questions categorized as “reflection questions (RQ)” or “multiple-choice questions (MCQ)”, along with the targeted outcomes, are shown in Table 1. There were a total of 14 reflections submitted by students and analyzed by the authors. The assessment was outcome-based as explained below.

Table 1. Targeted outcomes and reflection questions used to assess them.

outcome	reflection question (RQ)	multiple-choice question (MCQ)
explain how simple engineering solutions can be used to improve peoples’ lives	The plastic window covering and door sweeps were materials/systems that were designed and manufactured with processes developed by engineers. Do you think the materials you installed improved the lives of the home residents? Why or why not? If so, how did installation of the materials improve their lives?	I believe the materials installed by my group significantly improved the lives of the home’s residents. strongly agree agree neutral disagree strongly disagree
explain the importance of pro-active community service, and demonstrate an inclination to continue such service in the future	Do you believe that your participation in this activity was worthwhile? If so, why? If not, why not?	This activity has motivated me to make community service a vital part of my future. strongly agree agree neutral disagree strongly disagree
challenge stereotypes regarding others	What stereotypes were challenged, changed, or reinforced during the course of this activity? Explain.	One or more of my preconceived notions regarding low-income people was significantly challenged by this activity. strongly agree agree neutral disagree strongly disagree
exhibit an appreciation of communication with	Did you speak with the resident(s) about the benefits of your energy-	I believe my conversation with the residents was

non-engineers	saving modifications, or did you attempt to explain how or why the installation of the materials will reduce utility bills? If so, do you think the resident(s) understood the importance of the materials?	valuable. strongly agree agree neutral disagree strongly disagree
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Outcome 1

To gauge student’s ability to explain how engineering solutions can improve peoples’ lives, the students answered reflection question 1 (RQ1) and multiple-choice question 1 (MCQ1) of Table 1. For MCQ1, the vast majority of students (12/14) either agreed or strongly agreed that the materials installed significantly improved the lives of home’s residents. One student disagreed, while the other was neutral. As for RQ1, the two authors independently rated the explanation of each student. The rating systems ranged from 1 to 5, where a score of 5 indicated an excellent explanation. The scores given by the two authors were averaged for each student. The scores ranged from 2 to 5, with an average of 3.4 or 68.6%. An example of an excellent explanation (5/5) read: “I think the materials will improve the quality of their lives because it will save them money that they are normally wasting on heat bills. With this extra money they will be able to better take care of their family. Also it helps to create a warm area in the house for the family to spend time in, when they may have previously been avoiding the area.” While a poor explanation (2/5) read: “Yes, I think that they will help them to save money, as well as gave them ideas as to how they can save money other places. The homeowners seemed excited about doing things in their house to help them out.”

It should be noted here that probing students with such reflection questions and asking them to explain and elaborate triggers in them the activity of reflection- something not usually done when doing purely engineering work whether it is a homework exercise or a design project. To highlight this, we looked for positive, neutral, and negative indicators in the students’ responses to RQ1. Indicators for each of these response types are listed in Table 2. In order to quantify the results, positive indicators were assigned the number +1, neutral indicators were assigned 0, and negative indicators were assigned a value of -1. It should be noted that the numbers were obtained by simply summing indicators (for each student first and added up for all students). A graph of the results is shown as Fig. 1. It is very clear that the positive indicators outnumber the neutral and negative indicators.

Table 2. Words/phrases used as positive, neutral, and negative indicators for assessing students’ reflections on improving life of residents.

positive indicators	neutral indicators	negative indicators
(definitely) improve, improve lives (very) worthwhile immediately help more comfortable	somewhat some money worked at a smaller level	with any luck it will help maybe next winter

felt accomplished made a big difference so thankful benefit save, save money reduce cost good, good experience help, helped out, helped someone, it was nice to help, help out community dramatic impact feel good, great feeling enjoyed serving certainly interesting, unique learned things, learned tremendous amount engineering benefit a family give back to community	slightly improved make a small difference seemed excited I think it will help I believe it helped will be useful	
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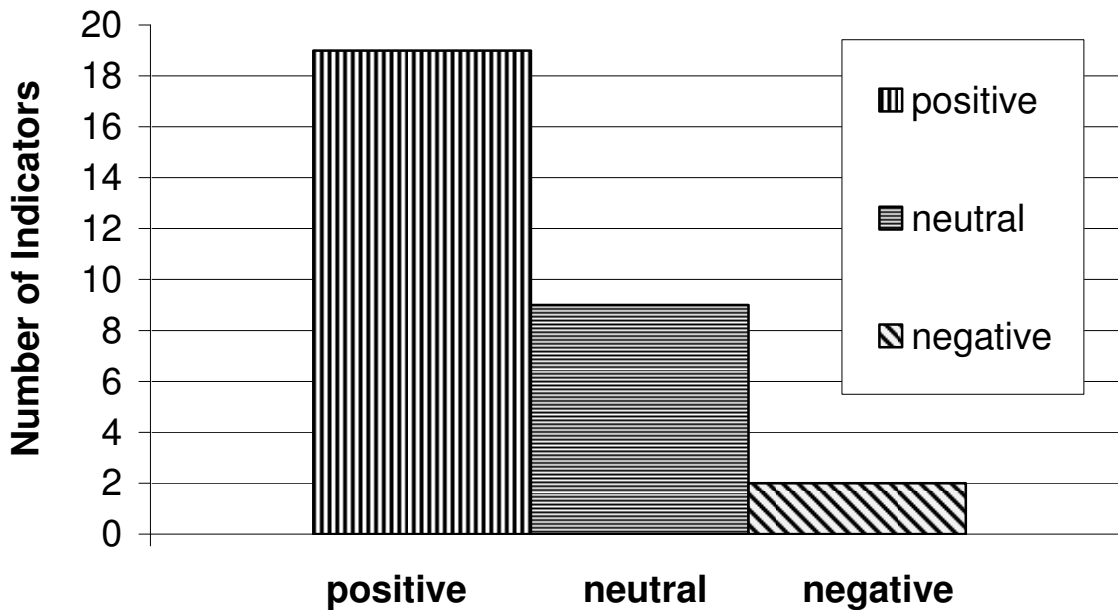


Fig.1 Total number of positive, neutral and negative indicators about the service learning.

This outcome as stated in Table 1 has two parts: explaining the importance of community service and show an inclination to continue it in the future. The first part was assessed by RQ2, while the other part as assessed by MCQ2. In response to RQ2, all fourteen students said yes, their participation in the service-learning activity was worthwhile.

Similar to rating of RQ1, the explanation part of RQ2 was rated by the two authors, and the two scores for each student were averaged. The ratings ranged from 2 to 4.5, with an average of 3.3 or 65.0%. An example of an excellent explanation (4.5/5) of as to why the service activity was worthwhile read: “My participation was very worthwhile. I have always enjoyed doing service and I think it should be an active part of everyone’s life. I think this experience was unique in the fact that I could apply first hand things I am learning in class to help someone’s life. I could also then calculate how much money we were saving the home owners.” A poor explanation (2/5) read: “It was certainly interesting and I even learned things about how to combat my \$400/month heating bills.”

To assess the inclination to continue service in the future, which is the other part of this outcome, the responses to MCQ2 were analyzed. A moderate majority of students (9 out of 14) indicated that they either agreed or strongly agreed that they were motivated to make community service a vital part of their future. The remaining five students were neutral. These numbers are reflected in Fig. 2.

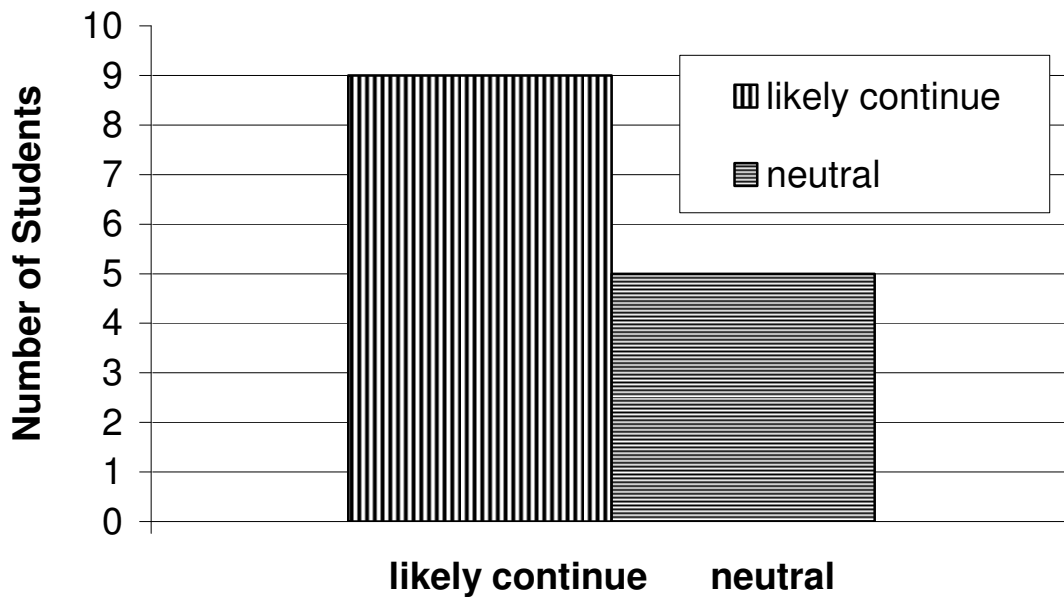


Fig.2 Number of students who will likely continue service and those who were neutral.

Outcome 3

The third outcome targeted by the service-learning activity was to challenge students’ stereotypes regarding others. This outcome was assessed by RQ3 and MCQ3 of Table 1. In response to MCQ3, only four students agreed or strongly agreed that one or more of their preconceived notions regarding low-income people as challenged as a result of participating in the service-learning activity. One student disagreed, while nine were neutral.

In response to the RQ3, students wrote about several stereotypes. A word of caution is in order here. Some of the students appeared not to have a clear understanding of what a stereotype exactly means, while others could not communicate their answers regarding stereotypes. Five students' responses fell under this category and were not discussed any further. An example of the former read: "Well there are mainly African Americans in Detroit. It is a demographic fact. The point that African Americans have been economically suppressed because of the color of their skin from 100's of years ago has held them back." An example of latter read: "I think the hardest thing for me was to see how vulnerable she was. Her front door knob didn't work and the door basically just rested shut. The huge holes/ breaks in her windows let in serious drafts and her house was extremely filthy. She had 5 children and only one of them came around ever to help her in her weakened condition. The stereotype that someone could "get out" of that situation was clearly wrong." One of the students said he was not sure while another indicated that he was free of stereotypes.

Table 3 lists the stereotypes that were challenged and others that were reinforced, as indicated in the students' responses. Students' responses were diverse. The same stereotypes could be challenged by one student and reinforced by others. In total seven of the students reported that they changed one or more of their stereotypes as a result of participating in the service. On the other hand, only three students had some of their stereotypes reinforced.

Table 3. Challenged/Changed and Reinforced Stereotypes

Challenged/ Changed	Reinforced
Inner city people dislike people from suburbs	City-founded programs are inefficient
Ungrateful	Homeowners are ill-informed
Used to having things done for them	Homeowners try to trick programs to get free furnace
Poor people are lazy	Detroit inner city is run down
Poor people are not nice, not easy going	Lazy, do not care about their house
Poor people do not care about their homes	Poor people try to make the best of what they have
Unwelcoming	Not fortunate, but good people

Outcome 4

Part of the service-learning activity was designed for placing engineering students in situations where they had to interact with non-engineers. In response to MCQ4, eight of the fourteen students found such conversations to be valuable, while five students were neutral and one disagreeing that the conversation was valuable.

RQ4 elicited explanation and elaboration on this issue. The explanations of the students were rated by the two authors. Scores ranged from 2.5 to 5 out of 5. Actually there were five students scoring 5, i.e., exhibiting an excellent level of appreciation and understanding of communication with non-engineers. The overall average for students who wrote about communication was 82.2%. As an example of an excellent explanation the following was stated by one student: "I

had to use different terminology than what we learned in class. As engineers we have more technical background and understand things differently. The people I worked with came from very different backgrounds so I had to take a different approach. I couldn't use heat transfer terminology such as conduction and convection, instead I had to describe what the process was by using non-technical terms." Five of the students were aware of the fact that they had to alter their communication and be selective in terms of vocabulary in order to reach their audience.

Other Comments

There were many interesting comments recorded by the students. Here are a few examples: "I enjoyed doing this project. I thought it was very interesting to apply what we were learning in class to real world application. It was also interesting to see some "extreme" cases where our application could really benefit a homeowner. I think in the future it would be interesting to show the homeowner how much money we were helping them save."

"This service project allowed me the same satisfaction as all of our community service opportunities. An experience like this is necessary periodically throughout ones life to be humbled, and become aware of what is truly important in life."

"I also think it is beneficial to stay Detroit centered... This is our home, it's about time people start opening their eyes to what's right under their noses."

"Overall it was a good experience that was rewarding. It was nice to be able to help out others less fortunate and also apply concepts from class. I think this is a great idea and it should definitely carry on for future classes."

Conclusion

A mechanical-engineering service-learning experience was presented as a way to increase students' social awareness of their role in society. The reflection component of service learning is a valuable exercise in reflective thinking that travels beyond the narrow boundaries of technical problems. The assessment of the service-learning experience's impact on students' ability to explain their role in changing peoples' lives, challenge and reflect on their stereotypes and appreciate the act of communicating with non-engineers was highlighted. It was evident that the service-learning activity had a direct and profound effect on the students. It is perceived that these impacts were both real and may be long lasting.

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