A Service-Learning Approach in a Basic Electronic Circuits Class

Fei Wang, California State University-Long Beach

Abstract

In this study, the author revised a basic electronic circuits course (EE330: Analog Circuit I) into a service-learning course with community engagement. The revised EE330 course required students to: 1) give a seminar to local high-school students on electronics topics, and 2) collaborate with local high-school students on a final project. The immediate goal of this re-design was to improve the communication skills of engineering students with a non-technical audience, and promote the awareness of engineering among future college candidates. Effectiveness of the service-learning approach was assessed through a variety of methods, including comprehensive reports and reflection responses from students, analysis of students' performance on key final exam problems, as well as surveys of high-school students and teachers. Reflection responses from college students indicated that the service-learning component enhanced their ability to communicate with a non-technical audience. It was also observed that students from the service-learning session outperformed the students from the regular session on design and complicated analysis problems. The majority of surveys from high-school students indicated that this activity stimulated their interest in choosing engineering as a college major in the future. It was also observed that female students showed less enthusiasm in technical topics when compared with their male colleagues, which suggests the needs for attention to gender differences in engineering education.

Introduction

Engineering educators are more and more aware that it is no longer acceptable to separate the teaching of engineering techniques from the social context necessary for a person to effectively contribute to society. Modern engineers must work and think both technically and socially, which requires them to acquire not only the knowledge of technology, but also the ability to communicate values and facts related to technology, mostly to audiences outside of engineering [1]-[2]

Nowadays, the service-learning method has been widely implemented in many disciplines. The specific methods may vary from project-based service [3], teaching-based service [4] and research-based service [5]. In general, when designing a pedagogy containing service learning, four basic principles need special attention. They are engagement, reflection, reciprocity and public dissemination. The engagement principle ensures that the service component meets a public good, which requires negotiation between university and community partners through outreach programs. The reflection component is especially necessary for the student to understand what they actually learn from the course. Whether the service is actually learning or not depends on whether the activity can encourage students to link their service experience to course content and to reflect upon the importance of the service. Reciprocity ensures that the students and the community teach and learn from one another. Public dissemination is basically the product of the service, which needs to be presented and delivered to the public.

While academic service learning usually provides community services, not all activities providing community services are considered service learning. Academic service learning should aim for both service and, more importantly, learning. Therefore, this study focused on the following criteria when designing the service-learning pedagogy.

- Relevant and Meaningful Service with the Community: This is the typical service component needed to ensure that the service provided within the community is relevant and meaningful to all parties.
- Enhanced Academic Learning: This is the typical learning component. The service provided must help students to reflect on and assimilate the knowledge they acquired in the course.
- Purposeful Civic Learning: This activity should intentionally prepare students for active civic participation in a diverse democratic society.

If any of these three criteria is missing, it is no longer a service-learning practice, but some other form of community engagement. Table 1 compares service learning with other types of community engagement. A common weakness of college students, especially engineering students, is an inability to communicate in non-technical terms with people from different backgrounds. Therefore, developing a learning environment that gives them the opportunity to articulate engineering problems or products in easy and organized terms is extremely important. Based on the NSF's survey of recent college graduates, only half of all engineering/science graduates enter engineering/science occupations after their graduation [7]. A great number of them take positions like technical marketing, sales, teaching or other related positions. These positions require great communication skills to non-technical audiences. Although engineering students receive basic communication training through general education courses required by ABET, they do not usually receive the training in technical communication, which benefits

them directly. The service-learning pedagogy designed for the EE330 course targeted this issue. Therefore, a teaching-based service-learning model was used. The community partner in this study was a local high school serving mainly minorities.

Table 1 Comparison of Types of Community Engagement [6]

	Community Service	Enhanced Academic Learning	Purposeful Civic Learning
Volunteering	Yes	No	No
Internship	Yes	Yes	No
Service Learning	Yes	Yes	Yes

From a community-service point of view, K-12 students are provided an opportunity to get to know the engineering world through this activity. They also come face-to-face with electrical engineering students, who share their college experience with them. This helps the K-12 students make well-informed decisions when they need to choose a college major in the future.

From the academic department's point of view, this service-learning activity has the potential to recruit future students, who are really interested in electrical engineering. This directly helps department enrollments, and indirectly improves the quality of the program.

Curriculum Design

EE330-Analog Circuit I is a required course for Electrical Engineering majors at California State University, Long Beach. It is offered in both Fall and Spring semesters. Depending on the student enrollment, at least one session is offered each semester. EE330 has both lecture and lab components, and students are required to work on hardware lab experiments. The "required" nature and the offering frequency of this course ensures that all students graduating from the Electrical Engineering department receive technical communications practice.

The current curriculum of EE330 includes a review of linear electronic circuits, introduction to diodes, transistors and operational amplifiers, and examination of their applications in electronic circuits. Application topics include rectifiers, DC-DC converters, amplifiers, sensors and I-V converters. During the course, students are expected to develop the ability to design and build circuits, troubleshoot them and explain the results. The addition of a service-learning component does not alter the learning objectives of the course; on the contrary, it enhances student achievement of those objectives.

The service-learning component of EE330 requires students to give a seminar to local high-school students on topics related to the course and collaborate with them on a hardware final project. Students are required to develop their presentation strategies so that youths from high school will understand. Topics selected for purposes of the seminars should be chosen very carefully, so that they are not only related to course content, but also relevant to everyday life in order to attract the attention of the audience. The hardware project, which is also the final project of the course, must reflect one of the circuit applications covered in class. Instructors suggest a few topics, but students can also choose their own topics given the instructor's permission.

The specific learning objectives of EE330 include:

1. Students should be able to describe basic electron transport phenomena, diode rectification, switching and amplification of BJT and MOSFET transistors and op-amp operation sufficiently well to convey that understanding to audiences without an engineering background. This objective is assessed through the service-learning presentation, reflection discussion and service-learning final report.
2. Students should be able to draw schematics of diode bridge rectifiers, DC-DC converters and complete power supply. This objective is assessed through exams and lab reports.
3. Students should be able to draw AC and DC equivalent circuits of bipolar junction and field-effect-transistor circuits. This objective is assessed through exams and lab reports.
4. Students should be able to mathematically analyze transistor and diode circuits and solve for Q-points using the MoHAT procedure. This objective is assessed through exams and lab reports.
5. Students should be able to design CS and CE amplifier circuits based on given design expectations. This objective is assessed through exams and lab reports.
6. Students should be able to synthesize the knowledge learned from lectures into a hardware circuit design to perform certain applications. Students should be able to troubleshoot and test their circuits. This objective is assessed through final project reports.
7. Students should demonstrate civic engagement with local communities to promote fundamental engineering knowledge through informal education seminars. This objective is assessed through the service-learning

presentation, reflection discussion and service-learning final report.

8. Students should demonstrate their ability to recognize different audiences and be able to design their presentations accordingly. This objective is assessed through the service-learning presentation, reflection discussion and service-learning final report.

The specific requirements of the service-learning activities include:

1. SERVICE-LEARNING PRESENTATION: Students are allowed to choose any topic that is related to this course in order to design a seminar presentation for high-school students in grades 8-12. The presentation is evaluated through feedback surveys from 8-12 students and the PowerPoint slides of the presentation.
2. SERVICE-LEARNING PROJECTS: Students are required to collaborate with 8-12 students on a hardware final project. Final projects must reflect one of the circuit applications covered in class. Instructors may suggest topics, but students can also choose their own topic given the instructor's permission. Final projects should require 10-12 hours of work. The final reports and seminar PowerPoint slides will be shared with 8-12 schools for educational purposes.
3. REFLECTION DISCUSSION: The discussion board on beachboard.com (a subsidy of blackboard.com designed solely for CSU Long Beach) is used as a medium for discussion. Students are required to respond to reflection questions posted by the instructor and share their learning experience with peers through board postings. At least three responses are required by the end of the semester including one before the seminar presentation, one after the seminar presentation and one during the final project. Extra credit will be granted to students, who actively participate in discussions.

Implementation

In the Fall 2008 semester, EE330 was offered as a service-learning course. The Center of Community Engagement on the Cal-State Long Beach campus was of tremendous help in terms of identifying service-learning opportunities within the Long Beach community. The New City School at Long Beach expressed their interest during the initial contact with the author of this study. Several campus visits to the New City School were conducted to identify the feasibility for setting up the equipment. A meeting with their science teachers was conducted to coordinate the educational needs of both parties and to negotiate an appropriate class schedule of both parties.

During the first week, the instructor of EE330 conducted an introductory lecture to the EE330 students about the educational benefits and the goals and requirements of the service-learning component. This lecture also covered technical communication topics such as strategies to approach the target audience, selection of topics/project, and design of a presentation. Safety issues that students should be aware of were also covered in the introductory lecture. Students were expected to approach the community partner to make arrangements for the scheduling of their presentation and the project.

Five groups—19 students—provided service to 8-grade students in the New City School. The topics of their seminar presentations ranged from interesting applications to basic science. Some of them taught 8th-grade youths to measure current, voltage and resistance using the digital multi-meter. Some of them lectured on the behavior of diodes, transistors and their applications. Some of them brought a microcontroller board to showcase how to control a toy car.

The selected final hardware projects included: Automatic light control using a Schmitt Trigger built from an operational amplifier; a power-supply design including diode rectification and DC-DC converter; small signal amplifier design using a BJT transistor (2 groups selected this project); light insolation meter using an operational amplifier as I-V converter. The students designed, built and tested their circuits in the EE department's laboratory before their community service. On-site at the high school, they re-built their circuits with high-school students and characterized the circuits with them again. This way, the high-school students were provided a hands-on experience on electronic hardware, which was expected to stimulate their interests in electrical-engineering topics.

Students were required to have reflection discussions before and after their service so that they could reflect on what they learned during the service activities. The reflection questions were posted on beachboard.com by the instructor. Students responded to questions by adding threads to the board. Sample questions posted by the instructor include:

1. What topic did you choose for this service and why?
2. Discuss your experience about the service presentation, such as questions received, audience interest and how you dealt with the non-technical audience.
3. If you had a chance to repeat this service, how would you improve the effectiveness?
4. Give your opinion on electronics-related service-learning topics and how you benefited from this service.

Assessment

The assessment of this service-learning activity was conducted in three ways: 1) Students' reflection responses were collected and analyzed in order to assess the learning outcome regarding technical communication; 2) Students' performance on key final-exam problems were analyzed and compared with a control session in order to assess the effectiveness of the service-learning activity in terms of enhancing the learning of technical topics; and, 3) Surveys of high-school youths (mainly 8th graders) were collected and analyzed in order to assess the effectiveness of the service-learning activity in terms of enhancing community's awareness of engineering.

- **Reflection Response**

This is a qualitative assessment method. All reflection responses from students were collected, analyzed and summarized on key issues. It was found that most of the students found it challenging to present the material to 8th-grade youth. The main reason was that they had a hard time attracting the youths' attention during the presentation. In addition, explaining concepts in non-technical terms was another thing they found to be challenging. The lesson they learned from this service was that the design of a presentation is extremely important when facing a non-technical audience. Some of them said that if they were to do the seminar again, they would include more hands-on demonstrations and more videos and pictures.

Those strategies attract the audience's attention more effectively, and can help them better understand the topic. Some of them mentioned taking control of the presentation pace and using an active tone during the presentation, which is also important. Regarding the learning outcome, most of them responded positively. They stated that they have to understand their project before they can explain it to others. One of the groups also mentioned that the questions they received during the service made them think about and improve the project. Another group stated that they remembered how "blind" they were when they got to choose a college major, and that they were glad that they could help others make informed choices. This comment indicated that the students started to become aware of their responsibilities to the community.

- **Performance on Key Problems**

Students' learning outcome on technical content was assessed quantitatively by comparing their performance on key final-exam problems with those from a regular session. When designing the two final exams, three identical key problems were intentionally included for assessment purposes. The three key problems were: a transistor analysis for dc and small signal analysis, a diode analysis problem for dc Q-point analysis, and an op-amp design problem. To exclude the psychological effects, these key problems were put in the same order for both sessions, i.e., problem 1 was the transistor analysis, problem 2 was the diode analysis, and problem 3 was the op-amp design. Problems that were not for assessment purposes were included thereafter. The average score of the assessment problems from both sessions are summarized in Table 2.

It was observed that the students from the service-learning session significantly out-performed the regular session students on design and transistor-analysis problems. This is probably because a majority of the students from the service-learning session chose final projects related to either the op-amp design or amplifier design using a BJT. Although students from the regular session were required to do similar projects, they still showed a weaker understanding on these topics. This clearly suggests that the service-learning component did enhance the students' learning outcome. While seeking a way to explain their final projects to 8th-grade youths, the students solidified their understanding on selected topics.

Table 2 Score comparison of key problems between service-learning session and regular session

	Service Learning Session	Regular Session
Transistor Analysis	71%	43%
Diode Analysis	61%	67%
Design using Op-Amp	62%	34%

- **Survey to High School**

The impact of the service-learning activity on the local community was assessed both quantitatively and qualitatively. The assessment surveys shown in Table 3 were distributed to 8th-grade audiences. Besides the numerical measures, audiences were also provided room to provide their comments and expectations on future presentations. High-school teachers were also invited to provide their qualitative comments on this activity.

Eighty copies of survey were distributed to the 8th-grade audience, of which 59 were returned. Among those returned, 30 were from males and 26 were from females; 3 others did not specify their gender. Some returned surveys were partially completed (20 copies) with one or two un-answered questions. The statistical results are presented in table 4. Questions 1, 5 and 6 focused on assessing the effectiveness of the service-learning activity in terms of improving high-school students' awareness of the engineering field, i.e., the audience's interest in engineering topics and enthusiasm for pursuing further study in this field. Questions 2, 3 and 4 focused

on assessing the technical communication performance of college students.

From the statistical results shown in Table 4, it can be concluded that the performance of college students turns out to be positive. Their presentations gained positive responses from the audience. Overall, they were able to convey the topics they selected in non-technical terms. A significant difference between male and female audiences on Questions 2, 3 and 4 was not observed. However, regarding the level of interest in engineering topics and the enthusiasm for pursuing further study in engineering, the difference between male and female audiences becomes significant. The male audience showed stronger interests and enthusiasm in engineering topics (Question 1- 4.65, Question 5- 4.1 and Question 6- 4.1) than female audience (Question 1- 3.75, Question 5- 3.43 and Question 6- 3.2). These results tell us that, as educators, we need to pay more attention to the gender differences in engineering education.

Table 3 Assessment survey to 8th-grade audience

	Strongly Agree				**Strongly Disagree**
Does the topic interest you?	5	4	3	2	1
Is the presenter well prepared?	5	4	3	2	1
Did the presenters provide interesting examples and/or demos that helped you understand the topic better?	5	4	3	2	1
Did the presenter try to communicate with the audience in non-technical terms?	5	4	3	2	1
Are you willing to learn more about Electronic and Electrical Engineering after this seminar?	5	4	3	2	1
Will you consider Electrical Engineering as your major in college?	5	4	3	2	1

The high-school teachers also gave positive feedback by stating that their students showed more enthusiasm on science topics after this activity. They received requests from multiple students about visiting the college of engineering at CSU-Long Beach after our students gave the seminar presentation. Thus, a campus visit was arranged in the same semester. High-school youths visited our electronics and micro-fabrication lab as well as some computer-aided classrooms. During the visit, the authors received multiple questions regarding the instruments in our lab as well as the admission requirements to the electrical engineering department. Visitors expressed high enthusiasm for further involvement in these kinds of activities.

Table 4 Statistical results of the assessment survey

	MALE (30 responses)		**FEMALE (26 responses)**	
	Mean	**STD**	**Mean**	**STD**
Question 1 (56 responses)	4.65	0.48	3.75	1.15
Question 2 (45 responses)	4.6	0.73	4.81	0.39
Question 3	4.42	0.94	4.6	0.61
Question 4 (41 responses)	4.53	0.82	3.94	1.03
Question 5	4.1	1.11	3.43	1.06
Question 6	4.1	1.14	3.2	1.47

Conclusion

An electronics core course (EE330-Analog Electronic Circuit I) was redesigned into a service-learning course in order to improve engineering students' ability to communicate with non-technical audiences and simultaneously promote engineering awareness among K-12 students. Students offered community service in the form of seminar presentations and project demonstrations to local high-school students. Assessment analysis show that: 1) all college students stated that the service-learning activity improved their capability to communicate with non-technical audiences; 2) students from the service-learning session outperformed the students from the regular session on key final exam problems, specifically on design and complicated analysis problems; 3) the majority of the surveys collected from high-school students indicated that they were interested in choosing engineering as their major in the future; 4) female high-school students showed less enthusiasm for engineering topics when compared with their male colleagues, which suggests the need for attention to gender differences in engineering education.

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Biography

FEI WANG is an assistant professor in Electrical Engineering Department at California State University, Long Beach, CA, since 2007. She was an assistant professor in EE department at California Polytechnic State University at San Luis Obispo, CA, from 2005 to 2007. She received MS and PhD degree in Electrical Engineering from University of Cincinnati in year of 2002 and 2005 respectively. She received her BS degree in Electronics and Information Science from Peking University, Beijing, China in year of 2000. Dr. Wang can be reached at fwang3@csulb.edu