AC 2010-313: INTEGRATING SERVICE-LEARNING IN THE FIRST-YEAR INTRODUCTION TO ENGINEERING COURSE

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1. Introduction

In the past several years community-based and service-learning curricula have received significant attentions. Through such programs, teams of students will engage in solving real-world problems benefiting their community. These programs provide unique opportunities for students to collaborate with diverse groups of community partners, develop professional skills and team work, participate in community building, improve leadership abilities, and learn project management.

This paper provides a brief description of a service-learning component that was integrated into the Introduction to Engineering course. Through this pilot project, engineering students were assigned to design a simple electro-mechanical throwing machine that can assist children with physical disabilities participating in the Sidekicks program. The Sidekicks program at Sonoma State University assists adolescents and children with autism and developmental disabilities to participate in recreational activities. Many of these individuals are not capable of fully participating in group activities. Existing studies suggest that increasing interactions among students with physical disabilities can considerably improve their peer interaction and social skills.

In the rest of this paper we elaborate on our methodology and outcomes and look at how the service-learning project improved communication and teamwork skills among participating engineering students.

2. Background

Service-learning is defined as a credit-bearing educational experience in which students participate in an organized service activity in such a way that meets identified community needs [1]. Studies suggest that service-learning can significantly impact various educational outcome measures, including academic performance (GPA, writing skills, critical thinking skills), values (commitment to activism and promoting racial understanding), self-efficacy, leadership, choice of a service career, and plans to participate in service after college [2].

In the past few years service-learning has become increasingly common pedagogy in engineering programs around the globe. One reason for its popularity is the industry's desire for individuals with the communication and collaboration skills who are better equipped for working in a global context [3,4].

In the United States, many different universities have also incorporated service-learning into their curricula[5]. Perhaps the best well-known example is the Engineering Projects in Community Service (EPICS) program[8] created by Purdue University in 1995 and now it includes 18 universities. Under this program freshman to senior undergraduate engineering students form multi-disciplinary teams to meet community needs.

Many of the existing engineering service-learning programs are primarily offered through capstone or elective courses[6]. By contrast, some engineering programs have integrated service-learning into core undergraduate courses. In order to be more effective some institutions have taken this concept even further and implemented the service-learning concept over the entire eight semester undergraduate curriculum[7]. In any case, the primary objectives are introducing the concept of social responsibility in the engineering profession to students, deepening their understanding of course content, building a bridge between theory and practice, and sharpening their abilities to solve problems creatively and working collaboratively.

The above objectives are well aligned with the Engineering Criteria 2000 promoted by Accreditation Board for Engineering and Technology (ABET) that emphasizes on the broad education necessary to understand the impact of engineering solutions in an environmental and societal context. In fact, ABET expects that engineering programs demonstrate that their students attain the following outcomes: an ability to communicate effectively (outcome 3g), ability to function in multidisciplinary teams (outcome 3d) and understanding the impact of engineering solutions in an environmental and societal context (outcome h) [9].

In 2009, the Department of Engineering Science at Sonoma State University introduced the service-learning to the Introduction to Engineering course (ES110). In collaboration with the Center for Community Engagement and Adaptive Physical Education program at Sonoma State, we required students to design and implement a simple ball throwing machine for young physically challenged students participating in Saturday Sidekicks program sponsored by the Department of Kinesiology. The purpose of this project was several-fold: generating real interests in engineering, incorporating engineering concepts to community needs, encouraging students to exercise civic responsibilities, involving students in a team-based project with diverse clients, and promoting leadership skills.

3. Project Motivation and Requirements

The proposed service-learning project was motivated by assisting the Saturday Sidekicks program[10], an on-campus physical activity program for school-aged children with special needs from local communities in Sonoma County, California. Through this program, three one-hour sessions grouped by age take place each Saturday morning for 8 weeks during fall and spring semesters. Each child or teen is paired with a Sonoma State student, who plays with them and guides them through activities that are set up around the gym, based on a weekly theme. In order to successfully establish appropriate physical education setting and ensure that each student will experience success in a safe environment the program can significantly benefit from specially engineered tools and assistive technologies to address variety of needs by individual students.

Motivated by such needs, through a collaborative effort between the Center for Community Engagement at SSU[11], Kinesiology Department sponsoring the Sidekicks program, and the Healthcare Technologies Laboratory (HTLab) at Engineering Science Department, we developed a unique service-learning component that was introduced to ES110. The objective of this project was to design and build a powered throwing machine that can throw a ball at least ten feet and can easily be customized for one or more physically disabled students, often sitting on a wheelchair.

4. Integration of the Service-Learning

In the following paragraphs we describe the course content of ES110 course and elaborate on how we integrated the service-learning component in this course.

4.1. Course Description

Introduction to Engineering (ES110)[12] at Sonoma State University is a two-credit hour core engineering course with one hour lecture and 2 ½ hours of lab per week. The laboratory assignments make up 50 percent of the overall course grade. As shown in the tale below, typically, most of students enrolled in this course are freshmen and this course is their first exposure to a college level engineering course.

Course	Male	Female	Freshmen	First Course in Engineering	Total
ES110	65 %	35 %	80 %	95 %	65

The objective of ES110 is to introduce the fields of engineering to the students and expose them to basic engineering concepts, with special emphasis on electrical engineering topics. Typically, ES110 lectures focus on describing different engineering fields. The laboratory exercises generally cover fundamental engineering topics.

We revised the laboratory activities such that students become familiar with basic design concepts used in building typical electro-mechanical ball throwing machines. In the first two lab activities we introduced basic mechanics and physics involved in designing a throwing machine. Students were introduced with a number of design examples and we compared performance, strengths, and weaknesses of each design.

In the subsequent weeks, laboratory activities were primarily focused on introducing electrical/electronic components potentially used in a powered throwing machine. The main approach in introducing such topics was through introducing related household items and demonstrating how they operate. Examples of these items were electric fans for demonstrating the concept of DC/AC motors, energized air freshener for demonstrating resistance and heat, solar lawn lights for demonstrating the concept of solar energy, and talking greeting cards for demonstrating sounds and tones. Throughout these brief lectures, we also introduced basic simulation tools and online applets to demonstrate topics such as power dissipation, diodes, photo resistors, and trajectory motions.

4.2. Student Assignments

All students in ES110 were asked to form a group of three or less and follow the deadlines as posted on the class web site. The main project deadlines and deliverables throughout the semester are listed in Table 1.

Table 1. Project deadlines and expected deliverables.

Week	Deadline	Week	Deadline
Week 2	Join the discuss ion group with a valid email address. Project discussion.	Week 10	Second Meeting (*): First Prototype must be presented to the client. / Visit the students with disabilities.
Weeks 3	Form a group. Submit the link to your blog page. Complete the Pre-Project survey (refer to Appendix A).	Week 11	Second project progress report is due. Post the report on your blog. Oral report is required.
Week 4	First Meeting (*): Visit the students with disabilities	Week 13	Third Meeting (*): Final prototype must be presented to the client.
Week 5	Create a http://delicious.com/ account and post your reference links on your blog.	Final Week	Create a movie (YouTube) and post it on your blog. Your Blog must be completed! / Complete the Post-Project survey (refer to Appendix B)..
Week 7	First progress report is due. Post the report on your blog. Oral report is required.	Notes: (*) All students were required to show up on Saturday to visit disabled children.	

Throughout this project we encouraged students to utilize available online tools for progress report and class discussions. Thus, as indicated in Table 1, all student groups were required to complete the following assignments:

1- Design a blog page for posting progress reports.
2- Create a http://delicious.com/ account to share and save all reference links;
3- Signup with the class discussion group created by the instructor using http://groups.google.com/;
4- Create a YouTube account and post the final presentation video in the blog page.

Occasionally, sometimes late at night, the discussion group proved to be an effective communication medium for students to discuss class assignments.

4.3. Project Assessment

As we mentioned before, the laboratory assignment in ES110 accounted for 50 percent of the total course grade. The laboratory grade, in turn, was divided into two parts: 50 percent for completing the service-learning project and the rest for completing individual laboratory assignments. In this section we mainly describe the assessment and grading techniques used to grade the service-learning project.

In order to create a more dynamic environment, we announced that only the best project would receive a grade of A. The second-place project would receive a grade of A-, and so on. Thus, the project grading was strictly product-driven.

Each project was evaluated by multiple judges, including special education instructors and parents of the disabled children, according to the following guidelines:

- How closely the design matches the clients' needs; (25%)
- How user friendly the design is; (25%)
- How well the design operates; (25%)
- How reliable the design is. (25%)

In order to further assess each student's progress in terms of communication skills and understanding the design progress, three of the lab assignments were based on describing the architecture of different electro-mechanical systems. Assignment deadlines were about one month apart from each other in order to better evaluate each student's progress.

4.4. Project Examples

The designs were highly diverse, ranging from implementing catapult concept using PVC pipes to designing pneumatic tires connected to two DC motors and operating with a wireless switch. We contribute such diversities of designs to the fact that only a few design constraints had been provided to the students. Although, initially, lack of clear specifications appeared to be very troubling for many students, it allowed them to utilize any approach that they felt more comfortable with.

5. Experiment Outcomes

At the end of the semester, the students were asked to complete a mandatory short survey for the lab section of the course and provide their feedback regarding the service-learning project. The survey was primarily based on quantitative questions with the last question asking for student comments and suggestions. The combined demographics of the two sections were 35 percent females and 80 percent freshmen. The responses to some of the quantitative questions concerning the service-learning experiment are shown in Table 2; the complete questionnaire is shown in Appendix B. In the following paragraphs we elaborate on some of student comments and in-class feedback.

In general, a high number of students, initially, were not comfortable with interacting with the disabled children, particularly those with very severe physical and mental disabilities; this was also true about some of the engineering faculties involved in the project. In fact, in their feedback some students indicated that they wished they could just design a ball throwing machine rather than customizing it for a child with special needs. For many students accepting such responsibility seemed to be overwhelming. In their initial meeting with the disabled students, most engineering students avoided any contact with the disabled students or their parents. In contrast, engineering students who had prior experience in interacting with people with special needs appeared to be comfortable communicating with the disabled children. In the second meeting with the disabled children, however, engineering students appeared to be much more proactive and involved. For example, many were asking specific questions regarding how their design could be improved. Later, some of the engineering students actually contacted the parents on their own. One engineering student became a volunteer for the Saturday Sidekicks program and attended the event every Saturday.

Table 2. Student responses to post-project survey.

Questions	4. Very much	3. For the most part	2. Almost /Not sure	1. Not really
Were the project objectives sufficiently defined and you were clearly told what you were expected to do?	**53%**	47%	0%	0%
Do you feel that the client (children and parents) were sufficiently involved throughout the project?	18%	**47%**	29%	6%
Did the project remain within the scope of the course?	**53%**	29%	18%	0%
Did you feel that you receive sufficient theory/background for completing the project?	29%	**35%**	18%	18%
Do you feel that you learned a lot by completing this project?	**71%**	18%	12%	0%
Do you feel you understand more about what engineers really do after this project?	**65%**	18%	18%	0%
Do you feel that working in a group was very beneficial to you and helped you learn more?	**76%**	12%	12%	0%
Do you feel you spent too much time on this project?	12%	**53%**	12%	24%
Are you more interested to become an engineer after doing this project?	**41%**	24%	35%	0%
Did you like the blog creation and YouTube presentation?	**29%**	**29%**	24%	18%
Do you feel more comfortable with hands-on activities after this project?	**53%**	41%	6%	0%
Did you enjoy the fact that this project was designed for students with disabilities?	**59%**	29%	6%	6%
After completing this project, do you feel more comfortable working with students with disabilities?	18%	**59%**	6%	18%
Do you feel that after this course you will be more interested to do community-based projects?	**47%**	35%	18%	0%

According to the class survey, 60 percent of the engineering students enrolled in ES110 had never built anything prior to this exercise. Almost 80 percent of the students had never been involved in building any project *collaboratively*. Consequently, the virtue of teamwork happened to be a challenging concept for many students. Two groups requested to change partners five weeks through the semester due to acute personal conflicts. Following faculty intermediation, these groups remained intact and eventually completed a working prototype.

In their responses, a majority of students expressed satisfaction with having clear deadlines for the project. They agreed that had the project not been divided into milestones, as specified in the syllabus, it would have been very difficult to manage.

Students liked the fact that we covered many potentially useful topics related to their design in the laboratory section. In our final class discussion, many were amazed that they had actually completed the project; our initial survey showed 90 percent of female students initially did not think they could complete the project (refer to the questionnaire in Appendix A). By the end of the project, female students were clearly very involved in the project.

Assigning project grades based on the best design appeared to be very motivating. At the same time, it weakened the collaborative spirit among different groups. Winning played a motivating role in designing the best prototype to the extent that some groups never discussed the details of their design with other groups, e.g., how to release the ball wirelessly or how to increase the throwing range of the ball.

Many students strongly believed that through this project they learned a lot about engineering challenges. Some students expressed that they never thought making a simple throwing machine can be such a challenging task. Students in one group attested that they spent two weeks finding a rugged push-button switch that can be suitable for any of the disabled children to use. Others indicated that when the project started they had no idea how to begin.

After presenting their final projects, students received constructive feedback regarding the strengths and weaknesses of their design from the parents of disabled students and several special education instructors.

It was clear that in several groups one or two members played the primary role. We felt that one of the critical weaknesses of this experiment was our inability to recognize less active students and how they could be motivated. A well defined process is required to ensure the project effort is evenly distributed among all group members and to identify individuals with less enthusiasm. For example, we intend to utilize a peer evaluation tool, such as CATME[13], to further improve team member participation.

Another serious shortcoming of our experiment was lack of funding for student projects. Some students expressed that the lack of sufficient financial resources did not allow them to fully implement their design. Furthermore, due to lack of sufficient laboratory facilities, most students worked at home. The machine shop was only used when students really felt they needed assistance. Having better lab facilities could have resulted in better designs.

As a final note, we must emphasize that more data is required to identify the definite impacts of this project on the engineering students. Furthermore, so far, we have not received any feedback as to how student designs have been used in the field.

6. Conclusion

In this paper we reported on our pilot service-learning project integrated in the Introduction to Engineering course. Our survey results indicate that our engineering students engaged in this project developed better teamwork skills, communications abilities, and interests in community-based projects. These attributes are fundamental to ABET accreditation process. Based on student responses, it was evident that the service-learning activity had a direct and profound positive impact on the students. We believe that these impacts were both real and may be long lasting. Furthermore, we believe that our pilot service-learning project can be considered as an effective model to be replicated by other colleges and universities offering engineering or engineering technology programs.

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Appendix A

Pre-Project Questions

Date: ________________________________**Male/Female** _____________________________________

Semester at SSU _____________________ **Team Name** _____________________________________

How much time do you feel you SHOULD spent on this project individually or collectively to complete it? ________________

Scores: 4=Very much; 3=For the most part; 2=Almost/not sure; 1=Not really

Answer to the following questions:	Score
1. Have you ever built anything requiring electrical components (at work or school)?	
2. Have you ever been involved in building something in a team that took longer than five weeks (at work or school?	
3. Have you even taken any physics class?	
4. Have you ever taken any electronic class?	
5. Do you feel you understand what engineers really do?	
6. Do you think you need considerably more time to complete this project?	
7. Do you prefer to work alone in order to complete this project?	
8. On a scale of 1-4, how difficult do you think this project will be?	
9. Have you ever been involved in any community-based projects?	
10. Have you ever interacted with disabled children?	
TOTALS	____

Appendix B

Post-Project Questions

Date: ______________________________**Male/Female** ___________________________________

Semester at SSU ____________________ **Team Name** ___________________________________

How much time do you feel you ACTUALLY spent on this project individually or collectively to complete it?_______________

Scores: 4=Very much; 3=For the most part; 2=Almost/not sure; 1=Not really

Answer to the following questions:	Score
1. Were the project objectives sufficiently defined and you were clearly told what you where expected to do?	
2. Do feel that the client (children and parents) were sufficiently involved throughout the project?	
3. Did the project remain within the scope of the course?	
4. Did you feed that you receive sufficient theory/background for completing the project?	
5. Do you feel that you learned considerably through completing this project?	
6. Do you feel you understand more about what engineers really do after this project?	
7. Do you feel that working in a group was very beneficial to you and helped you learn more?	
8. Do you feel you spent too much time on this project?	
9. Are you more interested to become an engineer after doing this project?	
10. Did you like the blog creation and YouTube presentation?	
11. Do you feel more comfortable with hands-on activities after this project?	
12. Did you enjoy the fact that this project was designed for students with disabilities?	
13. Did you feel a little uncomfortable working with students with disabilities?	
14. After completing this project, do you feel more comfortable working with students with disabilities?	
15. Did you receive adequate technical support and assistance from the machine shop?	
16. Did you use the machine shop at SSU?	
17. Did you receive significant assistance from senior students and the engineering club?	
18. Do you feel lack of financial support from the department significantly impacted the quality of your project?	
19. Do you feel you received helpful comments from the judges?	
20. Do you feel that after this course you will be more interested to do community-based projects?	
TOTALS	____