AC 2011-100: A SERVICE LEARNING PROJECT FOR A FRESHMAN ENGINEERING COURSE

Dan G. Dimitriu, San Antonio College

DAN G. DIMITRIU has been practicing engineering since 1970 and taught engineering courses concurrently for over 20 years. He has been involved with several engineering societies and was elected vice-chair of the Two-Year College Division of ASEE in 2005. He has been the coordinator of the Engineering Program at San Antonio College since 2001. His research interests are: alternative fuels, fuel cells, plastics, and engineering education.

Jerry O'Connor, San Antonio College

Jerry O'Connor has been teaching physics (and occasionally engineering and math) courses since 1980. He is currently the Department Chairperson for Physics, Engineering, & Architecture at San Antonio College, and has been involved in numerous initiatives to integrate the findings of physics and engineering education research with education practice.

A Service Learning Project for a Freshman Engineering Course

Abstract

Service learning has been repeatedly shown to be a highly effective teaching tactic in higher education. Nevertheless, Engineering classes have been slower than other disciplines to adopt it successfully. This paper presents in detail an account of the development and results of the inclusion of Service Learning as a component of a freshman level Introduction to Engineering course. A significant part of the required work for this course is comprised of team projects. One of the projects was selected to be a service learning activity, and the community partner was chosen to be the local "Children's Museum". A charge was given to the class by the museum's Education Coordinator to develop thematic toys and games to help teach visiting children various physics concepts. The concepts were presented in a list along with additional technical specifications and safety requirements. Each engineering team was tasked to choose a particular concept and develop a toy or a game according to the specifications and requirements provided. The teams were required to follow and document the entire design process, culminating with team presentations of their products to the "customer" and a formal product test with real children was conducted at the museum. The project was concluded with a team report and class discussion that provided a forum to exchange ideas and lessons learned during the project. The planning, implementation, and the results of five semesters of this service learning project are reviewed and analyzed in view of ABET accreditation criteria. Conclusions and suggestions are presented to help more schools start using a service learning component in their Introduction to Engineering courses.

Project Goals

The primary goal of this project was to introduce freshman engineering students to authentic problems related to everyday activities that are representative of engineering problems in general, and that can be resolved within their level of expertise. The project was intended to enhance their problem solving abilities and involve them in a complete engineering design process cycle, including design specifications, research, and building and testing a prototype product. These course goals support the larger effort to attract and retain students in the field of engineering. Specific learning objectives for the course in general and this project in particular, were tailored to support ABET required outcomes[1], particularly:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (g) an ability to communicate effectively

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Project Description

Since its inception in the Fall 2008 semester, this Service Learning project has been implemented in the author's Introduction to Engineering course at San Antonio College. This course addresses six primary themes:

- attract students to the engineering profession
- orientation to the engineering curriculum
- academic success strategies
- team building and community activities
- personal development
- professional development

As part of the normal required coursework, students are organized in teams to work together on three projects and other assignments. The projects are mandatory and each one contributes 20% of the final course grade. They are designed to expose students to various elements of "real life" engineering and build teamwork skills that are necessary to succeed in an engineering career. The first project was designed to emphasize the importance of teamwork skills and the importance of research activities in support of a design project. The second of the three projects is intended to simulate an authentic engineering design process based on service learning criteria. The third project is a popsicle sticks bridge contest.

The Introduction to Engineering course has been meeting for two hours each week, and conventional wisdom recommends that a student should devote from two to four hours outside the classroom for every hour spent in the class. Engineering courses typically require a student commitment in the upper half of the range. Based on this principle, and a project weight of 20% of the final grade, it was expected that each student would perform about 20 hours of community service by the end of the project. With an average enrollment of 20 students in the class, it was estimated that about 400 hours of community service would be provided.

After a less than successful previous attempt to incorporate service learning projects in this course [2], the San Antonio Children's Museum was chosen as the community partner for the service learning project. The Museum was selected from a list of potential community partners provided by the Service Learning office at our college. The selection was based on the alignment between their needs for volunteer work in the area of education and the learning objectives of the course project. The Museum provided a list of science topics that were considered to be difficult to convey to their visitors without a physical demonstration involving educational toys or games. The list was developed into an engineering-like specification with age appropriate science subjects and safety requirements (see Appendix A).

The project was introduced to students with a visit from the Children's Museum Education Coordinator, who presented the specifications and clarified safety and educational requirements. All teams were endowed with $50 for materials from a service learning grant to build and demonstrate their prototype toy or game, and they were required to provide an invoice for the materials used in the project to show that they stayed within the budget. The teams were directed to select a subject from the list and follow the engineering design process to create a toy or a game, including doing the research for age appropriate safety requirements, creating sketches, selecting materials, and building and demonstrating a prototype. During each week's class meeting the teams were required to provide progress reports. In the fourth week of the project the Children's Museum Education Coordinator was present to review the prototypes. The teams presented their projects and the connection with the selected science concepts, and received concerns and recommendations from the customer. They had one more week to make any required remediations, and the following Saturday was product testing day. The Children's Museum reserved their main hall for the demonstrations and the teams brought their prototypes for three hours of testing by the museum's visitors. Each project received product test evaluations that were recorded on specially designed ballots. Although only one team member was required to attend the testing, many teams opted for full participation. There were on average about 100 visiting children and the testing was so intense that even some of the accompanying parents participated. At the end of the testing period any prototypes still functioning were donated to the museum for future demonstrations. Local press and TV stations reported on the project very favorably in their daily news coverage. The project concluded with final team reports that examined the entire design process, including the conclusions derived from prototype testing as well as their personal reflections on the activity.

The grades students received for this project were based on the team reports demonstrating achievement of learning objectives and the validity of conclusions drawn from the test results. Every student also received a score based on the CATME report that reflected student's contribution to the team as evaluated by the team members, (Team activities and interactions related to all course projects were evaluated by the Comprehensive Assessment for Team-Member Effectiveness (CATME)[3] program). Scores from the children's evaluations were added as a bonus to each team.

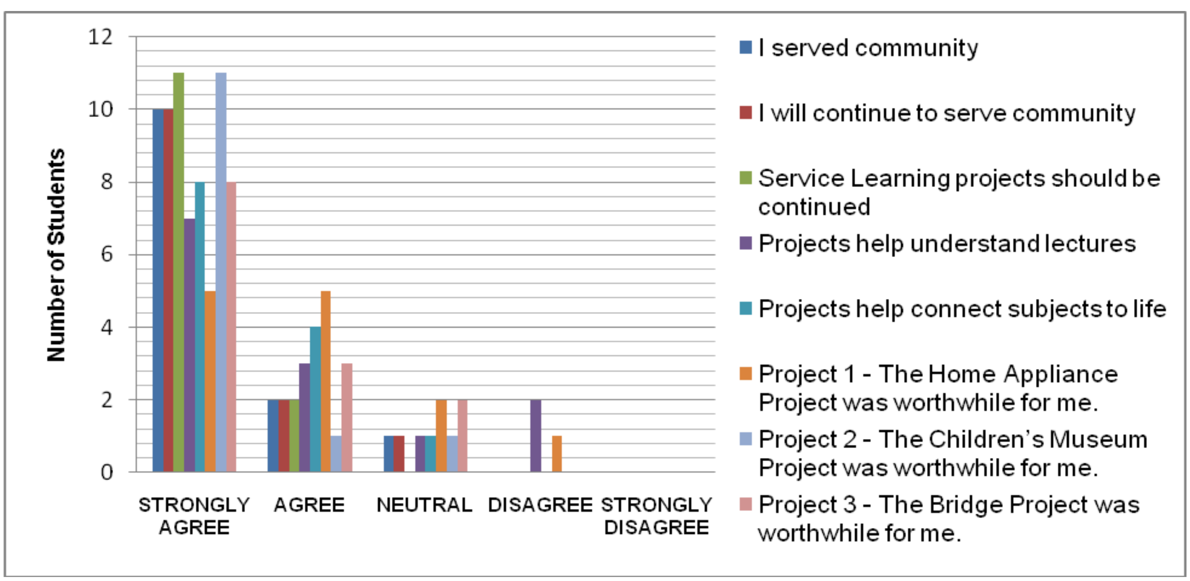

Figure 1
Student Survey Results from Fall 2008 Semester

Students completed an end-of-course survey comparing the projects and their value in relation to their educational goals. The results are shown in graphs one to five and the students' opinions are ranked from Strongly Agree (4 points) to Strongly Disagree (0 points).

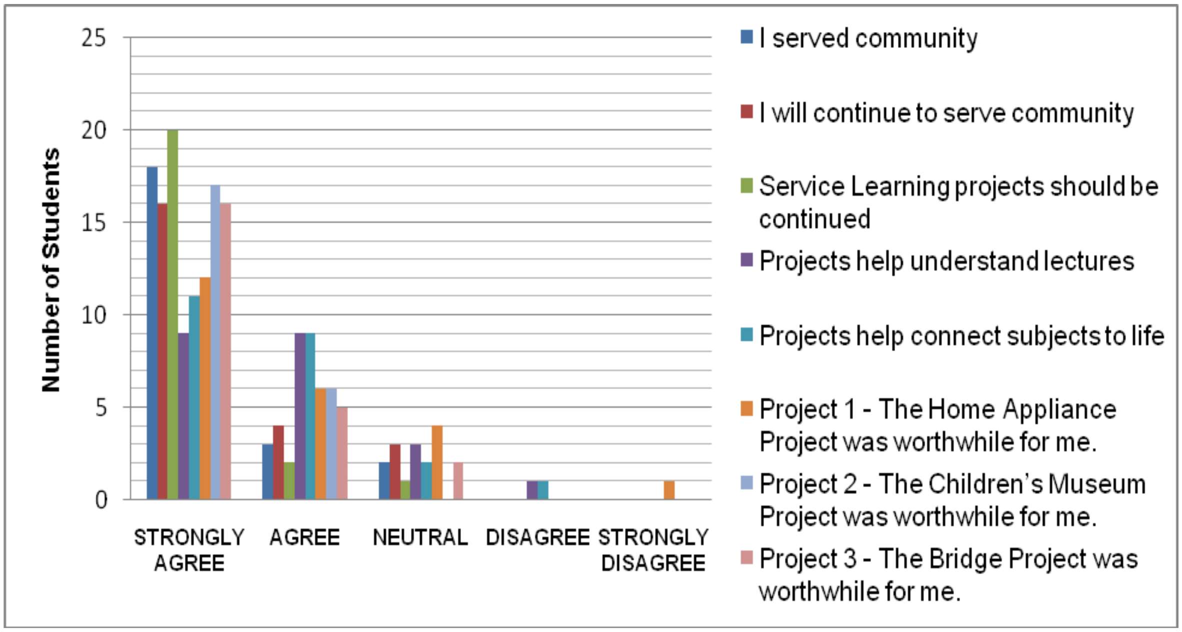

Figure 2
Student Survey Results from Spring 2009 Semester

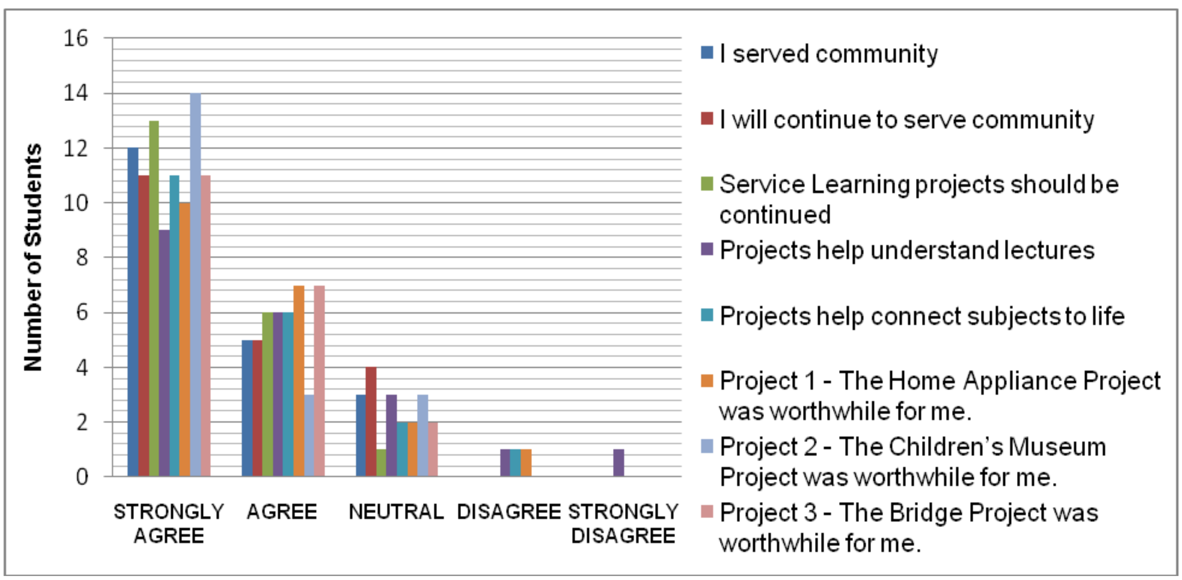

Figure 3
Student Survey Results from Fall 2009 Semester

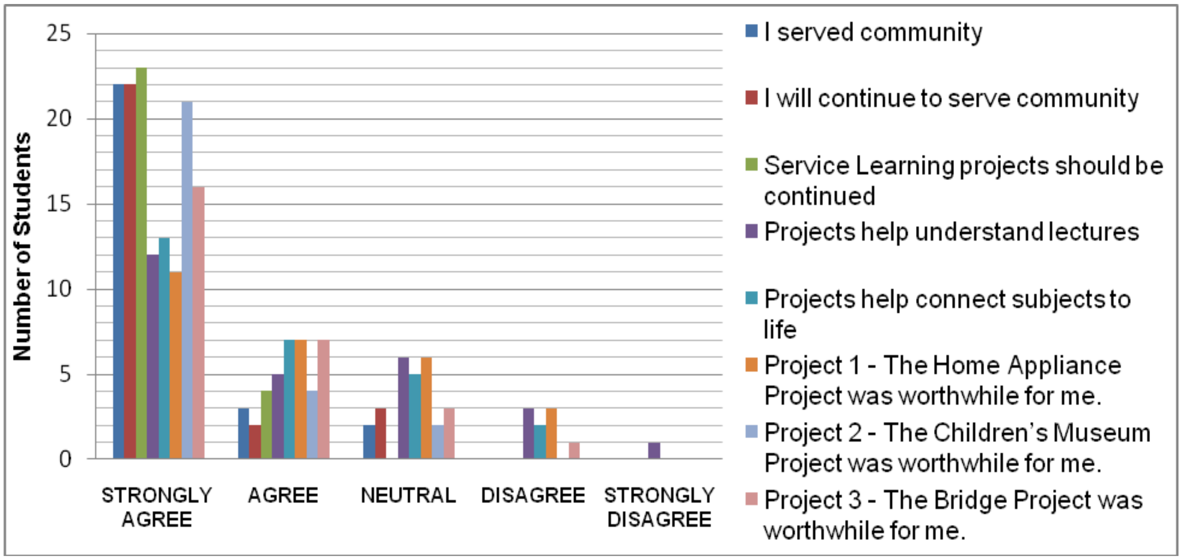

Figure 4
Student Survey Results from Spring 2010 Semester

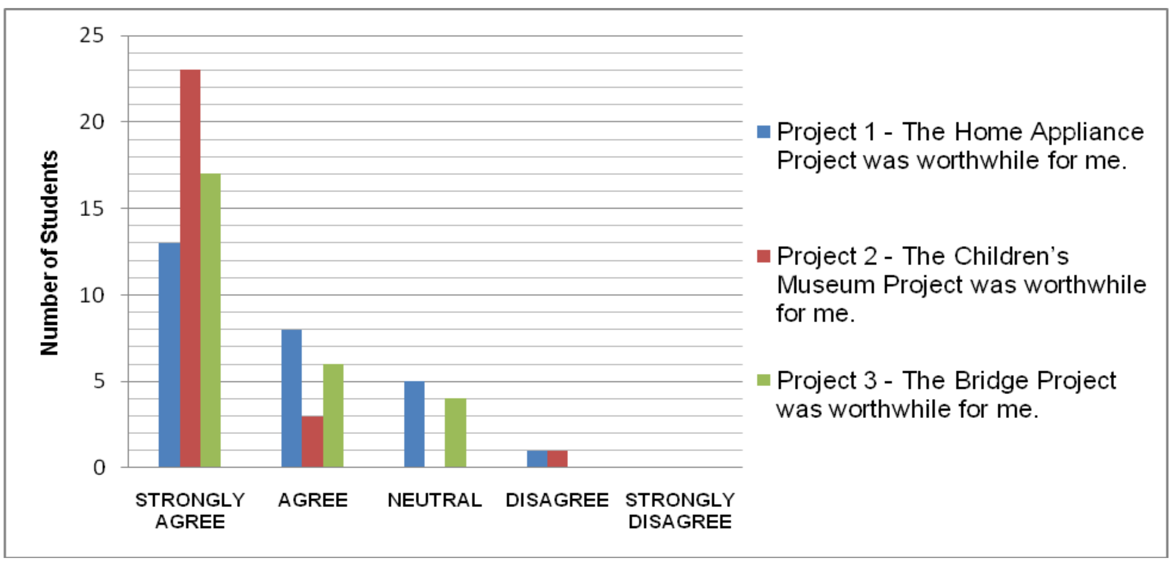

Figure 5
Student Survey Results from Spring 2010 Semester

A new component to the project was added for the fall 2010 semester. The service learning grant had ended and the $50 budget for building the prototypes was no longer available. This development prompted us to include a "green" aspect to the project, by requiring the prototypes be constructed from recycled materials. Each part provenience had to be fully documented and recorded in the list of materials and no new materials were accepted. The student survey questions pertaining to service learning were also dropped following expiration of the grant.

Conclusions

This project attempted to introduce students to a "real life" simulation of the engineering design process where they were required to utilize their creativity and integrate information acquired in the classroom and through research with physical and social constraints. Based on the team reports and student surveys it appears that most of the participating students valued the opportunity to provide assistance to the community, and most of them agreed that they learned a lot about the engineering design process. Most of the students also indicated that the experience reinforced their educational and personal goals of working in the field of engineering. A few students complained that the amount of time required by the projects was excessive in regard to the number of course credit hours received.

The primary beneficiaries of this project were the students, who were able to gain valuable experience and make connections between theory and practice by participating in authentic engineering work. The entire class was able to learn firsthand what is involved in an engineering design project from the initial specification all the way to product testing by the end users. The students were also able to see the importance of research for product safety and meeting customer requirements, the role engineers have in product development, and the importance of acquiring lifelong study skills.

Another beneficiary of the project was the Children's Museum, which received new, fully tested, toys and games as donations. As a non-profit organization their funding is limited, so every contribution helps them maintain and expand their outreach and fulfill their mission to expose children to science and engineering as early as possible in their lives.

The most noticeable benefits for the instructor were the satisfaction of engaging students in engineering, making a contribution to community improvement, and seeing improved relationships develop among students. As a result of conducting this project some valuable lessons were learned and some new practices were successfully adopted. For faculty that may be considering the implementation of Service Learning projects in their freshman engineering courses, the following points should to be addressed to ensure successful outcomes:

- Administrative support- this is very conducive to the success of service learning projects;
- Emphasis should be placed on academic rigor;
- Participation in faculty training offers a lot of help of implementing service learning projects in engineering courses and numerous chances to network with other like-minded faculty;
- Emphasis should always be placed on safety and quality at every step;
- Publicity and recognition of the project to raise awareness within the community of efforts and your program.
- All participants should be prominently recognized;
- Unexpected developments are inevitable; be prepared to be flexible and adaptable.

After five successful semesters this service-learning project will be retained in the Introduction to Engineering course as long as the Children's Museum will need help with materials needed in their demonstrations.

References:

1. Engineering Criteria 2000, Accreditation Board for Engineering and Technology (1998), < http://www.abet.org >.
2. Introduction of Service Learning in a Freshman Engineering Course, by Dan G. Dimitriu and Jerry O'Connor, ASEE Conference, Pittsburgh, PA, June 2008
3. https://engineering.purdue.edu/CATME

Appendix A

Toys / Games Project Guidelines from the Education Staff at the San Antonio Children's Museum

The Education Programs Department from the San Antonio Children's Museum requests your assistance in developing new toys and games that will help us teach our children various Physics topics, spark their curiosity for the subject, and develop an understanding of its basic principles. Since the museum is a non-profit organization there is no funding for this project and since San Antonio College is a leader in green initiatives it is mandatory that each project contains only recycled materials. It is also mandatory to create original work in order to avoid copyright and patent infringement disputes.

The toy or game should be centered on at least one of the following subjects that we found was difficult for children to grasp:

Aerodynamics	**Hydraulics**	**Propulsion**
Buoyancy	**Leverage**	**Pulleys**
Circuits	**Lift**	**Tension**
Force	**Magnetism**	**Velocity**
Friction	**Electricity**	**Equilibrium**

The intended audience for your game or toy is children of kindergarten and elementary school age.

When your toy or game is evaluated the following considerations will be addressed:

Is / does your toy or game:

1. Attractive in design?
2. Demonstrate an original idea?
3. Effectively appeal to your target age or grade range?
4. Exhibit gender and racial neutrality?
5. Durable to last for long-term use and abuse?
6. Effectively demonstrate one or more principles of engineering / physics?
7. Encourage experimentation through engineering / physics?
8. Non-hazardous?
9. Easy to carry, assemble, and clean by one single person without help?
10. Keep the interest of the child for an extended period of time?
11. Encourage group or grown-up participation?
12. Encourage language development?
13. Create a desire to continue exploration in engineering / physics after using the toy or game?

It is important to remember that when developing a product for children, simplicity is key!