Full paper: Re-imagining a first year design course to incorporate service-learning while minimizing traditional challenges

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Introduction

Foundations of Engineering Lab (EGN3000L) is a 1 credit hour introduction to engineering course taught to interdisciplinary first year students in the College of Engineering at the University of South Florida. Traditionally, the course is taught as non-service-learning through multiple, unrelated design projects. The projects prior to the Fall 2017 semester were simple, exposing students to engineering design with limited experiences that were thought to translate beyond the first year. The course was re-imagined based on principles of problem-based learning where the traditional learning objectives were accomplished through completion of a 1 semester long service-learning project. During the Fall 2017 semester, two sections of 45 students completed service-learning projects as part of this new course structure. The novel aspect of this work is the course structure which was specifically created to give students a useful project experience while minimizing logistical challenges. To evaluate the course, students were given an adaptation of Gelmon [1] service-learning based pre- post- surveys. These results are presented along with the course structure and a discussion of the future direction of the course.

Service learning is defined as a teaching method that combines classroom instruction with valuable community interactions to provide for the mutual benefit of all. At its core, this involves reflection on how the experience might improve critical thinking skills, increase student civic engagement, help to achieve learning objectives, impact the community or community partner, and/or provide for reciprocity between student and the community [2,3]. The course was changed to teach all of its course objectives as part of the semester long service-learning project. Students opted into their project of choice from five options, spending half of their semester designing and the other half fabricating deliverables. Service learning was thought to emphasize 1. The role engineers play in helping others, 2. The iterative and creative thinking aspects of design, and 3. The value of engineering tools, teamwork, and communication. Students involved community partners in the design process and delivered to their partners a working prototype.

Care was given in the course design to provide students with access to community partners while avoiding cumbersome logistical challenges. The premise for all projects was the development of a toy accompanied by learning materials for parents with middle school age children that have interest in STEM. Each project choice was based around a different technology with real parents coming into the classroom to work with students during two scheduled design review days. Although this approach was not expected to provide students with as personal of an experience interacting with their partner as seen with other successful service-learning approaches in the literature [4,5], it intended to minimize logistical challenges and provide reflection opportunities where students could consider themselves in the role of the kid for which they were designing.

The course was divided into three phases: (1) individual phase where students used CAD software to mock up potential solutions, (2) group design phase where students were grouped in teams based on shared ideas and worked to flesh out a design for fabrication, (3) group manufacturing phase where each group member adapted a specific role towards project completion, and (4) project finalization where groups made a working prototype and completed educational materials. This paper outlines a detailed structure of the course and presents the results of Gelmon [1] which suggest that students received a rich project experience with distinct advantages and disadvantages over 1. Non-service learning first year courses and 2. Those courses that are service-learning but pose more complex logistical challenges.

Project example

The design process used for the course begins with understanding the problem, proceeds to concept generation and selection, and ends with fabrication and testing. Figures 1-3 provide an example of this process for a project that was based around a mini-fuel cell technology.

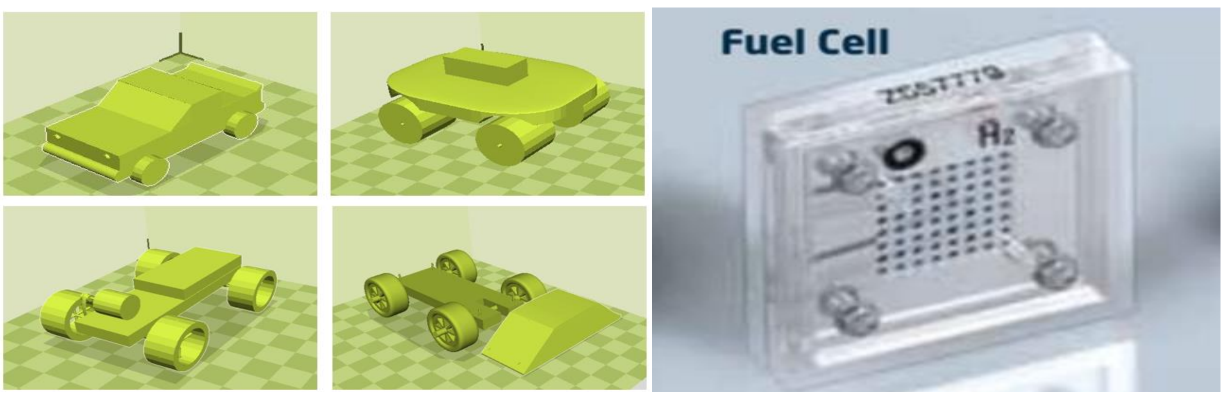

Figure 1: individual ideas from students on use of a fuel cell and visual of mini fuel cells used

At the start of the semester, students began the project by opting into their project of choice but without a team assignment. Each student individually captured their project ideas using CAD software. Figure 1 shows the ideas four individual students had for the fuel cell toy. Students were then placed in their project groups based on common ideas. As a group, the students combined their individual ideas into two group candidate designs. Figure 2 provides an example of the candidate designs developed for the fuel cell car example.

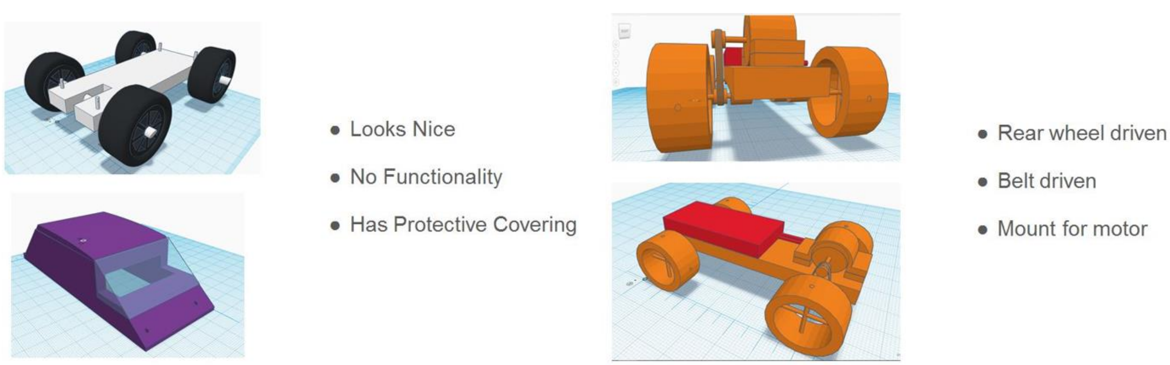

Figure 2: Candidate designs generated by each design group

After candidate designs were developed, students participated in their first design review where community partners were invited to the classroom to provide feedback on design ideas. Three parents joined the classroom for the design review, all of which were faculty at the University of South Florida with middle school age children. The design review itself was only one source of feedback the groups used to improve their designs. Groups also completed personal reflections on the project experience and asked their own parents to also complete reflections. Ultimately, these experiences culminated in selection of a final design for manufacture.

The second half of the course required students to finalize educational materials that would be useful for a middle school student to fabricate and use their design. They also manufactured and tested their design towards a final project showcase. As teams transitioned from their design just existing in CAD to a physical manifestation of their ideas, they participated in a second design review where they presented a draft of their educational materials and plans for manufacture. Two out of three of the parents that participated in the first design review returned for the second design review. Figure 3 provides a visual of the parts that were 3D printed for the fuel cell car example and the final product after manufacture.

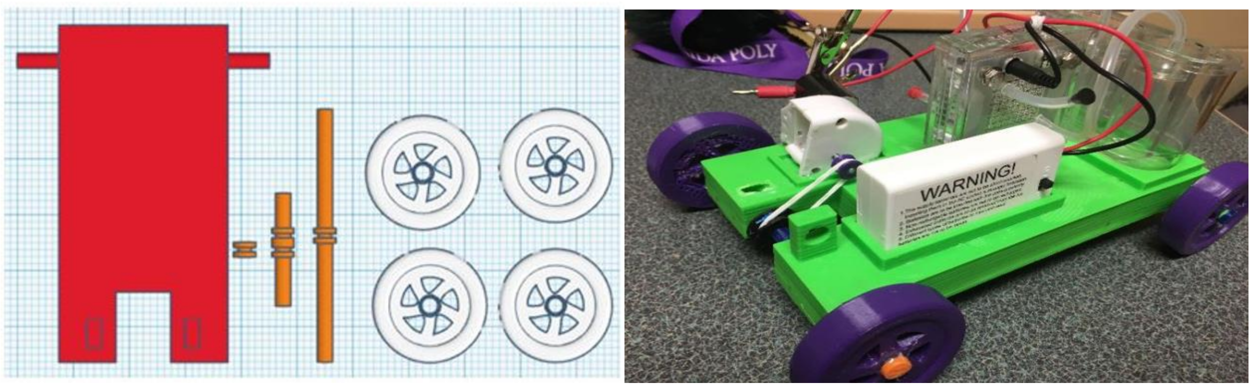

Figure 3: The 3D printed parts created in the design phase (left) and the final design after fabrication (right). The final design was functional, using the fuel cell for forward movement.

Methods

After receiving a definition of what service-learning is and the course structure, students were given the pre-survey version of Gelmon [1] service learning survey. For space reasons, the survey is just referenced with specific questions highlighted in the results section for discussion. The full survey is 23 questions and scored using a 5-point Likert scale. At the conclusion of the course, students completed the post-survey version of Gelmon [1] service learning survey. Sixty students completed both the pre- and post- surveys and asked that their survey results be used for the course evaluation. Both the pre- and post- survey results were analyzed using an Anova single factor analysis with Alpha = 0.05 to check for statistical significance. Subsets of the questions are organized by common themes and presented in the Results and Discussion section. The version of the question shown in Results and Discussion section are from the post-survey.

Results and discussion

Responses to questions 10 and 22 suggested that students were optimistic about service and remained optimistic at the end of the course. This was important considering we did not want to negatively effect the students' perceptions of service in formal educational settings.

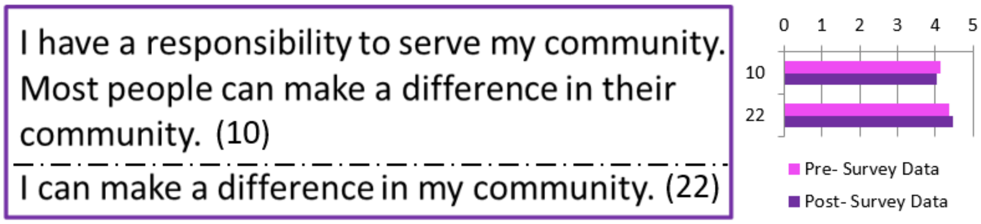

Figure 4: Results from Gelmon [1] showing interest in community work pre- and post- course

There was also a statistically significant increase for responses to questions 3 and 4 that specifically asked about interest in service-learning. Students seemed to be more optimistic by the end of the course about service-learning, albeit not highly optimistic.

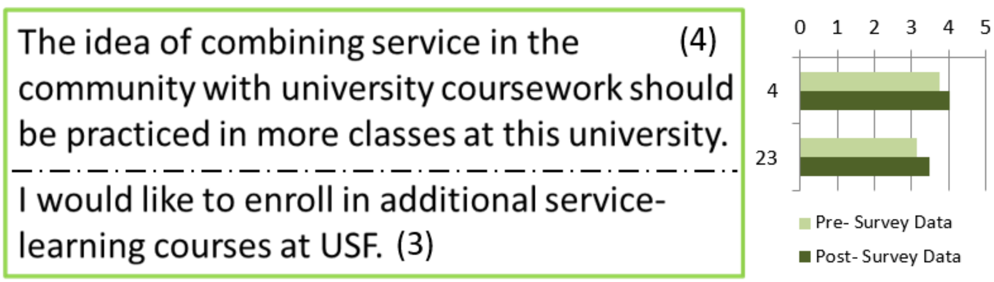

Figure 5: Results from Gelmon [1] showing statistically significant increase in service-learning interest pre- and post- course but limited initial interest.

Even though students were not highly optimistic about service-learning by the end of the course, they were high on their project experience. For responses to questions 1, 17, 19, 20, and 21, responses scored a 4 out of 5 on the Likert scale both pre- and post-. This outcome was thought to be very relevant for the course evaluation. The course was thought to successfully teach engineering design skills and some important inter-personal skills that are useful for engineering problem solving. Responses to question 3 also showed a statistically significant decrease which suggests that students thought they learned more through problem based learning than they would have in a more traditional course.

Other responses to questions that showed a statistically significant decrease might be more relevant to what is lost when providing for interactions with community partners in the classroom as opposed to outside of the classroom. Responses to questions 6, 8, and 15 reflected a statistically significant decrease between pre- and post- surveys. These questions reflected the student perception of project deliverable meaningfulness to their community partners.

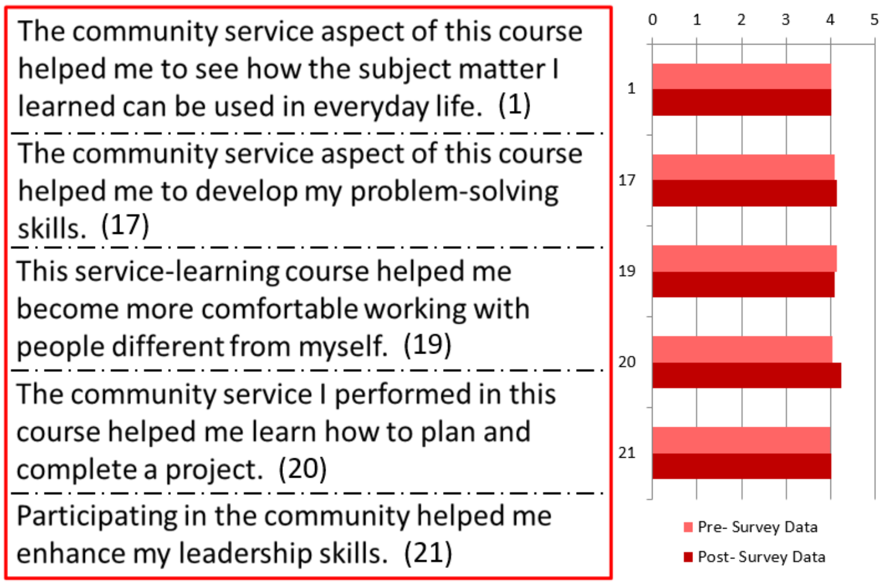

Figure 6: Results from Gelmon [1] showing the course was seen as a quality project experience

The statistically significant decrease suggests the students did not necessarily believe their deliverables benefited their partners, made them more aware of their partner's needs, or made them more aware of their own prejudices and biases. This might have been because the students never witnessed an actual middle school child use their project deliverable or because their interactions with the community partner were limited to the two design reviews.

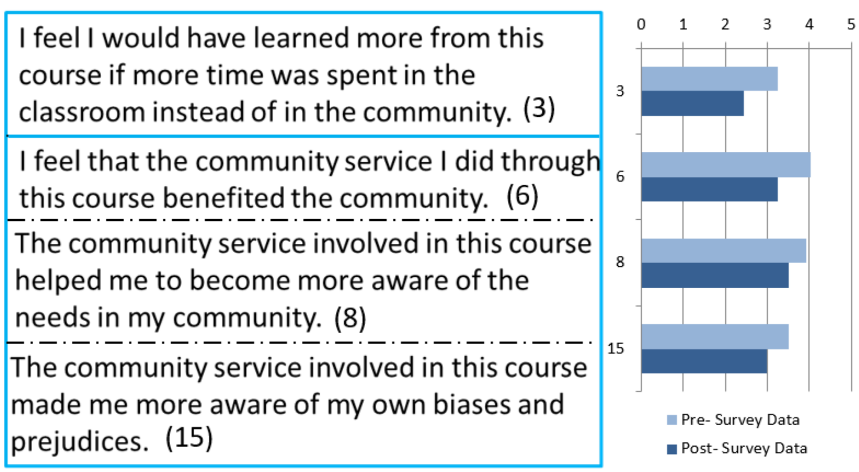

Figure 7: Results from Gelmon [1] giving statistically significant decreases pre- and post- course

A question persists of whether or not these statistically significant decreases are problematic. If the course objective is to emphasize project skills then this result might be acceptable. Certain responses also provide insight into a few areas of improvement that might be simple to implement. For example, question 16 mentions communication in a "real world" setting. To improve this aspect of the course, engineering communication could be emphasized a bit more. Marketability in the student's chosen profession as reflected in question 14 also could be taught with added emphasis along with communication of volunteer opportunities after the course.

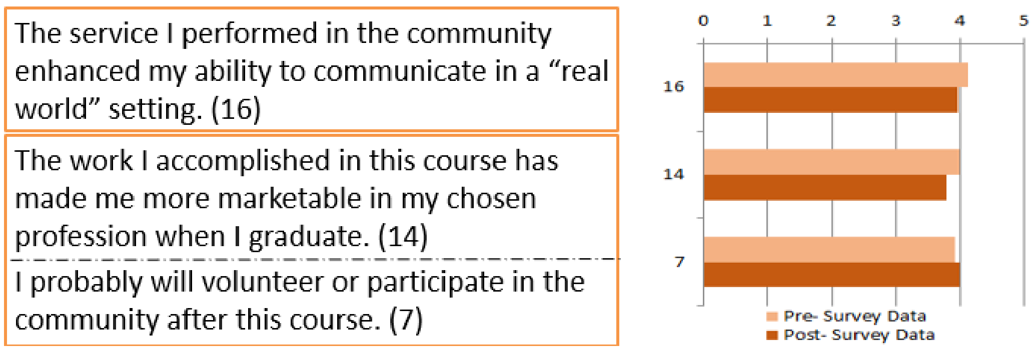

Figure: Results from Gelmon [1] showing potential areas of improvement for the course

The survey results provide enough evidence to build on for future semesters. Beginning in the Fall 2018 semester, this service-learning approach will be used in all sections of the course.

Conclusion

Most service learning experiences in the literature require project teams to go into the community and communicate frequently with the community partner. The project experience for EGN3000L was much more contained to the classroom. Students saw the value in the project experience and many of the traditional benefits to service learning in spite of the community partner's involvement being limited. The experience, however, didn't necessarily change the students' personal values or convince them that they had meaningful community impact. Future work would explore whether engineering-based service-learning courses should build more meaningful relationships than the redesigned course. This may be dependent on course outcomes. The course evaluation showed that the class promoted meaningful project skills and learning which might be significant when considering the lower amount of effort required.

References

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