Implementing Service-Learning into an Introductory Mechanical Engineering Course

Alta A. Knizley¹ and Tammy A. Coleman²

Abstract – A freshman-level Mechanical Engineering course at Mississippi State University has implemented a service-learning project into its curriculum, designed to allow students to utilize basic engineering, mathematics, and/or physics principles while working with the community. The students were able to choose to work with one of five community projects. Each of these projects serves to benefit the students by developing valuable engineering and overarching skill-sets such as: operating within a budget or with limited resources, working with a team as well as members of the community, fostering creativity through project design, developing an appreciation for personal responsibility, and fostering an environment that establishes the framework of diligence essential to successfully completing a mechanical engineering curriculum. Also, the benefit to the community by exposing young students to approximately 150 engineering role models is substantial. After completing a semester using this model, the implementation of service-learning is considered a success.

Keywords: service-learning, mechanical engineering, community, design

INTRODUCTION TO SERVICE-LEARNING

Service-learning consists of a synergistic relationship between community service involvement and classroom education. At Mississippi State University, service-learning consists of linking meaningful community service or civic engagement through experiential learning, instruction, and reflection to enhance educational experience, to teach civic responsibility, and to strengthen the community. Four principles – engagement, reflection, reciprocity, and public dissemination – must be met to qualify a course for the service-learning designation [1]. Duffy et al. [2] cite service-learning as a method of producing high quality engineering graduates with civic responsibility at the University of Massachusetts Lowell and state that service-learning can benefit student retention rate, among other things. Oakes et al. [3] describe several successful service-learning strategies for engineering schools including a first-year service-learning program implemented at the University of San Diego (USD) in which freshmen college students develop educational activities for middle school students. They stated that, though resistant at first, the students had a positive experience through their interaction as mentors to the middle school students. Whitman et al. [4] use service-learning to teach students that engineers can personally contribute to their local communities, as well as to raise awareness of the global contributions from the engineering profession as a whole. They also comment on the use of reflective writing assignments to increase student awareness of their own attitudes and to provoke thought about the broader context of engineering. In addition to educational and community benefits of service-learning, it can also help engineering departments measure ABET program outcomes. Specifically, service-learning strategies have been shown to positively impact ABET program outcomes (c) ability to design a system, component, or process to meet desired needs, (e) ability to identify, formulate, and solve engineering problems, and (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice, as well as to help students understand the environmental and societal context of engineering [5].

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Prior to the fall 2013 semester, service-learning had not been implemented within the mechanical engineering (ME) curriculum at Mississippi State University (MSU). This paper presents the motivation for implementing service-learning into the Introduction to ME freshman course, details the project selections available for the service-learning component of the course, discusses the challenges faced in the implementation, and quantifies the faculty and student response to the project.

MOTIVATION

Mississippi State, like many universities, has seen significant growth in mechanical engineering undergraduate enrollment within the past few years. This growth has greatly impacted freshman enrollment, as shown in Figure 1. The growing class size has presented a need to re-structure the course to accommodate enrollment of up to 150 freshmen students. From an instructor perspective, the motivation of implementing these service-learning projects is rooted in setting a high standard of work ethic, responsibility, and professionalism immediately upon entering our department. Service-learning is used to accomplish this by gently introducing students to a strong but manageable work-load, ensuring individual accountability by committing students to each other and to a community partner, and teaching students about engineering as a profession. From the student benefit perspective, service-learning provides a hands-on learning experience, strengthens team-building and communication skills, encourages leadership roles, strengthens civic responsibility and community involvement, provides project experience, and builds students’ resume strength. Students also learn to develop initiative and independent learning skills. For faculty participating in service-learning projects, community awareness and engagement is also strengthened.

Figure 1. Freshmen Enrollment Growth in ME since 2008.

PROJECT SELECTION AND IMPLEMENTATION

Over the fall 2013 semester, nearly 150 Introduction to ME students were required to participate in one of five service-learning projects to account for 50% of their course grade. These five projects, summarized in Table I, include developing a proposal to build an interactive educational space in the MSU Visual Arts center, working with Mississippi 4H, Bagley College of Engineering Outreach Family Engineering Nights, or a local elementary school to create science, physics, and engineering lessons and activities for elementary age Mississippi students, or mentoring high school students participating in the Mississippi BEST Robotics competition. After selecting a service-learning project, students were required to sign a contract with their respective community partners in which the students and community partners agreed to a set of minimum standards for successful project completion. If students did not meet the minimum standards, they were subject to removal from the project (and class) or a lowered course grade. Also as part of the course grade, students were individually required to submit short writing assignments, called reflective journals, twice a month. In these assignments, the students were asked to respond to a particular question about their service-learning experience. A total of six reflective journal assignments were collected throughout the semester. In each project, students were assigned to teams. This allowed for students to meet their classmates more effectively and thus be better integrated into the department through their relationships with one another. At the end
of the semester, each student was asked to evaluate their own performance as well as the performance of their team members. Throughout the semester, students were encouraged to effectively solve teamwork issues on their own, but had instructors available to help them understand how to approach difficult situations and to intervene when necessary. Finally, the service-learning projects culminated in an open poster presentation display where students were afforded the opportunity to show their work to junior and senior ME students, ME and other engineering faculty, and the communities with which they had been working. A best overall project was selected by the upperclass ME students, as was a best project for the MS BEST Robotics, Family Engineering Night (FEN), and local elementary school projects. The 4H projects had the community partners and the young 4H “cloverbud” students select their favorite presentation, and the MSU Visual Arts Center (VAC) administration and faculty members selected their favorite proposal. The winning proposal for the Visual Arts Center is scheduled to be implemented in the Spring 2014 semester, and the students who worked with that project will be afforded the opportunity to continue working on the implementation of their proposal through a special topics course offered in the ME department.

<table>
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<tr>
<th>Table I. Service-Learning Project Summary</th>
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<td><strong>Project</strong></td>
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</table>
| 4H          | Develop lesson plan and STEM activity for 4H “cloverbud” youth. Publish You-tube instructional videos for instructors and for youth Provide written document for instructions | 37 | Adhere to budget ($15)  
Explain engineering principles  
Creativity and innovation |
| FEN         | Create one long activity or four short activities for parents and children to do during FEN to introduce families to what engineers do | 28 | Adhere to budget ($5 short, $15 long)  
Material constraints: easily obtainable/non-consumable  
Creativity and innovation |
| Sudduth     | Create five STEM demonstrations/lessons for 2nd grade students at local elementary school, Sudduth elementary | 10 | Adhere to budget ($100 for semester)  
Creativity and innovation |
| MS BEST     | Mentor high school teams participating in MS BEST robotics competition  
Complete training for mentorship  
Meet regularly with teams  
Serve as judges and referees in game day competition | 48 | Robotics exposure  
Help high school teams with design, budget, and material selection  
Learn to troubleshoot |
| VAC         | Plan and propose educational space for MSU VAC. Students must research interactive educational spaces and plan their own space within room and budget constraints. Students should also provide illustrated plans or mock-up of space. | 22 | Work within budget ($1000)  
Work within realistic space constraints  
Research and proposal  
Creativity and innovation |

The most common challenge that the students reported with their service-learning projects was learning to communicate with each other, or learning to communicate at a level that elementary students could comprehend. Beyond communication, students also faced challenges of time-management and adhering to a small budget, but none reported that the projects were beyond what their technical skill-sets allowed. Most students embraced the learning aspect of their projects and followed a trial and error process to ensure that their activities were successful demonstrations. Many reported that they learned more trying to teach concepts to young students than they learned in their first-year physics and math courses, and the students enjoyed the hands-on reinforcement of classroom concepts.
As an instructor, the greatest challenge was in organizing the class and in keeping track of the projects and groups with which the individual students were working. The large number of students presented a challenge in finding enough community partners to be able to involve all of the students. Community partners had to commit to being involved with these students months prior to the start of the course, as well as to commit to a number of students with which they were capable of working. Once the community partners were selected to meet the needs of the course size, the only remaining challenge was staying organized and helping students learn to do the same. Many students initially wanted the instructors to keep track of all due dates and project assignments on their behalf, to communicate on their behalf with community partners, as well as to organize their teams and select the team leaders. Once the students understood that these objectives were their responsibilities, it became easier to take a mediatory role as an instructor. When mediation was required, between students or between student groups and community partners, instructors were readily available to address any issues causing difficulty in a manner that benefits as many parties as possible. One challenge presented was that the instructor was not always made aware of group issues in a timely manner, however, and sometimes too much time had lapsed to be able to help in ways such as group reassignment when a serious issue was reported by the student. While students were encouraged to bring problems forward to the attention of instructors, not all students complied and thus faced greater challenges than their peers. Instructors also helped students who were having difficulty getting their projects to perform as desired or in helping students form ways to realize their ideas.

**Faculty and Student Response**

Overall, the faculty and student response to the service-learning projects proved positive. In order to foster a constructive environment, ME 1111 students were initially asked to share their thoughts on the responsibility that engineers have to their communities. 92% of respondents stated that they believed engineers had some responsibility to their communities, and many students reflected that the role of an engineer is, at its core, to improve the lives of others. The following excerpts from student responses reveal the positive attitudes that several students expressed regarding service-learning in an engineering classroom.

> Overall, the various projects of the service-learning opportunity will teach the engineering students not only the importance of giving back to the community but also how [engineers] can benefit as well.

> Engineers possess the specific knowledge required to teach the youth about the sciences, not only in the most accurate way possible, but in a way that will interest any student thinking about studying math and science. Through service-learning, my group is going to be able to give back to the community in such a way.

> As engineers it is our job to help solve the problems facing the world today. We are to use the education and resources that have been given to us to make the standard of living for everyone better.

At the poster presentation event, the ME faculty and upperclassmen ME students, among others, had the opportunity to speak with the ME 1111 students and view their service-learning projects. Discussions with faculty and upperclassmen students indicated positive feedback about the implementation of these projects. Faculty was impressed with the accomplishments the freshmen students had made and with the work ethic of many of the student groups. Upperclassmen ME students commented that they wished they had had the opportunity to engage in such projects in their freshmen class and even suggested ideas for future projects.

By presentation time, most of the groups of freshmen students understood the goals of these projects and were happy to have completed them. Many students stated that the tasks were not as daunting as they initially believed, and most felt that they had made an impact on the community. Many students suggested that they believed engineers have a responsibility to others and to their community, and these service-learning projects served to reinforce such ideals. Several students also commented on how these projects broadened their perspectives of what engineers do and of what engineers are capable of doing. Additionally, these projects achieved the goal of bringing students together and allowing them integrate into the ME department earlier. Several student groups developed friendships with one another, and the freshmen students have also had the opportunity to interact with and get to know the
upperclassmen in our ME curriculum. This early integration is expected to have positive effects on retention rates as students can maintain a place within the department through these relationships, even though their next few semesters will be spent in coursework outside of ME.

End of semester data taken from this Fall 2013 freshman class also supports the viability of service-learning projects in terms reflection of student overall performance and retention rates. The end-of-semester overall GPA for the Fall 2012 mechanical engineering freshmen, who did not participate in a service-learning project, was 3.13. The end-of-semester overall GPA for 2013 mechanical engineering freshmen, the majority of whom participated in the service-learning projects, was 3.18. While this 1.6% increase cannot validate a hypothesis that service-learning may improve overall classroom performance, it can at least signify that the service-learning projects did not hinder students’ overall academic performance.

Of the 164 students initially enrolled in the fall 2013 ME 1111 course, 65.9% earned a final grade of an “A,” 14.6% earned a “B,” 6.7% earned a “C,” 1.2% earned a “D,” 0.6% earned an “F,” and 11% withdrew from the class, receiving a “W” on their transcript without receiving any grade penalty. Table II gives a summary of the end-of-semester course statistics from students enrolled in ME 1111 in the Fall 2013 semester. The average overall end-of-semester GPA for students earning an “A” in the Fall 2013 ME 1111 course was 3.45. The average end-of-semester GPAs for those earning “B,” “C,” “D,” “F,” and “W” grades were 2.65, 1.86, 1.00, 0.2, and 2.57, respectively. This implies that the performance of students in the newly re-developed ME 1111 course is, on average, directly related to the student’s overall semester performance. i.e., GPA averages indicate that students who were successful in ME 1111 were reasonably successful in their other courses, and those who did poorly in ME 1111 did not perform well in their courses, overall. Finally, Table II breaks down the percentage of students remaining in the mechanical engineering discipline at the end of semester for each letter grade classification. It is interesting to note that the lowest retention rate was for students who withdrew from the class, indicating that the structure of this course helped students determine their commitment to the mechanical engineering curriculum at an earlier stage in the curriculum, which should be beneficial to both the student and subsequent instructors. The overall retention rate for the students enrolled in this course, including those who dropped with a “W” grade, was 91.4%. If only students who completed the semester in ME 1111 are analyzed, then the overall mechanical engineering retention rate increases to 95.9%.

<table>
<thead>
<tr>
<th>Final Grade in ME 1111</th>
<th>Percent of ME 1111 Students Earning Final Grade</th>
<th>Overall Fall 2013 End-of-Semester GPA (4.0 scale) of students, with respect to ME 1111 Final Grade</th>
<th>Percent Retention of Students in ME Major, with respect to ME 1111 Final Grade</th>
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<tbody>
<tr>
<td>A</td>
<td>65.9%</td>
<td>3.45</td>
<td>96%</td>
</tr>
<tr>
<td>B</td>
<td>14.6%</td>
<td>2.65</td>
<td>96%</td>
</tr>
<tr>
<td>C</td>
<td>6.7%</td>
<td>1.86</td>
<td>91%</td>
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<tr>
<td>D</td>
<td>1.2%</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>F</td>
<td>0.6%</td>
<td>0.2</td>
<td>100%</td>
</tr>
<tr>
<td>W</td>
<td>11%</td>
<td>2.57</td>
<td>56%</td>
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CONCLUSIONS

Over the Fall 2013 semester, a semester long service-learning project was implemented into the ME 1111 Introduction to Mechanical Engineering course at Mississippi State University. These projects incorporate a community service aspect with experiential student learning to introduce freshmen students to engineering principles and to establish strong values of work ethic, accountability, responsibility, and professionalism in young mechanical engineering students. Students presented their work to ME faculty and upperclassmen ME students in a poster display at the end of the semester. The performance of students in ME 1111 reflected the overall student performance for the semester, and retention rate of students remained above 90% for the semester. Overall, student and faculty response to the service-learning projects was favorable, and it is expected that the projects will be implemented again in the Fall 2014 semester.

REFERENCES


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