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Student Experiences in Service-Learning: Engineering vs. Sciences

Ella Willard-Schmoe, University of Massachusetts Lowell

Ella Willard-Schmoe is a graduate research assistant with Solar Energy Engineering.

Dr. John J. Duffy, University of Massachusetts Lowell

Dr. John Duffy is professor emeritus of Renewable Energy Engineering.

Dr. Emmanuelle Reynaud, University of Massachusetts, Lowell
Ms. Linda Barrington, University of Massachusetts, Lowell

Linda Barrington is the Francis College of Engineering Service-Learning coordinator.

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Abstract

The cognitive and affective benefits of service-learning (S-L) for students have been well documented, and S-L has become more common in many disciplines, including engineering, the health sciences, and education. Opportunities in the core sciences, however, seem sparse. This paper compares the attitudes of science majors and engineering majors toward S-L through quantitative analysis of survey responses. The goal is to examine student experience and learning in the context of other factors that might influence participation in S-L, such as institutional support, faculty attitudes, and the intrinsic level of applicability of course material to community issues.

In the 2011-2012 academic year, 162 students in 9 courses in a College of Sciences participated in S-L projects and were surveyed about their experience. These responses are compared to those of 811 students in 33 courses from the College of Engineering, who completed the same survey; 93% of engineering students surveyed had done S-L that semester and/or previously. Compared to science majors, engineering students reported a significantly (5% level) stronger positive effect of S-L on their persistence in their major, their interest in the subject matter of the course, their ability to plan and carry out a project for the community, and their ability to address complex, open-ended problems.

Some conjectures can be made about the reasons for the difference: valuing applied work over theoretical work is part of the engineering identity, and makes S-L a rewarding experience for engineers in particular; institutional acknowledgement of the value of S-L in the College of Engineering has a positive effect on faculty's involvement with, and thus students' reception of, the projects; engineering course material is intrinsically more applicable to community issues than science course material.

Introduction

Service-learning, defined here as a hands-on learning approach in which students achieve academic objectives in a credit bearing course by meeting real community needs, has been shown in many studies to have a consistently positive impact on many affective and cognitive measures. These include community engagement, self-efficacy, leadership, academic engagement, and academic performance[1-3]. As more positive outcomes are demonstrated, S-L continues to grow in many disciplines.

In spite of these gains, participation in S-L in mathematics and the sciences remains low[4]. A 2009 study conducted by Sherman and MacDonald focused on the question of low participation in S-L in the sciences, interviewing participants in S-L projects in math and biology college courses. At the end of the study, both professors "felt the students were able to demonstrate a deeper understanding for the subject areas than in earlier versions of these courses."[4] The students, while agreeing that their learning was enhanced by the service aspect of their projects, were unsure about the net benefit of participating. Biology students were concerned that performance in traditional laboratory courses would be weighed more carefully than participation in S-L courses by graduate schools and employers, and many students worried that the perception of a lack of scientific rigor would reflect poorly on them. A barrier to faculty's implementation of S-L was a resistance to the idea of reflection as a learning or evaluation tool, in spite of its integral nature in the effective practice of S-L.

According to Astin et al., "providing students with an opportunity to 'process' the service experience with each other is a powerful component of both community service and service learning."[1] The importance of reflection as part of a S-L experience is supported by many other publications[2, 4-6]. The definition Bringle and Hatcher give of service-learning provides an insight into this link: "A course-based, credit-bearing educational experience in which students participate in an organized service activity that meets identified community needs and reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility."[7]

DeKoven and Trumbull studied the effects of an outreach program for science graduate students aiming to "increase scientific literacy in the community, increase voter comfort and understanding of scientific issues, to encourage people who have not traditionally considered careers in science to consider them, and to build positive university and community relationships."[8] Though the students interviewed found they gained a deeper understanding of their own research areas by teaching them in a way that younger students could understand, again the perceptions about the rigor and career-advancement elements of the project were a barrier to participation: "graduate students who were involved in outreach were perceived to be less serious about their research and their studies. Three volunteers did not feel that their advisors would support their involvement in outreach." These studies make clear that a condition for successful S-L implementation, especially for science courses, is that S-L must demonstrate disciplinary learning and academic rigor. Part of the evidence in support of S-L in all disciplines can be established by examining self-reported attitudes and cognitive growth.

Background

In the fall of 2004, the University of Massachusetts Lowell, a medium-size state university, began integration of service-learning (S-L) projects into required engineering courses within all five undergraduate academic departments of its College of Engineering (COE). The goal was to have students exposed to S-L in on average one course in each of eight semesters during their engineering program with an overarching aim to graduate better engineers and more engaged citizens. Previous papers have summarized earlier results[9-24]. The original motivation for attempting this service-learning program was rooted in the findings of classic studies in which service-learning was shown to be effective in a large number of cognitive and affective measures, including critical thinking and tolerance for diversity, and leads to better knowledge of course subject matter, cooperative learning, and recruitment of under-represented groups in engineering; it also leads to better retention of students, and citizenship[2].

Since the inception of the COE project, 58 faculty members have taught at least one course with S-L, with between 25 and 30 faculty practicing each year. Over 50 separate courses have incorporated S-L, with 30 to 35 courses offered per year, providing 1100 to 1750 student S-L experiences annually, for over 1,000 unduplicated students per year out of a total undergraduate enrollment of about 1600 students (2011). Thirty-eight community based organizations (CBOs) and over 1,000 individuals with disabilities have been served from the University home town to Peru, with about 15 to 20 CBOs and 80 to 100 individuals reached any given year.

Given its success, the S-L program was extended to the College of Sciences (COS) with a grant from the National Science Foundation in 2009. Nine courses with S-L were offered in the 2011-2012 academic year. Details about the S-L projects and the courses for both engineering and the sciences, as well as more background information, are available on the website: http://www.uml.edu/Engineering/SLICE/About-Us.aspx (Retrieved Mar. 21, 2013). The overall program is now known as SLICES (Service-Learning Integrated throughout Colleges of Engineering and Sciences).

In the first year of the program in the COE, 25 faculty members participated by assigning required or voluntary S-L projects to their classes. In the first year of the COS initiative, however, only 3 faculty participated. A persistent disparity in the receptiveness to S-L between engineering and the sciences has prompted an examination of student experiences in S-L in the two colleges. The goal of this paper is to determine whether students in the two colleges view S-L differently and experience S-L differently, and if so, why. The paper also focuses on the relationship between the different levels of success and/or implementation and the effects on students, as reported by the students themselves.

Methodology

In the 2011-2012 academic year, 162 students in 9 courses in the College of Sciences who participated in S-L projects were surveyed about their experience. These responses are compared to those of 811 students in 33 courses from the College of Engineering, who completed the same survey with minor wording changes to make it specific to engineering; 93% of engineering students surveyed had done S-L that semester and/or previously. A copy of the spring 2012 COS survey can be found in Appendix A; the fall 2011 survey was identical for the questions analyzed herein. One large class in the math department consisted mainly of engineering students, so when comparing the responses by major with duplicates removed, the split is 790 engineering majors, 76 science, math, or technology majors, and 36 from majors from non-STEM fields, who were not studied in detail.

The numerical analysis of the survey response data was done in SPSS Statistics. The statistical significance level used throughout is 5%. In our results we often refer to science, math, and technology majors as science majors, as shorthand. No differentiation is made between different departments in the College of Sciences.

Results

There were more similarities than differences between majors in the survey responses. Although a higher percentage of engineering respondents agreed that service and academic coursework should be integrated, the mean response of engineering majors was not found to be significantly higher than that of science majors by independent-samples t-test. Figure 1 shows the portion of science and engineering students who agree, disagree, or are neutral to the basic concept of service-learning: that service and academic coursework should be integrated. Students report their agreement with various statements on a 1-9 Likert scale, with 1 being strong disagreement/negative impact, 9 being strong agreement/positive impact, and 5 being neutral.

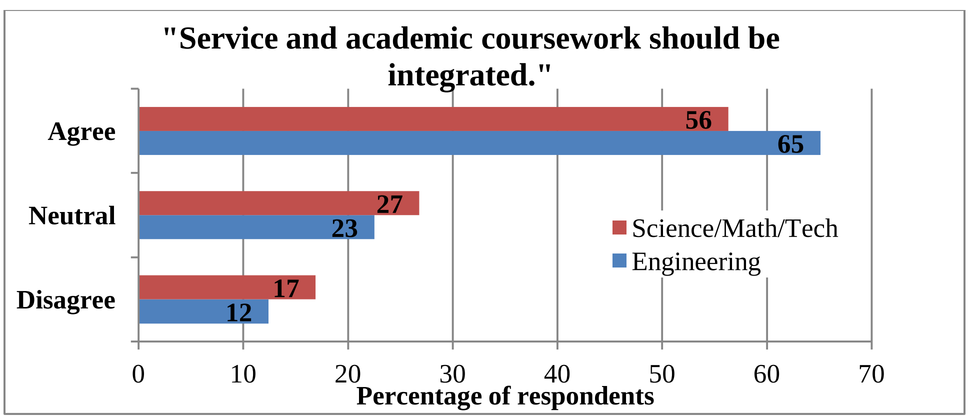

Figure 1. Students in both colleges agree similarly that service and academic coursework should be integrated.

Both engineering and science majors report a positive impact from doing S-L on a variety of skills and values, as measured with a t-test for mean difference from neutral (5 on the Likert scale). Relevant to the demonstration of disciplinary learning and cognitive development, our results show a positive impact of doing S-L on students' ability to write and speak credibly as a member of their profession, ability to address complex, open-ended problems (typical of community projects), and interest in the subject matter of the course. As positive as the whole-sample results look for the practice of S-L, engineering students consistently rank the impacts of these projects on their learning and development more positively than science students do.

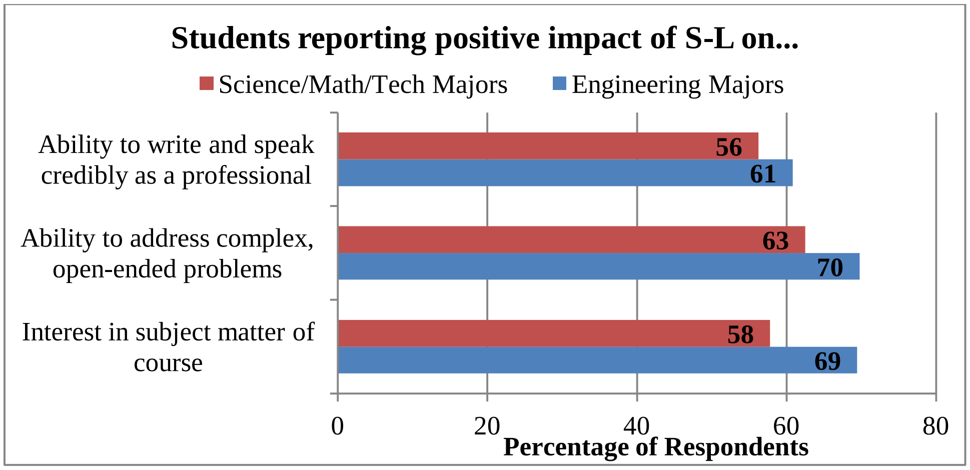

Figure 2. Percentages of students in each major agreeing that S-L had a positive impact on the certain skills and academic engagement.

In general, engineering students perceive greater personal benefit from doing service-learning than science students do. This includes both a positive effect on learning/skills acquisition, and on their engagement with the community and their chosen field.

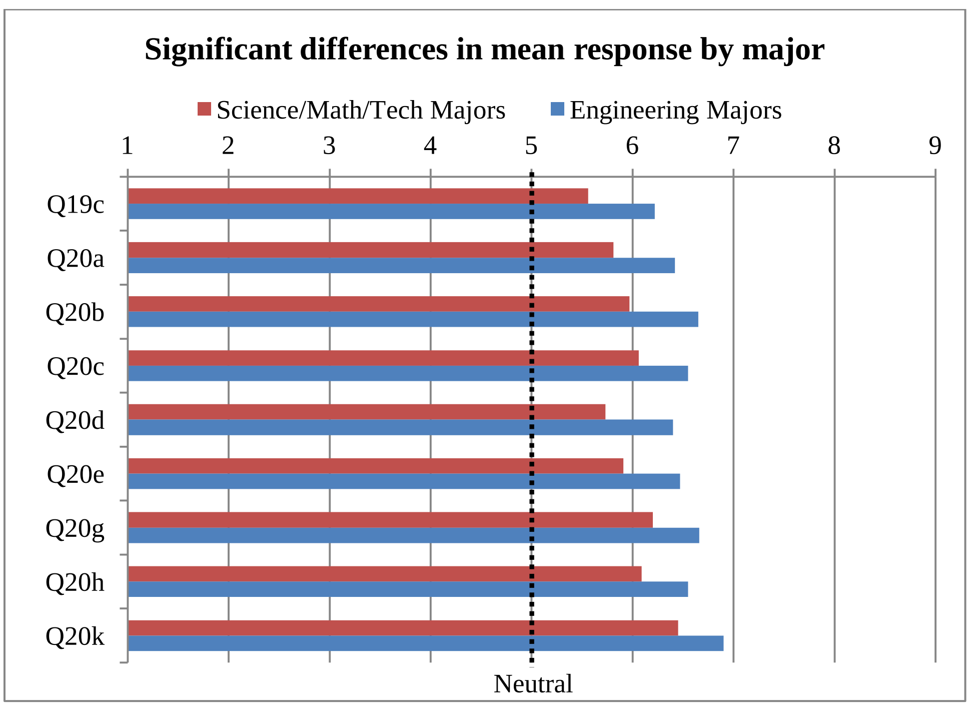

Figure 3. Significant differences (5% level, by independent-samples t-test) between engineering majors and science majors in the reported impact of service learning on skills and attitudes.

As shown in Figure 3, engineering majors report significantly greater agreement that in their service project(s) they learned how to work with others effectively (Q19c), as well as a greater positive impact of the service project(s) from that year on:

Q20a: The likelihood that they would continue in their major

Q20b: Their belief that they can make a difference in the community using major-specific skills

Q20c: Their interest in the subject matter of the course

Q20d: Their commitment to being involved in community issues as a member of their profession

Q20e: Their ability to address complex, open-ended problems

Q20g: Their understanding of the value of teamwork in addressing community issues

Q20h: Their ability to plan and carry out a project for the community

Q20k: Their view of their profession in a positive way

A question of particular interest is that of persistence: can participation in S-L improve a student's chances of continuing in the major? Q20a, above, is examined more closely in Figure 4, with levels of agreement and disagreement charted for the two majors.

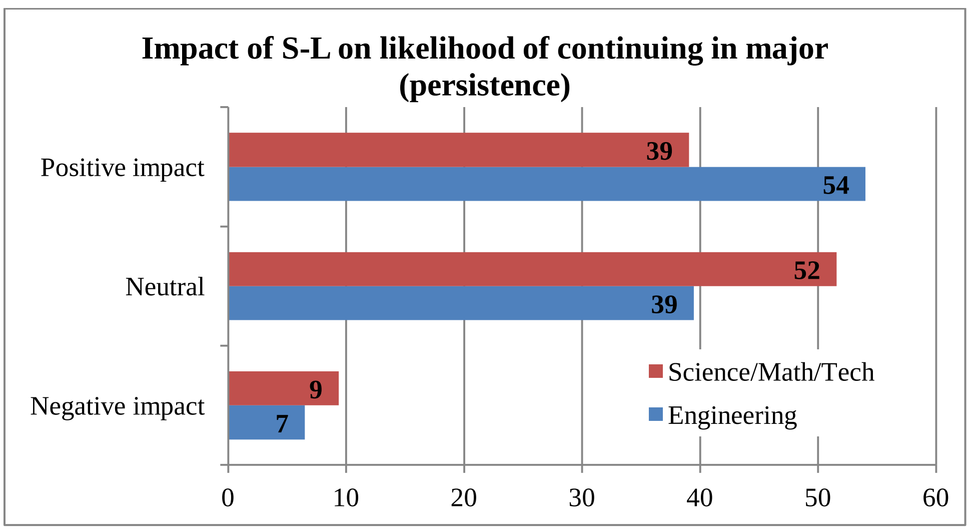

Figure 4. Percentages of engineering and science students who report a positive, neutral, or negative impact of S-L on their persistence.

While over half of engineering majors reported a positive impact of S-L on the likelihood of continuing in their major, and only 6.5% reported a negative impact, 40% of science majors reported a positive impact, with the majority reporting neutral impact. Acknowledging a disproportionate number of first-year students in the engineering sample, we investigated the respective attitudes of students of different academic statuses in regard to retention. As shown in Figure 5, the mean responses for the first-year students vary the most between majors, with the greatest agreement of all coming from first-year engineering majors and the most neutral response coming from first-year science majors. The non-freshmen of all disciplines have a similar average response: 6.00 (science) vs. 6.32 (engineering).

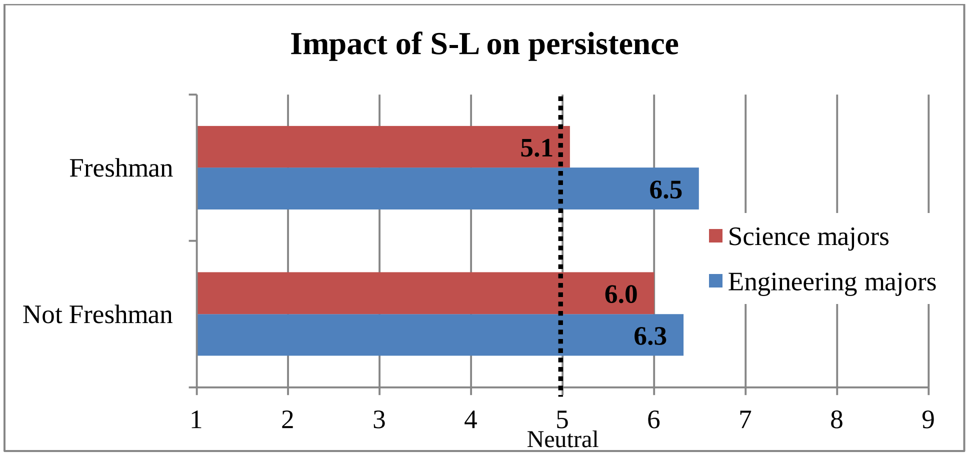

Figure 5. Mean responses regarding persistence (Q20a) for first-year students vs. second-year and older in the two colleges.

Considering the high rates of drop-out from the College of Engineering in the first year, this finding is loudly in support of service-learning in the first semester of college for engineering students. Drawing conclusions regarding the first-year science students would be unwise, considering the comparatively tiny sample size (13 students, almost all from one introductory biology course). The number of projects done may also be a factor.

Other differences in demographics within the engineering and science samples also have an effect on the aggregate numbers. For instance, while 35% of science/math/tech majors surveyed were female, only 11% of engineering majors surveyed were female.

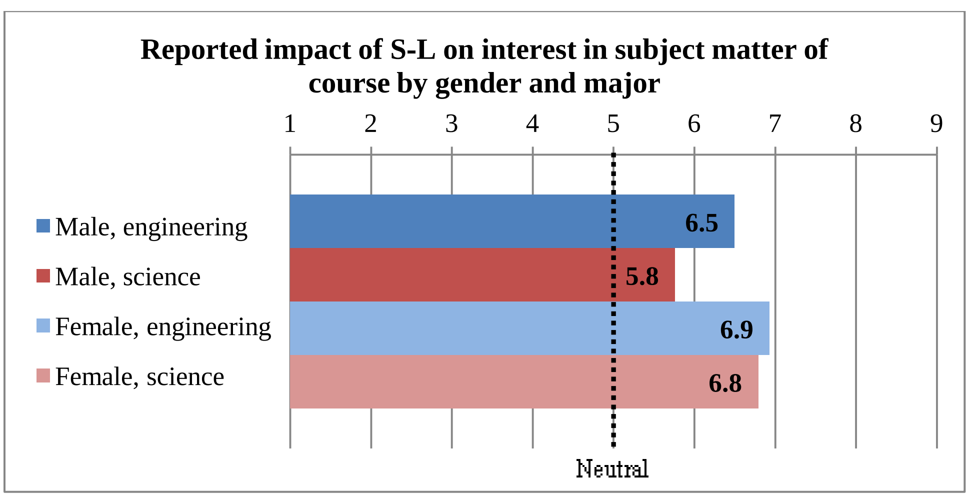

Figure 6. The mean rated impact of S-L on students' interest in the subject matter of the course, comparing by gender and major.

Since females report greater positive impact of S-L than men do on most attributes [10, 17], the disproportionate number of men in the engineering sample drives the mean responses for the major down. The pattern displayed in Figure 6 is duplicated, more or less, for each question featured in Figure 3: the mean responses of females in different majors do not differ significantly, but the mean responses of males do (with engineering majors more positive than science majors), and neither male subgroup answers as positively as either female subgroup. Significant difference in mean response is established by independent-samples t-test in this analysis.

The degree of exposure to S-L may explain some of the differences between engineering and science majors. As shown in Figure 7, the average number of projects done by engineering majors per year is 70% greater than the average number of projects per year done by science majors. It appears from previous analysis that more experience with S-L gradually improves the outcomes for students[9-24]. The causal relationship here could be reversed, of course: a higher regard for S-L among engineers could be driving the higher rates of implementation. These relationships are not mutually exclusive, and both effects could be at play.

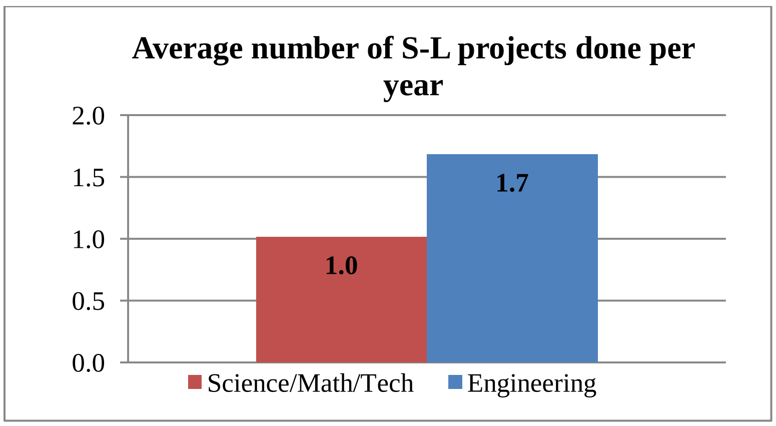

Figure 7. Average number of S-L projects done per year for each major.

The reflection component of S-L is difficult to quantify, but we collected responses about the formal mechanisms used to assess what was learned through the S-L projects. Assessments can form part of the traditional reflection involved in service-learning, since the major reason for reflection is connecting the S-L project with the subject matter of the course. The results can be seen in Figure 8. The most common method of assessment for engineering majors was making a presentation, followed by class discussion and written reports. The most common method of assessment for science majors was discussion, followed by making a presentation and written reports. Except for keeping a journal/log, engineering majors reported higher rates of participation in each assessment method. Overall, engineering majors were much more likely to indicate some form of participation in a formal assessment method. Although not all the assessment methods above constitute reflection, some do, and the greater benefit that engineering students perceived from doing S-L might arise in part from the increased reflection they participated in. To the authors' knowledge, all the courses with S-L projects required some formal method of reporting and assessment, so no response to this question is a survey accuracy issue.

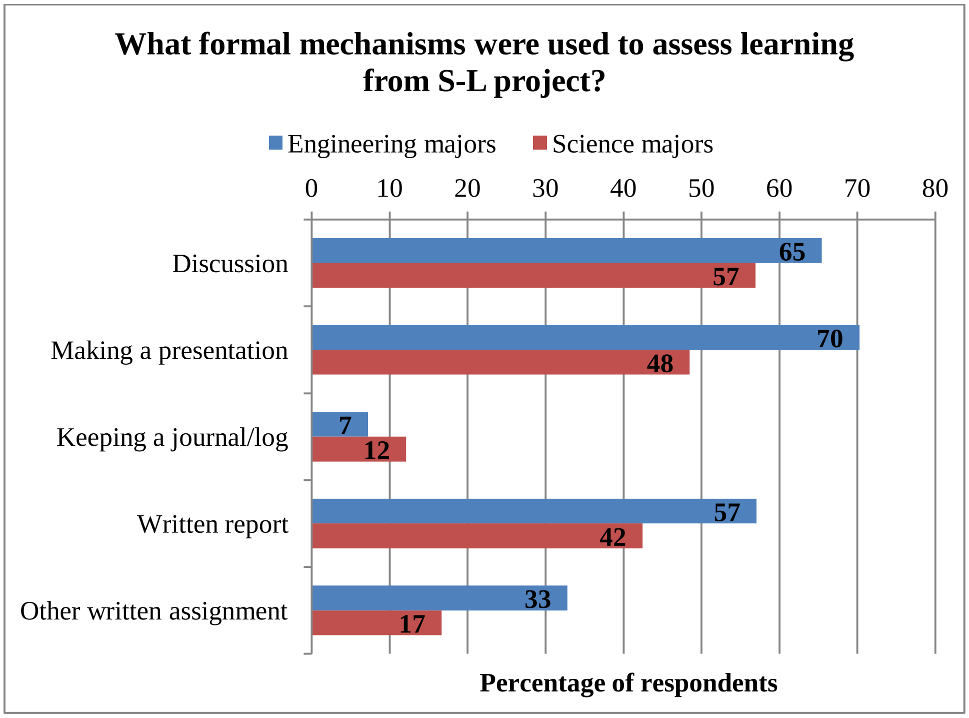

Figure 8. Percentage of respondents in each major who reported having participated in each formal mechanism of assessment during their S-L project.

There is a wide array of attitudes expressed in the comments submitted by the students in both colleges. In spite of the general agreement with the statement "Service and academic course work should be integrated," as shown in Figure 1, many student comments expressed strong disagreement with requiring S-L projects. For example, one engineering student wrote, "No point in making them mandatory. If people want to do it then they will do it to better themselves and career. They should be optional, out of class, projects." Both engineering and science students expressed some of the concerns about academic rigor that are summarized in the introduction. One engineering major wrote that he "would've preferred a more serious engineering project that I could learn from." Another called the service aspect "distracting from the course material," which is the opposite of what S-L practitioners intend. However, other students considered their S-L activities "immensely satisfying," "fulfilling," and "a great learning experience." One engineering student wrote that "They give students more motivation to understand the material as they are solving actual problems. Solving text problems only matters for exams and is then immediately forgotten. Developing solutions to meaningful problems is much more memorable."

Discussion

The findings of this study show a significantly positive net impact of S-L on many attributes, including the students' interest in the subject matter of the course, ability to address complex, open-ended problems, and intention of continuing in their major, among others. There are notable differences between genders and between males of different majors in the strength of that impact. That there is not a significant difference between the responses of females between majors is of some interest. While the student survey data cannot address in great detail the many possible reasons for the differences in student attitudes between the colleges, it does indicate that a) there is a difference, primarily in perceptions about the impact that S-L has on student learning and engagement, and b) the positive impacts reported by students are much more prevalent than negative impacts, in both science and engineering.

These findings should be of interest to engineering educators, as first-year engineering students take a heavy load of courses in science and math departments, and the dropout rate is typically highest in the first year. Since our data, in this paper and previous papers[9-24], show that S-L has a positive effect on retention, it may be to any College of Engineering's benefit to advocate for S-L in the core courses required in other departments. Why should science faculty be concerned about S-L in their courses? While by comparison with engineering students, science and math students are less positively impacted by S-L, our results nonetheless indicate a positive impact of S-L on many attributes for science and math students, such as a positive view of their profession and an interest in the subject matter. When these students are interacting with engineering students in calculus, differential equations and physics courses, as they often are at universities that offer engineering tracks, the benefits of S-L are enhanced (for example an understanding of the importance of teamwork). The result should be students who learn more and are more engaged, both in the classroom and in their communities.

One can speculate about the relative reluctance of faculty in science to embrace S-L relative to engineering by examining the basic aims and culture of the professions. Engineers create solutions to technical and social problems by applying mathematics and the laws of science; community service takes the form of solving "public problems" and so would have an inherent appeal for engineers. Scientists ask questions about the nature of physical reality by performing experiments and observing nature; community service has no immediate direct connection. Science in the service of the community is not as direct a path as engineering in the service of the community. Finding that path has been, and continues to be, a challenge.

Acknowledgements

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Appendix A

Student "Post" Survey about Service-Learning Spring 2012

Please fill in this survey registration area. This information is used for research purposes only, and has no bearing on your academic or program status. Your responses will form an important part of a research project on service-learning. Responses are kept confidential.

SURVEY REGISTRATION AREA

Student ID (ISIS No.): ______________________________

1. What is your gender?
__Male
__Female

2. Are you an international student?
__Yes
__No

3. What is your race? (check all that apply)
__ American Indian or Alaska Native
__ Asian
__ Black or African American
__ White
__ Native Hawaiian or Other Pacific Islander
__ Other:______________________________________

4. What is your ethnicity?
__ Hispanic/Latino
__ Non Hispanic/Non-Latino

5. How many miles do you live from campus? (if you live on campus, put zero: 0) ___________.
6. What is your age?_________
7. How many hours per week do you work at a paid job?__________
8. How many credit hours are you taking this semester?__________

9. What is your current academic status?
__Freshmen
__Sophomore
__Junior
__Senior
__Graduate

10. I am a transfer student.
__Yes
__No

11.What is your major? (check all that apply)
__ Biology
__ Physics
__ Mathematics
__ Chemistry
__ Computer Science
__ Polymer Sciences
__ Earth, Environment, Atmospheric science
__ Radiological Sciences
__ BioMedical Engineering
__Other ______________________________

12. Prior to UML have you ever been involved in community service activities? Check all that apply.
__No __Yes, during high school __Yes, during college __Yes, outside of school

13. If eligible, did you vote in the November 2010 public election?
__Yes __No __Not eligible then

We define "**service-learning**" as a learning approach in which students achieve academic objectives in a credit-bearing course by meeting real community needs.

14. Estimate the total number of service–learning projects you have participated in your entire academic career (K-12-college). __________

SURVEY RESPONSE AREA:

INSTRUCTIONS: Your responses will form an important part of a research project on service-learning. You may elect not to answer any question you choose. All responses will remain confidential and anonymity in any reported results is assured. The instructor of this course will not view the individual questionnaire responses. Filling out this questionnaire is completely voluntary, and you will not be penalized in any manner if you decide not to participate. Thanks from the SLICES project.

1. In your future career, how important is each of these values to you? Please choose the answer that makes sense to YOU; not what you think others would say. Please darken the appropriate circle with pencil or pen.

[1=Not important, 5=Neutral, 9=Very important]:

Challenge: Learning new skills or information, doing things in a new way	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
Helping: Doing things for others, building a better world	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
Income: Making a high salary	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
Security: Having stable employment and income not worrying about lay-offs	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
Variety: Doing many different activities, not doing the same things all the time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Please respond based on your honest reaction to each item. Please choose the answer that makes sense to YOU; not what you think others would say.

[1=Strongly disagree, 5=Neutral, 9=Strongly agree]

2. Service and academic coursework should be integrated.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
3. Professionals should use their skills to solve social problems.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
4. I learn more when courses contain hands-on activities.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
5. Service in general should be an expected part of my profession.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
6. People who receive social services largely have only themselves to blame for needing services.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
7. Most social problems are easy to solve.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
8. I can have an impact on solving problems that face my local community.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
9. I can have an impact on solving problems that face under-served communities internationally.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
10. Working in teams is a waste of time.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
11. It is important to me personally to influence the political structure.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
12. It is important to me personally to have career that involves helping people.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
13. I am uncomfortable working with people who are different from me in such things as race, wealth, and life experiences.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
14. I have a close working relationship with at least one faculty member at this institution.	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
15. If service-learning is integrated into a course, the service-learning projects should be required and not optional (with a choice of both service and non-service projects).	① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

The next section is about your experience with service-learning. ("Service-learning" is a learning approach in which students achieve academic objectives in a credit-bearing course by meeting real community needs.)

16. Was being able to take classes with service-learning one of the reasons you chose UMass Lowell?
__Yes __No __No, but If I knew, it would have been a factor

17. Please indicate the number of classes **this semester** in which you participated in a class project that addressed a real community issue or problem through service-learning.

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a. Total number of classes with service-learning projects that you have taken ⓪ ① ② ③
b. Number of the classes in which service-learning was required. ⓪ ① ② ③
c. Number of the classes in which service-learning was optional. ⓪ ① ② ③

18. Approximately how many hours total did you spend working on all your S-L projects? [Please indicate the number of hours].
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19. On average, across service-learning projects,

[1=Much less; 5=Same; 9= Much more]

a. The amount of effort I put into the service-learning project(s) relative to an equivalent class project without service was: ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

[1=Strongly disagree; 5=Neutral; 9= Strongly agree]

b. In the service project(s) I learned how professionals apply the concepts I learned in class to real-life problems. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
c. In the service project(s) I learned how to work with others effectively. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

20. To what extent have your service-learning project(s) this year had impact on the following:

[1=Strong negative impact; 5=Neutral; 9= Strong positive impact]

a. The likelihood that I would continue in my major. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
b. My belief that I can make a difference in the community using major-specific skills. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
c. My interest in learning the subject matter of the courses. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
d. My commitment to being involved in community issues as a professional. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
e. My ability to address complex, open-ended problems (typical of community projects). ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
f. My ability to write and speak credibly. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
g. My understanding of the value of teamwork in addressing community issues. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
h. My ability to plan and carry out a project for the community. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
i. My school pride. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
j. The likelihood that I would drop out of my major. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨
k. My view of my major in a positive way. ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

21. Did your service-learning project(s) lead you to further action (for example, volunteering) with the community agency or organization your worked with, or the topic/issue you worked on?

__ Yes __No

22. What formal mechanisms did you use in your class with service-learning to assess what you learned through your service-learning project? (Check all that apply.)

__Discussion
__Making a presentation
__Keeping a journal/log
__Other____
__Written reports
__Written assignments other than a report
__None

23. Comments and suggestions: