AC 2012-3805: SERVICE-BASED FIRST-YEAR ENGINEERING PROJECTS: DO THEY MAKE A DIFFERENCE?

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Service-Based First Year Engineering Projects: Do They Make a Difference?

Introduction

Service learning courses have been well-established in the social sciences, and are evolving in engineering colleges as a mechanism to elevate student professional skills and provide engineering students with meaningful learning experiences in a community-based context. However, the potential for learning through service is still not often integrated throughout engineering education curricula.

Practicing engineering in a community context, partnered with a strong emphasis on teamwork and reflection, project-based service-learning (PBSL) programs are potentially successful approaches to recruit and retain more students, including women and minority students, into the pipeline of engineering education and the engineering workforce. Unfortunately, little research has been reported to confirm this hypothesis. In fact, what, if any, groups of students are impacted by service-learning experiences?

The University of Colorado Boulder's *First Year Engineering Projects* (FYEP) course has been evolving over the last decade into a successful avenue for increasing the knowledge, skills, and retention of its students in engineering. One goal of this paper is to examine the impact of a community-based context in first-year projects courses. Specifically, we compared five sections of the FYEP course who engaged in service-based projects with five sections of the course who engaged in non-service based projects, all during the same semester. Using multiple methods informed by current education research, we analyzed how the context of service-based engineering impacts students' technical and professional skills, attitudes towards community service, and intent to complete their incoming major. We also examined any differential impacts on students by gender and retention into the next year of engineering courses for all the students who enrolled in FYEP during this semester. Specifically this paper addresses, *"When compared to conventional design experiences, do service-based design opportunities significantly impact first-year engineering undergraduate student self-perceived skills and attitudes?"*

Project-based service-learning engineering design

A review of the literature below provides strong support for hands-on, project-based engineering design experiences as an instructional method to increase student knowledge and attitudes towards engineering. While the well-known APPLES study concluded that first-year students tend to enter their engineering courses already highly confident in their ability to solve open-ended problems, their math and science knowledge, and professional/interpersonal skills, first-year engineering project-based learning (PBL) courses have reported increased gains in knowledge across genders and effectiveness in improving students' self efficacy and confidence in using the engineering design process.[1–4]

Related research suggests that incorporating service-learning into existing engineering curricula increases student learning. In a service context, the needs of the community define the design tasks and provide students with a sense responsibility for being members of a larger community.[5] Often combined with project-based learning in engineering to form project-based service-

learning (PBSL), studies indicate that instruction centered on service-learning experiences can improve academic learning of core material and provide participants with a deeper understanding of the social context of their work, increasing technical, professional, and interpersonal skills.[5–9] In first-year programs, PBSL has specifically been reported to positively impact students' perceptions of their roles as engineers, awareness of socially-responsible opportunities, and satisfaction with their first year-experience.[4,10,11] Unfortunately, there is very little previous work available in the literature that compares PBL to PBSL to determine any specific psychological and educational benefits from engaging in service-learning based PBL as compared to conventional PBL.

As for retention, research suggests that open-ended, hands-on engineering design courses are a key to recruitment and retention of students in undergraduate engineering. For example, research at the University of Colorado Boulder focused on the retention of engineering students who have exposure to hands-on design courses in their freshman year of undergraduate study shows an overall 64% retention rate into the seventh semester (compared to a 54% retention rate of students not enrolled in the course), with an even higher retention of women and minority students.[12,13] Several programs also report that participation in service-learning positively impacts students' determination to continue in engineering (retention) or was a factor in selecting the program (recruitment).[10,14,15] Specifically, Duffy (2009) found that consistently over 60% of students surveyed from year to year at the University of Massachusetts Lowell indicated that engagement in service-learning helped them stay in engineering; females were significantly more likely to agree with this sentiment.[14]

First-year students' belief in the usefulness of engineering has been positively correlated to their plans on choosing a career in engineering.[16] It is conceivable that first-year project-based courses which offer an opportunity to immerse students in hands-on engineering design for a specific or theoretical client demonstrate the social value and relevance of the trade in a concrete way. Anecdotally, showing students the broader impacts of engineering on society and allowing them to make immediate positive contributions using their new engineering skills, has already been confirmed as more attractive to underrepresented students, especially women.[17,18]

Research Hypothesis

The goal of this research is to focus on improving first-year undergraduate student engineering design experiences to address the gap between the teaching practices of engineering education and the learning styles of today's engineering student population, based on current understanding of learning theory. Specifically, five PBSL sections of the University of Colorado Boulder's FYEP course are compared to five non-SL PBL sections of the same course, and we investigate if the context of service-based engineering impacts student self-perceived technical and professional skills, attitudes towards community service, and intent to continue in an engineering major. *When compared to conventional design experiences, do service-based design opportunities significantly impact perceived skills and attitudes for a sample of engineering undergraduate student enrolled in a First Year Engineering Projects course? Are these outcomes impacted by gender? Do these outcomes differ by retention into the next year of an engineering undergraduate degree?*

Methods

Setting for analysis

The *First Year Engineering Projects* (FYEP) course at the University of Colorado Boulder is the setting for implementing our research question. This course offers students an interdisciplinary, hands-on design-build-test experience and includes a focus on product development, oral and written communication skills, project management, and teamwork. Student teams design and create engineering products that are displayed at an end-of-semester design expo for the public. These products, ranging from designs such as toys and Rube Goldberg machines to assistive technologies with actual clients, are chosen by the professor and differ across the many sections of the course each semester (See Table 1). Each section of the course is capped at a maximum enrollment of 30 students. Students typically work collaboratively in teams of 4-5 students per team.

The majority of the students do not volunteer to take FYEP, but complete it as a departmental requirement. The engineering departments that require this course for first-year students include mechanical, environmental, and aerospace engineering. Engineering students that are required to take FYEP by their departments do not necessarily enroll with a professor from their department, causing the sections to fill with a random mix of students from different disciplines. Students do not know section topics prior to enrollment.

Table 1. Section topics for the fall 2010 semester offerings of FYEP, divided by service-learning and non-service-learning

Service-Learning topics	Non Service-Learning topics
Section 2: Assistive Technology	Section 1: Rube Goldberg Machines
Section 3: Assistive Technology	Section 4: Robotics
Section 5: Assistive Technology	Section 6: Water systems
Section 8: Products for the Local Community	Section 7: Green Design
Section 10: Games for Health	Section 9: Robotics

Participants

The analysis in this report contains survey data information approximately 41% of the 2010 incoming freshmen class or 272 FYEP engineering students enrolled in 10 sections of FYEP during the fall 2010 semester; 20 students were eliminated from the study due to absences during either the pre- or post- survey. Participants included 25% females (n= 68) and 75% males (n=204). Most engineering majors offered at the university are represented, with students indicating on their pre-survey an interest in aerospace (n=60), architectural (n=10), chemical and biological (n=16), civil (n=39), electrical (n=11), environmental (n=42), computer science (n=1), and mechanical (n=40); many students did not answer this question (n=53). Half of the sections (n=5) had service-learning based projects and the other half (n=5) had non service-learning based projects. There were 10 professors for the 10 sections, with two sections taught by one professor and one section shared by two professors.

Instrument Design

Students were given an online engineering attitude survey during class in the first week and final week of the fall 2010 semester with choices on a five-point Likert-type scale ranging from "not at all" to "definitely." The goal was to measure any change in student attitudes towards engineering as a result of their first semester engineering undergraduate experiences including their FYEP course. Most students have similar schedules outside of the FYEP course including calculus, engineering chemistry or calculus-based physics, a 1-credit introduction to their engineering major, and a humanities or social science elective. Students typically completed the survey instrument within ~15 minutes. Several existing surveys from the literature around undergraduate engineering were integrated into the FYEP survey. The pre-semester survey contained 133 items relating to prior experiences, motivation, attitudes, interests, and demographics, while the post-semester survey repeated the 89 attitude and interest items. This paper will discuss items from two of those surveys:

- The Academic Pathways of People Learning Engineering Survey (APPLES), which includes measurements of students' self-estimates of knowledge of engineering and skills related to engineering design work (26 items from the 89 total attitude and interest items on the survey).[3]
- The Community Service Attitudes Scale (validated), which examines the participants' attitudes regarding community service (15 items of the 89 total attitude and interest items on the survey)[19]

"Do you intend to complete a major in engineering?" was a separate 5-point Likert scale intent question included in the survey, with responses ranging from "Definitely not to "Definitely yes." In addition, demographic data such as gender, ethnicity, and year/grade, were collected with missing values retrieved from the university student data system. Student retention into a second year of engineering was also collected and added to the dataset.

Surveys for all participating students are conducted under University of Colorado Boulder's Institutional Review Board (IRB) approval, reviewed annually by external and internal evaluators. Student responses are coded to protect participant identity.

Validity of the Instrument

The validity of our instrument was examined to determine how well the items measure the constructs that we intended. The items (n=85) had an internal reliability using Cronbach's Alpha of 0.97 (A value exceeding 0.7 is thought to be adequate).[20] High inter-item reliabilities indicated that the instrument items could be reduced to a smaller number of associated factors through factor analysis. A Principal Components Analysis (PCA) was performed on the sample to determine the theoretical constructs represented by the sets of response items. The PCA confirmed our intended factors and our items for technical skills, professional skills, and attitudes towards community service loaded onto three separate factors. The average of the items that loaded on a given factor is used as dependent variables in the reminder of this analysis.

Variables in this Analysis

The dependent variables for this analysis were selected on the basis of empirical research on service-learning and project-based learning and confirmed through reliability analysis. The three factors that are examined in this paper include students' self-estimates of their Technical Skills, Professional Skills, and Attitudes towards Community Service. Selected survey items for each factor are presented in Table 2. Other variables collected for this analysis include intent to complete a major in engineering and a demographic variable of gender. Student retention into the second year of engineering was collected after completion of the course and will also be discussed.

Table 2. Factors, Related Questions and Representative Constituent Items for the FYEP Survey

Factor, Question, and selected constituent items
Technical skills (10 items) [3]
Please rate how well prepared you are to incorporate each of the following items while practicing as an engineer:
Applying the Design Loop
Manufacturing Skills
Data analysis
Problem solving
Professional skills (16 items) [3]
Please rate how well prepared you are to incorporate each of the following items while practicing as an engineer:
Presentation Skills
Written technical communication
Teamwork
Management skills
Attitudes towards Community Service (14 items) [19]
Pretend you are going to volunteer for community service sometime in the next year. Rate how you feel about the following.
There are needs in the community.
I am responsible for doing something about improving the community.
It's my responsibility to take some real measures to help others in need.
I will seek out the opportunity to do community service in the next year.

Statistical Analysis

Each survey was scored by taking the average of the 1-5 Likert- scale responses for each factor; average response to the questions results in a composite score for each student. For example, a higher average of the nine pre-survey item scores for technical skills (analysis, design, etc.) indicates a student's greater initial overall opinion of their technical skills. Next each set of survey responses was paired pre- to post- for each individual.

Initially, we inspected the data for missing values and data entry errors. We removed 20 students who did not complete either a pre- or post- survey from the data set prior to analysis. Any missing values were examined for patterns, and no student skipped more than one or two items in each administration of the survey. Missing survey data was handled during subsequent

analyses with list wise deletion. Missing demographic data was retrieved from the university student database.

Paired sample t-tests were used with each analysis to determine mean, standard deviation, correlations, and paired differences. Repeated measures of analysis of variance (ANOVA) were used when appropriate to examine the differences among relationships of variables. Effect sizes were calculated for the paper to measure the practical significance of the relationship between pre- and post-assessment independent of the statistical analyses. For all analyses in the paper, IBM SPSS statistical software package (version 20) was used.

Results

The survey results reported in this paper are from matched pre- to post- surveys of 272 students enrolled in 10 sections of FYEP during the fall 2010 semester. Initial data screening generated descriptive statistics on each of the factors, as well as the individual question on intent to complete a major in engineering, that showed trends for the overall cohort of students in Table 3. A paired-samples t-test was used to analyze the within-person differences in factor scores over the course of the semester. The resulting paired sample correlations indicate that students who scored higher on the pre-survey also scored higher on the post-survey.

The pre- to post-mean scores of the overall FYEP students in Table 3 indicate a significant gain from the pre-assessment in self-rated technical skills, professional skills, and attitudes towards community service. The paired sample means also indicate a decrease in intent to complete any major within engineering. This cohort of FYEP students possesses a moderate initial level of perception of technical skills, and professional skills, with a relatively high initial perception of attitudes towards community service. These students also start with a high intent to complete a major in engineering and decrease in that factor over time. These scores are consistent with the APPLES study that found that engineering students come in to their degree programs with elevated confidence and self-perceived abilities in engineering, as well as the finding by Seymour and Hewitt that the #1 ranked factor contributing to the decision to leave an engineering major was a loss of interest in engineering, appearing in 50% of research subjects who switched out of engineering.[3,21] It is interesting to note the high standard deviation with respect to the question, "Do you intend to complete a major in engineering?" on the post-survey administration, indicating that there is a large variability within individual responses.

Table 3. **Overall Results**.
Cell entries contain mean scores, (standard deviations), mean difference, and post-survey effect sizes for overall student participation in First Year Engineering Projects on variables of interest.

Variable	N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference	Effect Size (Post Survey)
Intent to Complete Major in Engineering	**272**	**4.46 (0.68)**	**4.32 (0.93)**	**-0.14***	-0.21
Technical Skills	**272**	**3.16 (0.72)**	**3.63 (0.60)**	**0.47***	0.65
Professional Skills	**272**	**3.62 (0.59)**	**3.79 (0.59)**	**0.17***	0.29
Attitudes towards Community Service	**272**	**4.23 (0.63)**	**4.30 (0.66)**	**0.07***	0.11

** Significant at the $p<0.05$ level, paired t-test

How does a service-learning context impact perceptions and attitudes?

There is a push to examine the impact of a real-world service-learning based context to enhance engineering design courses. We divided the FYEP sections into two categories, service-based (N= 5 sections) and non service-based (5 sections) as shown in Table 1. Service-based sections were those where a specific need in a local community context defined the projects tasks. Some of these projects also benefited real local community clients while others focused on a theoretical local community client.

With respect to service-learning projects, we compared sections of the course with a service component (N=5 sections, 139 students) and no service-component (N= 5 sections, 133 students). The descriptive statistics are given in Table 4. There were significant gains in students' perceived technical and professional skills, similar to the overall course, with students in service-based sections out-gaining their peers in non service-based sections. There were also no significant mean differences pre-to post for attitudes towards community service, and only significant decreases in intent to complete a major in engineering for those students in service-based sections. Interestingly, the students in the non-SL PBL sections had lower initial responses for intent to complete a major in engineering.

Table 4. **Results by Service**.
Cell entries contain mean scores, (standard deviations), mean difference, post-survey effect sizes, and between-groups interaction significance for student participation by service in First Year Engineering Projects on variables of interest.

Variable	N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference	Effect Size (Post Survey)	Between Groups (sig.)
Intent to Complete Major in Engineering						
All	**272**	**4.46 (0.68)**	**4.32 (0.93)**	**-0.14**	**-0.21**	
Service -All	139	4.54 (0.64)	4.30 (0.89)	-0.24*	-0.05	0.568
No Service - All	133	4.39 (0.72)	4.35 (0.97)	-0.04		
Technical Skills						
All	**272**	**3.16 (0.72)**	**3.63 (0.60)**	**0.47***	**0.65**	
Service -All	139	3.15 (0.75)	3.67 (0.55)	0.52*	0.12	0.739
No Service - All	133	3.18 (0.69)	3.59 (0.65)	0.41*		
Professional Skills						
All	**272**	**3.62 (0.59)**	**3.79 (0.59)**	**0.17***	**0.29**	
Service -All	139	3.62 (0.63)	3.84 (0.52)	0.22*	0.17	0.151
No Service - All	133	3.62 (0.56)	3.73 (.66)	0.11*		
Attitudes towards Community Service						
All	**272**	**4.23 (0.63)**	**4.30 (0.66)**	**0.07***	**0.11**	
Service -All	139	4.24 (0.62)	4.31 (0.69)	0.07	0.02	0.926
No Service - All	133	4.22 (0.65)	4.30 (0.64)	0.08		

*Significant at the $p<0.05$ level, paired t-test

A repeated measures ANOVA was used to determine any within-subject and between-groups effect by service, resulting in no significant ($p<0.05$) within-or between-groups interactions. Students in both groups had similar changes in attitudes and perceptions over the course of the semester, reflecting the overall course patterns. This indicates that while some greater gains in skills were identified, service-based projects did not have a statistically different result than the non service-based projects. An independent samples t-test confirmed no differences in pre-or post-survey scores by group. As for the greater decrease in intent to complete a major in engineering, we note that the post-survey scores were still high, ranking between "probably yes" and "definitely yes."

Are students of different genders impacted differently by service projects?

In an effort to understand the impacts of emerging instructional practices in service-learning on females and males, we again analyzed our data set with respect to gender. For the fall 2010 sections of FYEP, there were 68 females and 204 males, divided fairly equally between the service-based and non-service sections of the course. For this paper, we compared females in service-based sections to females in non-service sections and similar for males. Again, descriptive statistics were generated using a paired-samples t-test and the results are given in Table 5.

Continuing the pattern by service in Table 4, both females and males in service-based sections had a significantly greater decrease in their intent to complete a major in engineering than their peers in non-service sections. Females and males in service-based sections also out-gained their peers in perceived technical and professional skills. While all groups started rather high on a 1-5 Likert scale for attitudes towards community service, the greatest gains were seen in males from non-service sections.

It seems as if the female students may have score much higher on both the pre- and post-surveys with respect to self-rated professional skills. An independent samples t-test was used to determine any significant differences between pre- and post-test scores. There were no significant differences between females in service-based sections and non-service-based sections for either the pre- or post-survey. A repeated measures ANOVA was used to determine between-groups effect, again resulting in no significant between-groups interactions.

Overall, the females and males in the service-based sections show a greater increase than their peers in self-rated technical and professional skills, with no difference in attitudes towards community service. Also, females in service-based sections indicate the greatest decrease in intent to complete a major in engineering, while still maintaining a relatively high score on this item.

Table 5. **Results by Service and Gender**.
Cell entries contain mean scores, (standard deviations), mean difference, post-survey effect sizes, and between-groups interaction significance for student participation in First Year Engineering Projects by gender on variables of interest.

Variable	N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference	Effect Size (Post Survey)	Between Groups (sig.)
Intent to Complete Major in Engineering						
All	**272**	**4.46 (0.68)**	**4.32 (0.93)**	**-0.14**	**-0.21**	
Service- Females	33	4.52 (0.67)	4.18 (0.95)	-0.34*	0.01	0.313
No Service - Females	35	4.20 (0.68)	4.17 (0.95)	-0.03		
Service-Males	106	4.54 (0.64)	4.33 (0.87)	-0.21*	-0.09	0.995
No Service -Males	98	4.46 (0.72)	4.42 (0.97)	-0.04		
Technical Skills						
All	**272**	**3.16 (0.72)**	**3.63 (0.60)**	**0.47***	**0.65**	
Service- Females	33	2.95 (0.69)	3.54 (0.52)	0.59*	0.00	0.950
No Service - Females	35	2.97 (0.68)	3.54 (0.59)	0.57*		
Service-Males	106	3.21 (0.76)	3.70 (0.56)	0.49*	0.13	0.521
No Service -Males	98	3.25 (0.68)	3.61 (0.67)	0.36*		
Professional Skills						
All	**272**	**3.62 (0.59)**	**3.79 (0.59)**	**0.17***	**0.29**	
Service- Females	33	3.80 (0.58)	4.01 (0.42)	0.21*	0.38	0.083
No Service - Females	35	3.64 (0.53)	3.74 (0.71)	0.10		
Service-Males	106	3.56 (0.64)	3.78 (0.54)	0.22*	0.08	0.986
No Service -Males	98	3.61 (0.57)	3.73 (0.65)	0.12		
Attitudes towards Community Service						
All	**272**	**4.23 (0.63)**	**4.30 (0.66)**	**0.07***	**0.11**	
Service- Females	33	4.53 (0.51)	4.55 (0.52)	0.02	0.03	0.888
No Service - Females	35	4.52 (0.63)	4.53 (0.60)	0.01		
Service-Males	106	4.15 (0.63)	4.24 (0.72)	0.09	0.03	0.778
No Service -Males	98	4.12 (0.63)	4.22 (0.63)	0.10 *		

*Significant at the $p<0.05$ level, paired t-test

Does retention relate to student perceptions?

Lastly, we wondered if there was a retention difference between students in service-based section of FYEP and non-service based sections. For this paper, and since the participants in this study are mostly still completing their second year of an engineering undergraduate degree, we chose to look at their retention into their second year of engineering. In other words, did the students who took FYEP in fall 2010 return to engineering majors in fall 2011. This data was collected one year after the students enrolled in the course.

For the fall 2010 cohort, 30 students (11%) did not return to engineering the following year (See Table 6 for retention rates). Approximately 9% and 12% of females and males (respectively)

were not retained. More students from non-service based sections (~13%) did not continue in engineering as compared to service-based sections (~9%). Equal numbers of females in service and non-service sections were not retained (n=3). It is interesting that more students in non-service sections left engineering than service sections, based on the opposite decrease in "intent to complete a major in engineering" scores from Table 5.

Table 6. **Retention into Following Year of Engineering Major**.
Cell entries contain numbers and percents of students.

	Not Retained		**Retained**	
	n	**%**	**n**	**%**
Overall	**30**	**11.0**	**242**	**89.0**
Female	6	8.8	62	91.2
Male	24	11.8	180	88.2
Service	13	9.4	126	90.6
No Service	17	12.8	116	87.2
Service -Females	3	8.6	32	91.4
No Service-Females	3	9.1	30	90.9

Those students who did not continue into the following year of engineering had some interesting patterns shown in Table 7. First of all, the intent to complete a major in engineering was significantly lower for students not retained in both service and non-service sections. This suggests that students who are not retained in engineering may already think about on leaving by the end of their first semester. There appears to be very similar gains in perception of technical and professional skills between students that are retained and not retained. However, those students that are not retained from service-based sections have the greatest increase in attitudes towards community service (though not statistically significant likely due to low sample size). Again this questions whether students impacted by service-sections conclude that their major in engineering was not well-suited for completing service projects.

While it seems as if the not-retained students may have scored much higher on the post-surveys for this variable, an independent samples t-test did not determine any significant differences between the post-test scores. A repeated measures ANOVA was used to determine between-groups effect, again resulting in no significant between-groups interactions.

Overall, the greatest disparity between students that continued into the next year of engineering and students that did not was the evident decrease in intent to complete an engineering major, as early as the end of the fall semester freshmen year. Also, students that did not continue in engineering in service-based sections show the greatest increase in attitudes towards community service, raising the question about the understanding of engineering as a helping profession after exposure to a hands-on service-based project.

Table 7. **Results by Service and Retention**.
Cell entries contain mean scores, (standard deviations), mean difference, post-survey effect sizes, and between-groups interaction significance for student participation in First Year Engineering Projects by retention on variables of interest.

Variable	N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference	Effect Size (Post Survey)	Between Groups (sig.)
Intent to Complete Major in Engineering						
All	**272**	**4.46 (0.68)**	**4.32 (0.93)**	**-0.14**	**-0.21**	
Service-Retained	126	4.58 (0.60)	4.43 (0.76)	-0.15*	-0.25	0.909
No Service - Retained	116	4.40 (0.73)	4.59 (0.64)	0.19*		
Service- Not retained	13	4.15 (0.90)	3.00 (1.08)	-1.15*	0.18	0.872
No Service- Not retained	17	4.29 (0.69)	2.76 (1.30)	-1.53*		
Technical Skills						
All	**272**	**3.16 (0.72)**	**3.63 (0.60)**	**0.47***	**0.65**	
Service-Retained	126	3.17 (0.75)	3.68 (0.55)	0.51*	0.13	0.743
No Service - Retained	116	3.15 (0.63)	3.60 (0.61)	0.45*		
Service- Not retained	13	2.97 (0.72)	3.54 (0.59)	0.57*	0.02	0.499
No Service- Not retained	17	3.34 (1.00)	3.52 (0.87)	0.44		
Professional Skills						
All	**272**	**3.62 (0.59)**	**3.79 (0.59)**	**0.17***	**0.29**	
Service-Retained	126	3.64 (0.60)	3.85 (0.51)	0.21*	0.14	0.279
No Service - Retained	116	3.59 (0.55)	3.76 (0.63)	0.17*		
Service- Not retained	13	3.45 (0.88)	3.74 (0.58)	0.29*	0.21	0.650
No Service- Not retained	17	3.84 (0.59)	3.56 (0.84)	-0.28		
Attitudes towards Community Service						
All	**272**	**4.23 (0.63)**	**4.30 (0.66)**	**0.07***	**0.11**	
Service-Retained	126	4.25 (0.61)	4.30 (0.68)	0.05	-0.03	0.980
No Service - Retained	116	4.24 (0.64)	4.32 (0.64)	0.08*		
Service- Not retained	13	4.17 90.72)	4.37 (0.79)	0.20	0.29	0.613
No Service- Not retained	17	4.13 (0.70)	4.18 (0.65)	0.05		

*Significant at the $p<0.05$ level, paired t-test

Limitations of the study

The findings of these analyses must be placed within the limitations of this study. First of all, the cohort of participants comes from one semester of FYEP at one large public university, which limits the generalizability of the findings. Also, not all students who entered as engineering majors in fall 2010 took the FYEP course (n=292, 41% of 2010 incoming freshmen class), and not all majors have FYEP as a course requirement at this time. Courses and experiences outside FYEP will also impact student perceptions and attitudes. However, most first semester students take very similar courses regardless of major (calculus, calculus-based physics or chemistry for

engineers, an introduction to engineering course, and a social-science or humanities elective). It would be useful to extend this study to all entering first year students across semesters to see if the trends continue.

Another limitation is inconsistency among instructors. To try and reduce the impact of instructor variation, numerous assignments and rubrics are offered to all instructors during a weekly FYEP meeting, with the intent to make the same resources and background research on student learning available to all. Of course, use of these resources is hard to enforce in the actual classroom. In an effort to understand instructor and section variability, the Faculty Course Questionnaire ratings (survey completed by the students for each course offering at the end of every semester) were compared. These surveys ask the students to rate different aspects of the course and instructor on a scale of 6. The students in the PBSL sections had less variability in their ratings by section, and rated the course overall (average = 5.02) and instructor overall (average = 5.12) with relatively high scores. There was high variability in course ratings for the non-SL PBL sections, and these students had a range of ratings for the course overall (average =4.47) and instructor overall (average =4.88). It is likely that these ratings are impacted by satisfaction with course project, perceived instructor availability, and grades [22]. As we continue to gather data on FYEP participants, we will increase the numbers of students that interact with a more comparable set of sections to analyze.

As for the specific survey items used in this study, it is important to note that the variable of "intent to complete a major in engineering" was measured using a single item. This item was asked both pre-and post-semester with the goal to measure student intentions with respect to completing any (current or different) major in engineering. It remains important to understand why students leave engineering, and we recommend that future students are queried about their change in attitudes during and after their first-semester of an engineering undergraduate degree.

Key findings and discussion

In conclusion, the key findings from these analyses include:

- Students in service-based sections out-gained their peers in non service-based sections with respect to perceived technical and professional skills.
- Students in service-based sections displayed significant decreases in intent to complete a major in engineering, while still maintaining a relative high score for that item.
- Females (and males) in service-based sections out-gained their peers in non-service based sections with respect to perceived technical and professional skills.
- Females in service-based sections indicate the greatest decrease in intent to complete a major in engineering.
- Students who were not retained in both service and non-service sections had significantly lower intent to complete a major in engineering, suggesting that students who are not retained in engineering may already decide on leaving by the end of their first semester.
- Students that did not remain in engineering from service-based sections had the greatest increase in attitudes towards community service, raising the question about switching majors out of engineering after exposure to a hands-on service-based project.

A general theme seen throughout this analysis was the student decrease in "intent to complete a major in engineering." While the scores and decreases remained relatively high between a score of 4 ("probably yes") and a score of 5 ("definitely yes) for service and gender, the scores dropped below 3 ("not sure") for students who did not remain in engineering in the following year. This could indicate that students who leave engineering already know by the end of their first semester experience.

Independent samples t-tests offered no significant differences between the pre- and post-survey intent between students who left from service and non-service sections. In other words, there are no differences in mean scores between the pre- and post-survey items, and students in both groups started at the same point and decreased similar amounts over time. The authors wonder about students switching out of engineering due to perceiving that engineering is not a "helping profession. This is most apparent in the students in service-based sections who increased in attitudes towards community service but did not remain in engineering the following year.

The good news is that students in service sections and female students in service sections out-gain their peers in non-service sections with respect to perceived technical skills and professional skills. It is possible that the context of a service client and completing a service project indeed offers first-year students a context for increased buy-in and learning during the project.

From discussions during the weekly FYEP meeting, instructors agree that there can be more work associated with developing real service-learning client projects, including finding new clients each year. While some instructors will continue this endeavor, others have changed to using theoretical clients in a service-learning context. More and more, FYEP instructors are using some project-based service-learning as a context for their design topics, noting the benefits to students and clients enrich the class greatly.

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