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Evaluating Student Project Choice, Course Satisfaction, and Performance between Community Service, Internal Projects, and Industry-Sponsored Projects in a Multidisciplinary Industry-Sponsored Capstone Program

Edward Latorre, University of Florida

Dr. Edward Latorre-Navarro is the Director of the Integrated Product and Process Design (IPPD) program within the Department of Engineering Education at the University of Florida. He joined UF from his previous role as Associate Professor of Computer Science at the University of Puerto Rico at Arecibo. As an educator, he is interested in improving the academic experience based on student engagement with educational goals. Research interests include co-teaching, teamwork, engineering leadership skills, natural language processing and human computer interaction for educational applications. https://www.eng.ufl.edu/eed/faculty-staff/edward-latorre-navarro/

Elizabeth Louise Meier, University of Florida

Evaluating Student Project Choice, Academic Performance and Program Satisfaction with Respect to Project Source in a Multidisciplinary Industry-Sponsored Capstone Program

This study stems from a well-established capstone design program where students work in multidisciplinary teams for two semesters in designing, building and testing projects from industry sponsors. Therefore, students traditionally join the program for an opportunity to work on real-world engineering problems along with experienced industry engineers, who are also potential employers. Recently, this program has included as project sources, faculty projects and service-learning projects. This study evaluates three years of student interest, performance, and satisfaction with respect to the different project sources, using data from the project selection process, the students' evaluations, and the faculty evaluations. Through this analysis, the program can determine whether to continue with this practice, and respectively improve the processes of choosing project sources, defining projects, promoting projects to students and the guidance provided during project development. Overall, students were similarly interested in projects of all sponsor sources. Students on projects with different sponsor sources have similar outcomes as far as team and individual performance and course satisfaction.

Keywords: multidisciplinary, capstone design, industry sponsorship, service-learning

Introduction

In multidisciplinary engineering capstone courses, students of various disciplines work in teams to complete design projects. Examples of project sources include problems assigned by the instructor, suggested by other faculty, sponsored by industry, proposed by the students and any combination of these. This study stems from a well-established capstone design program where students work in multidisciplinary teams for two semesters in designing, building, and testing projects from industry sponsors. Therefore, students traditionally join the program for an opportunity to work on real-world engineering problems along with experienced industry engineers, who are also potential employers.

Recently, this program has included as project sources, academic or research support and service-learning, henceforth respectively named, internal projects and service projects. Accordingly, internal and service projects must be measured up against industry sponsored projects regarding student interest, performance, and satisfaction. Finding the relationship between project source and student interest allows for improving the project pitch process to help students understand the importance and benefits of each project source type. Determining the impact of project source on student and team performance and satisfaction, may suggest if gaps exist between projects from different sources, and lead to creating measures for ensuring a fair educational experience for all students. This paper presents the analysis of this comparison for the three academic years between 2020 and 2023. The goal is to determine the extent to which the program should continue with this practice and provide an example to the community of its value in a multidisciplinary capstone design program.

Literature Review

Capstone courses use projects from a variety of sources, either homogeneously (the same for all students) or in a mixed environment (students or teams have different projects). Typical sources include industries, service learning, student competitions and faculty projects [1]. A study from 2015 of capstone programs in the U.S. showed that industry and government were the most common capstone project source for most engineering departments and for 96% of the surveyed multidisciplinary engineering programs [2]. The second most used project source for all respondents was faculty research, followed by student/entrepreneurial, external competitions, service learning and others.

Faculty projects are typically faculty from the same institution who have research or academic design projects. Service-learning projects are typically in collaboration with a community or even international partner and give students the opportunity to interact with people outside their disciplines. Key components of service-learning include critical reflection and reciprocity [3]. Reflection requires that students articulate the experience, while reciprocity requires that students address the real needs of sponsor to meet the learning outcomes. Because of reciprocity, these projects are more likely to be viewed by students as worthwhile given the creative freedom, the feelings of empathy or for personal satisfaction [1]. Notwithstanding, service-learning projects can bring risks such as an ill-defined project scope by not having a team of engineers define it, a lack of direction by not having a sponsor engineer, and budget constraints.

A 2015 study had 83 students from electrical, mechanical, and biomedical engineering, rank 14 pre-determined factors on how important these were for them when choosing capstone projects [4]. Their respondents overwhelmingly preferred industry-sponsored projects to ones offered by faculty. Respondents' top choices were gaining experience with the related technology and gaining industry experience. These answers are expected as most industry-sponsored capstone programs promote these two factors when recruiting students and industries.

Research Questions

This study provides an analysis of how students have valued and experienced non-industry sponsored projects compared to industry sponsored projects, given most joined the program with the expectation of working along an industry sponsor. This study explores the following questions:

1. In a well-known industry sponsored projects program, will students be equally interested in applying to service-learning and internal projects?
2. Are student and team performance negatively impacted by having a non-industry project source?
3. Does working on service-learning and internal projects meet the students’ satisfaction regarding their program expectations?

To explore these questions, this study evaluated three years of quantitative and qualitative data from the project selection process, the student evaluations, and the faculty evaluations.

Context and Data Collection

This study collects data from the students in the University of Florida (UF) Integrated Product and Process Design program (IPPD), which offers a two-semester team-based multidisciplinary capstone design course [5]. All senior students from the Herbert Wertheim College of Engineering are eligible to apply to IPPD, which includes 16 engineering and computing degree programs [6]. The program is known for providing real-world industry sponsored projects in collaboration with these industries. For each project, the sponsor must provide a liaison who will work with the team on a weekly basis. IPPD has sporadically included internal projects over its 28 years, however these are not part of IPPD mission or a reason why students apply to IPPD.

In 2020, due to the economic and traveling challenges during the Covid-19 pandemic, IPPD solicited two projects within the UF academic community and offered a pro bono sponsorship to one community service project. Without the intention to continue this practice, in 2021 one more academic project was allowed. In 2022, requests for projects were published again with an intent to permanently establish these types of projects. Therefore, the need to study the impact of hosting these projects while always keeping over 80% of the projects as industry sponsored.

The study will involve course data collected from all the IPPD students who participated during the academic years 2020-2021, 2021-2022 and 2022-2023. This data is used to study if students are equally interested in the internal or service-learning sponsored projects compared to industry sponsored projects, and if student and team performance and satisfaction is similar between the three project sources. Student interest is measured using the results from the Project Ranking Survey (PR Survey). Student and team performance are measured using their grades and the evaluations by the coaches. Student satisfaction is measured using the results of the TCP evaluations (Team, Coach & Program). Use of this data for the study was approved by the UF Institutional Review Board.

Students receive the PR Survey on the first day of class, during which the faculty advisor (coach) for each project gives a pitch presentation of their one or two projects, followed by a short Q&A session. The presentations use a standard template, and coaches do not compare projects or suggest unique workload expectations. Students have until the end of the day to review the presentations and their notes, and submit the PR Survey. Students are encouraged to rank a minimum of three projects, for which they could be placed in any of those three, and to be thorough in their answers to support their placement case. Therefore, the analysis done in this paper is based the students Top 3 project rankings. The surveys are not graded, but all students must submit it for team placement or drop the course (this meeting day is always within the window of drop/add without penalty). Team formation is done by the program staff, with consideration to the coach requests, though these are minimal.

Students must complete TCP evaluations twice each semester, at midpoint and end. The students complete a mixed-methods survey where they evaluate: Team – themselves and their teammates; Coach – their faculty coach; Program – the program overall. Students receive full credit for submitting the surveys by the due date, regardless of their answers. The program instructor

evaluates the results and addresses concerns with either the coaches, teams, or individuals. Except for the end of the year, statistics from the program surveys are shared during class to address general concerns. The team evaluations are shared with coaches, who address individual and team concerns. This study, specifically for research questions 2 and 3, analyses the TCP results from the end of years 2020-21 and 2021-22, and the end of Fall Semester for the year 2022-23. **Note to Reviewers: This 2022-23 data will be replaced with end-of-spring data by the final version.*

Table 1 shows the number of projects and students for each year. The number of students in the table refers to those who completed the program.

Table 1. Data for this Study: Number of Projects and Students for 2020 – 2023

Year	Students	Total projects	Industry projects	Internal projects	Service projects
2020-21	54	14	10 (39 students)	3 (12 students)	1 (3 students)
2021-22	59	11	10 (53 students)	1 (6 students)	0
2022-23	78	18	15 (67 students)	2 (6 students)	1 (5 students)
Total	191	43	79% of projects 83% of students	14% of projects 13% of students	5% of projects 4% of students

Results and Analysis

This section is organized by research question.

To evaluate the data statistically, nonparametric tests were chosen since the sample sizes for 2 of the 3 sponsor source categories were small (internal-research and service). In the case where the data collected was analyzed between two categorical variables (sponsor sources and Likert scale, coded data), a chi-square test was performed. Chi-square test was used to analyze the Likert scale data from the TCP surveys, the coded PR survey data, and the coded faculty grades. When data was analyzed for one categorical variable (sponsor source) and one quantitative variable (like grades or PR rank analysis), a rank sum test was used to evaluate differences between the sponsor sources. For each test, the null-hypothesis is there are no differences between sponsor sources for each variable. For p-values less than 0.05, the null hypothesis is rejected.

RQ1: Were students equally interested in applying to the industry, service, and internal projects?

The data used to answer this question is taken from the PR Surveys. The data represents 185 students, as some students joined the program after this process and were placed in industry projects as needed, instead of through their rankings.

Figures 1 through 3 show from the PR Surveys, how many students ranked each project as a top 3 choice. The analysis of this data showed no statistical difference between the three project

sources. However, the figures show that for internal projects, five out of the six were below the class average for each respective year, which shows most internals where not amongst the most popular projects. Similarly for the service projects, one was above average and one was below. Therefore, while in general students have similar interest in projects from the three sources, the industry projects tend to attract more students than the non-industry.

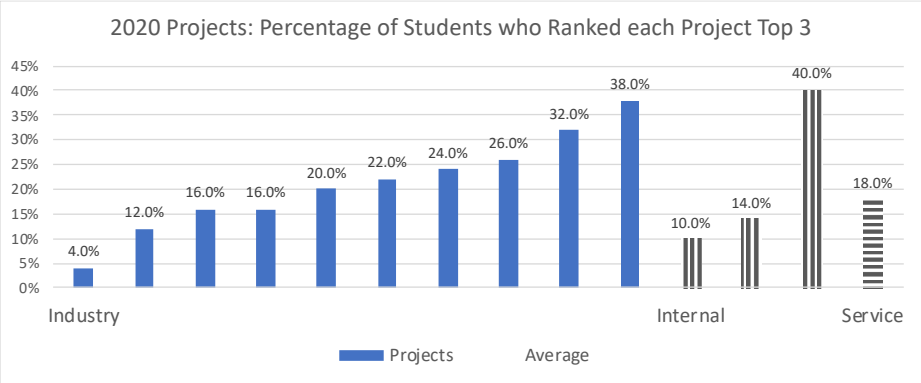

Figure 1: Students who Ranked each Project Top 3 in 2020, N = 50 students (p-value = 0.67)

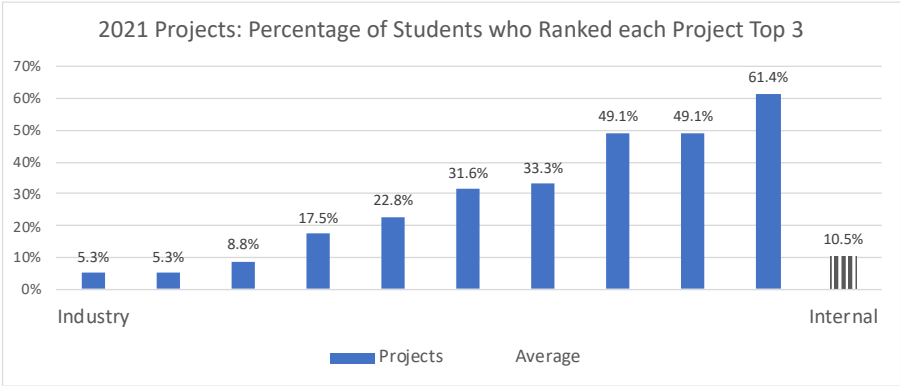

Figure 2: Students who Ranked each Project Top 3 in 2021, N = 57 students (p-value = 0.53)

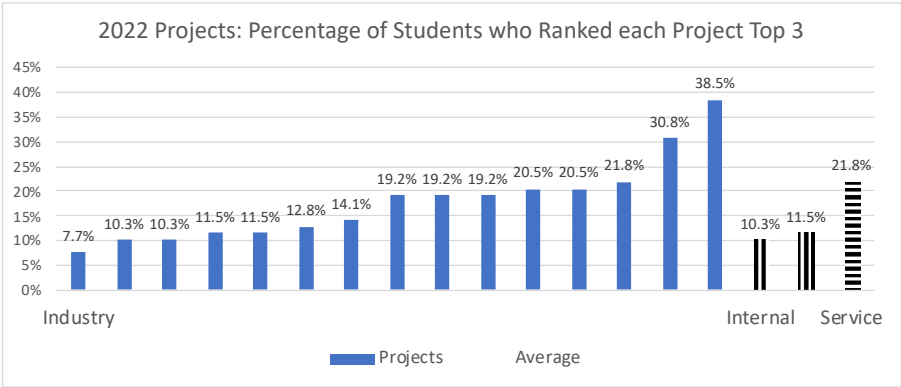

Figure 3: Students who Ranked each Project Top 3 in 2022, N = 78 students (p-value = 0.64)

As part of the PR Survey, for each project, students were asked to support their ranking choice by describing "*...why you are qualified for that project and why it interests you*". For this study,

these results were coded into following response categories: Engineering, Tech, Sponsor, Faculty, and Personal.

- Engineering if the student listed any engineering related qualifications that pertained to the project's needs.
- Tech if the student expressed interest in the technology of the project.
- Sponsor if the student expressed interest in working with the sponsor of the project.
- Faculty if the student expressed interested in working with the project coach.
- Personal if the student described personal reasons for their interest.

The percentage of each code identified in each response out of all responses for each project type were then calculated. Figure 4 shows the results of this coding for the Top 3 responses of all students over the three years.

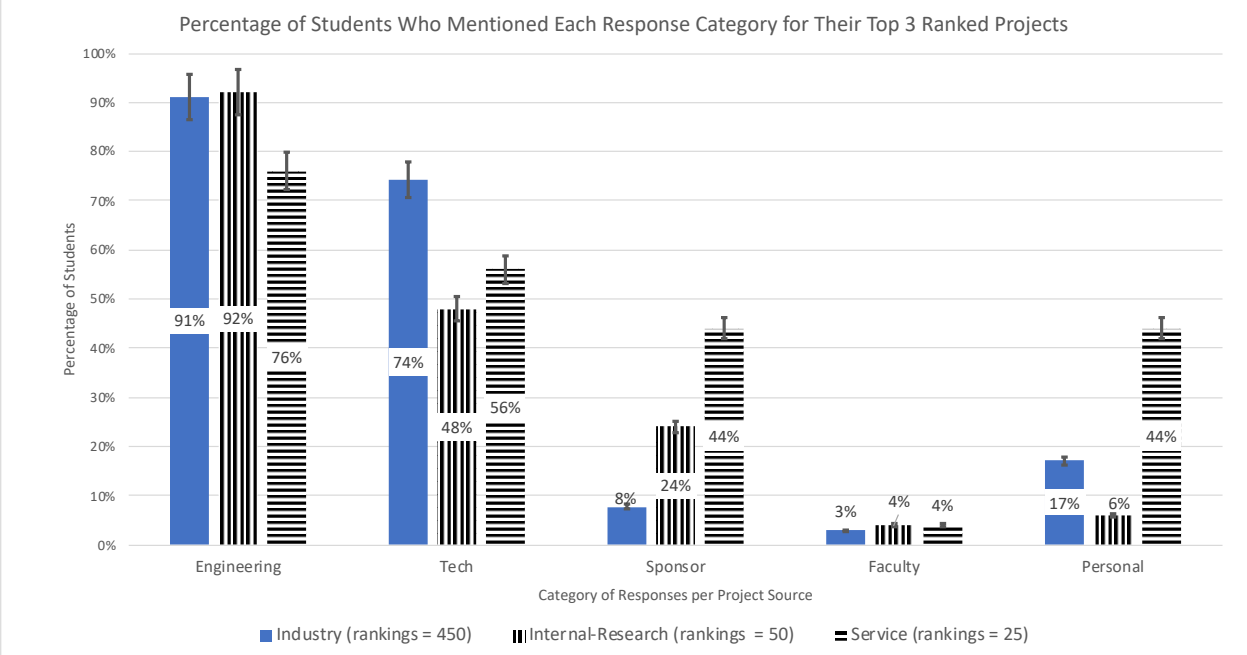

Figure 4: Percentage of Students over Three Years whose Interest/Qualifications to Support their Top 3 Ranked Projects mentioned each of the Response Categories (p-value < 0.05 except for Faculty)

The results show that student rankings of service projects had the least mentions of engineering skills, while rankings of industry and internal projects had a similar very high percentage of mentions of engineering qualifications to support the rankings. Considering the service projects were near average in rankings, further studies should determine whether these students were not compelled to also state engineering skills or if the projects did not inspire the need to mention engineering skills. Based on the faculty evaluations analyzed for RQ2 below, the service projects were comparable to the other projects with respect to engineering challenges.

On the other hand, student rankings of service projects had the most mentions of Sponsor and Personal as reasons for joining the project. This suggests that, as expected, service projects illicit personal connections with the related service cause, whereas industry and internals rarely inspire those connections.

Regarding the technology for the projects, student rankings showed that industry projects draw significantly more technical interest. The category Faculty was not influenced by sponsor type.

The PR Survey also included the following questions pertaining to their overall skills.

- Describe your experience as an active member of a student group or an organization, including any leadership roles.
- Describe your previous work experience (relevant to your preferred project).
- Describe specialized technical experience you have relevant to one or more projects (software, polymers, FEA, Altium, water chemistry, etc.).
- Describe any hardware you have worked with, e.g., repairing bikes, autos or technology devices, experience with mechanical and machinery tools, electrical wiring, or chemistry equipment, etc.

For this study, the results from these questions were coded into the following response categories: student organization involvement, work and research experience, post-graduation plans, current commitments, and additional technical skills. Of these categories, only two had enough mentions to merit analysis, specifically, internship experience and research experience.

The expectation was that students without any internship experience were more likely to only rank industry projects, such that they could fill this gap by gaining industry experience prior to graduation. Likewise, students who ranked non-industry projects were more likely to have had an internship experience. However, the results in Figure 5 show that more students with internship experience choose only industry projects, while more students without an internship experience chose to rank non-industry projects.

This suggests that not having internship experience does not preclude them from choosing a project from either an internal or service project. Perhaps students with internships had enough positive experiences to want to continue with these types of projects.

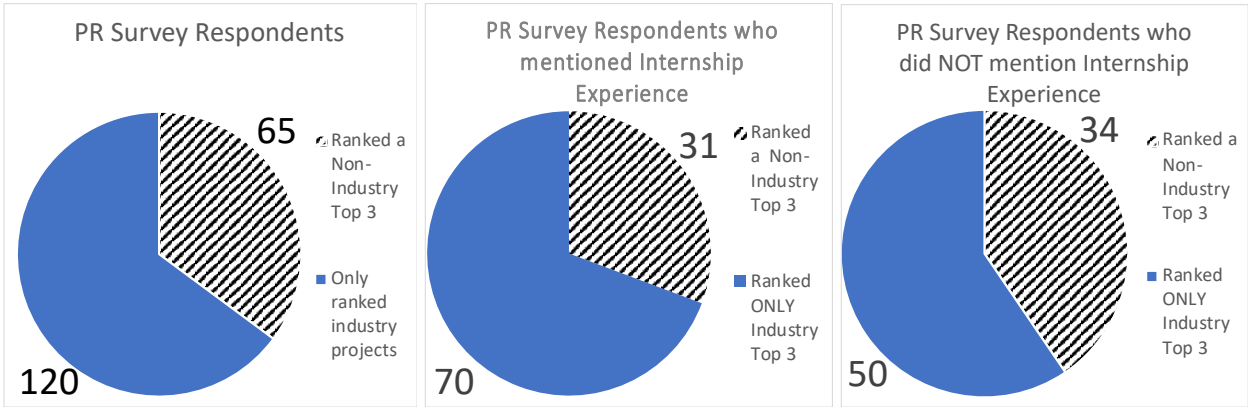

Figure 5: Students who Mentioned Internship Experience in the PR Survey (p-value = 0.22)

Similar results were obtained for students who mentioned having research experience. The expectation was that students with research experience would be more attracted to academic

(internal) projects if they had a positive experience or graduate studies. For consistency, again the comparison was made of students ranking only industry projects versus those who ranked at least one non-industry project. Figure 6 shows that the variation between these distributions was under 5%.

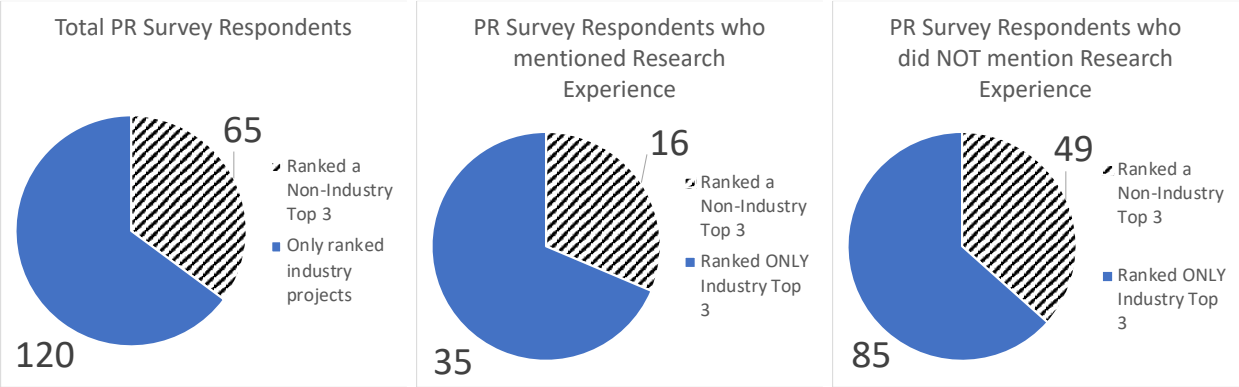

Figure 6: Students who Mentioned Research Experience in the PR Survey (p-value = 0.62)

RQ2: Is student and team performance negatively impacted by having a non-industry project source?

The data used to answer this question includes student and team grades, and from the TCP evaluations, student self-evaluations and student teammate evaluations.

Regarding individual student course grades and team grades from the teams' faculty coaches, these did not show differences between the three sponsor sources (p-value = 0.71 and p-value = 0.98, respectively). When providing grades each semester, faculty coaches must also provide feedback to support the grades. For this study, these results were coded into following four categories: exceeded expectations (4), met expectations (3), mostly met expectations (2), and less than met expectations (1). The results did not show statistical differences between these grade codes for the three sponsor categories (p-value = 0.68). Therefore, it is likely that the sponsor source does not have an impact on student and team success with respect to grades.

Regarding the TCP Evaluations, Figure 7 shows a screenshot of a portion of the Team section that includes the questions evaluated for in this RQ2. For this analysis one of the internal teams is missing due to an unknown technical error in the program archives. Therefore, in the context of Table 1, the data represents one less internal project with three less students. Table 2 shows a summary of these results, and Figure 8 shows the data for each year.

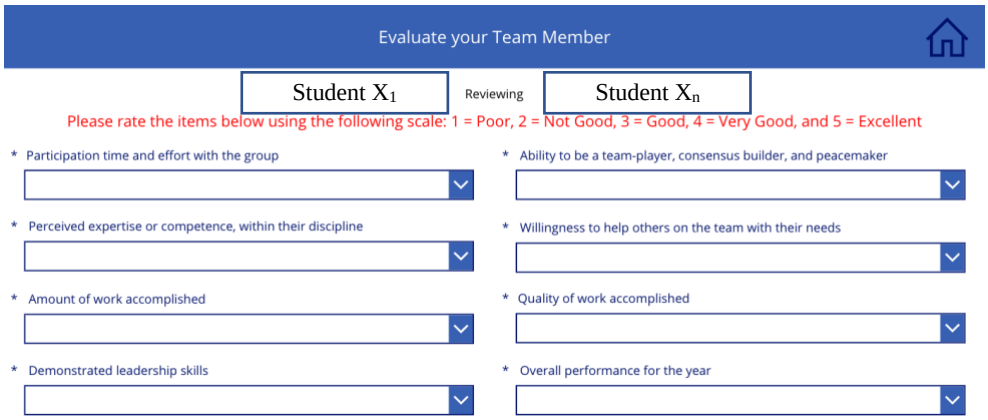

Figure 7: Portion of the Team Evaluation (self and teammate) of the TCP Evaluations

Table 2: Summary of Results from the TCP Evaluations of Self and Team Members

Average score per sponsor type (1 – 5)	**Industry**	**Internal**	**Service**
Participation time and effort with the group	4.61	4.78	4.59
Amount of work accomplished	4.58	4.73	4.53
Overall performance for the year	4.64	4.82	4.62

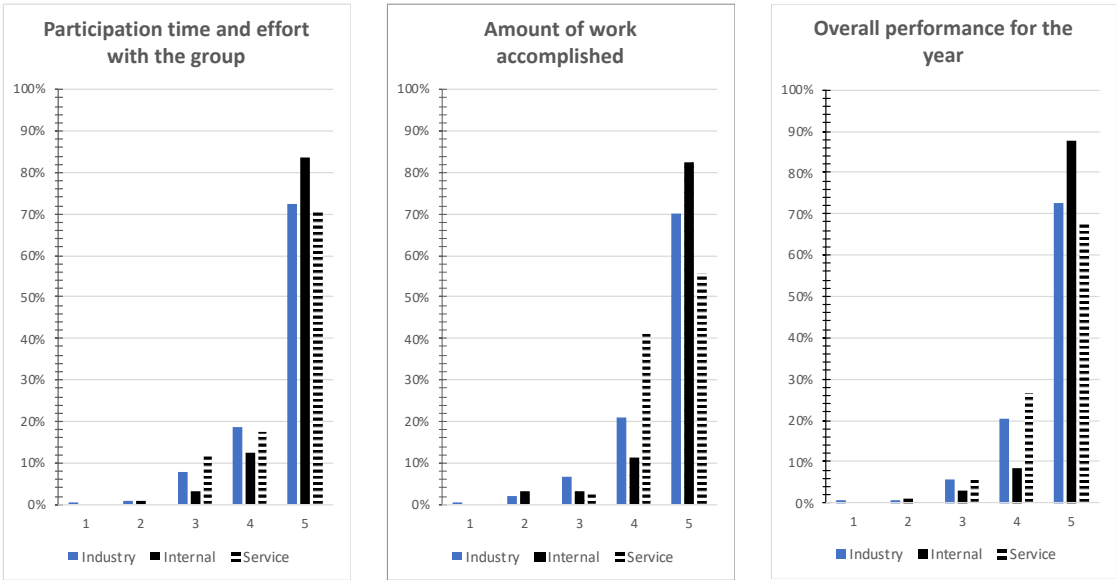

Figure 8: Self and Teammate Evaluations for: Participation (p-value= 0.44), Amount of Work (p-value= 0.02), Overall Performance (p-value= 0.14)

Most results show no significant differences between project sponsor sources for the results of student evaluations of both themselves and their team members. The exception is students' evaluations of amount of work, where for Service sponsors the results were lower, which through a deeper dive of the available data, was found to not be relevant to the sponsor type. Therefore, there is no clear indication that, from the students' perspective, sponsor type affects performance.

RQ3: Does working on service-learning and internal projects meet the students' satisfaction regarding their program expectations?

The data used to answer this question includes from the TCP evaluations, student overall score for the program, with the same scale from Figure 7.

Table 3 shows average scores by project source for students' evaluation of the program overall and Figure 9 shows the data distribution, which does not show a statistical difference between the three project sources (p-value = 0.42).

Table 3: Overall Program Evaluation by Students

Project Source	**Overall Score (1 – 5)**
Industry (students = 158)	4.11
Internal (students = 25)	4.33
Service (students = 8)	4.38

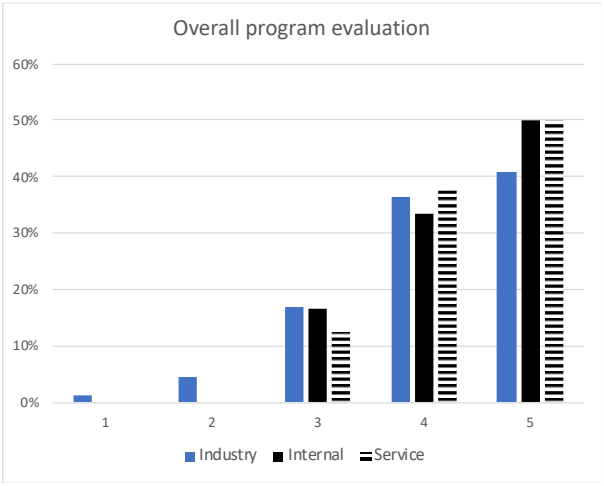

Figure 9: Overall Program Evaluation (p-value = 0.96)

The TCP Program evaluations include additional scoring questions and open questions for students to assess their experience. An analysis of their responses to the questions such as "improvements they would like to see" and "problems you've encountered" did not show any indication of sponsor source influence. One question, describe "experiences you particularly liked", includes some interesting highlights.

- Three students from internal and service projects, which have all been local to our community, appreciated that they got to work more closely with the sponsor on a continuous basis.
- Seven of the industry students, compared to none in non-industry projects, explicitly mentioned working with the liaisons as an enjoyable experience.
- Students who explicitly mentioned the sponsor: Non-industry = 2 vs Industry = 11
- Students who appreciated the "real-world experience": Non-industry = 0 vs Industry = 6

These student comments suggest that including the internal and service projects allows students to explore and build these relationships in the community, similar to how students in industry projects can build career connections and “real-world” industry experience with their industry sponsor liaisons assigned to the project. Students taking the course together allows them to share their experience and understand the intricacies of working the different project sources.

Conclusion

Students in their responses demonstrated personal connections to the service projects and sponsors, which correlates positively with the research on service-learning, specifically reciprocity. Student interests in projects varies by the project type even though sponsor source does not have a significant impact on project ranking. Also, students demonstrate an appreciation of the experiences they receive across projects with different sponsor sources, thus everyone, the program, students and varied sponsors, benefit from the program hosting a variety of projects that allow students to explore and gain experience in these interests and skills.

This study shows that students who joined the capstone program seeking an experience of working with industry sponsored projects, had similar interest, performance, and satisfaction with working with academic and service sponsors. Therefore, the capstone program should continue with this practice and actively promote these opportunities when recruiting students. Adding these projects benefits all the students by increasing the opportunities to join the program and adding a variety of real-world projects to compare within the whole class.

Future Work

This work can be continued through any of the following questions:

- Why did students mention significantly less their engineering skills when ranking service projects?
- Upon program completion, ask students to evaluate their project rankings in hindsight to determine how the experience changed their expectations.
- Is there a relationship between project source and perceived project difficulty?
- Do the students’ post-graduation plans impact their choice of sponsor source?

The authors look forward to collaborating with courses who also use multiple types of project sources to compare results and determine potential improvements for ensuring students have optimized learning experiences.

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