

Effects of Service-Learning Projects on Capstone Student Motivation

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Abstract

Many engineering programs incorporate project-based, service learning into traditional classes and capstone experience. These projects focus on service-related challenges that impact the local, national, or international community and could be described as “humanitarian” or “for the greater good”. While these projects have shown positive benefits for recruitment, retention, and student diversity, what has been unexamined is whether student motivations in these projects differ from their peers in more traditional capstone projects. We hypothesize that students in service-oriented capstone projects may feel greater motivation and engagement with their project due to its service components as compared to their peers in other capstone projects.

We address this question by examining the experiences of capstone students at two different institutions. York College of Pennsylvania and Valparaiso University are both small, comprehensive, private universities with engineering programs that engage in a variety of capstone projects. At each institution we administered surveys with capstone students to assess their interests, motivations, and engagement in their capstone projects. By comparing student responses and evaluating the level of service that each project embodies, we can assess whether students in differing projects show different motivations. Our results provide insights into methods for maintaining student success in capstone projects and for selecting future projects.

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1. Introduction

Capstone design courses are a culminating experience for engineering students involving one or two semesters with a design and build sequence focusing on “real-world” applications. These experiences prepare engineering students for future professional life and are critical junctures in their engineering education. Recently, some capstone projects have begun to incorporate elements of service-learning and can be termed Project-based Service Learning (PBSL)[1]. These experiences expand the traditional capstone projects to incorporate community service and/or humanitarian efforts at the local, national, and international level [2]-[5]. These new projects have shown positive benefits in recruitment, retention [6], increased student performance [7]-[8], and interest studying engineering [9].

While the “real-world” elements of capstone project can be highly motivating for students [10], recent work has shown that student motivation can be decreased after a capstone experience [11]. Furthermore, maintaining student motivation was listed as an instructional challenge by faculty in the 2015 capstone survey [12]. Given the linkage between student motivation and successful learning outcomes, it is important to understand what factors may affect student motivation during capstone projects. Given the rise of PBSL experiences, our research examines whether there are motivational differences between students engaged in service-based and non-service based capstone projects. Overall, we hypothesize that students involved in service-oriented capstone projects may be more motivated than their peers as their work is for the “greater good”. This exploration follows from previous work indicating that students on service-based projects felt more personally fulfilled by their engineering work than their peers on traditional projects [13]. Specifically, this work identifies two main research questions: (1) Do student motivations vary based upon the relative amount of service in a capstone project? (2) Do students value their

capstone experience differently based upon the relative amount of perceived service? Answering these two questions will provide insight into the experiences of undergraduate engineering students and help inform capstone faculty when selecting and mentoring projects.

To address these questions we conducted a survey of undergraduate engineering students at two institutions, York College of Pennsylvania (YCP) and Valparaiso University. Both universities are both small, comprehensive, private universities with engineering programs that engage in a variety of capstone projects. A short survey was administered that utilized the Aspirations Index [14] and Intrinsic Motivation Inventory (IMI) [15] to examine student views of community service, enjoyment, and value of their capstone projects. Approximately 120 students were surveyed across 21 projects incorporating varying degrees of service elements. Results show that, overall, students found positive value and enjoyment in their capstone experience across all projects. However, student perceptions of project value can be affected by their inherent view of the importance of community service.

The remainder of this paper is organized as follows: Section 2 discusses related work in capstone courses and motivates our work; Section 3 describes the educational settings for York College of Pennsylvania and Valparaiso University and briefly describes the capstone projects involved in the study; Section 4 outlines our methods, protocols, and the surveys used for this study; Section 5 presents our results and discusses the overall findings; and finally Section 6 concludes with a summary and description of future work.

2. Background and Motivation

Capstone/senior design experiences are common across engineering curricula within the United States. The 2015 Capstone Survey [12][16] provided reports from 256 US-based institutions and noted wide varieties across experiences including project origination, team size, and faculty roles. Capstone projects can range from small student independent studies, industry sponsored work, national engineering competitions, or faculty sponsored research opportunities. The overall learning objective is to offer a culminating design experience that involves design of a system with multiple constraints, creativity, technical documentation, and teamwork with peers [17].

Recently capstone courses have begun to incorporate more service-learning elements. These projects focus on engineering work towards local community [18], national [3], or international needs [2]. As of the 2015 Capstone Survey, nearly 30% of programs surveyed offer capstone service-learning projects [16]. These projects have been shown to have positive impacts on student retention, recruitment, and interest in studying engineering [6]-[9]. While these impacts are positive, what is unknown is whether these benefits extend into the capstone experience itself. While service-based projects may increase recruitment and retention for an engineering program, do they have an impact on the current students within capstone? In this work we address this question by examining capstone student *motivation* within the context of service or non-service capstone projects.

Motivation will vary in the degree to which it is intrinsic, or self-motivated, and extrinsic, or driven by external incentives (e.g., rewards, punishments) [19]. In this study we focus on

intrinsic motivation through the Intrinsic Motivation Inventory [15] which will be described in more detail in Section 4. As capstone projects represent a “culminating experience” for engineering students, it is valuable to understand the degree to which students are intrinsically motivated during the experience; higher intrinsic motivation has generally been associated with a range of positive academic behaviors, such as increased time on task, creativity, and persistence in the face of failure [19-20].

Given the importance of capstone experiences, it is concerning that recent work has shown that student motivations can decrease after capstone experiences [12]. Furthermore, the Capstone 2015 Survey listed “Student Engagement” as the #3 concern by capstone instructors. With these challenges in mind, this work examines student motivations at two US-based universities and explores whether the type of projects offered at each university influences student motivations. We describe our approaches for this study in more detail in Section 4 and our results from the survey in Section 5.

3. Comparison of Institutions and Capstone Curriculum

In this section we discuss the educational setting of each university, how capstone projects are organized at each institution, and provide brief descriptions of the capstone projects offered.

3.1 Capstone Design at York College of Pennsylvania

The engineering program at York College of Pennsylvania was founded in 1996 and offers degrees in Mechanical, Electrical, Computer, and Civil Engineering. As part of the curriculum, all engineering students undertake three semesters of co-operative work experience. After the sophomore year, students alternate between academic and co-op semesters until they graduate in the summer of their senior year. Because of this alternating sequence, the capstone courses are offered in semester 6 and 7, which correspond to the junior/senior student year. All mechanical, electrical, and computer engineering students participate two capstone courses called Capstone I and II. The first course focuses on design and initial prototyping for a new system, while the second course emphasis implementation and manufacturability of the proposed system. Students meet weekly as a team with their faculty advisor to provide updates on their progress, receive technical assistance, and set goals for the following week.

Capstone projects are identified by the faculty and supported by internal program funds. While some projects have received external or corporate funding, no projects within this survey do so.

Before entering Capstone I, students are asked to rank their project preference. Students are assigned to projects by the faculty based upon their preference and the need to balance student abilities across the teams. Overall, 40-50 students from ECE and ME are enrolled in Capstone I and II in a given academic year.

3.2 Capstone Design at Valparaiso University

The College of Engineering at Valparaiso University offers degrees Mechanical, Electrical, Computer, Bioengineering, and Civil Engineering. Students within the Mechanical, Electrical, and Computer engineering and Bioengineering programs take part in a required, common, two-course sequence: a three-credit course in the fall semester of the senior year and a

three-credit course in the spring semester of the senior year. The first course focuses on the conceptualization, definition, specification, and design of the system. The second-semester course focuses on the manufacture and testing of the system. At the end of the two-course sequence, each student will have participated in the development of an actual system, from conceptualization through testing. For each of the two courses in the capstone sequence, the students are required to attend two to four hours of instruction per week (consisting of lectures, presentations, and team meetings with their advisor).

The College of Engineering at Valparaiso University has made a significant commitment to the Capstone Senior Design course in terms of both faculty teaching load and financial support. Approximately 100 students are enrolled in the course each year and are divided into multi-disciplinary teams of five to seven students. Each team is assigned a faculty advisor, with each faculty member acting as team advisor to two teams. Additionally, although outside funding is occasionally available from industry sponsors or research funds, to better control the scope of the projects, the majority of funding is provided by the Valparaiso University College of Engineering and divided among the teams.

3.3 Comparison of Capstone Projects at each University

A list of the capstone projects offered in 2017-2018 and used in this survey are provided in Table 1 for both universities. A wide variety of projects are available to students including national competition projects, community-service work, and research-funded experiences. For the purposes of our later analysis, we categorize projects as either Service or Non-Service.

Table 1: Capstone projects at each university based upon service attributes

| | York College of Pennsylvania | Valparaiso University |
|----------------------|--|---|
| Service Projects | <ul style="list-style-type: none"> ● Medical Device ● Shadowfax Assistive Technology ● Agriculture Drone | <ul style="list-style-type: none"> ● Biometric Gait Identification ● Bottle Injection Molding ● Wrist Exoskeleton ● Solar Research ● Go Baby Go ● Automatic Baby Stroller Breaking ● Concussion Detection and Monitoring ● Bionic Children’s Hand ● Automatic Plant Watering |
| Non-Service Projects | <ul style="list-style-type: none"> ● Formula SAE Internal Combustion Race Car ● Formula Electric Race Car ● Baja Off-Road Vehicle | <ul style="list-style-type: none"> ● Automatic Drill Bit Sizing and Sorting ● Quiet Coffee Grinder ● Remote Home Lock ● Formula SAE Car ● Telepresence Robot ● Autonomous Go Kart |

Within the York College projects, three incorporate service elements: Medical Device (to assist ER nurses with monitoring arterial lines), Shadowfax (assistive technology for workers with disabilities), and Agriculture Drone (autonomously monitor crop health and conditions), while the other three do not (Formula SAE Internal Combustion, Formula Electric, and Baja). The three non-service projects are nationally established competition projects that are found at many universities. The service-based projects are derived from local contacts and community needs.

Some examples of the “service oriented” project include at Valparaiso University: Go Baby Go (development of mobility devices for children with disabilities), Bottle Injection Molding (reuse of plastics in third-world countries for new products), and Solar Research (mechatronic control of solar reactor for development of clean energy).

4. Methods and Protocol

This study utilizes two validated surveys to assess the motivations and aspirations of capstone students. The Aspirational Index [14] and Intrinsic Motivation Inventory [15] examine student life goals and motivations. In this section we will describe these surveys in more detail and outline the research methods and protocols used in this study.

4.1 Aspirations Index and Intrinsic Motivation Inventory

The Aspiration Index [14] aims to assess people’s aspirations, or life goals, in seven different categories. For the current study, we specifically focused on the intrinsic aspirations subscale related to community. The community subscale examines the degree to which an individual desires to contribute to and improve the community by helping others in need. As one of the intrinsic aspirations, the community subscale was particularly relevant to the current study’s exploration of how a focus on a service-orientation within the capstone project for engineering students relates to their motivation related to the project. For the survey, we focused on the 5 items related to importance of contributing to the community. Items included goals such as “To work for the betterment of society”. Participants were asked to rate how important each goal was to them, ranging from 0, being not at all important, to 4, being extremely important.

The Intrinsic Motivation Inventory [15] aims to assess a variety of aspects of individual’s drive related to specific tasks. The current study focused on the subscales of enjoyment and value of completing the capstone project. Both subscales include 7-items each. Items on the enjoyment measure included statements such as “I thought completing the capstone project was boring,” (reverse-scored) and “I feel that my capstone project is very interesting.” Items on the value measure included statements such as “I think that completing my capstone project is useful,” and “I think that the capstone project is an important activity.” The enjoyment subscale of the Intrinsic Motivation Inventory [15] most directly represents what would be considered self-reported intrinsic motivation. The value subscale is often assumed to represent an internalization of an activity [21]. Conceptually, activities that are driven by intrinsic motivation become more central to the self and prompt greater self-regulation in the completion of such activities, and in turn, are seen as useful. Participants were asked to rate how accurate each statement was in describing their experience during the capstone project, ranging from 0, being not at all accurate, to 4, being extremely accurate.

Students ratings for each of the scales items were averaged to create three single scores. One represented the degree to which students felt contributing to the community was important, and the other two represented their specific judgments about their experience completing their capstone project: one associated with the degree to which they enjoyed the experience and the other associated with the degree to which they found the experience valuable.

4.2 Research Protocol and Data Collection

To assess individuals differences in terms of project choice, students completing their capstone project were asked to complete the survey at the beginning of the spring semester. Electronic and paper forms of the survey were created from the scale described in Section 4.1. The survey was approved by the IRB at YCP. Teams were provided the survey in both paper and/or electronic formats during weekly capstone meetings. Paper surveys were then entered manually into the online survey by a faculty member. Student responses (including omissions or double selections) were retained in the electronic version.

In total, 118 responses were collected from both institutions. All Valparaiso University collections were completed electronically at a single meeting in January, while the York College administered the survey one week later across several team meetings. While each institution follows different academic calendars, both student populations were surveyed at approximately the same time within their capstone course sequence.

5. Results and Discussion

In this section we present the results from our survey described in Section 4. Overall, three scales were assessed in the survey: importance of community service, enjoyment of their capstone project, and value of their capstone project. There were 46 (39%) student responses from York College and 72 (61%) from Valparaiso University. Cronbach's alphas supported the reliability of all scales used (importance of community: $\alpha = 0.91$; enjoyment of capstone project: $\alpha = 0.89$; value of capstone project: $\alpha = 0.94$) and the response rate from both institutions combined was 93%.

5.1 Project Enjoyment/Value and Community Service Comparison Across Institutions

Table 2 presents the mean responses for each scale (community, enjoyment, and value) at each institution; possible values ranging from 0-4. For each scale, a 0 response would indicate the absence of that scale, e.g. a score of 0 for Enjoyment would indicate that students found no enjoyment in their capstone projects. Similarly, a score of 4 for Community would reflect a belief that community service is extremely important. Scales that showed statistical difference between institutions are indicated with a **.

Table 2: Overall response for Enjoyment, Value, and Community scales by institution

| Scale | YCP Score | Valparaiso Score |
|-----------------------|---------------------|---------------------|
| Community** (p<0.001) | $M = 2.80 \pm 0.78$ | $M = 3.21 \pm 0.54$ |
| Enjoyment | $M = 2.93 \pm 0.69$ | $M = 2.83 \pm 0.81$ |
| Value | $M = 3.18 \pm 0.71$ | $M = 3.03 \pm 0.83$ |

Across all participants, students expressed a relatively high importance of contributing to the goal of contributing to their community and value in their capstone project as indicated by their higher scores. Of the surveyed scales, only the importance of community varied between institutions with the scores from Valparaiso University statistically higher than York College. A possible explanation for the difference could be the religious background of Valparaiso and that those seniors are already familiar with community service.

5.2 Project Enjoyment/Value and Community Service Comparison Across Service and Non-Service Projects

Table 3 compares the mean responses for each scale (community, enjoyment, and value) based on whether the project was categorized as service or non-service oriented. As the degree to which participants valued contributing to their community presumably was an preexisting individual difference that could potentially influence their choices regarding their capstone project, a binary logistic regression analysis was conducted to determine whether that individual difference predicted whether they opted to complete a service or non-service oriented capstone project. The Wald criterion (6.78, $p = 0.01$) supported those who more highly valued contributing to their community in fact more likely to select a service-oriented capstone project.

Table 3: Overall response for Enjoyment, Value, and Community scales based upon project

| Scale | Service Projects | Non-Service Projects |
|--------------|---------------------|----------------------|
| Community*** | $M = 3.21 \pm 0.53$ | $M = 2.91 \pm 0.76$ |
| Enjoyment | $M = 2.77 \pm 0.81$ | $M = 2.98 \pm 0.68$ |
| Value | $M = 3.02 \pm 0.78$ | $M = 3.18 \pm 0.77$ |

*** Participants more likely to select a service-oriented capstone project based upon individual community value ($p = 0.01$)

Given both the enjoyment and value scale addressed participants perceptions of their projects, a multivariate analysis of variance (MANOVA) was conducted to compare those perceptions for participants who chose to complete service vs. non-service projects; participants' value of contributing to the community and the institution at which they completed the project were treated as covariates to control for any influence of the latter two variables. Although the trend

suggested that means were lower for the service-oriented group, neither difference reached statistical significance, $F(1, 108) = 2.85, p = .09$, and $F(1, 108) = 2.40, p = .12$.

Examining the relationship between our three scales further, Table 4 presents Pearson correlations of students ratings for the “contributing to community goal” and the “enjoyment and value of their capstone project”; results in the upper-right were from participants completing service-based projects, and results in the lower-left were from participants completing non-service based projects. Across both types of projects, as enjoyment of the projects increased, so to did value of the project, $r(115) = 0.73, p < 0.001$. This was true no matter what type of project students completed. Additionally, generally students who valued the project more were also more likely to feel it was important to contribute to their community, $r(115) = 0.26, p = 0.01$. As noted in Table 4, the relationship was statistically significant among students doing a service-based project, but only reached marginal significance for students doing a non-service based project.

Table 4. Correlations of students responses by project-type

| | Community | Enjoyment | Value |
|-----------|------------------------|--|--|
| Community | | $r(56) = .22, p = .11$ | $r(55) = .36, p = .01^*$ |
| Enjoyment | $r(58) = .07, p = .62$ | | $r(55) = .78, p < .001$ |
| Value | $r(57) = .25, p = .06$ | $r(57) = .66, p < .001$ | |

*Cells that are bolded are statistically significant.

Given that the degree to which participants valued contributing to the community was related to the perceived value of their capstone project, we conducted a multiple linear regression model of students’ value of their capstone experience, using project type and importance of contributing to community as predictors (see Figure 1). Based on the results of that analysis, both predictors appeared to reach marginal statistical significance, such that working on a non-service projects ($B = -0.19, t = -1.97, p = 0.05$) and reporting a higher value for contributing to their community ($B = 0.22, t = 1.93, p = 0.06$) predicted higher perceived value of students’ capstone project. Although the interaction of the two predictors failed to reach statistical significance ($B = 0.14, t = 1.22, p = 0.23$), the trend suggested that for participants completing service-focused capstone projects, those who were less concerned about contributing to the community did not feel their capstone project was valuable; however, this interaction did not reach statistical significance. These trends were similar for enjoyment, with the biggest difference being that importance of contributing to community was unrelated to enjoyment ($B = 0.05, t = 0.46, p = 0.65$).

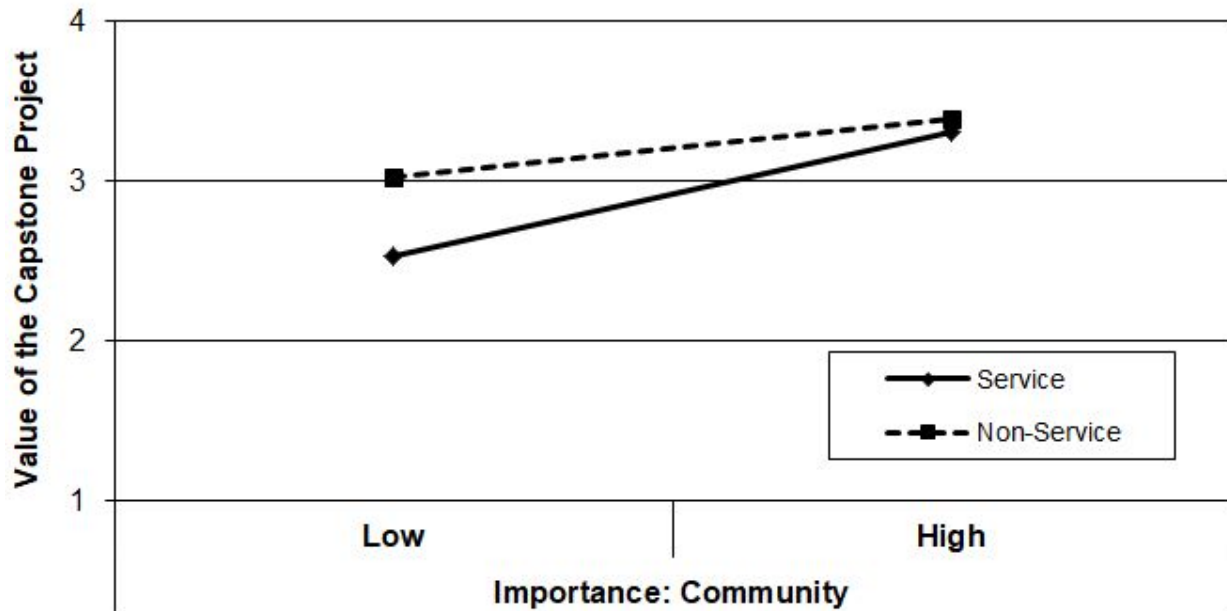


Figure 1: Multiple linear regression model of student project value based upon importance of community service and project type

5.3 Discussion

In this section, we describe our result as applied to the research questions identified in Section 1. Additionally, we discuss the implication of our work for faculty and their mentoring of capstone projects.

5.3.1 Addressing Research Question #1

Our first research question was: Do student *motivations* vary based upon the relative amount of service in a capstone project? We can address the first question from the result in Table 3. As the Enjoyment Scale is a self-report of intrinsic motivation and no statistical differences were found between students based upon project type, we can conclude from the studied population that student motivations does not vary based upon the project type. Students in both service and non-service projects reported the same positive enjoyment of their capstone project.

5.3.2 Addressing Research Question #2

Our second research question was: Does student *valuation* of their capstone experience vary based upon service components in their capstone project? From Table 3 there were no statistically significant differences in value based upon project type. However, the relationship between value and a student's perceptions of community service may be more complex than merely project type. As addressed with Figure 1, it may be, in part, a matter of matching the right student with the right project. For students who felt community service was importance, they seemed to feel that the service-focused or non-service focused projects were both equally valuable. However, for students who were less motivated to contribute to their community, they may have likewise seen less value in a project that was focused on serving the community. In other words, having students engage in projects that do not necessarily align with their pre-existing values may become problematic for their overall engagement in the project.

5.3.3 Implications for Capstone Faculty and Mentoring

Overall, there are several implications that can be drawn to assist capstone faculty in planning and mentoring their projects.

Advice #1: Students across all projects reported enjoying and valuing their capstone experience. Given the variation in projects, team sizes, and curricular differences at the two Universities, we assert that these different structures do not negatively impact student experience. Thus capstone faculty should not feel there is “one correct” method of teaching capstone.

Advice #2: Following from Figure 1, students assigned to projects that do not align with their pre-existing values may find less value in the overall experience, which could create obstacles for their overall motivation and engagement with the project. Assuming that the relationship continues, faculty members should not place students on service-based project if that student has a low value of community service. While this result may sound obvious, ***a student’s perception of community service may not be known to the faculty member and thus the student’s attitude should be a consideration when assigning projects.*** However, a student’s importance of community service should not be an overriding factor in project choice as students with a high importance of community service valued their project regardless of its focus.

Advice #3: As there were no discernible differences in motivation between service and non-service projects, capstone faculty will likely have equal challenge managing and mentoring projects regardless of type. Thus capstone faculty and program administrators should weight the external benefits of community-based projects (retention, recruitment...etc.) with the additional challenges (deliverable expectations, external relationships with client...etc.) [13] when engaging in these projects as the student’s perceived experience will likely be the same.

6. Conclusion and Future Work

Give the rise of project-based service learning experiences in capstone courses, this work examined whether students on service-oriented projects have different perceptions and valuations from students on more traditional or non-service projects. A survey of 118 students at two US engineering programs revealed no significant differences in motivation between students based upon their project type. However, several relationships between the student’s perceived *value* of their capstone project with their own views of community service were discovered. Notably, students with a low importance of community service valued their capstone experience less, but still positively, than their peers.

In future work, we will explore these relationships in more detail by developing a “service rating” for projects rather than the simple binary classification of “Service” and “Non-service” used in this work. This increased fidelity may provide additional insights to the relationships among student enjoyment and value of capstone projects and their views on community service.

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