Benefits and Challenges of Transitioning to Community Service Multidisciplinary Capstone Projects

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Abstract
Significant research has shown the positive benefit of service and community-based learning on student diversity, engagement, and retention. Elements of service-learning have been incorporated across disciplines into traditional classes as well as capstone experiences. While providing significant benefits, challenges also exist in managing relationships with external clients, finding administrative support for these experiences, and engaging students in more open-ended projects.

Recognizing these benefits, new capstone projects have been introduced at our mid-sized mid-Atlantic college over the last two years that focus on community outreach and service. These projects include a community bike rental station, an automated greenhouse for a K-8 school, and assistive technologies for employees with disabilities. These new projects exist along with "traditional" competition-based capstone projects such as Formula FSAE.

Given these two classes of multidisciplinary capstone projects, we examine the experiences of the students, faculty, and community partners during the transition to new service-learning capstone projects. Specifically, we report on interviews conducted: (1) with faculty to understand their administrative and instructional challenges in adding service-based capstone projects, (2) with community-partners and their perceptions of working with the college, and (3) with students to understand the differences in student experience and between traditional competition and new capstone projects. We believe that our experiences can provide a guide for other institutions to manage the transition to service-based capstone projects in their curriculum.

1. Introduction

Throughout the United States most engineering programs engage undergraduate students in senior design or capstone projects. These projects are intended to provide engineering students a culminating experience to design, build, and test a system them will exercise the skills learned over their four year education. Following from the Capstone 2015 survey [1], these projects cover many disciplines, team sizes, and project sources. Recently, capstone projects have begun to incorporate aspects of service learning to both broaden student's perspectives and to engage students who may have a more environmental or humanitarian view of engineering. This new focus in capstone projects has been termed Project-based Service Learning (PBSL) [2].

Examples of PBSL include international efforts such as Engineering Without Borders [3], national consortiums such as EPICS [4], and individual university programs [2,5,6].

While the benefits of PBSL are widely known there are also challenges in managing any multidisciplinary capstone experience [7,8]. In this paper, we examine the specific benefits and challenges faced at our institution as we begin to incorporate PBSL into our capstone experience. Our situation is unique in that we have continued to maintain our existing single-disciplinary capstone projects while bringing these new service-based multidisciplinary projects online. Furthermore, while previous work has examined the impact on students and capstone instructional faculty [1,8], we examine this change from additional perspectives including those of students, faculty (both instructional and administrative), and our community partners.

To better understand the impact of the transition to PBSL project we conducted surveys and interviews with capstone students, faculty, and community partners to assess their beliefs about the projects and what benefits and challenges they have encountered. From these sources, we have identified several findings that may be useful for other institutions if they incorporate PBSL into their capstone experience. First, there were concerns on the part of administrators and faculty members about an increased faculty workload to implement and sustain PBSL projects. Second, interest for becoming involved with PBSL projects differed among stakeholders. Third, there were logistical issues in transitioning from traditional competition-based capstone projects to PBSL capstone projects. These issues varied between stakeholder groups.

The remainder of this paper is organized as follows: Section 2 outlines related work in senior design and PBSL. To better situate the reader to our experience Section 3 discusses the current and historical state of capstone design at our institution. In Section 4 we discuss our interview and survey methods. In Section 5 we discuss our findings and provide conclusions and future work in Section 6.

2. Related Work and Motivation

Capstone/senior design projects are common across undergraduate engineering curricula. The 2015 Capstone Survey [1,9] received responses from 256 US institutions showing a wide range of variations but some commonalities. Notably, most capstone projects occur over two semesters and involve smaller students team (six students or less). Capstone projects provide engineering students a culminating experience and help meet core accreditation requirements. Researchers have examined the capstone experience from a variety of perspectives including management of student teams [8], faculty teaching beliefs [10], and the challenges of developing multidisciplinary projects [7].

Recent efforts have expanded the capstone experience to include elements of service-learning (SL). These new experiences incorporate the project-based elements of traditional capstone projects with service-learning to create a new experience called Project-based Service Learning (PBSL) [2]. PBSL projects can range in scale from international [3], national [4], and single projects/classes [11,12]. Service-learning courses are attractive to students and universities for a variety of reasons including increased student performance [6,13], student retention and recruitment [5], and interest in studying engineering [14].

Despite these benefits, PBSL courses are not without drawbacks. Specifically, service-learning projects are derived from the community and are typically less structured than instructor-led classroom projects [2,15]. Managing expectations between the students and community partner can be challenging due to differing objectives [16]. Inherently there is a tension between student's learning the "process" of capstone (engineering design and analysis) and the final "product" (the deliverable artifact). As an educational outcome, most capstone courses emphasis process rather than the final product or outcome [1]. However, the community partners might be more in the product as it directly impacts them.

Another challenge in PBSL is managing project uncertainty. Whereas in a classroom setting project-based learning is guided by the instructor, and likely designed to ensure the students "succeed", community-based projects engage with third parties (charities, service organizations, governments...etc.) that may introduce changes or new information during the design process. Furthermore, given the larger uncertainty in PBSL, students may feel less comfortable in their ability to tackle more open-ended engineering problems. Also, given that elements of the project influenced by third-party actions outside of the classroom, instructors and students alike may experience frustration due to changes and addressing unknowns.

Understanding and managing these challenges are critical for programs such as ours that are transitioning into PBSL projects. By understanding benefits and challenges. The impact of these changes is an important consideration in the work presented here. The existing capstone projects (discussed in Section 3) are all competition projects that explicitly describe rules and requirement for the project. This distinct from the community-based projects that are more open-ended and whose requirements could potentially change during the project.

3. Overview of Curriculum and Capstone

To better contextualize our work this section will describe the Engineering program at ABC institution (name anonymized) and briefly discuss the present and historical capstone projects.

3.1 Curriculum Structure

The Engineering program at ABC institution was originally founded in 1996 with mechanical engineering (ME). Electrical and computer engineering (ECE) was added in 2007 and civil engineering admitted its first class in Fall 2016. As of Fall 2016, the program total enrollment is over 300 students with 16 tenure-track faculty. This institution is a mid-sized, mid-Atlantic institution that is primarily focused on undergraduate education. As part of the engineering curriculum, all engineering students are required to engage in three semesters of cooperative work experience. Student's initial co-op semester is the fall after their sophomore year, and then students alternate academic and co-op semesters until graduation. Table 1 below shows the general course layout.

Table 1: Schedule of academic and co-op semesters within engineering

	Fall Semester	**Spring Semester**	**Summer Semester**
Year 1	Academic	Academic	Free
Year 2	Academic	Academic	**Co-op I**
Year 3	Academic	**Co-op II**	Academic (Capstone I)
Year 4	**Co-op III**	Academic (Capstone II)	Academic

In addition to co-op studies, all engineering students are required to take part in a two-semester capstone design sequence. In the first semester students focus on analysis and design of a particular system, and then prototype and finalize their implementation in the second semester. Given the course sequence in Table I, Capstone I has typically occurred in Year 3 summer, and Capstone II in Year 4 spring. The reason for these particular semesters is that many capstone projects have been national competitions where the culminating events generally occurred at the end of the Spring semester. The competition deadline necessitates beginning the summer before to ensure a full year for design and build.

3.2 Historical and Current Capstone Projects

As our research focuses in the transition into service-based capstone projects it is important show the historical capstone projects. Table 2 outlines the current and historical capstone projects that been conducted within Engineering. Since the beginning of the program a major source for capstone projects have been national automotive and robotics competitions. The SAE projects challenge students to design and build a car for track racing (Formula), off-road performance

(Baja), or electric power only (Electric). With the addition of ECE in 2006, a robotics ground vehicle challenge (IGVC) was added.

Table 2: Current and historical capstone projects with approximate team composition

Project	**Years Active**	**Approx. Team Composition**	**Project Type**
Baja SAE [17]	2002 - 2005 / 2014 - Present	9 ME	Competition
Formula SAE [18]	2007 - Present	16 ME, 1 ECE	Competition
Ground Vehicle [19]	2010 - 2013	2 ME, 8 ECE	Competition
Bike Rental	2014 - 2015	4 ME, 6 ECE	Community Based
Formula SAE Electric [20]	2016 - Present	4 ME, 7 ECE	Competition
Greenhouse	2016	5 ME, 7 ECE	Community Based
Assistive Technology	2016	2 ME, 2 ECE	Community Based

While many of these projects are conducted at other institutions, they are typically run as student-led clubs for which students may receive capstone credit. This provides a significant pool of undergraduate students to work on the project. Additionally, these projects are likely to have graduate student support as well. Given our curriculum structure and institution size there is not an availability of students to run these projects as a club and consequently each year starts “new” based upon the previous year’s design. This provides a strong challenge of each new student group but limits our “competitive” advantage against larger teams.

Starting in 2014 community-based projects were added. These multi-disciplinary projects were sourced from faculty contacts in the community and through the college’s Center for Community Engagement. The three community projects were an automated bike rental station, an automated greenhouse for K-8 educational use, and assistive technologies for persons with mental and physical disabilities. These community based projects were added based upon student interests and research indicating that women and minorities are likely more interested in projects with a societal or humanitarian objectives. Additionally, while the Baja and Formula projects are a large attractor for mechanical engineering students, the ECE students have little engagement in the projects.

As will be discussed in the findings section, a key element of this study is examining the faculty roles and student reactions to these two project types (competition and community-based). A significant challenge with the community-based projects is the need to source, plan, and manage the projects outside of the capstone semester. These elements will be discussed in more detail in Section 5.

4. Methods

We collected data for this study in four main ways: individual interviews with faculty and administrators, a focus group with a sample of community partners, a focus group with a sample of students, and student surveys. The parameters for each of these data collection methods will be detailed below. Furthermore, we will discuss the limitations of our data collection. Table 3 outlines the size of each population and the number of participants.

Table 3: Population size and participation

Population	Total Size	# Surveyed	# Interviewed
Instructional and Administrative Faculty	9	N/A	9
Students in Traditional Capstone Projects	38	33	6
Students in Community-based Projects	16	16	4
Greenhouse Community Partners	10	N/A	5

4.1 Study methods and protocols

4.1.1 Interviews

Individual interviews with faculty and administrators were arranged via email and conducted in a one on one setting by the researcher from the Education department. All faculty members of the Engineering department who were involved in the Capstone projects agreed to participate (n = 9). The interviews took place in the personal offices of the Engineering faculty and administrators and lasted an average of nearly 16 (15:53) minutes.

A focus group interview was conducted with a subset of community partners. The Garden Group is an outreach project of a local synagogue associated with the Greenhouse project. This group has adopted the inner-city K-8 elementary school where the greenhouse will be built. There are between 6 and 8 women that are intensely involved in the project. Five women were able to attend the focus group. The focus group interview was conducted by both researchers and took place at a local cafe. It lasted approximately 30 minutes (29:49).

Due to scheduling issues, focus group interviews took place with three groups of students. The first and second group of students were part of the competition based capstone projects. These interviews were conducted jointly by both researchers and took place in a conference room/classroom in the Engineering building on campus. The first interview had 4 students and the second interview had 2. The focus groups averaged about 25 (25:30) minutes. The third student focus group took place in the same location, but on a different day. It was conducted by the researcher in the Education department alone. Four students participated and it lasted for 27 minutes, 32 seconds.

4.1.2 Surveys

Two surveys were administered to students. One survey was a validated instrument given online called the Team Diagnostic Survey [21]. Students were broken down by capstone team. We did not receive a high enough response rate from each team to use data from this instrument. The other survey was an unvalidated survey called the Capstone Student Perspective Entrance Survey (CSPES). This survey was developed by faculty to annually assess capstone student perspectives. The paper-based survey was handed to students by their course professor two weeks into their capstone project. There were no names on this survey, but students indicated their capstone team so we could separate the data into two groups: community versus traditional projects. The survey was preexisting and had been given to capstone students in previous years. It contained 18 questions rated on a 4 point Likert scale. There was no neutral response. If students tried to provide a neutral response by marking between 2 boxes, their response for that question was discarded. We analyzed the results of this survey using Excel.

4.2 Study Limitations

Our methodologies did have some limitations. We tried to obtain survey and interview data from students across all 5 capstone teams, but were only able to secure a few surveys from the assistive technology team. We did not have any focus group participants from this team. There were only 4 students assigned to the assistive technology team, making it difficult to coordinate with them. Furthermore, the diagnostic survey obtained very few responses across all capstone teams. We believe this was due to the timing of our request to complete it. Students had left campus for their co-op semester and were not all regularly checking their college email accounts. As noted above, the CSPES did not contain a neutral response. This caused us to discard some responses for some questions. Additionally, some questions on this survey were not of interest to our study and were not analyzed.

5. Findings

In this section we describe our findings from the surveys and interviews conducted with faculty, students, and the community partners. We discovered three major findings from our data. First, there were similar workload concerns about the community based projects among all parties: students, faculty, and community members. Second, reasons for becoming involved with the project differed between parties. Third, each party experienced the transition in different ways- notably the logistics of the transition was different for each group. These findings will be discussed in detail below. We will use the acronym CB to refer to community-based (CB) projects, as compared to the traditional capstone projects.

5.1 Workload Concerns

In this section we discuss the perceived workload differences experienced by faculty and students. In general, faculty involved with the community-based projects felt that their workload was greater than their colleagues on traditional projects. This belief was not expressed by their colleagues involved in the traditional projects. Students and faculty both thought the student workload for all projects was the same overall, but experienced different workloads throughout the year. We also discuss the perceived workload of the community partners. Most of the workload concerns for the community partners was around sustainability of the project.

5.1.1 Faculty Workload

Faculty members who had little or no involvement with the CB capstones were more apt to believe that "*faculty involvement depends on the faculty member more than the project*" (Interview with assistant professor of ME). According to the Coordinator of the ME program, "*Different people are gonna have different approaches*" and the workload will vary depending on the students and faculty assigned to any particular project. These sentiments indicate that workload is more a function of the participants (students and faculty) rather than the project itself. However, faculty with more involvement on CB capstones believed that the community based projects included considerable more work on the part of the faculty. An assistant professor of ECE agreed that the faculty supervising the car projects don't have the same concern about workload and commented that he would like to see the senior faculty "*have more of a hand in helping form these projects and do the outreach rather than it just fall to the 2 new faculty*." With respect to the workload, the Coordinator of the ECE program noted that:

> *"If a project has been going on for several years, then the faculty that are in charge of the project are more used to what characteristics of good designs are and they've seen typical mistakes students can make and can protect them from the worst of those mistakes. Their role is more a knowledgeable guide and mentor. If it's the first time*

we've done a particular project, and that faculty hasn't done that project before, then in many cases the faculty is just one step ahead of the students in terms of thinking about the design and trying to keep the students from making the stupid mistakes that would result in a bad design. So in that case, in particular the first year, the faculty on that particular project do a whole lot more work. ... In one sense, the competition based projects because those are well scoped out, very well defined, they've got a several hundred page instruction book you just hand to the students and so that's a little bit easier on the part of the faculty."

In his opinion, the workload for faculty "*almost doubles*" when preparing for community based projects and begins "*almost a year in advance before the faculty teaches the capstone...and so that takes a lot of time*." The workload included selecting a project that would fit the parameters of capstone (scope, time constraints, engineering skills) and maintaining external relationships with community members. This concern was echoed in the 2015 Capstone Survey where project management (find appropriate projects, acquiring funding..etc.) was ranked as the number two challenge faced by faculty members [1] . The assistant professor of ECE who was deeply involved in the new PSBL capstones independently reiterated this:

"I think maybe the competition projects require less prep in the sense that they've done it for so long. They done the formula car for 3 years. So (colleague) has it down to the week what needs to be accomplished. Also, there's no prep before the year. They just say, we're gonna do this project, they download the rulebook and there they go. Whereas with the community service projects it's a year-round thing managing relationships with external clients, trying to develop new projects. I mean, we're in our off semester and I'm still working with the greenhouse trying to get permitting done and plans done and it's been constant work since January of this year (2016). I think there's more prep for the community based projects because there's more stakeholders, external stakeholders that you have to make happy and keep in the loop whereas if you're just delivering a car to a competition, you know, you're checking in with a rulebook rather than checking in with people."

Perceptions in workload differed between those faculty or administrators who were intimately involved with the community-based projects and those who were not. Those ingrained in the CB projects believed there was more behind-the-scenes work on the part of the faculty. Those not linked to the CB projects did not hold these same beliefs. One faculty member with little involvement on the community capstones did admit that "you spend more time really even developing the project and the specs" and that you could "take less time with the competitions, because [they] have been going on for 50 years and they all have detailed rules."

In the future, more faculty may be involved on CB project and so perceptions may shift as the engineering program expands its offerings of CB capstone projects.

5.1.2 Student Workload

Throughout the interviews and surveys the students did not believe that one project had a higher workload than the other. Most likely it was that the workload was spread out differently across the semester. According to the Coordinator of the ME program, "*maybe in the long run what happens is it's a stronger analysis phase, perhaps, for the cars and a stronger research, background, self-guided learning phase for the greenhouse. But in the end, I think, the workload – hopefully, I mean it's the first time through it so I can't say for sure – that hopefully they come out to about the same level but just in different ways.*" Students are not required to track the hours spent working on capstone projects, so there are no numerical data on differences in workload between the teams and/or subteams. In interviews, students from both CB projects and competition projects agreed that the overall workload for students was the same, but was chunked differently throughout the year. For example, one student on the greenhouse project stated that this project required "*a lot more R & D, research and development and project planning, speaking with other people learning how we're actually going to do this*" over the summer, whereas the competition projects had less work over the summer, but more work over the winter break period.

5.1.3 Community Partner Workload

Most of the workload concerns from the community partners was related to project sustainability. As one partner stated: "*The hesitation that I feel is how we stay on top of it with the teachers to make sure they are utilizing it*." Several times during the interview, the community partners speculated how they would ensure that teachers at the school would make use of the greenhouse. They expressed a sense of responsibility and having to "*really lay the groundwork*" for the teachers to increase the ease of use. They also referenced previous projects, lamenting that teachers had been previously scorned by other organizations and thus were skeptical about new partnerships. According to them, one thing working in the college's favor is that we're "*in their backyard*" and that increases the "*level of comfort for the teachers"* because we can be more "*accessible*" if a problem arises. The community partners mentioned wanting support from both the Education and Engineering departments. They wanted to make sure the Education department produced quality curriculum that would actually "*get into the classroom*." From the Engineering department, they wanted reassurance that someone would be available to fix mechanical or software issues that they couldn't address themselves. Workload for the community partners seemed to be more focused on the future use of the project rather than current business.

5.2 Reasons for becoming involved

In this section we describe faculty and student motivations for becoming involved in the community-based capstone projects. Three main topics emerged: both faculty and students were attracted to the "real-world" projects that will have immediate impact on the community; faculty saw these projects as a recruiting tool; and students personally believed that engineering should engage in service to others. Notably, we found that students engage in the community-based projects felt more fulfilled when engaging engineering service work. We also discuss reasons behind the community partners support of the project.

5.2.1 Recruitment tool

Faculty and administration at the college mentioned benefits to the engineering program and engineering students as reasons for implementing the community-based capstones. First, community-based projects were cited as a recruitment tool. The engineering program has relied heavily on the traditional car building competition to recruit students. According to an assistant professor of ME, "*we get the stereotypical White male who wants to build a car. And to be honest, this program was almost kind of built on that*." The CB projects were seen as a "*nice complement*" to the existing program. The coordinator of the ME program stated "*we can't just be cars*" and the addition of the CB projects is "*a diversification [he thinks] we need*" to attract a different demographic and build a more diverse student body. He indicated that the projects have "*engineering value and social value*" and the social value piece will attract female students and students from underrepresented minority groups. Another faculty member said "*we see...female engineering students are more interested in the community service*" (assistant professor of ME). An assistant professor of ECE stated that CB projects serves to "*get our name out there, we get known in the community. It's stunning to me that for 20 years we've had engineering and no-one in this county or city knows that we really do engineering.*" The CB projects will increase visibility in the local community and with industry partners. This is turn, will help recruit students to ABC institution and the engineering major.

5.2.2 Real-world aspects

Second, there is a real-world aspect to PBSL that isn't always present in the competition based projects. For example, the greenhouse project involves "*building a structure for people. You have a real client*." Cars, on the other hand, "*from an engineering perspective, it's boring. Especially from a computer engineering perspective. There's no work to do on any of the cars. Here, the students are engaged in building a wireless sensor network to control a space. That's a real, actual, challenging problem*" (interview with assistant professor of ECE). Another professor echoed that CB projects have "*real customers*" and students "*actually interact with them...So they get a real person, not just a rulebook*." The coordinator of the ME program stated that "*having the customer in front of you*" and the immediate "*feedback from the customer*" gave students "*such a different challenge*." From a faculty standpoint, there is a benefit to students in dealing with authentic customers because it more closely approximates what career engineers do in their daily work. Additionally, students must work in teams and do independent research, which further resembles engineering work in industry fields outside the classroom. Students also commented on the real-world aspect of CB projects, with one saying it's "a *lot more similar to real life engineering rather than concept engineering like we do in class. It's not just doing problems. It's thinking of ideas, working it out, fixing it, so it's more like real life*." No faculty explicitly stated that CB projects better supports the goals of capstone projects, but given the stated goals and the comments made about the current CB projects that would seem to be the case.

5.2.3 Community impact

Third, faculty made note of the impact on the community. Many faculty mentioned the assistive technology project explicitly. The other CB project (the greenhouse) was mentioned much more frequently by students but not as much by faculty members. The coordinator of the ECE program said the assistive technology team was the most interesting project to him because students were "*helping a group of people that is otherwise marginalized in many cases and then we're providing additional expertise so they can be more self-sufficient and have a little bit more income*." The coordinator of the ME program believed this as well "s*omeone is going to have a much better quality of life because our students* ***did*** *something….just the idea that we can make a difference that quickly to somebody*." The swift results from this CB projects seemed to be a driving factor of interest for many faculty members. Unfortunately, we were unable to interview any students who worked on this capstone and so we have no data to compare.

5.2.4 Student choice

Faculty believed that students generally self-selected into different capstone groups. A repeated consensus was that some students would always be interested in the cars and some students would never be interested in the cars. Those students who were interested in participating in the CB capstones did so because the point was not "*just not doing the design because [they] can do the design. But [they're] doing it to serve some purpose*." These students were "*interested in the challenge of the community based project and just thinking a little bit outside the box*" (interview with coordinator of ECE). Because of the increase in the types of projects offered, "*Students are all able to do a project in which they are more interested now*" (interview with coordinator of ME program).

Students overwhelmingly agreed with faculty members on this topic. One student stated "*I think opening it up was definitely a really good move…especially the greenhouse because it gives people who don't want to something mechanical, just a car, they get other options.*" Students who were drawn to the community projects gave several reasons. They weren't "*a car person*." Another student said he wanted to participate on the greenhouse team because he enjoyed "*heat transfer and flow mechanics more than machine design*" on which the car projects focus. Aside from the differences in engineering concepts, students who were drawn to the CB capstones repeatedly mentioned the direct benefit to the community. According to one student (who admitted this was his second time taking the capstone course), "*I didn't want to be a part of a project like previous capstones where you do your thing and at the end they just take it all apart. And it's like nothing really happened, it didn't really matter.*"

The idea that students self-selected based on personal characteristics was also supported by the survey given at the beginning of the capstone summer term. On the CSPES, students were asked two questions related to engineering's ability to help other people. These were:

- Question 12: *I am most fulfilled in my engineering work when I can solve problems that help other people and increase their quality of life*.
- Question 15: *It is important for engineers to use their professional skills to serve the public (e.g. by donating their time and skills to help underprivileged community groups)*.

On question 15, there was no statistical difference in the mean response between students doing the CB projects and students doing the competition projects. All students believed that it was important for engineers to serve the public using their engineering skill set. However, on question 12 there was a statistically significant difference in the mean response between the two groups of students. A two-sided t-test with a p-value of 0.0237 found that students assigned to the CB capstones were more likely to say that they felt personally fulfilled as an engineer when they could solve problems to help other people. All students support engineering practice for societal good, but students who self-selected to the CB capstones felt more personally satisfied doing the work. Students working on the greenhouse project noted this several times throughout the focus interview:

- "*The whole idea of the project is to help people. So not only is it something that sticks around for years to come, but it's also something that actually helps kids and it helps them learn...So we're not just making something cool, but we're also benefiting people.*"
- "*We are doing it for the kids. Right? And it is also for the school. It's not just our personal gain of building something to drive it around or whatever.*"
- "*It does feel like a serious engineering problem cause it's not like we're playing engineer and building things. We're also doing something that requires some serious engineering background that we also all don't have and we've had to go out … and work with other people outside of the school to accomplish this.*"
- "*What's nice about this project specifically is that you're applying it in a way that actually benefits people and is going to be used for years to come as opposed to other projects where they take it apart at the end and no-one really cares.*"

Students working on the competition projects made note of this as well. "*I know a big drive for greenhouse is they're helping the community. I've heard (friend) say that over and over again.*"

It appears that the community aspect of the greenhouse project was something that students were proud of. The students working on the greenhouse also felt a satisfaction about the longevity of their project. They mentioned the fact that the greenhouse wouldn't get torn down and that the Education department (who are partners in the project) would "*continue the legacy of the greenhouse by doing curriculum*." Off the record, students later mentioned that they would be interested in getting yearly updates on the greenhouse long after their project was finished.

All focus groups were asked what kind of capstone projects they would like to see offered in the future. Students from all groups suggested community based projects - something to address pollution in the local creek, new projects with local schools based on their needs, "*more of an environmental thing*" like renewable energy or hydropower. A student working on a competition project stated "*That's really what the basis of engineering is - solving for other people's needs*." Given the lack of statistical difference between the students in the competition projects and the students in the CB capstones for question 15 on the CSPES, this is not surprising. However, if students suggested community based projects on their own accord, it begs the question of why there was a difference in question 12. If students are suggesting community based projects on their own, wouldn't this imply that they would feel fulfilled by completing these projects? More research could be conducted as a follow up in this area.

5.2.5 Community choice

The members of Garden Group were already volunteering on a regular basis and did not have much of a say in participation with the college's project. In effect, their participation was mandated by school officials. However, they did believe there were benefits in being connected with the college. They also believed the end result of the CB project, the greenhouse, would be beneficial for the K-8 students. One member spoke of combating "nature deficit disorder" - the fact that inner city students are not often exposed to the outdoors and thus are fearful of it or don't appreciate it. Unlike their rural or suburban counterparts, inner city students aren't connected to nature and for the community members, a huge "*benefit was being able to introduce kids to something they would never encounter were it not for the garden we were going to create*." They reveled in the fact that they were giving the students "*something those kids can't get elsewhere*." Although their participation in the greenhouse project was effectively involuntary, they all seemed to be fully on board and engaged with ensuring the success of the project because of the benefits to the students at the elementary school.

5.3 Logistics in the transition experienced differently

In this section we discuss how the three parties (faculty, students, and community partners) experienced the inclusion of service learning in the capstone course. Notably, while faculty expressed a desire to include community-based projects, they had reservations about cost and concerns about losing existing recruitment tools. Also, the students in the community-based projects experienced more unknowns working on the project than their traditional project peers. Finally, the community-partners welcomed the project from the college but were concerned about remaining "in the loop" and the long-term viability after the students/faculty completed the project.

5.3.1 Faculty perceptions

Transitioning from the car-based competition projects to CB projects inevitably came with struggles. In the words of a student working on the greenhouse capstone, "*this project is a big learning curve for a lot of people, including the professors.*" Faculty seemed to desire more CB projects, but seemed hesitant to implement them. One reason provided was the time intensity in finding projects. According to an assistant professor of ECE, CB projects involves "*continuous work to find a project and scope it*." Two faculty members suggested that a "*solicitation process*" requesting proposals from the community would "*help smooth things out and lessen the workload on the faculty*." Another suggestion was a "*regular rotation maybe where we have a permanent partner that we always have projects*." This same professor of ECE noted that "*It would be nice to have more student engagement in creating the projects but on some level we need to find a project that's both doable, feasible, and meets the learning objectives. And I don't know if the students would necessarily be able to develop those on their own.*" The amount of time requirement to scope, plan, and implement community based projects was seen as a drawback of community-based projects.

In addition to being time intensive, the CB projects were also cited as being money intensive. The coordinator of the ECE program stated that since "*we're doing a production instead of a prototype model, it's typically going to cost more. And so where do we get the funds from? We're fortunate this year with the (college's internal) grant, but that's going away next year and I've got to find 15 thousand dollars next year.*" Concerns were also expressed about the costs variability, in addition to overall price tag. For example, the estimated cost to build the greenhouse increase over the course the year due to work on permits and consulted with contractors, new issues have appeared that add to the construction cost. While the faculty conducting the greenhouse project had attempted to estimate these costs, the specifics of constructing the greenhouse were outside of his expertise and the exact timeline and value were not properly estimated. Given that the CB projects may be outside of the leading faculty member's expertise, and that these projects are engaged with external entities, the cost of CB projects is typically higher and harder to predict than traditional competition projects. This uncertainty makes yearly budgeting a difficult task and has presented as another drawback in transitioning to CB projects.

A third transition issue for the faculty was student recruitment. As noted above, the engineering program was built on cars. Due to this fact, many faculty seemed hesitant to get rid of the competition projects completely. An assistant professor of ME noted that he was "*almost kinda bored of the car projects*" but didn't believe the program should eliminate them completely because they serve as a recruiting tool and are more visible to prospective students than the community based projects. Another faculty member mentioned that the program should retain the competition based projects "*so we can benchmark ourselves against our competitors*" (coordinator of ECE). The coordinator of the ME program stated he'd "*love for us to be more community engaged"* and didn't "*envision us have 3 cars for very many years*." He continued, saying he didn't "*want us to become that much of a niche sort of thing*" because it isn't "*healthy*."

Overall there was no faculty members advocated for elimination of the car-based competition projects and there was a strong desire to include more service-learning projects. However, given the concerns about funding and faculty workload, these two desires can be in conflict. While having a range of projects was often cited as a benefit for recruiting purposes, and was reported to be desirable by students, the faculty lacked a structured method to determine what capstone projects to offer year to year.

5.3.2 Student perceptions

From the student perspective, being on a brand new project was "*kind of irritating because it pushed us back so much, but … now we'll know all that stuff that leads up to the actual engineering work. … it was beneficial for us to see all this happening*." Another student noted that "*while it would have been nice to have all this stuff taken care of and kind of know that it would have been smooth, I think it's more realistic that problems come up and how we react to the problems is what really defines us as engineers.*" Students were able to recognize that their CB projects included more challenges than the competition projects, but did not think it led to more work overall and believed the challenges provided them with beneficial real life experience.

Additionally, students noted how communication on the new projects was important. One said "*I think from talking to other students that are doing other (capstone) projects, I think we're a little more open with our professors. I think the professors are more open with us. (Professor is) definitely very transparent about everything that's going on because he doesn't know. And when he finds stuff out, he has to tell us*." Students also reported that it was a "*big setback*" that the professors changed midway through the project (due to faculty loading and the project spanning two semesters). They felt like they had to "*re-explain everything*" to the professor who took over in the spring semester since he was not as involved in the summer preparations for the project. Additionally, students felt like the two professors had different perceptions of the goals. The professor involved in the beginning of the project felt as though the team was meeting its goals whereas the professor who took over in the spring felt the students were behind in meeting project goals. One student stated "*I think we should have a set professor the whole time through. That was a big almost slap in the face to us, I felt, switching our professor on us and not knowing that in the beginning.*" Greater continuity between the professors would have allowed students to go "full speed" at the beginning of the spring semester. Another suggested that a more gradual transition of power would have been helpful in mitigating some of the transition issues around communication.

5.3.3 Community perceptions

Communication was the biggest transition issue for the Garden Group community partners. They felt as though they weren't kept in the loop as much as they believed they needed to be. Even with the communication issues, the community partners seemed content with the interactions they'd had with the college thus far. They appreciated that college partners "were willing to be flexible...and listen to [their] input." Most of the communication issues stemmed from administrators at the elementary school or within the public school district. They believed more communication would allow them to better support the project and the teachers at the school. Additionally, as stated above they were concerned about the long-term maintenance of the project. They were assured they would be involved with the greenhouse, but worried that the partnership with ABC institution would breakdown if people left the college or changed positions.

6. Conclusions and Future Work

In this paper we have presented many findings from the surveys and interviews. Overall, significant benefits were noted by the faculty and students including: recruitment, expanded exposure by the college, and engaging students and faculty in "real-world" projects. Students across the projects noted that importance of community-based projects. Furthermore, the students on those projects felt more personal satisfaction in their application of engineering. However, no change is without difficult and several were noted, most strongly from the faculty. Challenges include the differences between perceived workload across project types and the administrative overhead of incorporating new projects where costs are more variable.

In future work we will continue to examine the differences between these types of project from several angles. Given the large concern about faculty workload, we will investigate methods to quantify if these differences are real or perceived, and by how much. Following on the survey results, students engaged in the community-based projects felt more strongly about their desire to apply engineering in service roles. Also, the faculty and students felt these projects provided more "real-world" applications. We will examine if these trends hold after students have graduated from the program and seek to understand the longer-term benefits of these projects.

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