2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #38740

Service Learning Capstone Projects to Enhance Civil Engineering Education

Dr. Xi Wang, Drexel University

Xi Wang is an Assistant Teaching Professor in Construction Management program at Drexel University. She received her Ph.D. and M.Eng both in Civil Engineering from the University of Kentucky and Auburn University. Her research interests include technology adoption in building trades, learning motivation, and engineering student success.

Dr. Hans M. Tritico, University of Mount Union
Kathleen M. Short
Vahraz Honary

Service Learning Capstone Projects to Enhance Civil Engineering Education

Abstract

Service learning is an educational approach that connects academic curriculum to community problem-solving. Research findings demonstrate that service learning is well-suited for educating Civil Engineering students because of the applied and service-oriented nature of the discipline. As an essential part of Civil Engineering undergraduate education, senior capstone design projects are an effective implementation of service learning. Community-based projects provide an excellent opportunity for students to realize the importance of life-long learning, integration of technical knowledge, and the relevance of civil engineering as a service profession. This paper discusses pedagogical aspects of service learning and presents two senior capstone projects in detail: designing and building a zipline tower and two timber bridges for a local community. This paper outlines the entire design and build process from conception to completion, with emphasis on problem definition, development of design ideas, communications and interactions with stakeholders, detailed designed improvement, and construction issues. Based on the learning outcome assessments and feedback from the local community, these successfully provided projects successfully provided vehicles to enable students to develop their technical skills and enhance their social self-efficacy and employability.

Introduction

Service learning was first pedagogically defined by Sigmon in 1979. Since then, there have been numerous adapted definitions proposed and used by various researchers and educators [1]. The definition used in this paper was proposed by Bringle, et al. in 2006:

> *Service learning is a credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of personal values and civic responsibility*

This definition of service learning works well for engineering classes because it explicitly describes the goal of students both identifying and working toward community needs. It also, importantly, requires that students tie their work with the community to a deeper understanding of their discipline.

Service learning plays an important role in engineering education because it connects the often theoretical engineering curriculum to the world they are seeking to better. Historically, most engineering classes have been heavily focused on imparting science and math knowledge to the students. The students often solve simple technical problems or design well-defined technical solutions to theoretical problems. There is, therefore, a gap between what students are told engineering will be (changing the world) and what they are practicing as students (theoretical, well-defined problems). Project-based service learning reintroduces the community back into the engineering problem, thereby making it both messy and meaningful [2]. The complexity arises by introducing clients who bring an array of constraints that are scrubbed from most project-based learning projects (e.g. multiple stakeholders with different perspectives, monetary constraints that can change, varying levels of technical knowledge, personality quirks, location, and weather factors). On the other hand, engineering students typically report that service learning projects are more meaningful [3]. By having more meaning, students are more engaged and, therefore, more likely to invest more of themselves into the project [4][5].

The incorporation of service learning with civil engineering has been increasingly common over the last twenty years. Conventional project-based learning in civil engineering involves the design of large infrastructure projects that have either already been completed or are too large in scale (both financially and temporally) to afford the students the ability to see the impacts of their efforts [6][7]. Service-based learning in civil engineering explicitly pairs student teams with clients who have a need, which allows students to design projects that are likely to be built. Furthermore, service learning projects can be chosen (or crafted with the client) to include a build phase that allows the students to practice their construction skills while seeing their designs come to fruition. Often, to make the design phase happen, smaller projects, such as pedestrian bridges, are identified [8].

Although service learning in civil engineering is certainly not new, there are various challenges that could prevent unleashing the full potential and effectiveness of service learning projects. For instance, one common challenge is related to the duration of projects. The timelines of some infrastructure projects for a community are longer than allowed in a semester or an academic year, which potentially complicates student involvement and learning assessment [2]. Moreover, students may not be able to see the impacts of their work on the community and thereby undervalue the service learning experiences [9]. For some global projects, students may not be able to visit and communicate with the community on a regular basis because of the project locations, which places a challenge in facilitating and enhancing interactions between students and the community. On the community side, a challenge in service learning projects could be the difficulties and risks for community partners due to the students' failure. The partnership with the community has to build on the understanding of the process through which students learn from failures. In addition, although there is strong evidence to suggest that service learning can be an effective pedagogy to achieve a wide range of learning outcomes [5][10], students do not automatically learn from just participating in service-learning projects. Rather, how and what students learn depend on the quality of their learning experiences [11], such as how to provide balance in the projects' learning and community service components, which could be a challenge in selections of the service-learning projects that should provide a unique learning experience for the students in which the project outcomes will bring long-term benefits to the community as return [9][12].

Thus, two selected capstone projects are introduced and discussed in-depth for the following purposes: 1) to understand pedagogical elements that might affect students' learning experience of service learning; 2) to demonstrate the potential of service learning for fulfilling the ABET learning outcomes [13] and 3) to suggest a possible strategy to overcome mentioned challenges in selection and implementation of service learning projects. Both projects are linked with a local community partner. The students who worked on these projects are senior undergraduates majoring in Civil Engineering. Substantial information related to these projects has been collected, including reflective written statements of students, extensive design documentation, construction progress weekly reports, and the experience and feedback of the faculty advisor and client from the community.

Descriptions of the Projects

Zipline Takedown Platform

One team of students partnered with a camp and retreat center to re-design and re-build an existing zipline takedown platform. The previous design of the zipline takedown platform consisted of an 8-foot-tall platform with an 8-foot-tall step ladder on top, giving the whole structure an overall height of 16 feet. The ladder on the platform was being used to retrieve the zipline participant that hung above the belly of the cable. The students had control over what could be designed but it must consist of a tower that had a total minimum height of 16 feet so that the zipline users could easily get down once coming to rest on the zipline. The client expressed that the design of the tower and ladder had a lot of safety issues which caused the zipline to be shut down for a few months. A platform and ladder system needed to be created that would pass the standards and allow the zipline to be back in working order. The client specified that he needed the entire design to be easy enough for a single person to operate. A finalized design of a new zipline tower for the camp needed to be completed in the fall, while the new zipline tower was to be built during the spring semester. The implementation of the design would allow the camp to resume using the zipline, with hopes of increasing demand and usage of the new facility.

The project's scope of work is shown in Figure 1, which includes the tasks to be completed in three phases throughout the year: scheduling (pre-design), planning (design), and construction. To kick off the project, students contacted the client and set up a site visit to examine the existing zipline setup and the space for new constructions. Three preliminary design ideas were developed and sent to our client during the design phase. Upon retrieving the feedback from the client, a design was chosen that became the primary focus to be completed by the end of the semester. The finalized design included AutoCAD and Solidworks drawings, the materials needed, and construction methods. Students kept in close contact with the client throughout the design and construction processes to ensure that the design fits all specifications and stayed within the budget. A fully scaled mockup was created before construction to test the structure's integrity. Afterward, a complete construction plan was created after mockup tests. The construction plan included the shipment of materials to the site along with estimates of the physical labor needed to complete the building of the zipline tower. Finally, the students executed their construction plan and completed the construction after obtaining approvals from the client.

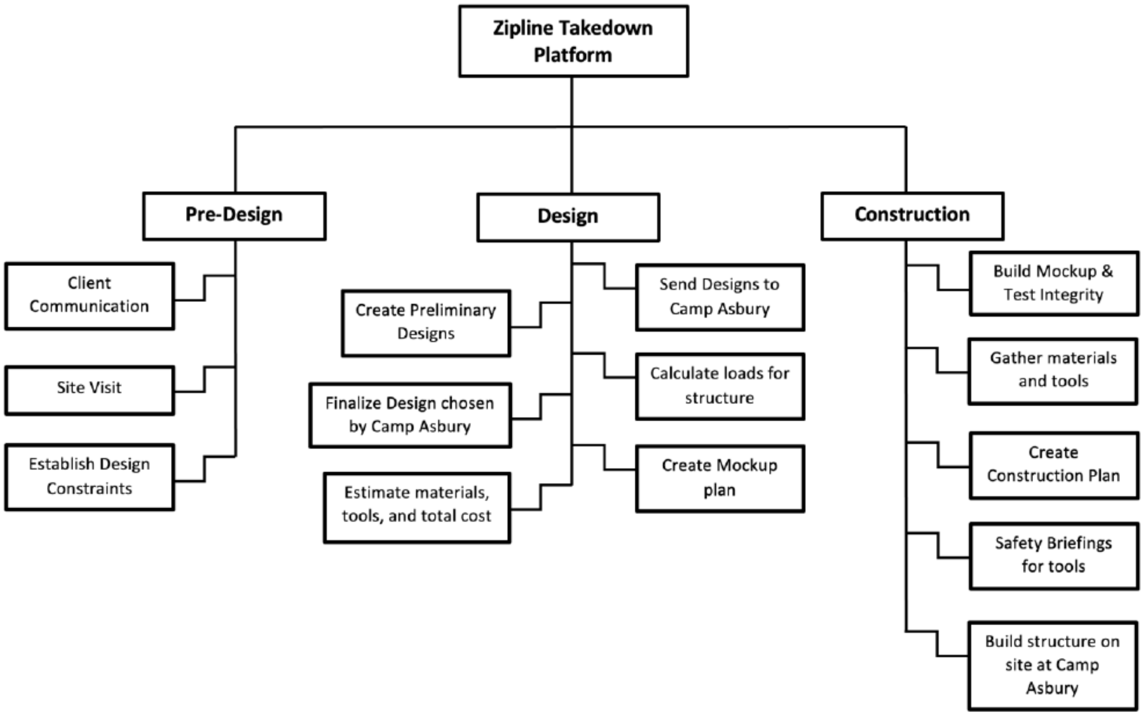

Figure 1. Scope of Work of the Zipline Takedown Platform Project

The final design of the zipline tower consisted of a 10'x16' deck above 8' posts. The posts were secured with cylindrical concrete footings below the ground. Joists would consist of 2" x6" boards at 12" on center spacing. On the deck surface, an 8' industrial ladder was to be purchased, and the wheels would be retrofitted to roll within a track system. The design of the foundation and the deck with the retrofitted ladder are shown in Figures 2 and 3. The industrial ladder included a platform with railings to allow the operator and zipline participants to safely dismount the zipline.

During the construction phase, all materials were delivered to the camp center and cut to exact measurements that would fit the designed platform. After pre-cutting the wood, the old tower was demolished, and the site needed to be cleared. With help from the client, students first drilled footer holes in the ground with an auger. Next, concrete was mixed and then poured into the footers while also setting the six 4x6 columns and bracing so that the concrete could set without them moving. String lines were set and measurements were taken to make sure each column was in line and was set to the exact lengths needed. This part of the construction took longer than expected due to drilling holes through tree roots and layers of large rocks. After that, students put up the exterior beams and as many of the joists and cross bracing as possible. The joist spacing was first marked out on the 16-foot-long beam and then the joists were connected using the joist hangers and screws to hold them in place. Then, students began screwing in the rest of the joist hangers and placing them in the last of the joists. Next, the cross bracing was finished on each of the four sides. The decking was also installed and the posts for the railing on each side were bolted into place. At the end, students finished the decking and getting the sliding ladder on the platform. Figure 4 shows the finished zipline tower.

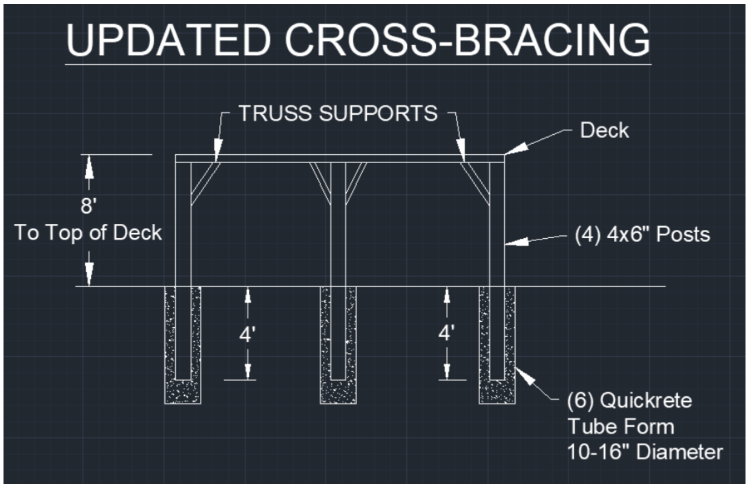

Figure 2. Truss support bracing along the 16-foot side of the platform.

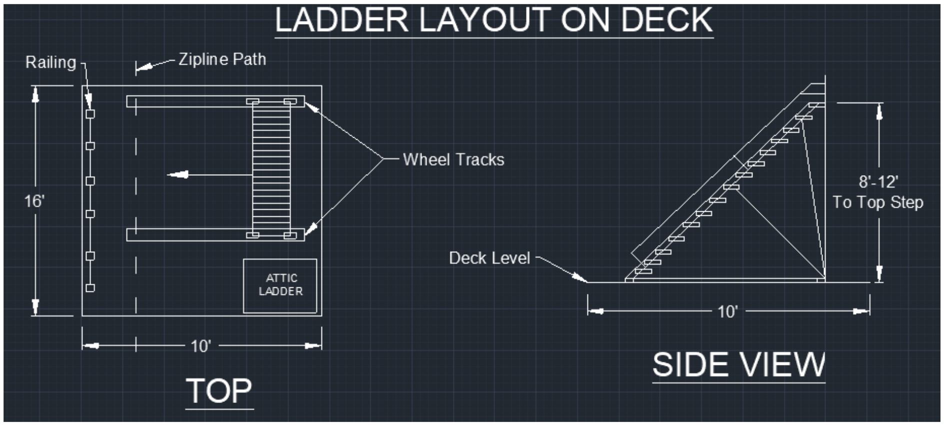

Figure 3. Top view of the deck that includes the Ladder and Track System.


Figure 4. Finished zipline tower

Timber Pedestrian Bridges

One team of students was tasked to design and build two timber pedestrian bridges for the same client, the camp and retreat center. The camp center features a trail running through the park and crossing two stream channels. The problem was that for one of the channels, there was a makeshift "bridge" comprised of fallen timbers placed into the mud. The other stream channel had an actual bridge, but it had begun to deteriorate quickly and was near the end of its life. The client requested that students design safe and non-slip bridges that improve the quality and safety of travel on the trail.

The scope of work of this project is shown in Figure 5. Students traveled to the site to collect some initial data, such as site location and conditions, channel characteristics, and design requests that the client had. From there, students developed and drafted three different designs incorporating design requests from the client and standard industry guidelines. The client was then asked to rank the different features of the three different designs in order to determine which design/features were preferred. Through advice from the client, professional engineers from the university's Engineering Advising Board, and Civil Engineering faculty members, students were able to finalize a design and begin the process of developing a 3D CAD model. Through additional data collection, such as soil samples and surveying, students designed two trail timber bridges that were code compliant and met the client's request. The final design of the two bridges has five key features: 1). They were supported at the base with 5-foot-deep column foundations; 2). there was a 20-foot span on the bridge with 10-foot ramps on both sides; 3). 6" decking boards across the whole bridge with a metal lath to prevent people from slipping; 4). a handrail was placed on one side of each bridge with a 6-inch curb on the other side to prevent people from falling off the bridge; and 5). the overall length of the bridge will be approximately 40 feet long and 3 feet above the water surface. Figure 6 shows the 3D drawings of the bridges.

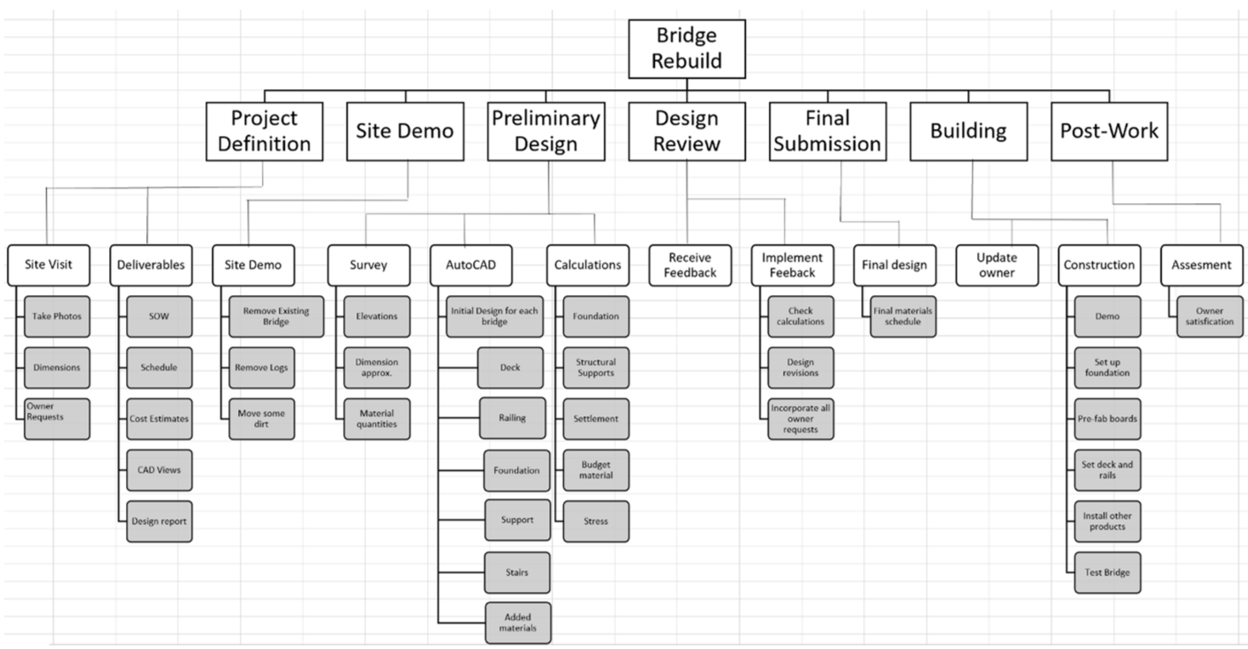

Figure 5. Scope of Work of the Timber Pedestrian Bridges Project

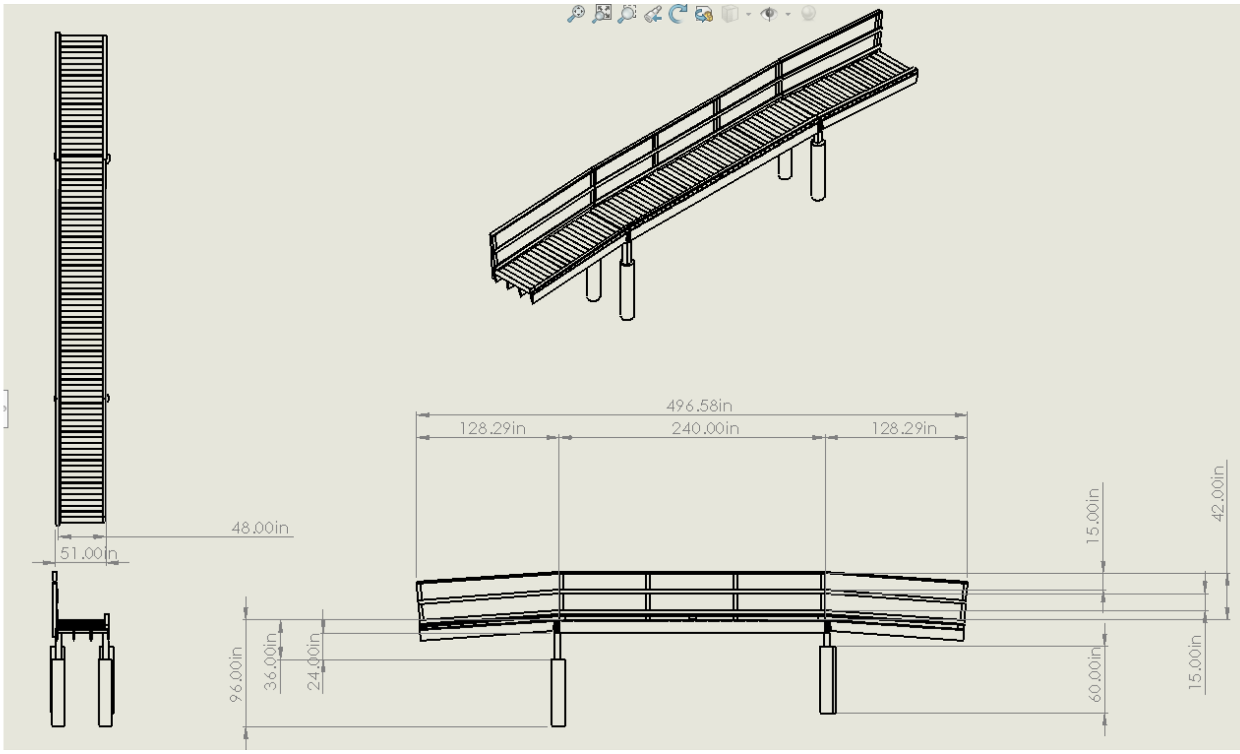

Figure 6. Design of Bridges

Each bridge took approximately five days to construct. Concrete column foundations were first poured for one bridge. The second day of construction involved installing the headers and joists and preparing the concrete slabs for the ramps on each side of the bridge to rest on. Then students placed decking boards all across the bridge and ramps. Finally, the railing was completed, and other finishing touches were added, such as a metal lath across the center and a 6-inch curb along the other side of the bridge deck, opposite the handrails. The former was to give the bridge a non-slip surface for people to traverse, and the latter acted as extra safety to prevent people from walking too close to the edge. When constructing the second bridge, its plan largely followed the same structure. Figure 7 shows the previously existing bridge and one new bridge.

Figure 7. The Previously Existing Bridge and the New Bridge

Assessment of Student Learning

Service learning scholars have demonstrated that students' engagement in service learning can benefit their intellectual, social, civic, and personal development [14]. Intellectually, service learning enhances students' problem-solving skills by deepening students' understanding of the academic content; Socially, service learning contributes significantly to students' communication, interpersonal, and leadership skills [15], among others; Civic development is associated with increases in students' awareness and understanding of social issues and willingness to volunteer in the future [16]; With respect to personal development, service learning enhances their self-understanding and attitude toward learning [17]. Among key course and pedagogical elements, the literature shows that eight elements have more influence on student service learning outcomes: 1) challenging and meaningful tasks; 2) interest in service learning subject/project; 3) perceived benefits to people served; 4) service appreciated by the community; 5) preparing students for service 6) student effort in service; 7) interaction with service recipients; and 8) structured reflection with clear instructions. Besides integrating the service learning outcomes and pedagogical elements discussed above, the assessment structure needs to demonstrate the attainment of ABET student outcomes. Systematic and formative assessment tools were developed and applied to evaluate these two service learning capstone projects, including personal progress logs, weekly project progress reports, surveys for client feedback, project design proposals, oral presentations, final project reports, confidential peer reviews, and teaching evaluation surveys.

In the weekly personal progress logs, each team member listed specific tasks and entered the number of hours that were spent on each task he/she personally completed in the last week. Each team member was also required to record any challenges or problems when completing the task(s). The weekly project progress report was completed by the “leader of the week”. Each team had a chance to be the project manager for a semester. The project manager's responsibilities included setting up meetings, communicating with clients, summarizing the completed work, and planning the tasks expected to be completed in the following week. The faculty advisor collected these two documents every week and addressed specific issues when necessary during the weekly team meeting.

During the design phase, the client was continually updated throughout the design process to ensure satisfaction was guaranteed. For each part of the design, students collected the initial feedback by sending surveys to the client and then scheduled virtual/on-site meetings with the client for further discussion when necessary. During the construction phase, each team worked closely with the client to complete tasks such as finalizing a detailed construction schedule and plan, material preparations, safety training, and implementation and testing of the completed structures.

Both teams delivered project reports and oral presentations to the entire class at the end of the fall semester and again at the end of the spring semester as well as invited guests such as the client, Civil Engineering faculty members, and advisory board members. The guest feedback and evaluation grades would also be part of the evaluation, especially from the client and advisory board members. The project reports and presentations were graded based on problem definition, engineering standards, project constraints, development of alternative solutions, project execution plan., detailed engineering design, implementation, and construction, following the requirements of ABET learning outcomes. Table 1 lists the ABET criteria that were addressed and fulfilled by the selected projects [13]. Every team member was required to complete the peer evaluation, self-assessment and teaching evaluation. Faculty advisors who were responsible for entering course grades determined the proper weights for such student evaluations. In peer evaluation, each team member was asked to estimate the percentage of total contributions that the other team members made and comment on their leadership style, work performance, and communication effectiveness. The faculty advisor assigned proper weights for this assessment tool by combining the weekly personal progress logs and project progress reports in grade determination. Every student was also required to complete a survey to evaluate the faculty advisor and the project associated with the generic and service learning-specific learning outcomes, pedagogical methods, and elements. The survey was developed by the faculty advisor with reference to the ABET and literature reviewed, including questions asking students to rate their attainment of the intended learning outcomes relating to their intellectual, social, and civic development as a result of participating in the service learning projects [18]. The survey used a 7-Point Likert scale to provide more varieties of options, which increases the probability of meeting the objective reality of people. On the 7-point scale, the opinions can be further divided to meet the actual sentiment of the individuals. The opinion options are more in the case of the 7-point Likert scale. In other words, this larger spectrum of choices offers more independence to a participant to pick the exact one rather than to pick some nearby or close option [19]. Table 2 lists the survey questions and the responses from a total of 10 students.

Table 1. Evaluated ABET Learning Outcomes [13]

Student Outcomes No.	Description
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3	An ability to communicate effectively with a range of audiences
4	An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Table 2. Student Survey Questions for Learning Outcomes Assessment

Questions	Average rank on a seven-point scale (1= very little; 7 = very much)
1. The project helped me improve my ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	6.4
2. The project helped me improve my ability to communicate effectively with a range of audiences.	6.6
3. The project helped me improve my ability to recognize ethical and professional responsibilities in engineering situations.	6
4. The project helped me improve my ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	6.4
5. The project helped me improve my ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	6.8
6. The project helped me improve my ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	6.5
7. The project helped me to see how the subject matter I learned can be useful in everyday life.	6.1
8. The project helped me become more aware of some of my own biases or prejudices when trying to solve problems.	5.9
9. The project helped me to learn how I can become more involved in my community.	6.2
10. The project helped me have a better understanding of my role as a citizen.	5.6
11. The project helped me become more likely to volunteer in the community in the future.	6.7
12. The project provided challenging, meaningful, and educational tasks for me to accomplish.	6.6
13. If you found out that there was a problem in your community, but there was no group or service agency to help, would you be the one to organize a group to address the problem? (Yes or No)	Seven answered “Yes,” and three answered “No.”

Discussion and Conclusion

Although the number of survey responses is small regarding lessons learned by students during the year, the results do provide some empirical support for the following practices in designing and implementing service learning projects in Civil Engineering to maximize student learning effectiveness:

1) Students need to fully understand the community or the client they serve, including their needs and concerns. Direct interactions with the client, who is also the service recipient, helps to enhance students' understanding of social issues and provide direct feedback on the value and effectiveness of the service they provide. Through communication with the client, the service to be performed can be perceived by students as something meaningful that will bring about real benefits to the community or the people they serve. It gives students incentive to improve learning when they believe that they are making a real difference to others through their work.

2) It is important to challenge students to move outside their comfort zone by involving students in challenging tasks that require them to apply the knowledge and skills they learned in the classroom to deal with real-world problems in the service setting. Voluntary service only is not sufficient to have their attention and motivate them to make a full effort. Through the projects, students experienced many facets of a real Civil Engineering project for the first time, such as surveying, structural design, structure testing, learning different design standards, and construction management. In addition, students were challenged to make adjustments in the design and construction plan due to various unexpected factors, including last-minute changes requested by the client and delays caused by weather or material deliveries. Students actively communicated with the client and ensured follow-ups for any changes and updates.

3) Student leadership has proven to be critical to the overall success of the project and to the satisfaction of the client. The team leader determines the dynamics among participating students. Without a student leader with good personal efficacy and strong technical background, students would quickly feel overwhelmed due to the pressure from the client and the high demand of the time commitment. Students are more motivated to work if they have a peer who is setting up plans, working alongside them, and encouraging them the whole time.

The project also comes with challenges for the faculty advisor. A capstone project typically requires different technical skill sets, and a single faculty member may not be able to give students advice on all aspects of Civil Engineering design. Thus, the faculty advisor needs to identify and build connections with necessary technical support for students. Additionally, the faculty advisor needs to follow up with students on the advice they receive from other resources to help them make correct decisions. That also supports timely and frank communications with students being essential. Another challenge is associated with the search for and identifying a service learning project. In many cases, community projects come with low budgets and limited resources. This has the potential to pose a dilemma for both the client and the students. Conversely, a service learning project in these circumstances creates an opportunity to train students in the skills needed to manage risk and loss prevention, as well as learn professionalism and business ethics to meet requirements and serve the interests of the client, especially for Civil Engineering projects given the inherent uncertainty of site and sub-surface conditions.

Another challenge for the faculty advisor is to search for and maintain an active relationship with the community partner. Reciprocity is central to social exchange theory. People act based on calculations of costs and benefits and seek to maximize rewards [20]. Both entities must find value in the interaction as applied to community partnerships. Based on this premise, it might be expected that community partners enter into and remain in a partnership they see as beneficial. When searching for a community partnership for potential projects, public service or outreach programs for any civic engagement would be valuable sources. Such programs always have long-term relationships with many partners throughout the community to create experiences for students and aim to make positive changes, and have a presence that reaches beyond campus. The community partners could include government agencies, non-profit organizations, businesses, education institutions, and churches in the local area and beyond.

After locking a partner in the community, the level of match between university and community partner expectations is one potential barrier to the extent that partners are or are not aware of what the other hopes to achieve and how realistic these expectations are given available resources such as time, expertise, and funding [20] [21] [22]. Although collaborations are based on mutual needs, communication, commitment, and compatibility may not always be available and adequate to keep the relationship progressive [23]. For instance, during the construction process of the presented two projects, on the students' side, many practical concerns were raised, such as schedule conflicts outside class time, transportation availability, and fees. Some students also had some negative emotional reactions to the project's progress, such as feeling disinterested, coerced, ill-suited, or unprepared. Likewise, the staff from the community partner had challenges in this process. For instance, they had some difficulties in setting up machines for students to cut timber materials. Materials delivery got delayed multiple times due to the schedule conflicts of the staff. In addition, the added responsibilities such as training, supervising, and evaluating students were challenges for the community partner. As the faculty advisor, who is the bridge connecting the university and community, close tracking and detailed planning will be the key to successful collaboration. In this project, the faculty advisor required students to report every activity that they worked on for the project, including phone calls, emails, meetings with community partners, purchase orders, checklists of materials and equipment, budget tracking documents, and so on. The faculty advisor created “micro-level” detailed tasks every week to minimize the possibility of students misunderstanding any details or instructions, and also easier for both the faculty advisor and community partner to track the progress.

The limitation of this study is the sample size of the survey outcome evaluation. The student population of the program is small, considering the nature of a liberal art college. Also, unlike student competition projects, the project is not repeatable. For the future study, the authors will conduct a larger scale of student learning outcome evaluations by increasing the size of participants from multiple similar programs/schools. To promote a more sustainable relationship with the community and a broader impact on service, the authors would like to work with multiple community representatives to develop an educational model and repeatable projects for students and faculty.

Reference

[1] P. Felten and P. H. Clayton, "Service-learning," *New Directions for Teaching and Learning*, vol. 2011, no. 128, pp. 75–84, 2011, doi: 10.1002/tl.470.

[2] A. Bielefeldt and C. Swan, "Measuring the Value Added from Service Learning in Project-Based Engineering Education", Accessed: Feb. 16, 2023. [Online]. Available: https://www.academia.edu/29495914/Measuring_the_Value_Added_from_Service_Learning_in_Project_Based_Engineering_Education

[3] B. Ropers-huilman, L. Carwile, and M. Lima, "Service-learning in engineering: a valuable pedagogy for meeting learning objectives," *European Journal of Engineering Education*, vol. 30, no. 2, pp. 155–165, May 2005, doi: 10.1080/03043790410001664363.

[4] T. D. Mitchell, "Traditional vs. Critical Service-Learning: Engaging the Literature to Differentiate Two Models," *Michigan Journal of Community Service Learning*, vol. 14, no. 2, pp. 50–65, 2008.

[5] C. I. Celio, J. Durlak, and A. Dymnicki, "A Meta-Analysis of the Impact of Service-Learning on Students," *Journal of Experiential Education*, vol. 34, no. 2, pp. 164–181, Sep. 2011, doi: 10.1177/105382591103400205.

[6] T. El-Maaddawy, H. El-Hassan, and H. A. Jassmi, "Student perceptions of the use of project-based learning in civil engineering courses," in *2018 IEEE Global Engineering Education Conference (EDUCON)*, Apr. 2018, pp. 243–250. doi: 10.1109/EDUCON.2018.8363235.

[7] J. M. Coronado, A. Moyano, V. Romero, R. Ruiz, and J. Rodríguez, "Student Long-Term Perception of Project-Based Learning in Civil Engineering Education: An 18-Year Ex-Post Assessment," *Sustainability*, vol. 13, no. 4, Art. no. 4, Jan. 2021, doi: 10.3390/su13041949.

[8] B. Wambeke, "Building Bridges – Spanning the gap between the classroom and professional practice," presented at the 2020 ASEE Virtual Annual Conference Content Access, Jun. 2020. Accessed: Feb. 16, 2023. [Online]. Available: https://peer.asee.org/building-bridges-spanning-the-gap-between-the-classroom-and-professional-practice

[9] A. Mostafavi, J. L. Huff, D. M. Abraham, W. C. Oakes, and C. B. Zoltowski, "Integrating Service, Learning, and Professional Practice: Toward the Vision for Civil Engineering in 2025," *Journal of Professional Issues in Engineering Education & Practice*, vol. 142, no. 3, p. B4013001, Jul. 2016, doi: 10.1061/(ASCE)EI.1943-5541.0000179.

[10] P. L. Yorio and F. Ye, "A Meta-Analysis on the Effects of Service-Learning on the Social, Personal, and Cognitive Outcomes of Learning," *AMLE*, vol. 11, no. 1, pp. 9–27, Mar. 2012, doi: 10.5465/amle.2010.0072.

[11] S. C. Chan, G. Ngai, and K. Kwan, "Mandatory service learning at university: Do less-inclined students learn from it?," *Active Learning in Higher Education*, vol. 20, no. 3, pp. 189–202, Nov. 2019, doi: 10.1177/1469787417742019.

[12] G. Ngai, S. C. F. Chan, and K. Kwan, “Challenge, Meaning and Preparation: Critical Success Factors Influencing Student Learning Outcomes from Service-Learning,” *Journal of Higher Education Outreach and Engagement*, vol. 22, no. 4, Art. no. 4, 2018.

[13] ABET Engineering Accreditation Commission. "ABET criteria for accrediting engineering programs." Baltimore, MD., 2004.

[14] B. Jacoby, *Service-Learning Essentials: Questions, Answers, and Lessons Learned*. John Wiley & Sons, 2014.

[15] A. J. Wurr and C. H. Hamilton, “Leadership Development in Service-Learning: An Exploratory Investigation,” *Journal of Higher Education Outreach and Engagement*, vol. 16, no. 2, Art. no. 2, May 2012.

[16] D. A. Greenwood, “Outcomes of an Academic Service-Learning Project on Four Urban Community Colleges,” *Journal of Education and Training Studies*, vol. 3, no. 3, pp. 61–71, May 2015.

[17] S. H. Beatty, K. N. Meadows, R. SwamiNathan, and C. Mulvihill, “The Effects of an Alternative Spring Break Program on Student Development,” *Journal of Higher Education Outreach and Engagement*, vol. 20, no. 3, Art. no. 3, Oct. 2016.

[18] A. Astin, L. Vogelgesang, E. Ikeda, and J. Yee, “How Service Learning Affects Students,” *Higher Education*, Jan. 2000, [Online]. Available: https://digitalcommons.unomaha.edu/slcehighered/144

[19] J. Dawes, “Do Data Characteristics Change According to the Number of Scale Points Used? An Experiment Using 5-Point, 7-Point and 10-Point Scales,” *International Journal of Market Research*, vol. 50, no. 1, pp. 61–104, Jan. 2008, doi: 10.1177/147078530805000106.

[20] R. J. Karasik, “Community Partners’ Perspectives and the Faculty Role in Community-Based Learning,” *Journal of Experiential Education*, vol. 43, no. 2, pp. 113–135, Jun. 2020, doi: 10.1177/1053825919892994.

[21] J. V. Barnes et al., “Creating and Sustaining Authentic Partnerships with Community in a Systemic Model,” Journal of Higher Education Outreach and Engagement, vol. 13, no. 4, Art. no. 4, 2009.

[22] A. Petri, “Service-Learning from the Perspective of Community Organizations,” *Journal of Public Scholarship in Higher Education*, vol. 5, pp. 93–110, 2015.

[23] E. Tryon and R. Stoecker, “The Unheard Voices: Community Organizations and Service-Learning,” Journal of Higher Education Outreach and Engagement, vol. 12, no. 3, Art. no. 3, 2008.