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Engagement in Practice: A model for community partnership in an infrastructure capstone course

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Abstract

In the Fall 2020 and Spring 2021 semesters, capstone design faculty in the Department of Civil and Environmental Engineering at the University of Nebraska-Lincoln engaged in a partnership with the University of Nebraska-Lincoln extension, industry and community organizations including the Chamber of Commerce from the city of Columbus, Nebraska. The partnership between the university and the municipality provided students an opportunity to create comprehensive and creative design solutions to real engineering challenges identified by community stakeholders. The community projects were identified prior to the beginning of the Fall 2020 semester by the city chamber of commerce as well as local industry partners. At the initiation of the partnership, the city entities realized the benefit of receiving creative potential solutions to meet real community needs. Benefits to the students of this community-engaged capstone partnership included gaining real world experience communicating with the public and clients to understand their needs, learning to ask questions to discover underlining reasons for specific requests; working with professional engineers to find existing data, and learning to accept feedback from the public, clients, and professional engineers about their work. Student and public stakeholder responses indicate that both groups recognized benefits from the engagement aspect of the project.

Background and motivation for the project

Project Motivation. Civil Engineering is often referred to as a 'people-serving profession', yet many civil engineering students do not gain experiences working on realistic projects as part of their educational preparation. As early as 1997, engineering faculty were noted for using real project sites for capstone projects. These were still typically simulations without engagement with real client-stakeholders [1]. Service learning is a 'credit-bearing, educational experience in which students participate in an organized service activity that meets identified community needs and 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 civic responsibility" [2]. Participation in service learning has been showing to positively impact various student outcomes including enhancing student curiosity, connecting learning to personal experiences and deeper understanding of subject matter [3]. Although service learning has numerous benefits, it can be challenging to implement as part of engineering capstone courses. Coordination of such projects requires a significant commitment of time, similar to a new course development [4]. This paper describes a partnership between engineering capstone instructors, university extension and community partners to infuse service learning into a civil engineering capstone course.

Partnership development. Our partnership was built out of the college's desire to collaborate with the city of Columbus, Nebraska. The city of Columbus, Nebraska has a population of 23,195 and is located approximately 75 miles from the University of Nebraska-Lincoln. There is a strong community support for the College of Engineering in the city, including industry partners such as the chamber of commerce, Behlen Industries and the local public power district.

Other benefits of a partnership with the city of Columbus include its equidistant location between Lincoln, Nebraska and Omaha, Nebraska, the locations of the two campuses of the College of Engineering. The community has also recently experienced significant flooding, which resulted in transportation and infrastructure challenges which inspired several of the student design projects. Another important collaborator in the partnership development was university extension. Initial meetings took place between the Chamber of Commerce, university extension educators, and capstone instructors. After making an initial commitment to partner, the chamber of commerce representatives assembled a list of potential community partners, including the local public power districts, local industries as well as public works departments such as water and wastewater treatment, planning, emergency management, and parks. Each of the potential community partners shared ideas of what types of projects they thought would be interesting projects for students to work on. The projects ranged from cybersecurity, logistics, data collection, roadway design, flood protection, drinking water quality, structural integrity analysis, efficiency and quality engineering, and park and recreation design. Based on these candidate projects, the Civil Engineering capstone instructors decided to take on infrastructure related projects such as roadway design, flood protection, and park and recreation design projects.

Project Design and Execution

Through the project ideation process, five projects were scoped for use in the civil engineering capstone course, which is a one-semester course.

Project 1 – Loup Public Power District fishing pier. The client for this project was LPPD, represented by Todd Duren, vice president of corporate services. Loup Public Power District (LPPD), based in Columbus, NE wanted a handicap accessible fishing pier designed at a lake with public access located on their property. Lake North is the northeast portion of Lake Babcock which is part of a storage system used by the power district to hydrocycle their power generation. Besides power generation, LPPD gives back to the community by creating recreational areas for people to enjoy. They had already established locations for fishing in the community, but LPPD wanted to design an accessible fishing pier for community members with mobility limitations.

Project 2 - Golf course redevelopment. The client for this project is the City of Columbus, NE, represented by Trevor Harlow, city planner. The City of Columbus wanted to develop a plan for redevelopment of a public golf course area, which is an underutilized area of the city. The redevelopment plan was required to be recreational in nature and must not increase site runoff. The golf course is located in a low lying area in the city and floods during heavy rains, but this helps reduce flooding in other areas of the city. To the south of the redevelopment area is a levy which cannot be disturbed.

Project 3 – Alternative transportation route. The client for this project is the Columbus Area Chamber of Commerce represented by Kara Asmus, chamber of commerce Director. The goal of this project was to design a new road connecting highway 30 and highway 64. The existing connector between these two highways flooded during a recent extreme precipitation event, and this proposed alternative would represent an alternative route less likely to flood during future precipitation events. Additionally, the current connector road goes through the city's downtown

area and the alternative route would keep truck traffic out of the downtown area. The goals of the project were to identify the location for the alternative route, design the road, and assess the feasibility of construction.

Project 4 – Drinking water and wastewater planning. The client for this project was the city public works department represented by Chuck Silva. The city had just recently implemented changes in water and wastewater treatment to accommodate changes in the water quality of their source water, future population growth, an issue with a new national pollutant discharge elimination system (NPDES) permit and a new fats, oil and grease (FOG) program. Student teams explored multiple alternative water and wastewater system solutions for the city. After analyzing these alternative solutions, teams presented their recommendations and relevant designs to the city public works department.

Project 5 – Columbus, NE Riverwalk. Similar to the Golf course redevelopment, the client for this project is the City of Columbus, represented by Trevor Harlow, city planner. The City of Columbus, NE wanted to develop a plan for redevelopment of a park across the street from the public golf course area. The redevelopment plan was required to be recreational in nature and must not increase site runoff. The park is located in a low lying area in the city but just to the south of the redevelopment area is a levy which cannot be disturbed but the top of the levee offer beautiful vistas of the Platte River. The client requested the design of an elevated walkway so that park users could walk and enjoy an elevated view of the river, over the levee.

In the capstone course, student teams were formed based on students' CATME survey responses. CATME is an online survey tool developed by Purdue University. This tool optimizes student groups based on survey responses. The survey allowed students to identify their preferred project, civil engineering sub-discipline of interest, and other factors. Each project was assigned to 1-2 teams, with 4-5 students per team. The teams experienced a simulated client-provider relationship that included meeting with the project clients to hear their needs and wants for the project, receiving feedback from the client on their midterm project presentations, and presenting final designs to the client. A site visit would have been conducted but was limited due to COVID-19 travel restrictions at the University. Data for projects was collected from local, state, and federal databases as well as survey data from local engineering consulting firms.

The stakeholders met with the students virtually three times. The first meeting was at the beginning of the semester where the clients explained their projects, the constraints, and the goals. The second meeting was at the midterm of the semester. The students presented their preliminary findings and design options. The clients then offered feedback to the students. The feedback provided by the clients included not only discussions about the design, but also feedback regarding how the students presented their work. The clients were able to refocus the students' work. The final meeting occurred at the end of the semester where the students presented their final designs. Upon completion of the class, the clients were sent the final design reports, CAD files, project data files, models, and student presentations.

Lessons Learned

Students were given multiple opportunities to provide feedback following their capstone course experience. Data from the student learning evaluation (SLE) provided information that students felt challenged by the course, engaged in active learning and received opportunities to work with and from other students. The student course evaluation is standardized across the university and asks students to indicate their level of agreement with statements on a five-point likert scale, from Strongly Agree (5) to Strongly Disagree (1).

Table 1. Responses from Fall 2020 and Spring 2021 SLE.

Student learning evaluation prompt	% of respondents selecting Agree or Strongly Agree
I feel challenged in this course	96
Course activities effectively promote my learning and interest in the subject	96
I am invited to be an active participant in my learning	96
I have opportunities to learn with and from other students in this course	100

In addition to these prompts, students had opportunity to respond to the question, "What has been beneficial to your learning?" Respondents are asked to select one option from a prescribed list of responses, and subsequently prompted to provide comments on their choice. Selected comments and their related prescribed response are given here:

One comment linked to the response, "Course Challenge" was, "This class really challenged me in thinking in different ways. The project was challenging for me because I am a transportation focused [engineering student] and the project dealt with water resources and environmental [engineering]." Another response was, "The challenge of doing the work on our own was a challenge and really gave a perspective of what real life looks like."

Another chosen response to the "What has been beneficial?" question was "Engagement in Assignments or Projects." With that response a student remarked, "The structure of the course encouraged me to work on the project throughout the semester. I found myself enjoying myself when working on a particular design aspect. The Columbus, NE Riverwalk was the perfect type of project to work on as a group. One student who chose "Course Learning Materials and Tools" added the comment, "Being put into direct contact with clients help provide more specific tasks and requirements while also allowing for more realistic tasks and useful data and sources that had not been emphasized in prior classes."

This response in particular captures the benefits of the student-stakeholder interaction that is a component of service-learning projects. Students are encouraged to meet the needs of real clients, rather than focus on a pre-determined and potentially narrow solution to an engineering problem. The capstone design projects described here promoted a more comprehensive approach to engineering problem solving, while stakeholder engagement encouraged creativity and flexibility on the part of the students.

Another prompt given to respondents of the course evaluation was, "What could use improvement?" Several respondents chose "Course Performance Expectations". Their comments included, "As the class project is designed to be fairly open-ended, it is difficult to sometimes see if you are on the right track in regard to different areas of the project.

Some students struggled with the open-ended nature of the design projects with feedback that included comments such as: "I really wish there was more structure in this course," and "…it seemed too open ended at times." These comments seem to address the larger challenge of capstone projects; helping students transition from discrete problem-solving to open-ended, integrated solutions to larger scale design challenges.

In addition to the end-of-semester SLE, students participated in a course-end reflection exercise. A sample of student responses are included here. Many indicate a positive response to the interaction with community stakeholders on real life engineering problems.

"One thing I will remember from this course in 10 years is that this is the first major project I've ever designed. It was really cool to be able to work on an actual project for the first time."

"The transportation route project allowed me to put my knowledge to the test in completing real life problems. As stated earlier, I have also learned a lot about wildlife and habitat protection which will help me in my career. I think that the project will be a good resource to refer back to if any specific questions arise in the future."

"In 10 years, I will still remember the Riverwalk project and the coordination my design team had with City officials. I will be interested in 10 years to see if this project, or a similar one, was ever professionally designed and constructed. Being able to work on a real project with real design constraints is something that will stick with me into the future."

"In 10 years, I think that I will most remember this course as being the first time that I fully worked all the way through on a project while taking specific input from the client. Being able to produce a design for Behlen Manufacturing with my project team of engineers has been challenging but a great experience and one that I won't soon forget."

"In school most of the concepts we learn are very quantitive [sic] but in real life that isn't always the case. I realized how important social skills were during the project when I had to reach out to other engineers in the community for help."

"[Something I will remember in 10 years is,] Writing a professional proposal to the client, addressing their needs, writing up the executive summary."

Future work will include obtaining feedback from the project clients on their experience and the use of the final design project reports. Based on preliminary student and stakeholder feedback, our community engagement efforts are having a positive impact on both groups.

Conclusions and Next Steps

Much like the work of Dulaski, we found that students received multiple benefits from a capstone experience that engages them with real community stakeholders. These benefits include developing engineering skills that are transferrable to real-world engineering problems and enhanced skills in oral communications by delivering presentations to stakeholders [5]. Students were also able to practice professional written communication skills while writing emails, proposals and reports for their clients. We will continue to refine our approach to community engaged capstone projects and seek similar engagement opportunities with additional communities throughout the state. One area for future work is clearly articulating the project outcomes to the potential clients. In particular, engaged stakeholders must understand that undergraduate student groups will not take the place of licensed engineers, and their work should not be considered as a substitute. Rather, student work may provide creative alternatives for consideration by the community/client before retaining professional engineering services.

To date, students have engaged only with specific individuals, typically a small group of owner representatives. They have not had opportunities to connect directly with community members, who often represents the end users. Part of the reason for the more limited involvement with community members related to the time constraints imposed by a one-semester capstone, as well as limitations due to COVID-19. Future plans for broader community engagement could include solicitation of feedback on design alternatives as well as presentations of final projects, however, groundwork must be done with the community members and stakeholders to ensure the community understands the difference between creative student work and actionable designs of licensed engineers. The student learning process and outcomes also need to be balanced with community needs and social justice principles in mind [6]. Work to involve more community member involvement in the process will include discussions with University of Nebraska Extension and community stakeholders and should be done with an intentional goal of inclusion of a diverse set of community members. Initially, involvement of the general public could be focused on community organizations with an interest in the specific project, rather than just an open public forum. Another idea being discussed is how to involve K-12 students who live in the community, as they are an important community constituent, and their participation in the project may stimulate their interest in engineering careers.

Meeting student expectations regarding the capstone experience will include syllabus revision and early course meetings that clearly describe project expectations and encourage students to embrace the unique opportunity provided by the community focused design project. Early feedback from instructors should ease some of the confusion or overwhelmed feelings that students seem deal with when presented an open-ended problem. In the Spring 2022 semester, one capstone design section will be given more frequent project deadlines and outcomes will be compared against a section with less frequent project deadlines. The addition of these defined milestones may be a benefit to those students who struggle with the open-ended nature of the course and project.

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