



Building Community Connections in Civil Engineering Senior Capstone Design Projects

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Each year the Civil and Environmental Engineering Department at Rose-Hulman Institute of Technology solicits projects from our local, regional, and global communities for our senior capstone design course. We seek community partners who would benefit from the communication and design skills that our civil engineering students bring to help understand community needs, develop design options and feasibility, and produce a design solution. Students are placed in teams of three to four people, and each team works on a different project directly with a community client. To get a thorough understanding of the project site, student teams are expected to visit the site and meet directly with the client, who is a representative of the community organization sponsoring the project. The ability for students to visit the project site and meet with the client or community representative provides a place-based experience that provides students with a deeper understanding of the community needs related to their design project. Once the design is complete, student teams are required to present their work in a public forum, which could include a town hall meeting, a city planning meeting, or an organization's board meeting. Through place-based experiences and stakeholder engagement during the design process, students gain a more holistic understanding of potential benefits and impacts their design has on the community.

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Introduction

For our capstone design projects, we solicit community partners who would benefit from the communication and design skills that our civil engineering students bring to help understand community needs, develop design options and feasibility, and produce a design solution. Example projects include assessment and redesign of roadway alignments and water infrastructure, multi-use trail and bridge designs, and building and foundation designs. The ability for students to visit the project site and meet with the client or community representative provides a place-based experience that provides students with a deeper understanding of the community needs related to their design project. This informs their decision making through the design process by gaining a new perspective of how their design work can provide notable benefits to residents in the community. By having a better understanding of the environmental and societal setting for their project, they can make design choices to reduce or mitigate potential negative impacts of project implementation. Once the design is complete, student teams are required to present their work in a public forum, which could include a town hall meeting, a city planning meeting, or an organization's board meeting. Again, this requires students to meet with members of the community where their design project may be implemented. Through these immersive experiences,

students learn to communicate in a competent and professional manner to a non-technical audience.

As a department, we have adopted a student learning outcome that students will partner with a community to create positive change. Criteria to evaluate this are that students independently initiate or lead civic projects, demonstrating sustained commitment and responsibility; and integrate community context deeply into project planning and decision-making, demonstrating cultural competency and adaptability. This outcome is assessed through artifacts collected during senior capstone design experience as described in this paper.

Implementation Plan

To increase depth of student learning for a more comprehensive understanding of impacts their design has on the community, we integrated community engagement activities throughout the design process across the entire senior capstone design course sequence. The entire length of the course sequence is 30 weeks, broken into three 10-week terms. Average class size is 32 students, divided into teams of three to four students. This yields roughly eight different projects each year. Although there are two course instructors, each team is assigned a faculty mentor who assumes the role of a team coach to assist with project-specific challenges and

provide overall guidance in setting team expectations and project scope.¹

During the first term, students collect information to better understand current physical conditions and land development feasibility of their project site. They also address the current and historical community setting and needs, environmental impacts and challenges, and economic needs and opportunities. To get a thorough understanding of the project site, student teams are expected to visit the site and meet directly with the client, who is a representative of the community organization sponsoring the project. Most projects are in the public sector, but student teams could also work with clients managing private property. The site visit is an essential part of the project planning and design process, as students collect site-specific data, such as land survey information, soil samples, and water quality data. Students not only gain a comprehensive perspective of the physical site, itself, but also how the site could be developed in a way that provides an optimal benefit to the stakeholders in the community. The site visit helps students more fully gain place-based knowledge about the client and other stakeholders affected by the potential implementation of their design project. Examples of community partners include city governments, county fairgrounds, county planning departments, and non-profit organizations. Potential risks involved with student travel to project sites for data collection and public meetings are managed by a strict institute protocol that all student teams are required to follow.

As part of the planning process for concept development, student teams go through an empathy mapping exercise² and identify the real needs that exist that have led to the client's request for the project. Then, they develop a purpose statement that identifies the needs of the community and how their project will meet those needs (the goal of the project). At this point in the design process, students have met with their client and any other community partners and have likely visited, or are soon to visit, the location of the project site (if possible). Student teams analyze stakeholder perspectives by responding to the following questions from the empathy map²:

- WHO are you empathizing with?
 - Who is the person you want to understand?
 - What situation are they in?
 - What is their role in the situation?
- What do they need to DO?
 - What do they need to do differently?
 - What job(s) do they want/need to get done?
 - What decisions to they need to make?
 - How will you know when they were successful?
- What do they SEE?

- What do they see in their immediate environment?
- What do they see others saying and doing?
- What do they SAY and HEAR?
 - What have you heard them say?
 - What can you imagine them saying?
 - What are they hearing others say?
- What do they DO?
 - What behavior have you observed or learned?
 - What can you imagine them doing?
- What do they THINK and FEEL?
 - What are their fears, frustrations, anxieties, or dissatisfactions with the current situation?
 - What are their wants, needs, hopes, and dreams?

Student teams then develop project goals and design objectives, centered around the empathy mapping exercise and focused on the function of their design and what it will do to provide a benefit to the community where it will be implemented. Each student on the team generates a conceptual design option and describes how their option meets the project goals and design objectives set by the team. With preparation in effective teaming strategies,³ students share their design option with team members, and the team determines a final design recommendation with justification on how their recommended design meets the project goals and design objectives.

During the second term, students utilize the team's established design objectives to guide decision making during the technical design of their discipline-specific component of the project. For the technical design portion of the course, students are split into sub-discipline specific course sections to work directly with faculty experts in that technical area.⁴ With each bi-weekly technical design submission, students reflect on how their design work adheres to the established design objectives. Additionally, student teams utilize the Institute for Sustainable Infrastructure's Envision Rating System⁵ to assess sustainability, equity, and resilience of their designs. Categories of Quality of Life and Leadership include target area credits to "enhance public health & safety, . . . advance equity & social justice, . . . preserve historic & cultural resources, . . ., foster collaboration & teamwork, . . . provide for stakeholder involvement."² Each credit provides documented approaches to measure how well the project meets the intent of the credit. Students utilize this guidance to address how well their project meets relevant credits.

During the third and final term, student teams return to the communities where their project is located and deliver their final design in a public forum, which could include a town hall meeting, a city planning meeting, or

an organization's board meeting. Faculty instructors and mentors guide students on presenting their work to non-technical audiences and responding to community questions in a professional and civically-minded manner.

Assessment of Student Learning

At the end of the capstone design experience, students complete a reflection on their contribution to addressing a community need. As part of the reflection, students are asked to respond to prompts including the following:

- Identify and justify the stakeholders related to your project
- Describe and provide examples of how your final design was informed by the stakeholders identified
- Explain the challenges you faced during the design of the project for the community and how your team resolved these challenges.
- Describe your personal contribution and skills utilized throughout this project.
- Discuss how appropriate your team's solution was culturally, economically, socially, and environmentally?
- Describe additional solutions that may better serve the community.

Through the public meeting process of presenting and responding to client and stakeholder feedback, as well as through the end-of-project reflection on addressing community need, students demonstrate a commitment to reciprocity of their design work within the community, itself. Examples of student responses on how their design addressed an existing need demonstrate how place-based experiences helped students grasp a more comprehensive understanding of stakeholder impact.

- Project A: The neighborhood is mostly composed of narrow lots, smaller than what the city allows, with this being an unincorporated community, making it part of the city. The community wanted to preserve the distinctive curved roadways at the eastern edge of town. The community representative is hoping to add more sidewalks to improve the safety of the residents who live in Terre Town as there is only one true sidewalk on the eastern edge of town.
- Project B: The community is in need of a more efficient and viable way to enter and exit the county fairgrounds from the highway. There is constant traffic across the highway which makes it difficult for vehicles to enter or exit the fairgrounds. There used to be a stoplight at the main entrance of the fairgrounds that made it easier to navigate but it was relocated to the intersection of a lower traffic road and the

highway. The community will benefit from the project because connecting the fairgrounds to this stoplight will give people a better and safer way of entering and exiting the fairgrounds. Connecting to the stoplight will eliminate the risks associated with people having to pull out into oncoming traffic from the highway since people are generally moving fast on the highway and the highway is constantly busy. The additional building will benefit the community as it will be a large multipurpose space that companies or individuals will be able to rent out and use.

- Project C: The community regularly utilizes the existing trail infrastructure in the city to access various public facilities, businesses, and restaurants. These multi-use trails are incredibly popular as they allow the citizens to travel throughout the city through various modes of transportation other than a vehicle. The trail project will benefit the health of the community as it adds yet another path for people to utilize to travel throughout the city. Outdoor exercise including trail walking has been shown to improve physical and mental wellbeing. The addition of the trail may cause safety concerns especially among the residents living along the trail. With the new trail residents may be concerned about who will be using the trail, and how well maintained the trail will be. Living along the new trail, the residents may be worried about increased crime, and hazards on the trail if it is not well maintained. One point of friction that may occur depending on the final trail layout is the acquisition of private property for the trail project. Depending on the final location of the new multi-use trail, there will be significant portions of private property that will need to be acquired for the project. While the community as a whole is in support of the project, some of the homeowners may not be supportive of the project since it will require acquisition of their property. While there may be some holdouts due to the required acquisition of private property, the community as a whole is in support of the project, as citizens are requesting the addition of an east-west multi-use trail.

Discussion and Conclusion

Our work to continue these community engagement efforts will continue each academic year as our senior capstone design projects are solicited throughout the local community, established community partners, and

alumni to provide students with real-world, authentic community-based design projects. Increased depth of student learning through place-based experiences and stakeholder engagement provides a more holistic understanding of potential benefits and impacts their design has on the community.

Some challenges we have encountered include financial support for student travel to visit the project site and meet with clients and community members and communication difficulties with clients or community contacts. This course is taught every year, and several of the community organizations sponsor projects on a recurring basis. The institutional support and community engagement aspects of this program are strong, but the financial support is not always available. Minimal funding is supported at the cost of the client, but community partners are not always able to afford travel costs, which means not all teams are able to travel to their site or meet with community partners in person. This project demonstrates reciprocity between students and community partners in that students gain the experience of working directly with a client in their local or regional community. They witness and understand the needs that exist in the community to warrant their design project, and the community partners and stakeholders gain an engineering design report that can be utilized to assist with further funding to support project implementation. This supports the continued strength of community partnerships with our department and institute. It is also a great experience for your students to achieve academic gains and contextualize their didactic learning.

For students to get a comprehensive understanding of the community needs, it was important for the students to meet directly with the community contacts. Community members had varying amounts time and availability to meet with students. The community contacts were all volunteering their time in participating with the student projects, so the available time each contact had to share with students varied. This may have impacted how well students fully understood the needs of the community when recommending their design. Travel time to sites limited the number of physical visits students could make to the community. As faculty instructors and mentors, we can coach students with guidance to target most essential questions needed to be answered to fully understand the community need that exists and to pursue project objectives if time and reliable communication is a challenge. It is important to ensure community contacts have a full understanding of expectations for student interaction and to guide students to prioritize most needed information to obtain from community contacts.

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