Improving Students' Capstone Experience with Community Participation

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Senior design projects are a culmination of students' academic and lifelong lessons, and as a result, should be meaningful, have multiple outcomes, and far-reaching benefits. Moreover, they should challenge students and provide a real-world experience. One component of the design process it that is often overlooked is community involvement. Local citizens are a critical part of the project success and must be included.

In order to provide the students with a project that prepares them for the real-world as well as given them an opportunity to "give-back", the transportation capstone program in the Civil and Environmental Engineering Department at Northeastern University has relied on 18 municipal projects in 12 communities over the last several years. All projects have had had significant impact on the students and communities involved. Part of the process has been community participation to improve the design process and overall experience for the students.

The projects have not only been financially supported by the some of the communities, but have also received a significant amount of input from community members during over the semester. The program has gained such popularity that municipal stakeholders have contacted the instructor to have their city/town included in the program. Based on feedback from the community and students, the program is well-received and beneficial. The following paper details the program.

Introduction

At Northeastern University (NU), the Civil and Environmental Engineering Capstone (CEE) class is taught in the spring semester of senior year. Each student must select one of three tracks – environmental, structural, or transportation. The track complements their undergraduate classes and their cooperative experience. It also provides an opportunity that is often not included in a program – community presentations.

To ensure that the capstone experience is as close to real world as possible, the transportation capstone has relied on community involvement since 2010. The transportation capstone instructor has contacted local municipalities in an effort to identify community needs that may be addressed through capstone. The capstone instructor sends out requests for projects (RFP) to community officials in Massachusetts well in advance of the spring semester, typically in the fall prior to capstone. The RFP highlights NU's capstone program and asks them if they have projects that they would like considered.

Officials are told that if they have a project that integrates all three sub-disciplines, namely environmental, structural, and transportation (the three sub-discipline capstone groups at NU), which would create a well-rounded, multi-disciplinary project then that it would be placed at the top of the selection list and may be considered for design. Historically, some officials have suggested projects that would integrate the three sub disciplines; unfortunately, each one was not equally weighted. One (e.g., environmental) or two (e.g., environmental and transportation) components of the projects may have significant substance; however, the second or third component has required less rigor. As a result, the sub-disciplines have typically assigned

projects that are independent of one another. This is not viewed as a limitation – most consulting firms offer sub-discipline specializations.

More recently, due to the previous years' projects and the program's reputation, community officials have contacted the instructor, requesting assistance. Many municipalities have a civil engineering need; however, the officials may not have the money to fund studies or design. As a result, many officials welcome the technical assistance.

If the municipality cannot identify a project, then the instructor may identify one. Often times, the instructor has driven through a community and has identified an infrastructure need and will share that with the stakeholder.

Other Programs

Municipal participation in capstone is varies in programs throughout the United States. Several programs have designed municipal infrastructure facilities as part of the capstone course although the depth and breadth of community participation is often unknown. Students at the University of Missouri-Kansas worked with the public works department to redesign a bridge and an adjacent intersection (1). Students at the University of Colorado worked on water and wastewater municipal projects as part of their capstone experience (2). In some instances, the community is engaged. North Dakota State University addressed a neighborhood's drainage issues through a capstone course that culminated with a presentation to community representatives at the end of the semester (3). Although there are ample opportunities for civil engineering programs to improve the community as well as student experience through capstone, experiences appear to be limited.

Program Success-Identifying the "Optimal" Community Leader

A critical step in reaching out to the municipality is finding the right contact person. Caution needs to be exercised in selecting a town representative. Depending on the stakeholder's responsibility, the project may have different direction than that intended by the instructor. In the municipality there are typically "visionaries" and "day-to-day" problem solvers. In some instances one individual may have both the "day-to-day" knowledge and the vision.

The project's outcome is completely dependent on the municipal representative. The "day-to-day" stakeholder typically takes a "brick-and-mortar" approach to the project, resulting in an outcome that is extremely useful for the student experience, yet may not be as progressive in design. If the stakeholder is a visionary or critical leader in the municipality, then the project will require the students to "think outside the box" and apply all of their skills, knowledge, and experience. Moreover, the visionary is typically in a position to exact change.

After a community has been identified, the instructor meets with municipal officials to discuss either the specific project (if previously identified) or a new project. Once a project is identified on the global level, a project scope is typically created by the NU instructor. The scope is then reviewed by the municipal official and refined if needed.   The scope is typically broad so that students can solve the challenge creatively.

Financial Support

Stakeholders for projects that are geographically removed from Boston, MA (e.g., > 10 miles or inaccessible by the region's transit authority) are asked to financially support the project. The support typically covers student expenses such as travel and food. Most projects completed to date have cost a community $800 - 2,000.00. This expense is relatively minor compared to the community benefit.   When projects are in the greater Boston area (i.e., within a 10 mile radius), the students typically use their own resources to travel to the site.

Project Motivation I – Community Involvement

Full-time civil engineers present to communities frequently, throughout a project's life. Proposal presentations to a group of select individuals may be required to acquire a project, while community presentations are made, where anyone from the community may attend. The community meetings are extremely helpful for a project, in terms of fact-finding and feedback. Since engineers will be required to make the presentations, it is critical to their success that it is done effectively. This requires the engineer to make professional presentations that are coherent, and concise. As with most aspects of the engineering profession, presentations typically improve through experience. Based on this, the NU transportation capstone has been designed to provide exposure to the community involvement process over the course of the semester.

Project Motivation II – Given Back to the Community

A capstone experience is one of the last opportunities that instructors have to share their ideas with students in an academic setting. One "parting charge" for students leaving campus is giving back to the community. Since 2010, Northeastern University's Transportation capstone program has successfully integrated the academic and real-world experience resulting in a culminating experience. When done properly, both the community and students will benefit from the community-based capstone project.

A student's academic career is typically spent on a college campus with very little interaction with the surrounding community. Throughout their academic careers, students are surrounded with "text book" problems. The "given" that is provided in homework assignments, classroom lectures, and examinations limits the students. Often times, their first exposure to a "real-world" meeting may be through the capstone class.

Students in their senior semester of a traditional civil engineering program have spent close to 360 hours in the classroom. If you use a ratio of 2:1 in terms of study to classroom time, the student would have spent approximately 1,080 hours working on academic material. Over the course of their academic career, students may have committed some of their "extra" time to extra-curricular activities (e.g., student groups). Some students may have worked on community service projects that would better the community; however, they haven't necessarily worked on a community project from their discipline-specific major (e.g., transportation engineering).

In capstone, students have been exposed to ways to assist the community with their technical expertise. Although the magnitude of the projects requires a team and an extended period of time to complete, the projects are a collection of smaller, more manageable, individual components. Throughout the semester students are reminded that they have the necessary tools to identify,

analyze, and solve community challenges. They are reminded that there is more to life then financial incentives and that they should consider "giving back" to the community in which they work and live.

The capstone experience provides pragmatic exposure, for both the short-term and long-term. On the short-term, the community benefits from the final project design. Although it may take many years to fund and construct, the concepts and preliminary design is complete. Secondly, the students have realized that they can apply their "academic knowledge" to community challenges.

Project Timeline for Community Involvement

At the beginning of the semester, once a "consulting" team of students (i.e., groups of 4-5 per "firm") is identified, the team generates a schedule for the work over the semester, including major milestones and interaction with community members. The schedule includes meetings with the instructors as well as with the community. Over the course of the semester, the student team typically meets with municipal officials at least three times, one of which is a formal presentation in the municipality. If possible, all meetings will take place in the municipality, although there are instances in which two of the three may take place on campus. The last two meetings are formal presentations.

The first meeting, which typically takes place in late January or early February, is an introductory/preliminary assessment visit (Table 1). This informal meeting is typically held at the municipality. During the first visit, the students typically request material from the municipality, and the officials typically provide anecdotal material that requires the students to explore even farther. The project is discussed, a historical background is typically provided, and the students have an opportunity to ask questions. Several municipal representatives may attend this meeting - in addition to the primary contact (e.g., town administrator), several interested municipal stakeholders (e.g., police chief, fire chief, planning director) attend as well. The collection of personnel provides unique insight for the students.

Table 1 Community Meeting Schedule for Northeastern University Transportation Capstone over a 14 Week Semester

	Presentation Type		Jan (week 3 of the semester)	March (week 7 of the semester)	April (week 12 of the semester)
	Formal	Informal			
Preliminary assessment		X			
Conceptual designs	X				
Final design	X				

After the meeting, data collection effort, and analysis, the students generate ideas for the project. At this point, they are not identifying one solution; they are generating multiple ideas to address an observed concern. This approach is an important step in the process, specifically directed toward addressing the needs of the community.

Approximately half-way through the semester (which happens to be just before spring break), the teams present their concepts to the community. Often times the presentation to community officials and citizens is the first one of its kind. If they have worked throughout college, or as part of their cooperative experience, they may not have had the opportunity to present to officials. They may have prepared material for the meeting, and attended the meeting with their colleague; however, the actual presentation was performed by someone else.

The objectives of this presentation are twofold – it gives the students a tremendous opportunity to experience presenting to a community and it creates an opportunity for dialogue during which ideas are exchanged and feedback is provided.

Based on the geographical location of some of the projects, this presentation has occurred on-campus, as well as in the community. Each one has its advantages.

When the meeting is held on-campus, the number of community representatives is typically limited. Again, some of the projects may be several miles away from campus, and as a result, the attendance is relatively minimal. The contact person, as well as another interested municipal stakeholders typically attend. Although the attendance may be minimal, there are some advantages.

The benefit of this meeting is not only community-based for the community in which the work is being performed, it also benefits other communities when officials are present. In a typical capstone semester there are four or five projects that students are working on. When the formal presentation is made, leaders from other communities provide benefit on two levels. First, they may provide valuable insight for the project that may have been overlooked. They may have had the same challenge, and may have addressed it in a way that may benefit the other community. Second, the community leaders have an opportunity to see what other communities are doing, and it is not limited to capstone. Third, it provides an opportunity for community leaders to share their ideas on projects that they may not see otherwise – if the presentation were only occurring in the community, there may not be the input from "outside" parties, namely those not living in the community. Lastly, their community benefits from others' ideas. A community official may see a design for one community that may benefit their community, either on the project or in a different part of their municipality.

When the mid-semester meeting is held in the community, the benefits are realized in a different way. Community sponsored meetings tend to be well-attended, not only by community officials, but also interest groups and citizens. This is not necessarily the preferred approach; however, for the sake of the project, it is probably the "best" approach due to the potential for public participation.

Interest groups typically have a vested interest in the community, they know the community on a different level (compared to the decision makers), and most importantly, they may be the people that are most impacted by the project. Therefore, having them on-board early, involved, and supportive gives the students' insight as well as motivation to move forward.

After the formal presentation, the consulting firms present their findings to the client and discuss ideas for next steps. After the formal presentation is made, the engineers present a conceptual to

the client that has the baseline ground survey, as well as their preliminary recommendations. This is an ideal time for the client to provide feedback as well as re-direct if necessary.

Finally, the third time the client interacts with the students is at the end of the semester. The engineers formally present their final design to the client. Typically, the client comes to campus for the presentation; however, there have been instances when the students went to each community to make a formal presentation. Attendees at the meetings have included mayors, town administrators, public works officials, concerned citizens, and interest groups.

Community Level Input

On the municipal employee level, community input on projects has included town administrators, representatives from police and fire, representatives from planning and economic development departments. On the volunteer level, concerned citizens and organized interest groups typically provided input. Overall, community participation has varied based on the proposed ideas.

Students have presented to limited groups (e.g., five) and large groups (e.g., 80). In all instances the students' feedback was extremely positive. The students' observed the following:

> "Community members, at least those present at the meetings, are extremely passionate. Often times there were debates between audience members which the students were able to observe. Also, community members are informed. Although the students spend a considerable amount of time in the field observing behavior and trying to identify transportation issues, the citizens of the area have the "best" insight to "the way things move and work".

When the community is involved, the students benefit on a number of levels. First and foremost, student preparation is different when they are preparing to present to the community rather than their peers. Second, their understanding of the challenges in the community is better understood – hearing it from the community members rather than a professor adds another layer of understanding and motivation – students want to solve ALL the problems.

In most instances, the instructor is present during the community meetings, not to present formally, but to introduce the capstone program, facilitate the question and answer section, and keep the focus limited to the project scope.

Post-Meeting Debriefing

Students are always amazed after meeting with community members and public officials in a formal setting for a number of reasons. Typically, it may have been their first opportunity to meet with the public, ever! In most instances, their preliminary assessment recognizes the passion, interest, and thought the many members of the community have devoted to a challenge in their project area. The students also appreciate and again, are amazed, when community members offer them a perspective that may not have been properly vetted prior to the meeting.

After the mid-semester presentation the students finalized their designs, in preparation for the end of semester requirements, which includes another public presentation.

Exposure to the Public Process

The benefits of involving a community are far reaching. On the organization level, the municipality provides data that are required for the project, rather than having the instructor gather data. The data typically include topographical information that may be used for a base map. Other data that are typically provided are reports for current and past reports. Another major benefit is cooperation from the police department which has unlimited benefits, in both terms of anecdotal information and data.

End-of-Semester Requirements - Presentations

At the end of semester, the students are required to make at least one presentation, and in most instances, they make two. Every student is required to present to their peers in a formal setting. The other presentation may take place in the community. This presentation highlights and summarizes their final design, including recommendations for the municipality.

Prior to the final presentation, the students are required to make a presentation "dry-run", which is nothing more than a "dress-rehearsal". During this time, students make their presentation to their peers as well as to the instructor. No requirements, including an outline, were given to students prior to this. The "dry-run" is an opportunity for the students to present what they have learned, not only from the semester perspective, but also from an academic perspective. Most of the students at this point in the semester have polished their presentation skills; however, they typically lose sight of the "big picture". As a result a considerable amount of time is spent refining the presentation.

In order to ensure that everyone benefits from making formal presentation, one of the class requirements is that everyone must present. Based on this requirement, each student presents at least two times over the course of the semester – once at the mid-semester meeting, and once at the end of the semester.

Students' Reactions

The students' growth over the fourteen week semester includes the application of traditional learning complemented with the softer skills that engineering requires. Two of the biggest realizations are the discovery that it is very difficult to identify an optimal solution from a set of useable alternatives, and most importantly, the realization of the impact and import of community participation. Due to the magnitude and import of these projects, many have had a significant following, both in terms of community participation and press, adding value to the student experience.

A survey was created and distributed to recent graduates to assess their view of capstone. The survey asked over two dozen questions to recent graduates from the Transportation Civil and Environmental Engineering (CEE) program that was directed toward addressing the impacts of the capstone program. Students had five options for responding to the questions – "similar, almost identical, identical, different, and not applicable."

The survey had a response rate of 38%, resulting in a sample size of 24. The students were asked how closely the capstone experience emulated their real-world experience. Two specific categories were evaluated, namely public presentations and public speaking. Out of the 24 respondents, 85% indicated that the experience was similar to the real-world from a public presentation perspective and 83% from a public speaking perspective. The survey also had a section that allowed students to provide feedback:

> "Capstone was a challenging yet rewarding experience which I enjoyed very much. Looking back, it presents many real world scenarios I encounter on a day to day basis in my career".

> "I thought the overall process was very similar to the real world. The process of "applying" for your project, managing a team, meeting with with (sic) the clients, and presenting your work was done very professionally".

> "The overall Capstone experience is extremely beneficial to starting a career in the transportation field".

> "I remember two distinct thoughts about this during and after the capstone project. 1.) I thought the deadlines should have remained firm and 2.) There is too much emphasis on the project report. However, after working in transportation engineering I realize that those two things are standard. Deadlines are always changing and being able to adapt is important".

Conclusions

By identifying the proper community stakeholder and involving the community throughout the process, the semester long experience, not just the final product complements the community's needs and provides tremendous benefits to the students. Community benefits extend well beyond the final design and report. Through the capstone experience, significant benefits have been realized by the community and students. The process has allowed community officials and leaders to vet the ideas in a public forum thereby garnering community support, identify the solutions that benefit the community the greatest, and identify funding sources to build the projects.

With community involvement, the students benefit on a number of levels. The students leave the program with real-world, transferrable skills. Not only do the community presentations benefit their graphical communication, it also sharpens their oral communication. They also have an improved understanding of the value of involving the community. Finally, they realize that citizens are passionate about their communities and that the process of designing and ultimately implementing new designs is a potentially challenging process.

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