

MS Projects from Partnership with City Government

Allison Carlson

Mr. Travis Jensen, University of Minnesota Duluth

Mr. Andrew Frank Lund, University of Minnesota Duluth

Dr. Eshan V. Dave, University of Minnesota Duluth

Dr. David A Saftner, University of Minnesota Duluth

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ABSTRACT

This paper describes graduate student projects that were conducted through cooperation between University of Minnesota Duluth and the City of Duluth. While graduates students at the University of Minnesota Duluth can complete a traditional thesis-based MS, they also have the option of completing additional course work and a MS project. The graduate projects are designed to be realistic engineering problems that allow students gain and apply higher level civil engineering analysis and design knowledge. This paper describes two of these projects resulting in three MS projects. The first project determined a method of using fine dredge material from the harbor as engineered fill using locally available additives. The second project focused on transportation and structural issues in a neighborhood revitalization. These projects were evaluated using recently developed graduate student learning outcomes. The MS projects from this partnership were successful in meeting the graduate student learning outcomes when compared to MS projects from other sources.

INTRODUCTION

The objective of this paper is to describe a partnership between the University of Minnesota Duluth (UMD) and the City of Duluth resulting in civil engineering Master's of Science (MS) projects. UMD offers two paths to a MS degree. The first is a traditional thesis option while the second requires more course work than the thesis option and a MS project. The graduate projects are designed to be realistic engineering problems that allow students to gain and apply higher level civil engineering analysis and design knowledge. The City of Duluth provided several real world civil engineering projects requiring graduate-level analysis. While similar partnerships have proven effective at the undergraduate level, this paper demonstrates the mutual benefit to both academic institutions and local government in collaborating on graduate projects.

First, the motivation for this partnership and a review of previous published academic-government partnerships are presented. In the next section, two example projects are described in more detail. The first project found a use for fine dredge material as engineered fill. The second project involved redesigning a transportation network as part of neighborhood revitalization. Finally, these projects are evaluated using graduate student learning outcomes.

LOCAL GOVERNMENT & UNIVERSITY PARTNERSHIPS

Several partnerships between universities and both public and private agencies have been previously described in the literature. Tener (1996) describes the integration of Purdue University's Construction Engineering and Management program with its Industrial Advisory Committee. Industry was heavily involved in ensuring that the program met the needs of the profession. The paper provides insight into setting up and maintaining such a partnership. Najfai and Chaudhry (2005) discussed incorporating real world examples of public works projects into a management course at the University of Florida. This course utilized guest speakers from local public works departments. Walker et al. (1999) presented the results of a partnership between Ohio State University and the City of Columbus. Two projects were incorporated into a required senior level course in environmental engineering, including investigating the water quality of the

ponds, lakes, and streams in a local park and conducting a water quality survey of a nearby river and presented the results to a community group. De Asis Ramirez Chasco et al. (2010) discuss the increasing weight placed on university-industry relationship in European engineering education.

Other authors describe partnerships similar to the one described in this paper where students conduct the initial project design as part of an undergraduate capstone design experience. O'Bannon and Kimes (2006) summarized a capstone design course taught at the University of Missouri-Kansas City based around a project from the City of Kansas City. A 14 student team designed a bridge to replace an existing bridge that was deemed unsafe. Catalano et al. (2000) describe a capstone experience at the United States Military Academy in which students worked with a nonprofit agency to design tools for a person with advanced cerebral palsy. Ruwanpura and Brown (2006) discuss a project at the University of Calgary in which students developed designs for an urban renewal project in Lisbon. In addition to the benefits of working with practitioners, this project provided students with invaluable international experience. Both Howe (2010) and Todd et al. (1994) provide comprehensive reviews of capstone courses across the country. Projects involving public and private entities make up a significant portion of both of their reviews, indicating the utility of such partnerships to both parties.

The projects described above demonstrate the value of partnerships between government and academia. Additionally, the Department of Civil Engineering at the UMD places great value on hands-on, real-world projects. The UMD recently published a strategic plan consisting of several goals. One of these goals was to strengthen ties with local communities in an intentional, visible, and mutually beneficial partnership. Following the publication of the strategic plan, the City of Duluth approached UMD with the idea of partnering on several civil engineering projects. The City planned to use the results of these projects in grants to state and federal funding agencies in order to bring the students' work to fruition. Providing real world engineering problems to students was of great interest to UMD faculty. While similar projects could be used for capstone design projects or independent studies meant to prepare students for graduate work, the complexity of the problems and higher expectations led to the decision that the proposals should be used as MS projects.

PROJECT DEVELOPMENT PROCESS AND SUMMARY

In the summer of 2012, the faculty from the civil engineering department at the UMD approached the City Engineer's office to have a discussion on developing working relationship that would result in educational activities for undergraduate and graduate students. The City Engineer introduced the UMD staff to Duluth Economic Development Authority (DEDA) staff as well as presented a few civil engineering projects that were planned by the City and DEDA to be undertaken in next five years. Through a series of meetings with City staff as well as internally, the faculty identified three projects that would have necessary attributes of MS project and would enable faculty to assess the learning objective of the program. The learning objectives associated with the project-based MS degree are discussed later in the paper. The projects were discussed with the MS students and after their approval the faculty and students met with City and DEDA staff. Over the course of the projects the students and faculty met on routine basis to discuss the progress on the projects. At least once a semester a meeting was also scheduled with

the City and/or DEDA staff to provide the update and to request any necessary information for continued progress on the projects.

It was clearly established between all the stakeholders (City, DEDA, UMD faculty and students) that the MS projects will provide the City with potential solutions to non-trivial civil engineering problems. It was also established that while the designs and solutions will be provided, the main objective of these projects will be to aid City and DEDA in determining feasibility of such projects, to get preliminary budget estimates and to develop State and Federal grant proposals. The objective will not be development of design plans that are typically developed either internally through the City Engineer's office or through use of consultants. Thus, in the end City and DEDA benefits by gaining a feasibility study and estimates for budgetary planning purposes, the students benefit through project based learning through a real life scenario.

In the fall of 2012, three students began work on project-based MS degrees. One student was primarily interested in geotechnical engineering and was assigned the City's highest priority project with a geotechnical focus. Two other students were assigned a project combining their interest areas of structural engineering and transportation engineering. The follow section provides more detail on these projects.

Improving Fine Dredge Material for Use as Engineered Fill

The US Army Corps of Engineers (USACE) removes approximately 100,000 cubic yards from the City's harbor. State law prevents this dredge material from being placed offshore, leading to storage of dredge material on an 89 acre pier constructed in 1978. The coarse dredge material is sold for use in transportation projects and requires only short term storage. However, the fine dredge material has fewer practical uses, including wetland reclamation and retention ponds, and is generally stored on site.

One of the City's projects involves improving a former industrial park to allow new development. The site, pictured in Figure 1, contains the damaged foundation of a previous plant. Previous investigations recommended that the area be used as a parking lot, with new tenants on the surrounding area. The goal of this project is to determine a method of using the fine dredge material and other locally available waste products as engineered fill for this area. Products considered in project include mine tailings, lime kiln ash, and fly ash.



Figure 1. Site of former industrial park intended for revitalization.

The fine dredge material is classified as SM using the Unified Soil Classification System (USCS) and the grain size distribution is shown in Figure 2. Using permeability as a controlling factor, several mixes of fine dredge material and locally available waste material were tested. The most economical mix was determined to be a 2:1 mix of mine tailings and fine dredge material. Table 1 shows the original fine dredge material's properties as well as the improved soil's properties. More details on this project are presented by Lund (2014).

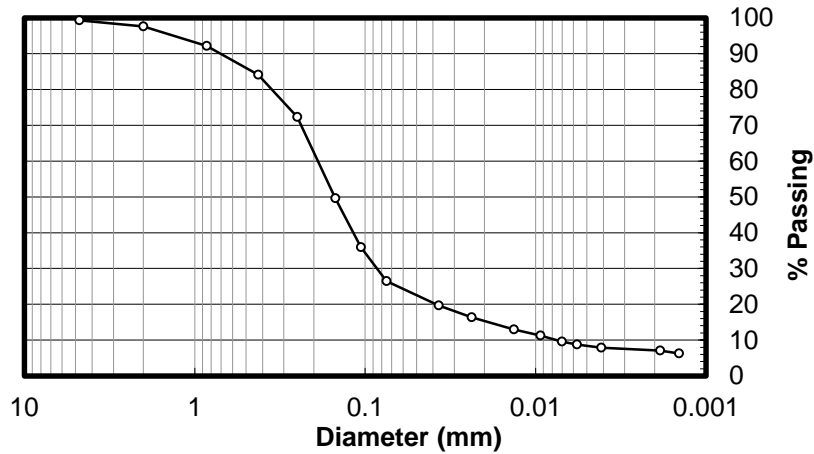


Figure 2. Grain size distribution curve of the fine dredge material.

Community Improvement in West Duluth

In the western part of Duluth a residential neighborhood is adjoining industrial infrastructure. A primary residential street (Raleigh Street) that runs across the neighborhood has a very high volume of truck traffic (approximately 450 trucks per day) that feeds the industry. Majority of the truck traffic is during the day time hours. This poses a safety hazard, especially to children. The general overview of the location along with the current traffic volumes is shown in Figure 3.

Table 1. Comparison of fine dredge material to improved soil properties.

	Permeability, k (cm/sec)	Mod Proctor Max Dry Density, γ_d (pcf)	Mod Proctor Optimum Water Content, w (%)
Fine Dredge Material	10^{-7}	115	12
2:1 Mine Tailings and Fine Dredge Material mix	10^{-3}	131	8

In an effort to tackle this problem the City has already completed first phase of highway improvement. This phase included widening and reconstruction of Waseca Industrial Road

(shown in Red in Figure 4). The goal of this project is to propose a solution that utilizes the previous improvement to Waseca Industrial Road and would provide an alternative highway route for the trucks to connect from neighboring arterial and interstate highways to the industry so that the truck traffic could be taken away from Raleigh Street.

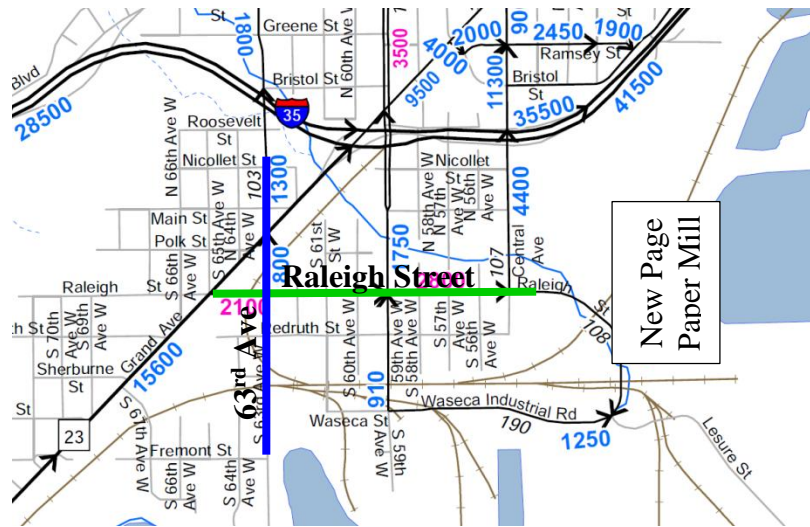


Figure 3. Overview of the residential neighborhood (Raleigh Street is shown in green; 63rd Avenue is shown in blue).

The scope of the MS projects involves planning, alternatives analysis, preliminary design, and a cost estimate for a new highway alignment that would solve the aforementioned problem. The design components involved highway geometric design and bridge design. It is typical for the cities to rely on State and/or Federal Aid Grants for a major construction project such as phase-II development of the Waseca Industrial Road. Typical applications to these grants include: statement of need, description of the project, and estimated costs. The MS projects have provided the City with the solution to the problem, preliminary engineering design and cost estimate. This information can be used for developing strong State and/or Federal Aid Grant proposals.

As a first step, a number of alternative alignments were evaluated. The evaluation was conducted through continuous communications between the students and the City engineers and planners. Both students working on this project worked together as this phase of the project affected both the highway and bridge designs. The alternatives took into account the following factors:

- Potential for a new industrial park to emerge on South side of Waseca Industrial Road
- Comprehending suitable project funding sources and appropriate regulations
- Understanding the current and future desires of residents, governing bodies, and businesses.
- Evaluating land ownership and property values to help come up with potential alternative routes.
- Solving the original problem of removing truck traffic from residential areas

- Existing right of way (ROW)

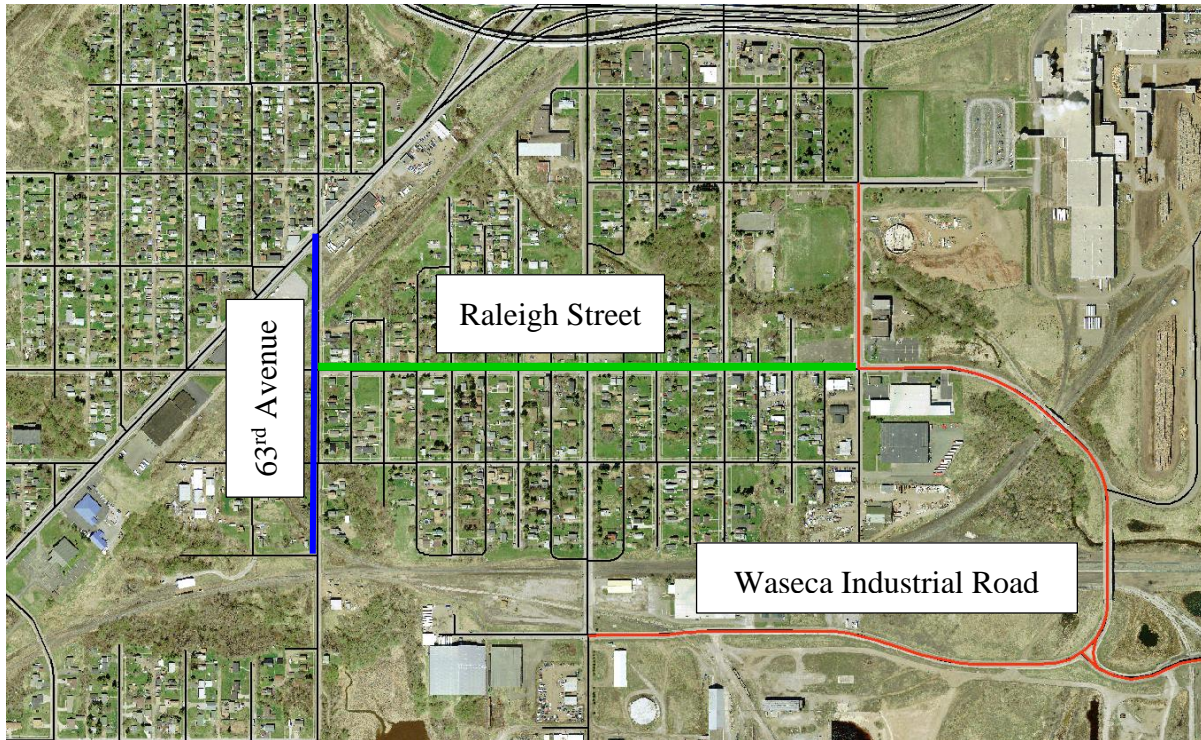


Figure 4. Waseca Industrial Road (Phase-I) (shown in red).

Based on the above factors it was decided that utilizing 63rd Avenue (c.f. Figure 4) in some capacity was the best approach as an existing ROW and infrastructure was already in place. The description of alignment alternatives and their comparisons are beyond the scope of this paper, they are discussed elsewhere (Jensen, 2013). For the selected alignment, a highway design was developed. The design included detailed elevation and cross-sections. Designs of new and upgraded intersections were also developed. The final submittal included design drawings, earthwork calculations, recommendations for intersection signage and markings, and cost estimates. The details are available in Jensen (2013).

To connect the existing truck route (Grand Avenue) to Waseca Industrial Road it is necessary to provide a bridge structure that would cross over railroad lines. Use of 63rd Avenue as the connection between Grand Avenue and Waseca Industrial Road requires providing a bridge structure that crosses over two set of railroad tracks. Figure 5 shows the general location of the four span bridge that would be necessary to cross over the railroad tracks.

The design of the bridge initiated with determination of vertical and horizontal clearances. The clearances were determined through communications with the railroad as well as by following the state bridge office guidelines. Once the preliminary geometry of bridge was determined the AASHTO LRFD and the state bridge design manuals were utilized for determining the loads and conducting the design of superstructure (deck and girders), substructure (pier caps and columns) and foundation (footings and piles). The RISA software was utilized to generate moment

envelopes. The maximum live load envelope for the entire length of bridge is presented in Figure 6.

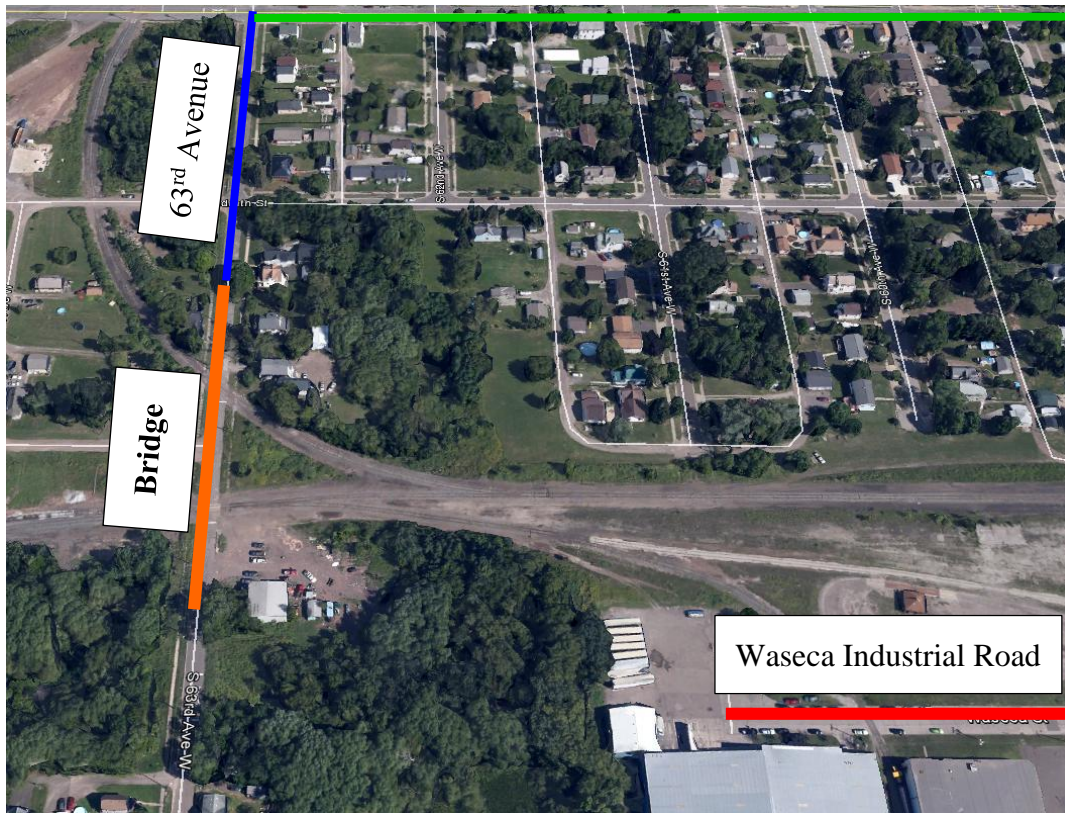


Figure 5. General location of the bridge.

The superstructure was designed as reinforced concrete deck on prestressed concrete I-shaped girders. The substructure design included reinforcing analysis and design of column pier caps, columns and foundation. Details on load calculations and analysis and design of superstructure, substructure and foundation are discussed in Carlson (2014).

DISCUSSION

Several graduate learning outcomes were developed for the Department of Civil Engineering at UMD. Three of these apply directly to the project-based MS degree projects discussed in this paper. The first outcome is the ability to communicate (oral and written) effectively. This outcome is evaluated through the MS project report and the MS project presentation or oral exam. While this outcome relates directly to the project-based MS degree, the source of the projects (i.e. University/City partnership vs. other sources) does not affect the evaluation.

Another learning outcome is the ability to conduct analysis and/or design through correct interpretation of technical literature, design codes and agency/client requirements. This is evaluated through student's project submittal and presentation. Prior to this partnership, most MS projects were not focused on development of design or are on a topic where design codes are not applicable or available. In these cases, the projects include a review of published technical

literature. The MS projects described herein utilized local, state, and national design codes or manuals. The partnership based projects provide students with more code experience and more agency/client interactions than MS project from other sources.

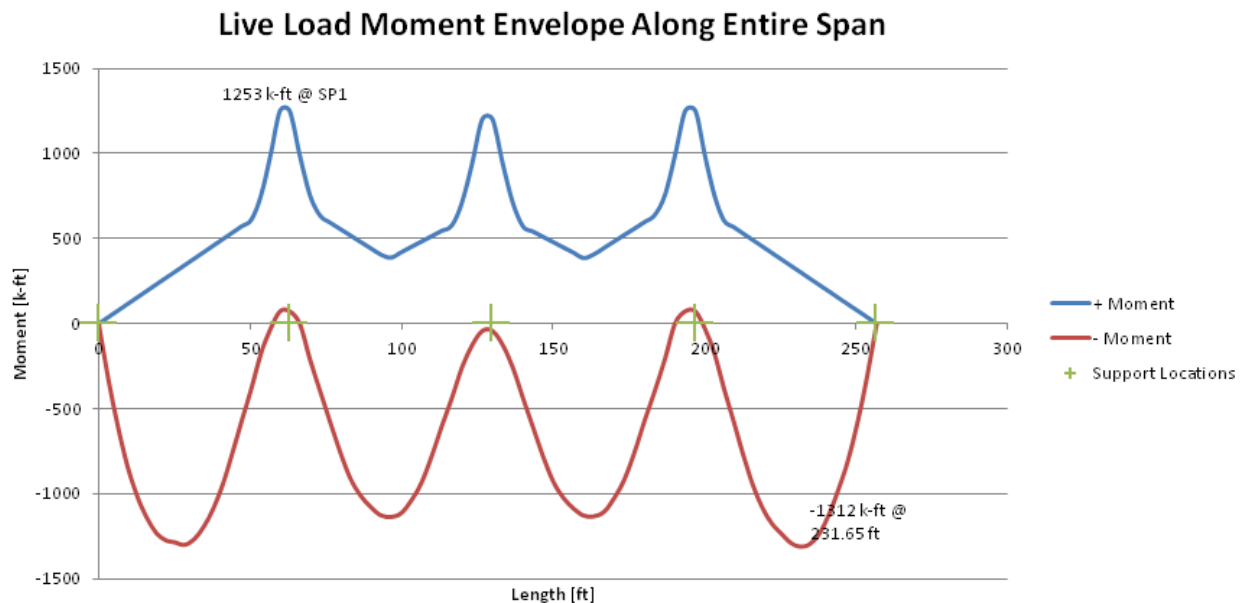


Figure 6. Maximum live load envelope along entire span of bridge. Maximum moment is 1253 kip-ft at support 2, minimum moment is -1312 kip-ft at 231.65 ft.

Finally, there is a learning outcome to provide the ability to provide solution(s) to a real-world civil engineering problem in one of the following four recognized major civil engineering areas: environmental and water resources engineering, geotechnical engineering, structural engineering, and transportation engineering. This outcome is also evaluated through student’s project submittal and presentation. The students in the project based MS program are provided with a real-life civil engineering problem. The type of problem varies in nature and ranges from conducting civil engineering designs to development and conducting of experiments to evaluate use of new materials. The outcome of each project should include a proposed solution to the problem that has been assigned to the student. The primary difference between projects from the University/City partnership and from other sources is the breadth of the projects. While both sources provide real-world projects, the near-term implementation of City projects provide urgency not common to MS projects from other sources.

All three student projects discussed herein met the above discussed learning objectives. Significant credit to this can be attributed to the selection of the projects. A lot of attention was paid by the faculty in identifying the project components in a manner that they included provision of solution real-world civil engineering problem and required students to conduct analysis and/or design through correct interpretation of technical literature, design codes and agency/client requirements. As discussed earlier in the paper each of the MS projects required students to go beyond the engineering skills learned through classroom environment and gave them experience of working in a client-agency framework.

CONCLUSION

In summary, UMD and the City of Duluth initiated a partnership to provide civil engineering MS projects. This paper describes two of these projects. The first determined a method of using fine dredge material from the city's harbor as engineered fill using other locally available materials. The second project focused on community development of a neighborhood through several civil engineering projects. These projects were evaluated using newly developed graduate learning outcomes. All projects met the outcome requirements.

The first trial of the partnership discussed herein was successful and it is anticipated that in future more projects will be initiated. The identification of the project scope will continue be of priority to ensure that all learning outcomes can be met. Faculty will continue to play the critical role of liaison between the students and the client.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Heidi Timm-Bijold, Ross Lovely, and Cindy Voigt from the City of Duluth. Their efforts in initiating this partnership and support of students throughout their studies were essential to the success of this project. The anonymous reviewers provided thoughtful feedback during the submission process and greatly improved this paper. Their contributions are gratefully acknowledged.

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Reviews

- **The chair commented on the draft:**

Please address all reviewer comments.

- **A reviewer commented on the draft**

I saw a few areas that could be fixed:

1. It would be helpful to have Raleigh St and 63rd Avenue shown on both Figures 3 and 4. As shown, it is not really possible to see how the spatial relationship of the two roads. In fact, Figure 4 may not really be necessary if 63rd Avenue is also shown on Figure 3.

Fixed

2. Figure 5 has no spatial context with the other figures. Either include some common labeling on that figure that appears on other figures, or simply put the bridge location on Figure 3.

Fixed

3. It would be beneficial to know if the students met the three outcomes that the projects were evaluated on, rather than just knowing that the projects were evaluated.

Added a couple of sentences to this effect.

4. Some grammatical errors and typos

a. 1st paragraph of Introduction, 5th line, insert "to" before "gain"? fixed

b. 2nd page, 2nd full paragraph, 1st line, change "describe" to "described". fixed

c. 2nd page, 2nd full paragraph, 4th line, change "strength" to "strengthen" fixed

d. Insert "the" before "bridge" on the 1st line of the 2nd paragraph on page 6. fixed

e. First sentence of 2nd paragraph in Discussion, should "analysis" be "analyses"? and insert "of" between "interpretation" and "technical". fixed

f. 3rd sentence of 2nd paragraph in Discussion, change "is on a topic" to "are on a topic" fixed

- **A reviewer commented on the draft**

While reviewing the paper, I identified some grammar/spelling errors, but only a few. I encourage another careful review.

I reviewed your abstract and am encouraged by the paper you have submitted. I think you have something good share, but it is not about the projects, but rather the other parts. For example -

1. I've been reviewing ASEE papers for a number of years now and have seen documentation of similar projects, either as international projects or as collaborations, that appear similar in scope but as capstone design projects. I have no doubt your students' work on these probably progressed to greater depth than those senior projects, but I see an opportunity for you to cite some of those earlier capstone papers and not only highlight differences, but also remind faculty members projects like yours could be used for capstone design, or as undergraduate projects that could be prep for a graduate experience. or even transitional projects that begin with a senior or team of seniors. See new lit review to see if this is addressed now. I'll be around this weekend if you have suggestions for improvement.

2. Your relationship and that of the student with your client is crucial here. How did you form the connection, how did you confirm the student was working effectively with the client, and what did the client think when the project was completed? Could you do that better? What advice would you give to others who would be seeking opportunities like this with clients?

Added a paragraph on how projects were developed and how faculty was involved in the connection between students and client. Also near the end of paper reemphasized the importance of project selection.

3. What do you plan to do differently in the future? Do you envision this growing, being an alternative, or not doing this in the same way?

Added a line at end.

4. Do you have any suggestions for how faculty may evaluate potential projects before they accept? Did you weigh the merits of the project carefully (I'm sure you did) and if so, what was key to making the project viable to offer to a student?

Previous additions responded to this.

I like what you have done. Our own program has been doing the same thing with seniors and with graduate students for about 15 years and we find it to be very fruitful. I'm excited that you are hopeful to share this so others may consider it more carefully for themselves. There are many undergraduate or Masters-focused engineering programs that would consider this, and some already doing this (I can think of three I know of right now), but I recall only one paper I've seen on this approach. Thus there is great value in what you have learned, but again, it isn't about the actual projects, but how they were planned/facilitated/managed.

Thanks for sharing your work.