External Collaborator/Mentor Requirement for Senior Capstone Engineering Design Courses

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Abstract

To meet the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC of ABET) curriculum requirement of a "major design experience" Civil Engineering Students at Wentworth Institute of Technology are required to successfully complete a Civil Engineering Capstone Design Course during the final semester (summer) of their senior year. In groups of four to six students, students develop, implement, and present a comprehensive, intra-discipline civil engineer design project. In the summer of 2014, the Faculty of the Civil Engineering Department at Wentworth Institute of Technology instituted a new requirement for the students enrolled in this Capstone Design Course. Each student group was required to identify and obtain the services of at least one External Collaborator (Mentor). The mentor' role was to act as a valuable resource throughout the semester for the students providing design guidance, regulation interpretation, actual project details, key contacts, and other relevant information. In addition to guidance throughout the semester, the external collaborator was to participate in an onsite mid-semester design review and attend/assess an end of semester formal presentation by the students of their design. All student design groups were successful in obtaining the assistance of at least one professional to act as a mentor, with many groups having several mentors with expertise in various sub-disciplines of civil engineering.

Some of the many benefits achieved by this new course requirement included mid-semester design review, professional networking, external assessment, showcasing of the program, and student employment possibilities. This paper addresses the successes of this new requirement in a capstone design course as well as the lessons learned from the first semester trial of the requirement.

Background

Wentworth Institute of Technology had a long standing history of delivering a highly regarded Civil Engineering Technology program. Early in 2010, the Administration of the Institute and the Faculty of the Department of Civil Engineering and Technology began the dialog related to developing a Civil Engineering program at Wentworth Institute of Technology. Following the requirements of Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC of ABET) "Criteria For Accrediting Engineering Program" and the recommendations of the American Society of

Civil Engineer (ASCE) report "Civil Engineering Body of Knowledge for the 21st Century Preparing the Civil Engineer for the Future", a new Civil Engineering program was developed. After much debate and effort, in the fall of 2011 Wentworth Institute of Technology accepted its first class into a newly created Civil Engineering Program. This class consisted of both freshman applicants and sophomore transfer students from the Civil Engineering Technology Program.

The mission of the Civil Engineering (BSCE) program at Wentworth Institute of Technology is to "provide a high quality undergraduate education that prepares graduates with the appropriate knowledge, skills, and attitudes to successfully begin a career in the civil engineering profession and continue to grow professionally and personally throughout their career". The mission of the program is accomplished through the program curriculum which include courses with traditional lecture course, lecture/laboratory courses, design project courses, and two mandatory Co-op semesters.

Civil Capstone Design - Course structure, scope and schedule

Civil Capstone Design (CIVE 650) is the program's capstone design course to meet the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC of ABET) curriculum requirement of a "major design experience". Senior status is required to enroll in CIVE 650 and the course is scheduled in the senior's final summer semester. In this course, students utilize acquired knowledge and developed skills from the previous program and other coursework to create civil designs and solve practical problems encountered during the design process. While developing their designs, students work cooperatively in a four to six member intra-discipline design team, demonstrate oral and written communication skills and apply independent research skills while interpreting design criteria and formulating appropriate design solutions. The open-ended design/build projects must include a design component in each of the following civil engineering sub-disciplines:

- Geotechnical Engineering
- Structural Engineering
- Civil/Site Engineering
- Environmental Engineering

Additional topics covered include value engineering, cost, safety, construction feasibility, construction scheduling, engineering ethics, and a wide range of engineering design elements.

The course format is one – one hour lecture and two three-hour studio/labs per week. The total credits assigned to this course are four. Multiple faculty advisors each with specific expertise in the above mentions disciplines are assigned to the course. The faculty advisors are available to advise the students during the lecture, studio/lab, and outside of the scheduled class times.

The beginning of a typical lecture period is used to review expectations for the upcoming week and the requirements for the upcoming deliverables (submittal requirements, deadlines, presentations, and the final report). Following the course update, a topic related to an engineering design project is discussed by one of the faculty advisors. See Figure 2 for a typical lecture schedule. Sufficient time is allowed in each lecture period to answer general questions the students may have.

The studio/lab is held in an oversized open space studio with individual space assigned to each design group. The individual space consist of a large working surface, bulletin boards, and secure storage. The two three-hour studio / lab sessions per week give students time to work on their designs and allow the faculty advisors to meet twice per week which each group individually. During these meetings the work completed since the last meeting is reviewed, design schedules are updated, problems are addressed, and working needed to be completed for the next meeting is agreed upon.

The structure of the Civil Engineering Capstone course was adapted from the previously taught Civil Engineering Technology Capstone Design course. One of the many changes to the technology version of the course that was incorporated into the new class was the requirement for the students enrolled in this Capstone Design Course to identify and obtain the services of at least one External Collaborator (Mentor). The mentor' □role wa□to act a□a resource throughout the semester for the students providing design guidance, regulation interpretation, actual project details, key contacts, and other relevant information. In addition to guidance throughout the semester, the external collaborator participated in an onsite mid-semester design review and attend/assessed an end of semester formal presentation by the students of their design. Table 1 list the project teams, a description of the student project□and t□e Mentor' □associated with each project.

Table 1 - 2014 Civil Capstone Design Projects			
Project Title	Students/Lead Area	Description	External Collaborators
Brewery Design, Westport, CT	James Clough - Structural Thomas Julian -Geotechnical Brian Mangiamele -Site/Civil Branden Roberts -Water Treatment Kevin Russ - Environmental Zaharadeen Sadiq -Structural/Site/Civil	The proposed project is to construct a brewery on a selected site in Westport, CT. To be considered in design are the structural elements of the building, site layout/drainage, environmental impact mitigation, geotechnical analysis, as well as water and wastewater treatment for the brewery. Some issues specific to the brewery will be: high biochemical oxygen demand of effluent, heavy brewing tanks, and parking for tour groups.	Tom Bowker-Cardno ATC Peter Salvatore-Boston Water and Sewer Commission
Morses Pond Well Field & Treatment Facility, Wellesley MA	Michael Buonincontra - Structural Dana Judge - Geotechnical Erin Cahill - Site/Civil Tyler Schmidt - Site/Civil Jeffrey Leggett - Hydraulic Saajan Patel - Environmental	The project focus is potable water infrastructure. The project involves the installation of public wells on a site next to a public pond and the construction of a pump station and treatment plant. The Town of Wellesley expects this facility to be rehabilitated to a capacity of 3 MGD year-round.	Blake Lukis-Director of Water and Sewer in Framingham, MA
Stony Brook Residential Development Project, Jamaica Plain, MA	Abel Arguedas - Structural Juan Morales - Geotechnical Wilfredo Reyes - Water/Civil Viana Reyes - Water/Civil Steven Glover - Environmental Daniel Rowett - Environmental/Geotechnical	The Stony Brook Residential Development Project was started as an Architectural Design project from the Spring Semester. The project was a two phase redevelopment project. The group will use the architectural rendering from the previous semester and develop the structural design of a four story mixed use building, a parking lot in compliance with local zoning regulations, storm water/water/sewer designs and an accompanied green space. The building will be 245 ft. by 75 ft. in size and the green space area will be 125 ft. by 245 ft. Phase 2 of the architect's project which consist of the design for a second residential building and the restoration of Stony Brook Canal will be considered in the laying out of the site but no design work will be completed in Phase 1.	Brent Shannon-McNamara/Salvia Inc. Bryan Mah-Wentworth Institute of Technology
Hotel, Parking Garage, and Green Roof, 1271 & 1282 Bolyston St., Boston, MA	Brian Barker - Civil Brendon Cloto - Geotechnical Nicholas Dempsey - Structural Cody Gibb - Structural Daniel Jameson - Environmental Christopher Pyman - Environmental Abele Komguep - Geotechnical	The proposed project is for the redevelopment of two site in the Fenway Park area along Boylston Street. The current Howard Johnsons at 1271 Boylston Street would be demolished and a new multistory hotel would be constructed in its place. Across the street, at the 1282 parcel, the existing parking lot would be expanded to a multilevel below ground parking structure. At street level, there would be retail and restaurant space. The 1282 Roof Top would be made into a green space, accessible to the public and hotel guests across the street. The Hotel at 1271 Boylston and the Green Roof at 1282 Boylston would be connected be an elegant walking bridge spanning Boylston street.	Kevin Wong-Haley and Aldrich Lee Vanzler- Haley and Aldrich Michelle Jose-HNTB Christopher Brennan-Walker Parking Tom Fennick-McPhail Associates Jonathan Patch-McPhail Associates Tim Lombard-Leggat McCall Properties Eric Kramer-CB&I Linda Gardiner-CB&I Paul Greco-Weston & Sampson Engineers Shawn Cloto-Intercontinental Hotel
Mitchell River Bridge	Travis Archambault - Environmental John Devlin - Structural (Steel)	The Massachusetts Department of Transportation has identified the Mitchell River Bridge of Chatham, MA as structurally deficient and as a result has placed it within	Mark Shamon URS Corporation

Replacement, Chatham, MA	Freddie Falcone - Geotechnical Nathan Goldman - Civil (Hydraulic) Kristen Houatchanthara - Structural (Reinforced Concrete) James McCarthy - Civil (Highway/Transportation)	the Accelerated Bridge Program. This proposed capstone design project is to design a replacement bridge to cross Bridge Street over the Mitchell River. It will be assumed that all components of the existing bridge will be demolished. The group will use their knowledge of the civil engineering sub-disciplines, structural; structural, geotechnical, transportation, hydraulics, and environmental in a comprehensive project by designing a new composite steel and concrete bridge superstructure supported by reinforced concrete piers/abutments and piles. Other design elements to be considered are roadway alignment, pavement design, drainage, and environmental impact.	Eric Johnston CB&I

Successes

Many benefits were achieved by this new course requirement. A few of the more notable included:

1. Mid-semester Review - Each group conducted a mid-term review of their design project. The Mid-term Review was given to the faculty and t□e group'□external collaborator(□)□mentor(□). The review was conducted outside of the design studio in a conference room with the options of teleconferencing if an external collaborator was not able to be on campus. Each team member was graded based on technical content and contribution, quality of presentation material, quality of presentation and how questions were addressed. These 4 categories are equally weighted in grading of the presentation. After the review, each group prepared an External Collaborator(s) Mid-term Report noting significant issues addressed, decisions made, and issues raised but not resolved at the Mid-term review. This report was forwarded to the External Collaborators and Faculty Members in attendance within one week of the meeting for review. The mid-semester review with the external mentor(s) provided the students with valuable design guidance, regulation interpretation, current industry practices, actual project details, project meeting experience (preparation, delivering project status in an organized fashion, and responding to questions), and key contacts.
2. Professional Networking – At the beginning of the semester, the majority of the external collaborator(s)/mentor(s) were known only by one or two of the student group'□member□and many were introduced for the first time to the faculty. After interacting with the students and t□e faculty for t□e □eme□ter□t□e mentor□□ad become part of t□e □tudent'□a□well a□t□e faculty'□profe□□ional network.
3. External Program Assessment – All of the external collaborator(s)/mentor(s) were involved in the mid-term review and many were pre□ent at t□e □tudent'□end of □eme□ter for formal presentation. At the completion of each of these presentation, the mentors completed an

External Collaboration Grading Rubric sheet. The results of the Rubric gave valuable insight into t□e □tudent'□performance and were incorporated into t□e Department'□ABET Student Outcome assessment.

4. Showcasing of the Program – Many of the external collaborator(s)/mentor(s) were unaware of the new civil engineering at Wentworth Institute of Technology and many had never been or □ave not recently been on Wentwort□'□campu□. By inviting t□e mentor□to t□e campu□for t□e □tudent'□pre□entations allowed them to see and learn about all the new and exciting things happening at Wentworth.
5. Student Employment Possibilities – Through the interactions the external collaborator(s) /mentor(s) had with the students throughout the semester, they became aware of the talents/capabilities of the individual students. Though only one student currently is known to have obtained employment from her/his advisor, the possibility for such employment is a benefit for the students.

Failures

Overall, the faculty involved in teaching CIVE 650 Civil Capstone Design did not identify any major drawbacks to requiring the student groups to identify and obtain the services of at least one External Collaborator (Mentor). As describe above and documented in t□e □tudent'□end of semester course evaluations, the program seemed beneficial. As with most beneficial endeavors, there was an increase time requirement by both the students and faculty to initiate and coordinate the process. The results however appear to far overshadow this slight increase in time commitment.

Lessons Learned

In the planning stages of CIVE 650 Civil Capstone Design, there was a concern by the faculty that some of the student groups would be unable to identify and obtain the services of at least one external collaborator / mentor. The initial fear of the faculty that was unfounded. All of the student design groups were successful in obtaining the assistance of at least one professional to act as a mentor, with many groups, as see in Table 1, having several mentors with expertise in various sub-disciplines of civil engineering. One group in fact, had eleven. Throughout the course of the semester, it became apparent that such a large group of mentors is difficult to coordinate and keep abreast of t□e □tudent□ progre□□. Thus it is planned that the next time the course is run, to limit the number of mentors to five. This would translate into one per student.

A second issue that surfaced during the semester was the amount of expertise the mentors had. Though most of the mentor identified by the students were licensed Professional Engineers with many holding senior positions in their firm, a few of the mentors identified were recent graduates. These recent graduates lack enough practical experience to meaningfully assist the student design groups. These younger engineers were too inexperience to act as effective mentors. In light of this, it is proposed that the next time the course is run all mentors have a minimum of five years of experience.

The third and final lessoned learned during the semester arose from the fact that in engineering there is often numerous solutions to a particular problem. Though a seasoned engineering is aware of this, many students are not. There were a few instance during the design phase of the course were a faculty advisor would recommend the students to approach a problem in one way, while the external mentor unbeknown to the faculty recommended another. Though both approaches were correct, these conflicts in directions caused delay and required portions of the student project to be reworked, thus resulting in unhappy students. Moving forward, at the beginning of the semester a discussion with the students about differences in design methods is planned. Additionally, all recommendations by the mentors need to be reviewed by the faculty and the faculty have final say in the method chosen.

Conclusion

The introduction of the requirement for student groups in a senior capstone course to identify and obtain the services of at least one External Collaborator (Mentor) has numerous benefits as highlighted in first year of incorporating the requirement into CIVE650 Civil Capstone Design at Wentworth Institute of Technology. The use of such mentors with the suggested minor changes is planned again for the next semester the course is run at Wentworth Institute of Technology.