

Providing an Intradisciplinary Team Experience for Off-Track Students in a Senior Level
Capstone Design Two Course Sequence

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By

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Abstract

Practicing Civil Engineers today must have the ability to work as a team member with other civil engineering sub-disciplines (Intradisciplinary) as well as with professionals from other fields (Interdisciplinary). One of the learning outcomes of the two-course capstone design sequence at Wentworth Institute of Technology in Boston, Massachusetts is an intradisciplinary team design experience.

In the first course of the capstone design sequence (CIVE4000), teams of five students develop and initiate the design of their original project with each project covering five different civil engineering sub-disciplines. Each student on the team is responsible for one of the technical areas of their project. During the laboratory sessions, the students must work together with the different civil engineering disciplines on their team as well as meeting with the faculty members/external collaborators to review their work. In the following semester, the same design team in the second capstone course (CIVE5500) complete the design of their project, present the project to technical reviewers, and write the final report.

When a student is off-track, providing the intradisciplinary team design experience is difficult and often requires the student to postpone graduation for an academic year. One student recently was in this scenario. In order not to postpone the student's graduation more than one semester, the student joined an existing capstone team in CIVE5500. The student completed all the requirements of CIVE4000 while interacting with the other team members who were enrolled in CIVE5500. The student then worked independently in the following semester to complete the requirements of CIVE5500. As reported by the student, the team experience and only graduating one semester beyond the student's original graduation date proved to be very valuable for the student. This paper presents the methodology of how an off-track student can be integrated into an existing capstone design group to provide the student with an intradisciplinary team design experience.

Introduction

The Capstone Design experience in the Department of Civil Engineering at Wentworth Institute of Technology in Boston, Massachusetts is a two-course sequence – CIVE4000 and CIVE5500. In the spring semester students are required to take CIVE4000 which is a 4-credit course with 1 hour of lecture and six hours of lab/studio. In CIVE4000, students form design teams, develop the scope of their project and initiate the design of their project. CIVE5500 taken in the Summer semester is also a 4-credit course with 1 hour of lecture and six hours of lab/studio. In CIVE5500, students complete the design of their project, present the project to technical reviewers, and write the final report. The two courses are both modeled after a professional practicing civil engineering firm as much as possible in an academic setting.

In CIVE4000, teams of four or five students develop original projects with each project covering the following technical areas of Civil Engineering: structural, geotechnical, civil/site, and environmental engineering. In addition to the four-technical areas above, each project can also have either a traffic engineering component or a GIS/geomatics component. Each student in the group is responsible for one of the technical areas/components of their project (“lead engineer”).

Each lab section has a faculty member with technical expertise in the above-mentioned technical areas of civil engineering. During the laboratory/studio session each week, the student teams meet with the faculty members in their lab section to discuss /review their design work. Table 1 below list the required deliverables in CIVE4000 and if the individual deliverable is a group and/or individual assignment.

Table 1: CIVE4000 Course Deliverables

<u>Deliverables</u>	<u>Type</u>
Initial Project Presentation	Group & Individual
Draft Scope of Work with Project Schedule	Group & Individual
Ethics Report	Individual
Final Scope of Work with Project Schedule	Group & Individual
Sustainability Paper	Individual
External Collaborator Meeting	Group & Individual
Freshman Presentation	Group & Individual
Design Criteria	Individual
25% Design Submittal	Individual

In the following summer semester, the same design teams from CIVE4000 continue working on the design of their project in CIVE5500 to a completion point of about a 75% design submittal phase. The teams then present/defend their projects in a final oral presentation to a large group of peers, faculty, and outside professionals. The final submission in CIVE5500 is a report binder which is a compilation of all the work from CIVE4000 and CIVE5500. A complete list of the deliverables in CIVE5500 are presented in Table 2 below.

A review of the course descriptions and course deliverables in CIVE4000 and CIVE5500 reveals that the combination of the two courses is an intradisciplinary team-based design experience. As can be see in Table 1 and Table 2, more than half of the deliverables have a group component associated with the assignment.

Table 2: CIVE5500 Course Deliverables

<u>Deliverables</u>	<u>Type</u>
Overall/Individual Schedules	Group & Individual
Provide Guest Lecturer	Group
Value Engineering Report	Individual
Mid-term 60% Submittal Review	Individual
Drawing/Design Summary for Final Reviewers	Group
Final Presentation	Group & Individual
Final Report	Group & Individual
College Showcase	Group

“The position of capstone courses in the curriculum, their integrative nature, and their mandatory presence in accredited engineering degree programs make them excellent environments for observing and cultivating students’ professional competencies and for documenting student achievement of these in support of program accreditation.”¹ The Engineering Accreditation Commission (EAC) of ABET has developed and approved new Student Outcomes (SO’s) in Criterion 3 to be implemented in the 2019/2020 accreditation cycle. The previous a-k Student Outcomes have been replaced with the new 1 -7 Student Outcomes. “These criteria apply to all accredited engineering programs. Furthermore, these criteria are intended to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of its constituencies in a dynamic and competitive environment. It is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the following criteria.”² The intradisciplinary team-based nature of the CIVE4000 course is used at Wentworth Institute too clearly show that ABET Student Outcome 1 (SO1) – “Ability to identify and formulate *complex engineering problems* by applying knowledge of engineering, science, and mathematics” is met. ABET describes *Complex Engineering Problems* as: “Complex engineering problems include one or more of the following characteristics: involving wide ranging or conflicting technical issues, having no obvious solution, addressing problems not encompassed by current standards and codes, involving diverse groups of stakeholders, including many component parts or sub-problems, *involving multiple disciplines*, or having significant consequences in a range of contexts.”²

Issue

When a student academic progress is “off-track”, and the student has not completed all the required pre-requisites for an intradisciplinary team-based engineering design course, such as

CIVE4000, providing the intradisciplinary team design experience can be difficult. This is especially true at a smaller university and/or in a smaller academic program where in any academic year you may only have one or two students off-track. The typical result of being off-track is the student's graduation being postpone for a full academic year. The possibility of delaying one's graduation for a year for any students is a financial and unnecessary hardship. In the 2018 academic year, one student from the Class of 2018 was in the scenario as described above. This paper presents the results of a pilot study and a possible methodology from the trial on how an off-track student can be integrated into an existing capstone design group to provide the student with an intradisciplinary team design experience.

Methodology

When a student is off-track by approximately one semester, it is possible for the student to experience an intradisciplinary team-based engineering design project in their capstone design by adding the student to an existing student design team in the second course of the two-course capstone design sequence (CIVE5500). The student being added to the existing design team should be bringing different qualifications/expertise (different civil engineering design disciplines) than those of the original team. The student is able to complete all the requirements of CIVE4000 while benefiting from the interaction with the other team members who are enrolled in CIVE5500. The existing team benefits from the supplementary knowledge base added to the group. The increase diversity in the knowledge base results in an increased learning opportunity for all the team members and can result in better overall project results/project grade.

After successfully completing the requirements of CIVE4000 in the Summer semester, the off-track student can enroll in the second course of the two-course capstone design sequence in the fall. Since the design teams from CIVE5500 for the previous Summer semester have completed their capstone requirements and, in most cases, have graduated, the student must work independently to complete the requirements of CIVE5500. To provide a modified intradisciplinary team-based engineering design experience in CIVE5500 for the off-track student, the student should meet regularly with one or more external collaborator of different technical backgrounds to review and discuss the student's progress. In the capstone design sequence at Wentworth, an external collaborator is defined as a practicing professional engineer. Sources of external collaborators include intern/co-op employers and bosses, industrial advisory groups, and colleagues of the faculty. In addition to meeting regularly with external collaborators, the student can also attend professional seminars/conferences and visit local civil engineering firms. The end result of this approach is the off-track student being provided with an intradisciplinary team-based engineering design experience with out postponing the students anticipated graduation date by more than one semester.

Student Perspective

To gain insight into the off-track student's prospective of the design experience and to be used as supporting data relevant to the merits of the pilot study, the off-track student was asked to comment on her experience. The student's comments were as follows: "As an off-track student enrolled in CIVE4000 in an off semester, I was added into an existing design team enrolled in CIVE5500. The design team consisted of a civil/site engineering student, a structural engineering student, a geotechnical engineering student, and an environmental engineering student. I was added to the team in the role of a traffic engineer. I completed all the requirements of CIVE4000 while interacting with my team members. I then worked independently in the following semester to complete the requirements of CIVE5500. During the laboratory/studio sessions of CIVE4000, I worked with different civil engineering disciplines as well as meeting with the faculty members to review my work. In the following semester, I worked independently to complete the requirements for CIVE5500. To provide an interdisciplinary experience in CIVE5500, I was required to meet with external collaborators (practicing engineers) to review my work, attended two conferences, as well as attending several projects meetings in the Boston Area."

"My experience for both courses, CIVE4000 and CIVE5500, was very valuable. During CIVE4000, I gained valuable skills in the following five areas: communication, ethics, teamwork, creativity, and design. My experience during the second capstone course was different. I worked independently and struggled to develop my project. To assist me in this task, I attended two civil engineering conferences, had project meetings with my advisor, and weekly meetings with two different external collaborators. During the two sequence courses of capstone design, my project went very well, and I am satisfied with the outcomes. I value my intradisciplinary team experience and the skills that I gained as an off-track student in a senior level capstone design course."

Results and Recommendations

The results of this trial as highlighted by the above student's testimony and as see by the Faculty involved in teaching this course, show that it is possible for an off-track student to gain the benefits from an intradisciplinary team-based engineering design experience while not extending one's graduation date by more than one semester. The trial was a success. Though the pedagogy of capstone design course varies from university to university, program to program, many of the ideas and practices from this trial can be incorporated into many different capstone design courses.

References

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2. https://www.abet.org/wp-content/uploads/2018/03/C3_C5_mapping_SEC_1-13-2018.pdf