AC 2011-1363: INDUSTRY UNIVERSITY PARTNERSHIP IN SENIOR CAPSTONE DESIGN COURSE

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John S. Polasek P.E. retired from the Michigan Department of Transportation (MDOT) after over 38 years of service in 2009.

John received his B.S. degree in Civil Engineering from MSU in 1972 and was hired at MDOT. Over the years, he has worked in the Design Division, as a Staff Engineer for the Local Government Division, as the Kalamazoo District Design Engineer and Project Development Engineer, as well as Region System Manager. In June 2003, John was appointed Director of the Bureau of Highway Development, which oversees statewide road and bridge design including quality assurances and specialty areas such as electrical, hydraulic and municipal utilities. The bureau is also responsible for administration of federal aid to local agencies and has statewide responsibilities for real estate, utilities and transport permits.

In Fall of 2009 John accepted his current position at Western Michigan University (WMU) as Adjunct Professor for the Capstone Senior Design Courses. The position is responsible for the development and coordination of real world projects that are sponsored by industry partners.

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Capstone Design Factory

"Industry University Partnership in Restructuring Senior Design Course I & II"

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Abstract

A two semester senior level capstone design course has been restructured (Senior Design I and II) in response to the outcomes defined by the industry to assure job ready engineers and outcomes set by the academicians to assure math and science based fundamentals. The restructuring purpose was also to align the course outcomes with the college mission of graduating 'Career- Ready' engineers. The department offers programs in civil engineering and construction engineering. Both program curriculums require a two semester course on a comprehensive design application. The courses are designed to meet specific ABET outcomes. Also to meet an additional program outcome of: students are able to explain basic concepts in management, business, public policy and leadership. In response to assessment results that included various constituent feedbacks, the course sequence has been redesigned for first offering during the fall 2009. The course is restructured to bring together industry and academia to enable the civil and construction engineers of the future to attain real life experiences through these partnerships. The first step was to partner with engineering companies, contractors and governmental agencies from around the state. During the first semester of Senior Design these partnerships produce real life projects sponsored by the various firms and agencies. Within this first semester, students form teams then choose from these projects their Senior Design Project. The project scopes vary greatly and contain most all elements of the civil and construction engineering profession. Once projects are selected by student teams, industry assigns a project sponsors to establish a client/consultant relationship. This emulates the business world by the sponsor becoming the client that has sent out a "Request for Proposals" (RFP) for their proposed project. The article also describes the first assessment cycle that is in part based on student and sponsor feedback collected following the first two offerings of the course sequence.

Introduction

Currently the Accreditation Board for Engineering and Technology (ABET) requires all graduates to undertake a "capstone" design project which requires students to apply their knowledge and experience toward real-world projects in a team-oriented environment. In the Western Michigan University College of Civil and Construction Engineering (CCE) curriculum, a Capstone Design Factory was implemented in a two-course sequence. The first course covers the project definition, planning, scheduling, and control techniques. The second course deals

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with project design, analysis, and implementation. These courses result in a Capstone Design Project where the students produce a working design, written report, and oral presentation.

In response to various constituent feedbacks, the course sequence has been redesigned for first offering during fall 2009. The restructuring purpose was to align the course outcomes with the college mission of graduating 'Career- Ready' engineers. The course is restructured to bring together industry and academia to enable the civil and construction engineers of the future to obtain real life experiences through these partnerships. This article will describe the restructuring of the two semester senior level capstone design course (Senior Design I and II) in order to assure outcomes defined by the industry and academicians for math and science basic fundamentals.

Literature includes various articles describing industry collaboration with capstone design courses in the engineering curriculum. Norback et. al. (2010) described an executive panel for direct interaction with students about workplace communication. Also Paretti (2008) discusses improving technical communication in the comprehensive design process. Perhaps the most comprehensive industry collaboration is by Lamancusa (2008) described as "industry-partnered active learning." The implementation presented I n this article is emulating the changes by Lamancusa (2008) and adapting these changes to a civil and construction engineering environment.

The department offers undergraduate programs in civil engineering which started in 2002 and construction engineering dating back to 1999. Enrollment of both undergraduate programs during Fall 2010 was 268. Both program curriculums require a two semester course on a comprehensive design application. The courses are designed to meet specific ABET outcomes of A, C, D, F, G, H, I, J and K. Also to meet an additional program outcome: students are able to explain basic concepts in management, business, public policy and leadership.

Program Outcomes are as follows:

A) An ability to apply knowledge of mathematics, science, and engineering
B) An ability to design and conduct experiments, as well as analyze and interpret data
C) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, and safety, manufacturability, and sustainability.
D) An ability to function on multidisciplinary teams.
E) An ability to identify, formulate, and solve engineering problems.
F) An understanding of professional and ethical responsibility.
G) An ability to communicate effectively.
H) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
I) A recognition of the need for and an ability to engage in life-long learning.
J) A knowledge of contemporary issues.
K) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The specific ABET outcomes and associated activities that are covered in this course pair is shown in Table 1 and Table 2. Further into the article further elaboration of the program outcomes will be presented in Tables 3 and 4.

TABLE 1: CCE4830 Program Outcomes and Associated Activities (Fall 2009)

Week	Topic	Program Outcomes	
		Civil	Construction
1	No Class-Labor Day	---	---
2	Introduction/Discus Syllabus and Projects	---	---
3	Engineering Ethics** Project Selections & Team Formation Due	I1, F1	I1, F1
4	Final Projects Returned to Teams Proposal Outline and Content	---	---
	Scoping Meetings with Sponsors (on own time)	---	---
5	Discuss Sponsor Meetings	---	---
	Engineer Your Career Workshop*	---	---
6	Energy Conservation Efforts at WMU**	I1	I1
7	Ethics of Leadership	I1, L4	I1, L4
	Etiquette Dinner*	---	---
	EAS Career Fair*	---	---
8	MSPE: Professional Licensing	F2, I1	F2, I1
9	Engineering Written Communication** Final Proposals Due	I1 G1, G3	I1 G1, G3
10	Final Proposals Returned	G1, G3	G1, G3
11	National Environmental Policy Act	I1, L3	I1
12	Contact Sensitive Solutions	H1, I1	H1, I1
	Engineering Oral Communication**	I1	I1
13	Design/Build & Design/Build/Finance	I1, J1	I1, J1
14	Progress/Course Evaluations	---	---
	Attend Senior Design Project Presentations	I1	I1
15	No Class-Exam Week	---	---
	Regional ASCE Activity	I1	I1
	ASCE Student Chapter Meeting	I1	I1

*Must attend two of three University activities

**Must attend all 4 CEAS Capstone Lectures

TABLE 2: CCE4850 Program Outcomes and Associated Activities (Fall 2009)

Week	Topic	Program Outcomes	
		Civil	Construction
1	Introduction, Discus Syllabus, and Progress Meeting Schedule	---	---
2	Progress Meeting and FE Registration	F2	F2
3	No Class	---	---
4	Progress Meeting	---	---
5	Organizational Concepts	L4	---
6	Progress Meeting	---	---
7	No Class	---	---
8	Progress Meeting	---	---
9	Management	L1	---
10	Progress Meeting	---	---
11	Leadership	L4	---
12	No Class-Thanksgiving Break	---	---
13	Presentation Run Through and Discussion	---	---
14	Presentations	A2, C1, D1, G3, K1	A2, D1, G3, K1, L7
	Final Report Due	A2, C1, D1, G3, K1	A2, D1, G3, K1, L7
15	No Class-Exam Week	---	---
	Jury--Graduates can apply knowledge of mathematics, science, and engineering.	A2	A2
	Jury--Graduates can design systems, components, and processes to meet desired needs.	C1	C1
	Jury--Graduates demonstrate effective oral communication skills.	G1	---
	Jury--Graduates demonstrate effective written communication skills.	G2	---

Industry (Sponsor) Involvement

The CCE Department's Capstone Design Factory is organized as a University-Industry partnership in which industry participates in the students' education to help produce highly-qualified civil and construction engineers. This is accomplished through the integration of design, construction, and business realities in an active learning environment. Students work on real-world projects sponsored by the industry using state-of-the -art modeling, analysis, and design tools in a modern facility. This will give the student's experience that directly prepares them for careers in civil and construction engineering, with general problem solving abilities. Industry sponsored projects is an essential component of the Capstone Design Factory. In fact, this program is in response to the industry demand for graduates who are well trained in

engineering fundamentals, as well as professional skills to effectively compete in today's market place, such as teamwork, project management, cross functional networking, communications and design. The development of our facilities and curricula is overseen and guided by our Industry Advisory Board (IAB). The IAB members come from a variety of industries, such as consultants, developers, contractor and governmental agencies that contribute their time, money, and provide sponsorship, guidance, mentorship, and student job opportunities to make this program a success.

Sponsor Benefits

Industry partner benefits are very easy to justify. The letter presented to the industry partners describe some of the benefits to them as:

- Opportunities to evaluate potential employees through internships, collaborative projects and classroom interactions,
- Direct assistance in design problems through sponsorship of senior design projects,
- Professional development of industry personnel through teaching and curriculum development,
- Technology transfer through Industrial-Academic exchanges--industry engineers in the classroom, and faculty internships in industry,
- Opportunity to influence and improve the education of civil and construction engineers well into the century,

Additional benefits that directly impact the industry partners include:

- Fresh ideas, solutions to real problems
- Low cost, low risk investigation of "back-burner" ideas
- Corporate exposure on campus
- Project management experience for junior staff engineers
- The mental stimulation of interacting with bright, energetic, creative young minds
- Networking with other companies and Western Michigan University faculty

Project Solicitation Process

The first step is to partner with engineering companies, contractors and governmental agencies from around the State. During the first semester of Senior Design these partnerships produce real life projects sponsored by the various firms and agencies. Each prospective sponsor is directly contacted by our Senior Project Design faculty to solicit a candidate project. If the industry agrees to sponsor a project, then a packet of information is sent out. (Appendix A) The packet includes: a cover letter that thanks the sponsor and has critical dates identified with contact information, an information document explaining the Capstone Design Factory with scheduled dates and finally a project submission form. Once the submission form is submitted, Senior Project Design Faculty work with each sponsor to clarify and make sure the project meets academic requirements.

Capstone Design Projects: Parameters and Constraints

Requirements vary from project to project but in general contain the following:

<u>Construction Engineering Projects:</u>

- The proposed projects should have more than 200 activities. Upcoming or recently completed industrial, commercial, and highway projects are examples of projects.
- Students should be able obtain the plans and specifications of the projects

- The following is a suggested list of tasks which the students need to complete during their capstone design experience:
  - -Work Breakdown Structure (WBS)
  - -CPM Network Plot/Reports
  - -Detailed Estimate (Labor, Equipment, Material, Overhead, Contingency, Profit)
  - -Construction Methods, Detail and Design
  - -Project Management System (Data collection, Safety Plan, Reports)
- Technical report
- Oral presentation

Civil Engineering Projects:

- The proposed projects should incorporate at least two focus areas of study(Construction, Environmental, Geotechnical, Transportation, and Structure)
- The following is a suggested list of tasks which the students are expected to complete during their capstone design experience:
  - -Planning and site development
  - - Modeling and analysis
  - - Design and detail different components
  - - Environmental and Transportation issues related to the proposed project
  - - Technical report
  - - Oral presentation
  - - Hydrology and Hydraulics

First Senior Design Course

Within the first course, students form teams then choose from the submitted projects their Senior Design Project. The project scopes vary greatly and contain most all elements of the civil and construction engineering profession. Once projects are selected by student teams, industry assigns a project sponsors to establish a client/consultant relationship. The teams then meet with their sponsors/clients for a "scope verification" meeting so they properly understand the scope, deliverables and sponsor expectations. This emulates the business world by the sponsor becoming the client that has sent out a "Request for Proposals" (RFP) for their proposed project. The student team responds as a consultant, proposing on the project. They then write a project proposal to send to the client for consideration to contract their firm to design the proposed project. The written proposal constitutes 70% of their grade. (Appendix B, grading criteria) Each proposal contains elements of real life proposals such as project understanding, scope of work, deliverables, production work schedule and their team's expertise. Each student team is also assigned a faculty advisor to assure that the project meets the academic deliverables. The faculty advisors emphasize active learning, and experience with state-of-the-art modeling, analysis and design tools. The industry project sponsor emphasizes integrating design, regulations, specifications and codes, construction (implementation), and business realities. Both the CCE faculty advisor and the Senior Design faculty monitor each team's progress and solicit feedback from sponsors.

The remaining 30% of the student's grade is from briefing paper on various topics from presentations at class. Topics include: Ethics of Leadership (Ethicana 2010), Engineering Ethics (Lecture by the Dean), Professional Licensing (Lecture by Associate Dean), Lifetime Learning (ASCE Local and Student Chapter Meetings), Written Communication (Lecture by Faculty),

Public Policy (US EPA-NEPA 2010), Engineering and Society (CSS) and Contemporary Issues (Design/Build Contracting). (Appendix C, grading criteria)

Second Senior Design Course

During the second semester of the program, projects scopes and deliverables are completed. To once again simulate the real world, detailed progress reports are due bi-weekly and sent to the clients and faculty. These reports contain information on what the team has completed, whether they are on schedule, if they are not on schedule, what are they doing to get back on schedule and revised production work plan. Once again, senior design faculty and each faculty advisor monitor each team's progress as well as continually soliciting feedback from sponsors. Briefing papers on class lectures and presentation account for 15% of their final grade. Topics include: Small Business Management, Concepts of Leadership and Organizational Structure Concepts. (Appendix C, grading criteria) Finally, the student teams present the final projects at the Senior Design conference and prepare a final report.

As a result of assessment based on Juror feedback data, one class is dedicated to a video on presentation preparation and delivery. Each team prepares a draft presentation and mock presentations are presented by each team. CCE senior design faculty, faculty advisors and, if possible, the project sponsor critique each presentation. Critiques are on organization, content, analysis and delivery. These mock presentations have proven very valuable and are well received by the student teams. Each team's final presentation is presented at the Senior Design Conference before jury of faculty and IAB members and evaluated on a Juror Evaluation Form. (Appendix D) The Jury evaluations are 40% of the team member's final grade. The last requirement for Senior Design is the final report. During the semester, one class is dedicated to the final report outline and grading criteria. (Appendix E) Also during the semester, they submit a draft final report outline and draft final report to the faculty advisor for review and comment. This is very important to ensure the quality of the report. The final report is 45% of the team member's final grade.

Assessment

As stated previously, assessment data is collected during the semester from sponsor as well as faculty. Some of this data is unstructured and attained by emails, phone calls and private conversations. Structured data collected for assessment are summarized in Table 3 and 4 for civil engineering and Table 5 and 6 for construction engineering. Data is also collected in the form of input solicited from the IAB both by correspondence and quarterly IAB meetings. Many of the IAB members are also project sponsors and their input and willingness to help has been invaluable and contributed greatly to the success of the program.

Some examples of program adjustments as the result of assessment include refining the jury assessment form to better evaluate the competencies of each team and assurance that candidate projects are appropriate. Other examples of program adjustment have been revision of the project submittal form, to clarify constraints and deliverables. Also, in the area of communication, the senior design staff now assists with the arrangements of appropriate meeting space that is both convenient to the sponsor and the team. Lastly, student feedback is solicited at class periods and through an exit interview meeting and exit interview form that is completed by graduating seniors. (Appendix F) The exit interview form has sections (4, 4a, 4b, 5) dedicated to the Capstone Senior Design course. Exit interview results are presented in Table 7.

TABLE 3: CCE 4830 Civil Engineering Outcomes and Assessment Data (2009-2010)

Program Outcome	Assessment Means	Metric	Spring 2010 Outcome
F 1. Graduates have knowledge of engineering ethics and ethical responsibility.	CCE 4830 Ethics Paper	75% students earn a C or better from the Ethics Paper.	100% of students earned a C or better from the Ethics Paper.
F 1. Graduates have knowledge of engineering ethics and ethical responsibility.	College Seminar and/or CCE 4830 Speaker/Video	100% of CCE 4830 students attend at least one college seminar and/or course speaker/video on ethics.	100% of students attended at least one college seminar and/or course speaker/video on ethics.
F 2. Graduates have an understanding of the importance of professional registration.	CCE 4830 Paper on Professional Practice	75% of students earn a C or better on PE registration paper.	85% of students earned a C or better on PE registration paper.
G 1. Graduates demonstrate effective oral communication skills.	CCE 4830 Proposal	75% students earn a C or better on the senior design project proposal.	100% of students earned a C or better on the senior design proposal.
G 3. Graduates demonstrate effective written communication skills.	CCE 4830 Proposal	75% students earn a C or better on the senior design project proposal.	100% of students earned a C or better on the senior design proposal.
H 1. Graduates understand the impact of engineering on society.	College Seminar Series and/or CCE 4830 Speakers	All CCE 4830 students participate in at least one seminar related to Impact of Engineering Solutions on Society.	100% of students participated in at least one seminar related to Impact of Engineering Solutions on Society.
H 1. Graduates understand the impact of engineering on society.	Impact Paper in CCE 4830	75% students earn a C or better from the Impact of Engineering Solutions on Society Paper.	100% of students earned a C or better from the Impact of Engineering Solutions on Society Paper.
I 1. Graduates understand and embrace the need for life-long learning.	Participation in Student chapter	At least 25% of the students in CCE 4830 participate in at least one ASCE chapter meeting.	100% of the students participated in at least one ASCE chapter meeting.
I 1. Graduates understand and embrace the need for life-long learning.	Participation in Regional Society Meetings	At least 15% of the students in CCE 4830 participate in one regional ASCE activity.	100% of the students participated in one regional ASCE activity.
I 1. Graduates understand and embrace the need for life-long learning.	College Seminar Series	All CCE 4830 students participate in at least 4 college-wide seminars.	100% of students participate in at least 4 college-wide seminars.
J 1. Graduates have knowledge of contemporary issues.	College Seminar Series or CCE 4830 Speakers	All CCE 4830 students participate in at least one seminar on a contemporary issue	100% of students participated in at least one seminar on a contemporary issue
J 1. Graduates have knowledge of contemporary issues.	CCE 4830 Contemporary Issues Paper	75% of students earn a C or better on the Contemporary Issue Paper.	100% of students earned a C or better on Contemporary Issue Paper.
L 3. Graduates are able to explain basic concepts in public policy.	CCE 4830 Public Policy Paper	75% of students receive at least a C or better.	85% of students received at least a C or better.
L 4. Graduates are able to explain basic concepts in leadership.	CCE 4830 Ethics of Leadership Paper	75% of students receive at least a C or better.	100% of students received at least a C or better.

TABLE 4: CCE 4850 Civil Engineering Outcomes and Assessment Data (2009-2010)

Program Outcome	Assessment Means	Metric	Spring 2010 Outcome
A 2. Graduates can apply knowledge of mathematics, science, and engineering.	CCE 4850 Senior project	75% students complete the design project with C or better.	100% of students completed the design project with C or better.
A 2. Graduates can apply knowledge of mathematics, science, and engineering.	CCE 4850 Senior project - Jury	At least 75% of all respondents agree with this statement.	100% of all respondents agreed with this statement.
C 1. Graduates can design systems, components, and processes to meet desired needs.	CCE 4850 Senior project - Jury	At least 85% of the project jurors agree with this statement.	100% of project jurors agreed with this statement.
C 1. Graduates can design systems, components, and processes to meet desired needs.	CCE 4850 Senior project	75% students complete senior project with a C or better.	100% of students completed senior project with a C or better.
D 1. Graduates can work as part of a design teams.	CCE 4850 Senior project	All students will work as part of design teams.	100% of students worked as part of design teams.
D 1. Graduates can work as part of a design teams.	Exit Interview	At least 80% of the students agree that all members of the team contributed to the final project	100% of the students agreed that all members of the team contributed to the final project
F 2. Graduates have an understanding of the importance of professional registration.	CCE 4850 Evidence of FE Sign-up or FE Result	100% of all graduating seniors have completed the Fundamentals of Engineering Examination or are registered to take it.	100% of all graduating seniors have completed the Fundamentals of Engineering Examination or are registered to take it.
F 2. Graduates have an understanding of the importance of professional registration.	Exit Interview	75% of graduating seniors indicate their intent to pursue PE registration.	100% of graduating seniors indicated their intent to pursue PE registration.
G 1. Graduates demonstrate effective oral communication skills.	CCE 4850 Senior Project - Jury	At least 75% of the jurors agree with this statement.	96% of jurors agreed with this statement.
G 2. Graduates demonstrate effective illustrative communication skills.	CCE 4850 Senior Project - Jury	At least 75% of the jurors agree with this statement.	100% of jurors agreed with this statement.
G 3. Graduates demonstrate effective written comm. skills.	CCE 4850 Senior Project	At least 75% students earn a C or better on the senior design project.	100% of students earned a C or better on the senior design project.
K 1. Graduates can use techniques, skills, and modern engineering tools necessary for engineering practice.	CCE 4850 Senior Project	75% of students complete senior design project with a C or better.	100% of students completed senior design project with a C or better.
L 1. Graduates are able to explain basic concepts in management.	CCE 4830/CCE 4850 Management Paper	75% of students receive at least a C or better.	88% of students received at least a C or better.
L 4. Graduates are able to explain basic concepts in leadership.	CCE 4830/CCE 4850 Leadership Paper	75% of students receive at least a C or better.	100% of students received at least a C or better.
L 4. Graduates are able to explain basic concepts in leadership.	CCE 4850 Organizational Structure Paper	75% of students receive at least a C or better.	100% of students receive at least a C or better.

TABLE 5: CCE 4830 Construction Engineering Outcomes and Assessment Data (2009-2010)

Program Outcome	Assessment Means	Metric	Spring 2010 Outcome
F 1. Graduates have knowledge of engineering ethics and ethical responsibility.	CCE 4830 Ethics Paper	75% students earn a C or better from the Ethics Paper.	100% of students earned a C or better from the Ethics Paper.
F 1. Graduates have knowledge of engineering ethics and ethical responsibility.	College Seminar and/or CCE 4830 Speaker/Video	100% of CCE 4830 students attend at least one college seminar and/or course speaker/video on ethics.	100% of students attended at least one college seminar and/or course speaker/video on ethics.
F 2. Graduates have an understanding of the importance of professional registration.	CCE 4830 Paper	75% of students earn a C or better on the PE registration paper.	100% of students earned a C or better on the PE registration paper.
G 1. Graduates demonstrate effective oral communication skills.	CCE 4830 Proposal	75% students earn a C or better on the senior design project proposal.	100% of students earned a C or better on the senior design project proposal.
G 3. Graduates demonstrate effective written communication skills.	CCE 4830 Proposal	75% students earn a C or better on the senior design project proposal.	100% students earned a C or better on the senior design project proposal.
H 1. Graduates understand the impact of engineering on society.	College Seminar Series and/or CCE 4830 Speakers	All CCE 4830 students participate in at least one seminar related to Impact of Engineering Solutions on Society.	100% of students participated in at least one seminar related to Impact of Engineering Solutions on Society.
H 1. Graduates understand the impact of engineering on society.	Impact Paper in CCE 4830	75% students earn a C or better in CCE 483 Impact of Engineering Solutions paper.	100% of students earned a C or better in CCE 483 Impact of Engineering Solutions paper.
I 1. Graduates understand and embrace the need for life-long learning.	Participation in Student chapter	At least 25% of the students in CCE 4830 participate in at least one ASCE chapter meeting.	100% of students in participated in at least one ASCE chapter meeting.
I 1. Graduates understand and embrace the need for life-long learning.	Participation in Regional Society Meetings	At least 15% of the students in CCE 4830 participate in one regional ASCE activity.	100% of the students in CCE 4830 participated in one regional ASCE activity.
I 1. Graduates understand and embrace the need for life-long learning.	College Seminar Series	All CCE 4830 students participate in at least 4 college-wide seminars.	100% of students participated in at least 4 college-wide seminars.
J 1. Graduates have knowledge of contemporary issues.	College Seminar Series or CCE 4830 Speakers	All CCE 4830 students attend in at least one seminar on a contemporary issue.	100% of students attended in at least one seminar on a contemporary issue.
J 1. Graduates have knowledge of contemporary issues.	CCE 4830 Contemporary Issues Paper	75% of CCE 4830 students earn a C or better on the Contemporary Issue Paper.	100% of students earned a C or better on the Contemporary Issue Paper.

TABLE 6: CCE 4850 Construction Engineering Outcomes and Assessment Data (2009-2010)

Program Outcome	Assessment Means	Metric	Spring 2010 Outcome
A 2. Graduates can apply knowledge of mathematics, science, and engineering.	Senior Project	75% students complete the design project with C or better.	100% of students completed the design project with C or better.
A 2. Graduates can apply knowledge of mathematics, science, and engineering.	Senior Project - Jury	At least 75% of all respondents agree with this statement.	100% of all respondents agreed with this statement.
C 1. Graduates can design systems, components, and processes to meet desired needs.	CCE 4850 Senior project - Jury	At least 85% of the project jurors agree with this statement.	100% of all respondents agreed with this statement.
D 1. Graduates can work as part of a design teams.	CCE 4850 Senior project	All students will work as part of design teams.	100% of students worked as part of design teams.
D 1. Graduates can work as part of a design teams.	Senior Exit interview	At least 80% of the students agree that all members of the team contributed to the final project.	100% of the students agreed that all members of the team contributed to the final project
F 2. Graduates have an understanding of the importance of professional registration.	CCE 4850 Evidence of FE Sign-up or FE Result	75% of graduating seniors have completed the FE Exam or are registered to take it.	100% of all graduating seniors have completed the Fundamentals of Engineering Examination or are registered to take it.
F 2. Graduates have an understanding of the importance of professional registration.	Exit interview	75% of graduating seniors indicate their intent to pursue PE registration.	100% of graduating seniors indicated their intent to pursue PE registration.
G 1. Graduates demonstrate effective oral communication skills.	CCE 4850 Senior Project - Jury	At least 75% of the jurors agree with this statement.	67% of jurors agreed with this statement.
G 2. Graduates demonstrate effective illustrative communication skills.	CCE 4850 Senior Project - Jury	At least 75% of the jurors agree with this statement.	100% of all respondents agreed with this statement.
G 3. Graduates demonstrate effective written communication skills.	CCE 4850 Senior Project	At least 75% students earn a C or better on the senior design project.	100% of students earned a C or better on the senior design project.
K 1. Graduates can use techniques, skills, and modern engineering tools necessary for engineering practice.	CCE 4850 Senior Project	75% of students complete senior design project with a C or better.	100% of students completed senior design project with a C or better.
L 7. Graduate can apply the knowledge of decision and optimization methods.	CCE 4850 Senior Project	75% of students complete Senior Design Project with a C or better.	100% of students completed senior design project with a C or better.

TABLE 7: Senior Capstone Design Exit Interview

#4	**During the Capstone Senior Design Courses (CCE 4830/4850), did you feel that your team worked cohesively and productively towards the successful completion of your project?**

Yes	No
14	

#4a	**If you answered 'yes' can you please elaborate on what were the positive interactions**
	As a group I felt we did a great job splitting up the work and then after completing the work explaining it as best as possible to other group members. We truly were a team with role players.
	Overall team effort was very high. My general impression is that those of us graduating are very interested in our careers and our future
	My team worked well together as we each brought different strengths to the group. We had also previously worked together, which proved very helpful
	We all worked toward on final project goal and helped each other.
	We divided the project up into parts and worked equally. The best thing is that we were able to communicate amongst each other regarding the project and successfully present our topics to a large group of people.
	A multi disciplined project helps all the members broaden their knowledge, and see how different disciplined interact with one another in a given project
	We came together to create a comprehensive design and produce an exceptional project
	Early project work and amazing cooperation on project, as well as understanding of extenuating circumstances
	Working with the sponsors came together well when it came down to completing work
	Everything, great team members, worked well to get her and reliable
	Team member talked to each other to distribute responsibilities and supported each other with their knowledge in the subject
	We all worked very well with one another. Each of us took our strengths and applied it to the area of the project.
	Given that we all had separate strengths, not only did we share knowledge but learned how to better the project in different ways than we were used to
#4b	**If you answered 'no' please indicate specific issues that your team dealt with and what actions you had to take to overcome those issues**
	Please add any comments or suggestions you might have that would make project teams more cohesive and productive
	Define someone in a group to be leader and that person will make sure everyone is doing their part to achieve the project goal. They will give updates to John and they will be the one's to take blame if others are not getting the job done. Might add a new dynamic.

Encourage/Facilitate "team building" based on strengths and weaknesses
Maybe offer group building activities early on
Have more reference material for students to use, such as AASTHo, AISC, ASTM, and other applicable.

#5	**Please rate your overall experience with the Capstone Senior Design course sequence**

Low				High
1	2	3	4	5
			7	7

Please give comments and suggestions you have to improve your overall experience with the program
Having interned with our sponsor the previous year was definitely a benefit. I got to do a project and found I have true passion for transportation design. I don't really have a suggest other than try to make sure students get a project that truly have a passion for.
More direction on project presentation and report. Possibly make report more part of CCE4830
Dr. Hu, as our faculty advisor, was very helpful w/design. We had trouble with our sponsor not responding to questions in timely manner and not understanding that we were not at all experienced in the design. However this may prove helpful in an entry level position.
When seeing what previous projects used as far as software, incorporate those into our electives instead of CTT Math Cad. Such as SAP 2000, & actual teacher for traffic software
A would have preferred more site visits rather then lectures
More variety in the available projects relating to all areas within civil engineering.
Give more tutorials for programs we may use during the projects
More team-study orientated senior design lab. Cubicals really do help the situation
Perhaps a more intensive first half (4830)

Summary and Conclusions

In summary, industry and community involvement is the key. An Industry Advisory Board that has members that are committed to the development of a strong CCE curriculum and have a passion for the civil and construction engineering profession is imperative. Their commitment and enthusiasm also carries over to others industry organizations and candidate projects are submitted. It is important to have a faculty member with experience in industry practice, as we have here at WMU, to take advantage of professional contacts and experience to solicit even more candidate project. Having a faculty member that has ties and contacts with the regional civil and construction engineering industry is invaluable to the success of the program.

As we have mentioned throughout the paper, a course assessment process in essential to continually monitor and enhance the program. Formal feedback is acquired from the annual program review process as well as the course review process performed each semester. Feedback

is also collected from each sponsor, the faculty advisors and students, on a regular basis, throughout the semester. All feedback collected is then taken into consideration at our program assessment retreats. Recommendations from the retreat are reviewed at our quarterly IAB meetings and final recommendations are set for implementation.

Because these are real life projects and we are emulating real life project development engineering, setbacks can occur from changes made by the client that the effected team will need to resolve. We had one situation which changed the scope of a project at the beginning of the second semester. That project team was able to move forward and was able to develop the revised project on time and within the parameters the client assigned. That is real world engineering. Some other success stories from our program have been community projects. One of the teams project was a non-motorized facility in the Kalamazoo area. They presented their project once for the jury and once at a community meeting with 30 people and they made the front page of the local news paper with a positive article praising the efforts. The city will use their design in a future project. We have had other community project such as flood management system for Holland Township, MI completed by our students that have been presented to drain commission boards and community action groups. Real world projects in real life situations to make our student market ready for the engineering profession.

Further success stories include the reconstruction of Balch street in Kalamazoo sponsored by the City of Kalamazoo Public Services Department. The team for this project developed a set of plans that showed existing road conditions and locations of utility lanes and pipes. Using recycled pavement, the group came up with a new pavement design, repaired damaged sidewalks and replaced existing sidewalk ramps to meet ADA standards. The project team also created a construction schedule, cost estimation and a safety and mobility plan that can be used by the City of Kalamazoo when the project gets underway. Design of a wastewater collection system project sponsored by the Wightman & Associates, Inc. was to check the design that was near the start of the construction phase. The sponsor asked the student team to come up with a better design that they had already come up with. The team was able to come up with three different designs for the wastewater collection system, one of which was the same design the sponsor had originally planned. The student team was able to confirm the sponsor's design was the most economical and was able to confirm this with researched facts.

TABLE 8: Senior Design Project Sponsors and Description during 2009-2010 Academic Year

Sponsor	Title	Student Team	Description
Michigan Department of Transportation	I-94 at county road 652	4	Interchange Traffic Congestion.
City of Kalamazoo	Balch Street	4	Urban Road Reconstruction.
DLZ	Bridge of Railroad	4	New concrete grade redesign and bridge over CN railroad.
Hurley & Stewart	Site Development	3	Expansion of trade center. Commercial development with four story office tower.
Fleis & Vandenbrink	Historical Bridge relocation	4	Relocating I-94 bridge for pedestrian use on new abutments.
Miller Davis	St. Thomas Moore Construction	3	Construction documents and staging plans for a church to remain operational during active construction.
FTC&H	Inter County Drain	4	Feasibility study of flood mitigation system in Holland, MI.
Whiteman & Associates	Design of a Wastewater Collection System	4	Design of wastewater collection system for small lake township.
Ford Yacht Club	Yacht Club Seawall Replacement	4	Seawall and dock replacement for improved service. Feasibility and cost estimate.

Finally, by the use of real world projects with real clients/sponsors, teams are able to present themselves as quality engineers to these prospective employers. This exposure to industry and other agencies during their project is very valuable after graduation as a contact for job opportunities. There were 5 students, out of 34, that were hired by industry partners from a senior design project team in the 2010 graduating class.

References

1. J.S. Norback, E.M. Leeds, K. Kulkarni. (2010) "Integrating an Executive Panel on Communication info an Engineering Curriculum" IEEE Transactions on Professional Communication. New York: Dec 2010. Vol. 53, Iss. 4; pg. 412.
2. M. C. Paretti. (2008) "Teaching Communication in Capstone Design: The Role of the Instructor in Situated Learning" Journal of Engineering Education. Washington: Oct 2008. Vol. 97, Iss. 4; pg. 491, 13 pgs.
3. J. S. Lamancusa, J. L. Zayas, A. L. Soyster, L. Morell, J. Jorgensen.(2008) "The Learning Factory: Industry-Partnered Active Learning" Journal of Engineering Education. Washington: Jan 2008. Vol. 97, Iss. 1; pg. 5, 7 pgs.
4. Accreditation Board for Engineering and Technology (ABET) inc. Criteria for Accrediting Engineering Programs, 2009-2010 Review Cycle, http://abet.org/forms.shtml.
5. http://www.ethicana.org/

WESTERN MICHIGAN UNIVERSITY
College of Engineering and Applied Sciences
Department of Civil and Construction Engineering

APPENDIX A

Date

Sponsor Agency Address
City, State Zip

RE: Sponsorship of WMU's Senior Capstone Design Factory

Dear Sponsor,

Thank you so much for agreeing to sponsor a project for Western Michigan University's Senior Capstone Design Factory. It is industry folks like you that will be shaping the minds of our future engineers. Your willingness to participate shows your commitment to the quality of our profession. It is our hope you're your commitment to this important program will last many years and we can count on your participation in years to come.

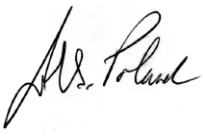
In addition to having quality projects, it is also our goal to be very respectful of the sponsors' time. We have attached a detailed overview of our Capstone Design Factory including a detailed schedule.

The timeline in the schedule shows that we need the projects returned by August 24, 2009. We will then work with you directly to review and revise the project scope as needed. This will ensure that the student teams have the right information to be successful and criteria for the Accreditation Board for Engineering and Technology (ABET) and the University's goals are met.

The culmination of this year's Capstone Design Factory will be the presentations by each team on April 20, 2010. Sponsors are encouraged to attend.

Thank you again for your time and I hope this is the beginning of a long-term relationship. Please feel free to contact me at (269) 276-3210 or my cell at (269) 491-3533

Sincerely,



John S. Polasek, PE
Department of Civil and Construction Engineering
Western Michigan University
1903 W. Michigan Ave.
Kalamazoo MI 49008-5316

Capstone Design Factory

Overview

Currently the Accreditation Board for Engineering and Technology (ABET) requires all graduates to undertake a "capstone" design project which requires students to apply their knowledge and experience toward real-world projects in a team-oriented environment. In the Civil and Construction Engineering (CCE) curriculum, the Capstone Design Program is implemented in a two-course sequence. The first course covers the project definition, planning, scheduling, and control techniques. The second course deals with project design, analysis, and implementation. These courses result in a Capstone Design Project where the students produce a working design, written report, and oral presentation.

Industry Involvement

The CCE Department has established a Capstone Design Factory that will be a University-Industry partnership in which industry participates in the students' education to help produce highly-qualified civil and construction engineers. This will be accomplished through the integration of design, construction, and business realities in an active learning environment. These real-world problems will meet state-of-the-art modeling, analysis, and design tools in a modern facility that gives the students an experience that directly prepares them for careers in civil and construction engineering, with general problem solving abilities. Industry involvement is an essential component of the Capstone Design Factory. In fact, this program is in response to the industry demand for graduates who are well trained in engineering fundamentals, as well as professional skills to effectively compete in today's market place, such as teamwork, project management, cross functional networking, communications and design. The development of our facilities and curricula would be overseen and guided by our Industry Advisory Board (IAB). The IAB members come from a variety of industries and are willing to contribute their time, money, and provide guidance, mentorship, and student job opportunities to make this program a success

Sponsor Benefits

Industry partners directly benefit from this partnership by

- Availability of well-prepared graduates who understand the design and construction process
- Opportunities to evaluate potential employees through internships, collaborative projects and classroom interactions
- Direct assistance in design problems through sponsorship of senior design projects
- Professional development of industry personnel through teaching and curriculum development
- Technology transfer through Industrial-Academic exchanges--industry engineers in the classroom, and faculty internships in industry
- Opportunity to influence and improve the education of civil and construction engineers well into the century

Additional direct benefits to the industry partners from the Capstone Design Factory include:

- Fresh ideas, solutions to real problems
- Low cost, low risk investigation of "back-burner" ideas
- Identifying talent for employment
- Corporate exposure on campus
- Project management experience for junior staff engineers
- Contributing to engineering education at Western Michigan University
- The mental stimulation of interacting with bright, energetic, creative young minds
- Networking with other companies and Western Michigan University faculty

Sponsor Expectations: Spring Semester

A successful Capstone Design Project requires the sponsor to be actively involved by assigning a motivated individual to interact with the student throughout the duration of the project. First, this requires the sponsor to fill out the Capstone Design Factory Project Submission Form with as much detail as possible. Then the individual projects will be reviewed by faculty. Next, the teams will choose a project and meet with the sponsor to discuss details of the project. Finally, the sponsor and students will hold routine progress meeting (approximately one to two hours per week) to discuss the current status of the project and give guidance.

Date	Activity
8/24	Projects back from sponsor
8/24-9/14	Review and revise projects as needed with sponsors
9/14	Projects available to teams
9/28	Project selections due from teams
9/28-10/9	Scoping meetings with sponsor

During the remainder of the fall semester and the spring semester, students will develop a final proposal for the project and begin regular meetings with sponsors to develop deliverables. Teams will continue to work on the projects until the Senior Capstone Design Factory Projects Presentations on April 20, 2010

Capstone Design Projects: Parameters and Constraints

Requirements vary from project to project but in general contain the following:

CONSTRUCTION ENGINEERING

- The proposed projects should have more than 200 activities. Upcoming or recently completed industrial, commercial, and highway projects are examples of projects.
- Students should be able obtain the plans and specifications of the projects
- The following is a suggested list of tasks which the students need to complete during their capstone design experience:
    - Work Breakdown Structure (WBS)
    - CPM Network Plot/Reports
    - Detailed Estimate (Labor, Equipment, Material, Overhead, Contingency, Profit)
    - Construction Methods, Detail and Design
    - Project Management System (Data Collection, Safety Plan, Reports)
- Technical Report
- Oral Presentation

CIVIL ENGINEERING

- The proposed projects should incorporate at least two focus areas of study (Construction, Environmental, Geotechnical, Transportation and Structure)
- The following is a suggested list of tasks which the students are expected to complete during their capstone design experience:
    - Planning and site development
    - Modeling and analysis
    - Design and detail different components
    - Environmental and Transportation issues related to the proposed project
- Technical Report
- Oral Presentation

Capstone Design Factory Project Submission Form

Sponsor Information:

Company/Agency Name: _____

Address: _____ City: _____ State: _____ Zip: _____

Contact Person: _____

Phone: _____ E-mail Address: _____

Project Title:

_____

Project Description (please attach additional pages if necessary):

_____

_____

_____

_____

Project Details (location, existing information, etc.):

_____

_____

_____

_____

Proposed Project and Constraints (traffic, environmental concerns, construction methods, etc.):

_____

_____

_____

_____

Project Deliverables (Site plan, drawings, quantities, estimation, schedule, etc.):

_____

_____

_____

_____

APPENDIX B

CAPSTONE SENIOR DESIGN PROJECT PROGRAM

CCE4830 – PROJECT DESIGN AND CONTROL

PROPOSAL GRADING SCALE

Project: _____

Team Members: _____

Criteria	Possible Points	Points Received

Understanding of Project
• Content
• Organization of thoughts
• Grammar
• Projects Details
  o Constraints
  o Significance (environmental, social, etc.)
  o Other factors (to show owner)
	20	

Scope of Work
• Identifying elements of project work
  o Content and details (thoroughness)
  o Organization of elements
  o Grammar
	20	

Deliverables
• Proper identification
  o Consistent with scope
  o Includes presentation and report
• Appropriate detail
• Organization of deliverables
	20	

Production Work Schedule
• Identification of tasks (detail)
• Schedule detail
• Inclusion of the 3 elements
  o Project scope and deliverables
  o Presentation
  o Final report
• Organization of plan
	30	

Team Members
• Team structure details
  o Roles
  o Strengths
  o Operation
• Contact information
• Organization of details
	5	

Resources • Appropriate identification of resources	5	
Total	100	

APPENDIX C

CCE 4850 – SENIOR PROJECT
LECTURE BRIEFING PAPERS GRADING SCALE

Grading Scale (0-10)
- Content (0-4)
- Organization (0-3)
- Mechanics (0-3)

	4	3	2	1	0
Content (0-4)	Strong Central Idea. Appropriate Writing Level	Central Idea that is not well developed. Appropriate writing level.	Mention of a central idea. Appropriate writing level.	Mention of a central idea. Not at an appropriate writing level	No central idea. Not at an appropriate writing level.
Organization (0-3)		Ideas clearly presented in a logical order	Ideas loosely follow a logical order	Ideas randomly presented and tend to follow no outline	Ideas not clearly presented and follows no outline
Mechanics (0-3)		Free of spelling and grammatical errors. Good sentence structure.	Minor spelling and grammatical errors. Good sentence structure.	A few spelling errors. Poor sentence structure.	Numerous spelling and grammatical errors. Poor sentence structure.

APPENDIX D

Western Michigan University
Department of Civil and Construction Engineering
John S. Polasek, PE
Instructor
CCE4850 – Senior Project
Jury Assessment and Evaluation Form – Fall 2010

Project

Team Members

Team Project Assessment (please circle response):
Rating Range; 4 = Strongly Agree to 1 = Disagree

1. Team members demonstrated knowledge of mathematics, science, and engineering through their project design:

4 3 2 1

Comments:

2. Team members demonstrated ability to design a system, component or process within their project design: 4 3 2 1

Comments:

3. Team members demonstrated the ability to formulate and use engineering models and construction management tools:

4 3 2 1

Comments:

4. Team members demonstrated effective oral communication skills (presentation):

4 3 2 1

Comments:

5. Team members demonstrated effective graphical and written communication skills (presentation content): 4 3 2 1

Comments:

Best Senior Project Rating: Project relates to an issue with social, economic, environmental or infrastructure implications, service learning and demonstrates great potential for the "Best Senior Project" award:

4 3 2 1

Comments:

APPENDIX E

Senior Capstone Design Factory

Final Report Outline and Content

Outline

- Acknowledgements
- Introduction
- Body of Report (make sure to have tables and figure with proper captions and citations)
- Conclusions/Summary
- References (standards, codes, specs, guides, etc.)
- Appendices (only relevant materials, i.e. calculation sheets, copies of relevant codes, etc.)

Example Construction Engineering Reports

- Acknowledgements
- Background and Overview
    - Description of project and background
    - Scope of work
    - Deliverables
- Body of Report
    - Engineering Analysis
        - Methods Used
        - Options Analyzed
        - Discussion of Results
    - WBS
        - Discuss a sample and list the details in appendix
    - Scheduling
        - Construction Methods
        - Equipment List/Production Rates
        - Crew Sizes
        - CPM Tabular Reports
    - Estimating
        - Summary Tabular Estimates (details in appendix)
    - Project Management System
        - Data Collection
        - Reports
        - Safety Plan
- Summary and Conclusions
    - Deliverables accomplished
    - Recommendations
    - Actual conclusions vs. assumptions
- References
- Appendices
    - Detailed WBS figure
    - Estimating Sheets
    - Detailed Design Calculations
    - Structural Analysis Software Outputs
    - Transportation Simulation Software Outputs

Example Civil Engineering Reports

- Acknowledgements
- Background and Overview
    - Description of project and background
    - Scope of work
    - Deliverables
- Body of Report
    - Engineering Analysis
        - Methods Used
        - Options Analyzed
        - Discussion of Results
    - Structural Design
        - Design Assumptions/Considerations
        - Load Calculations Summary (details in appendix)
        - System/Material Selection
        - Design Steps
        - CAD Drawings
        - Staging
    - Transportation Design
        - Traffic Analysis/Simulation and Summaries (details in appendix)
        - Pavement Design
        - Staging
        - Geometretric
        - Capacity Analysis
- Storm Water Consideration
    - Environmental
        - Storm Sewer/ culvert design
- Summary and Conclusions
    - Deliverables accomplished
    - Recommendations
    - Actual conclusions vs. assumptions
- References
- Appendices
    - Construction Staging
    - Critical Path
    - Cost Estimate
    - Detailed Design Calculations
    - Structural Analysis Software Outputs
    - Transportation Simulation Software Outputs
    - Storm Sewer/culvert Design Calculations
    - Pavement Design Calculations
    - Geometrics Design Calculations
    - Capacity analysis

Senior Capstone Design Factory
Criteria for Grading Final Report

Project: _____

Team Members: _____

_____

Evaluator: _____

Criteria	Possible Points	Points Received
Organization • Report was presented in a clear, organized format	20	
Spelling and Grammar • Report is free of spelling and grammatical error • Correct sentence structure • Appropriate writing level	5	
Content and Details • Sufficient explanation of project work • Sufficient engineering analysis • References to tables, charts, figures, etc.	30	
Quality of Visual Aids • Graphs, spreadsheets, drawings, figures, etc. are clear and add clarity to report	10	
Summary and Conclusions • Deliverables accomplished • Recommendations • Actual conclusions vs. assumptions	35	
Total	100	

APPENDIX F

Civil and Construction Engineering

Senior Exit Interview

1. To what level did the curriculum allow you to achieve the following program outcomes:

Understanding of and the ability to apply knowledge of traditional mathematics, differential equations, calculus-based physics, science, and engineering skills.	1 2 3 4 5
Able to design and conduct experiments, as well as analyze and interpret data in more than one Civil Engineering disciplines.	1 2 3 4 5
Can design systems, components, and processes to meet desired needs.	1 2 3 4 5
Can work in design and project management teams.	1 2 3 4 5
Able to identify, formulate, and solve engineering problems	1 2 3 4 5
Understand professional and ethical responsibilities.	1 2 3 4 5
Able to communicate effectively.	1 2 3 4 5
Understand the impact of engineering on society.	1 2 3 4 5
Understand and embrace the need for life-long learning	1 2 3 4 5
Have knowledge of contemporary issues	1 2 3 4 5
Can use the techniques, skills, and modern engineering tools.	1 2 3 4 5
Able to explain basic concepts in management, business, public policy and leadership.	1 2 3 4 5

2. Please indicate the elective courses that added most value to your education.

Courses you did not take please indicate N/A

	Low High	
4340 Hydraulics	1 2 3 4 5	N/A
4350 Hydrology	1 2 3 4 5	N/A
4360 (civil program only) Construction Estimating, Bidding and Cost Control	1 2 3 4 5	N/A
4380 (civil program only) Construction Project Management	1 2 3 4 5	N/A
4450 Design Of Steel Structures	1 2 3 4 5	N/A
4500 Reinforced Concrete Design	1 2 3 4 5	N/A
4550 Design of Steel Structures II	1 2 3 4 5	N/A
5300 Construction Project Delivery Systems	1 2 3 4 5	N/A

5310 Advanced Construction Project Management	1 2 3 4 5 N/A
5400 Transportation Planning	1 2 3 4 5 N/A
5560 Foundation Design	1 2 3 4 5 N/A
5610 Waste Water System Design	1 2 3 4 5 N/A

3. What additional specialty areas and extended course offerings in existing specialty areas you would like to see in the program, please list potential titles.

Construction	
Environmental	
Structures	
Transportation	
Additional Specialty Areas (Please list):	

4. During the Capstone Senior Design Courses (CCE4830/4850), did you feel that your team worked cohesively and productively towards the successful completion of your project?

Yes	No

4.a If you answered '**yes**' can you please elaborate on what were the positive interactions

- -

- -

- -

4.b If you answered '**no**' please indicate specific issues that your team dealt with and what actions you had to take to overcome those issues:

- -

- -

- -

Please add any comments or suggestions you might have that would make project teams more cohesive and productive:
_ _

5. Please rate you overall experience with the Capstone Senior Design course sequence:

Low High

1 2 3 4 5

Please give comments and suggestions you have to improve your overall experience with the program:
_ _

6. What was your level of participation in student professional organizations.

Low High

ASCE	1 2 3 4 5
AGC	1 2 3 4 5
ITE	1 2 3 4 5
SWE	1 2 3 4 5
EWB	1 2 3 4 5
Other (Please indicate)	1 2 3 4 5

7. Are you planning on becoming a registered professional engineer (PE)?

Yes	No

7.a What is your assessment of why you believe you should become registered? Choose the most significant reason or add a reason

Potential for promotion		
Higher salary		
My job will require a PE		
Professional recognition		
Essential for protecting public safety and health		
Other		

8. Rate the overall effectiveness of the Academic Advising during your education based on following questions. Also include comments if you like.

Low High

Adviser availability	1 2 3 4 5
Adviser responsiveness	1 2 3 4 5
Accuracy of Adviser recommended curriculum	1 2 3 4 5
Faculty availability for career advising	1 2 3 4 5
Other (please specify):	1 2 3 4 5

Please add additional comments on Advising and Advisers:
_ _

9. Will you be starting graduate program immediately after graduation

Yes	No

If not, do you have plans to pursue graduate education in the near future	
Yes	No

10. Please include any other issues this survey should address.

11. Please provide additional comments regarding the program that will be useful for us to incorporate in our assessment for future changes.