Mini-Capstone Final Project Implementation and Assessment

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Abstract

The students at Youngstown State University (YSU) are required to complete two courses, Specifications and Estimating (CCET 3711) and Hydraulics and Land Development (CCET 3724) at the end of the associate's program. Professor Sanson instructs the Specifications and Estimating course and Professor Korenic instructs the Hydraulics and Land Development course and have combined the final project of these two courses into a mini-capstone. This paper will describe how the mini-capstone project has been developed, the instruction the students receive in each of the courses, how the students implement the instruction in the capstone project, and the components that make up the project.

The outcomes detailed and assessed in this paper are based on student performance and pertain to how well the students work as a team. Also assessed are how well each student was able to implement concepts learned in each class, which include estimating various aspects of a real construction project as well as their ability to determine the storm water volume quantities, specify erosion and sedimentation control measures, and design an appropriate storm water detention structure. The culminating event of the project is a professional oral presentation in which the students compile their findings of each aspect of the mini-capstone project.

1. Specifications and Estimating (CCET 3711)

The CCET 3711 syllabus course description is as follows: fundamentals of interpreting and understanding specifications for materials and methods. Estimating material, equipment and labor costs for construction projects.

The CCET 3711 course objectives are

- Understand how typical construction specifications are set up using the Construction Specifications Institute (CSI) categories.
- Ability to develop an organized format for quantity takeoffs, apply prices, and prepare a project estimate.
- Identify the different types of estimates and discuss the pitfalls and legal implications of each.

The students entering this course have no prior estimating experience and are not required to have any experience. The first two to three weeks of the semester are spent instructing the

students the following subject matters to help understand the bidding and estimating process.

- Contracts, bonds, and insurance
- Specifications sections
- Estimate components
- Overhead and contingencies

After the students have been exposed to the above components of an estimate, then labor productivity, equipment, and material costs are discussed. The students are instructed to set up a proper estimating spreadsheet that will aid in future assignments and projects. The students are now ready to look at each division of the construction of a project, starting with excavation and then following the usual construction steps. Each of the following divisions are instructed on proper quantity take-offs, materials, labor productivity, and equipment requirements:

*Concrete	*Masonry
*Metals	*Wood
*Thermal and moisture protection	*Doors and windows
*Finishes	

The students are assigned problems for each of the above division to prove they have mastered the proper estimating skills for each of the divisions.

2. Hydraulics and Land Development (CCET 3724) Requirements

The Hydraulics and Land Development course is broken into four distinct units that the students are required to learn:

- The land development process: includes an overview of all of the constituents necessary to develop, design and implement a successful construction project. These include the project owner, architect, engineers, economists, community leaders, utility companies, construction manager, and general contractor. The students must understand that in order to develop and implement a project many people are included to make it a success.
- Site grading and cut and fill calculations: the ability to grade the site correctly and sustainably as well as calculate cut and fill volumes by hand and with AutoCAD Civil 3D. Most students taking this course have already taken or will take Civil 3D concurrently.
- Techniques of open channel flow hydraulics: once the site is graded, the students then study traditional open channel flow hydraulic techniques for calculating the area of channel necessary, the wetted perimeter, hydraulic radius, and friction losses in earthen and manmade channels. The continuity equation, the Bernoulli quation as well as the Darcy-Weisbach equation in conjunction with the Moody diagram and Jain-Swamee equation are used.
- Calculation of storm water volumes using the modified rational method, natural resource conservation (NRCS) method and unit hydrograph method are used to calculate accurate storm water volumes. These methods require the use of weighted land use statistics for runoff quantities indicating if the site is primarily undeveloped and the subsequent developed site. Furthermore, they must calculate the area and volume of any storm water retention facility necessary. Hydraflow Express is used to facilitate the pond design.

3. Mini-Capstone

The mini-capstone project has been developed over the past eight years as a collaboration between the CCET 3711 and the CCET 3724 courses. The instructors of each course determined the combination of the final project would be a good exercise to prepare the students for their final senior capstone course. The CCET 3711course includes determining the cost estimate and construction of a commercial building, and the CCET 3724 course includes the required land development and hydrology for a construction site.

4. CCET 3711

The students in CCET 3711 are required to complete two projects during the semester, with the second project being the mini-capstone. The projects are group projects consisting of no more than four students in a group. Each student is required to perform at least one division of the take-off and may collaborate with another student in another division. The students are required to submit the project in a bound professional report. The report must include at a minimum of the following information: the required bid forms with all blanks filled in and signed (replicating a public bid submission), spreadsheets of quantities for each division, hand calculations, and subcontractor/material quotes. The group must present the project conclusions and estimate describing to the potential clients why their estimate is the lowest and best bid to construct the project.

The first project the CCET 3711 students must complete and submit is an estimate for a commercial garage/office building. The project is set up to mimic a real public construction bid. The students are provided an Invitation to Bid document that outlines the requirements of the project. The invitation to bid outlines where each group can obtain copies of the plans and specifications, bid date, and the pre-bid conference date and time (which is usually the next class meeting). The students are required to have copies of the plans and any questions they may have regarding the project plans and specifications at the pre-bid conference. Should the groups have any questions for clarification regarding the project after the pre-bid conference, they must submit a request for information (RFI) through the Blackboard message board. The instructor utilizes the Blackboard message board so everyone can see the questions being asked and the response. The students are required to determine the quantities of the required materials to construct the project along with material pricing for each of the quantities. Labor cost is not included in the first project. For certain items do not have material cost, such as excavation of the footer or clearing of the construction site, students must provide the required quantity to perform the operation. The students are required to request material quotes from local material suppliers, and the instructor will also provide quotes for certain items. The students have one week to compile the cost estimate and must follow the required bidder information instructions for submission for the date and time. The groups are given score reductions on a late submission and if the bid forms are not correctly filled out and submitted (non-responsive bid). The groups are graded on the professionalism of the report submitted, how close each individual group is to the instructor’s estimate, and each individual group member is graded on the divisions that were their responsibility. Project #1 provides the students a preview of what is required for the mini-capstone project. The students are provided feedback on the performance of the project to assist in the preparation of providing an excellent mini-capstone submission.

The CCET 3711 portion of the mini-capstone portion consists of a project that was constructed in the local Youngstown, Ohio, area. The project is a new cemetery chapel constructed of concrete, masonry, and wood. The project consists of CSI divisions 3 thru 10. The project costs consisting of subcontracted electric, plumbing, and HVAC work are provided as quotes from the instructor. The students are given the option to retain the groups from the first project but are permitted to change groups if they would like. Most retain their original groups. The mini-capstone is set up similar to the first project outlined above, except this time the groups are required to estimate the labor cost required to construct the project.

Labor costs are determined through the productivity rates provided from the textbook or sources such as RS Means. The students are required to estimate an item from the project, such as the concrete floor, from the quantity (square foot of floor) they use a productivity rate such as 0.05 hrs./Sf. The students obtain how many hours is required to complete the construction of the concrete floor and use an hourly labor rate provided for the project.

The groups are required to utilize the spreadsheets they developed from the first project to bring the material, labor, equipment, and subcontractor costs together in an organized manner. The spreadsheets are to be organized by the CSI divisions.

5. CCET 3724

The groups of students described in the CCET 3711 section above are also tasked to grade the site and perform cut and fill calculations. This consists of drawing proposed contours in order to allow the storm water to travel to the outlet structure or retention pond. They must also calculate site cut and fill where they indicate if the site is balanced (equal cut and fill) or if soil must be brought to the site or taken off site if there is excess. Finally, the students must use either the modified rational method or the NRCS method to calculate storm water runoff volumes for several storm intervals. We typically ask for the 2-year, 5-year, 10-year and 25-year volumes to be calculated. We then use the critical storm method to identify detention pond release rates. Students are permitted to use Hydraflow Express, which is part of the AutoCAD software to verify their calculations and to help them size the pond. The Mahoning County or Trumbull County *Drainage Criteria and Storm Water Manual* is the primary resource used for all land use constants as well as rainfall intensity values required to use the rational method or NRCS method.

This course sequence typically is taken in the final semester of the AAS degree. While this is not the terminal degree for most students, this project offers a student who does not pursue the BSAS degree the opportunity to work on an all-encompassing project similar to one encountered in practice. It is worth noting that because this course sequence is in the AAS portion of the degree and following with ETAC ABET criteria that the students are not required to be assigned open-ended projects. Therefore, in each portion (CCET 3711 and CCET 3724) significant guidance is given regarding the scope of the work required as well as appropriate design and analysis constants in order for the students to have success in theoretical and practical calculation techniques. This follows directly the findings of Kotys-Schwartz, Knight and Pawlas, who state: “This research is an investigation of the growth of professional and technical skills in students throughout their undergraduate career, with a goal of targeting an appropriate curriculum structure to facilitate development. Given the ABET engineering accreditation criteria, and

industry expectations for entry-level engineers, it is imperative to understand and identify the most effective curricular organizations for cultivating professional engineers" [1].

6. Statistical Relevance

To assess the effectiveness of the CCET AAS mini-capstone in preparing students for the BSAS capstone, several years of survey data have been tabulated. Below are the final assessment data from two semesters of AAS capstone and BSAS capstone ETAC-ABET assessments. The CCET 3711 and 3724 data listed below is to be compared with BSAS capstone data in which students in the AAS portion then completed the BSAS portion. In this way, we can draw a parallel between student developments early in the academic career with the same students in their final semester. A discussion of the data will follow.

Table 1. Final assessment data

2015 YSU CCET 3711 & 3724 assessment data				
Student #:	**Category 1**	**Category 2**	**Category 3**	Data taken from a representative sample of student surveys from each team.
1	4	4	3	
2	3	4	3	
3	4	3	4	
4	4	3	2	
5	3	3	3	
6	4	3	4	
7	4	3	4	
8	3	3	2	
9	4	3	2	
10	4	3	4	
Total:	37	32	31	
Average:	3.7	3.2	3.1	

2016 YSU CCET 3711 & 3724 assessment data				
Student #:	**Category 1**	**Category 2**	**Category 3**	Data taken from a representative sample of student surveys from each team.
1	4	3	3	
2	3	3	4	
3	3	3	2	
4	2	3	3	
5	3	3	3	
6	3	3	3	
7	3	3	2	
8	3	3	4	
9	4	4	3	
10	3	3	4	
Total:	31	31	31	
Average:	3.1	3.1	3.1	

Category 1: Individual Technical Contribution
Category 2: Individual Leadership Contribution
Category 3: Teamwork

Metrics 1 through 9 listed in Table 2 are ETAC-ABET assessment categories for BSAS programs and are listed in the appendix to this report.

Table 2. ABET assessment data

ETAC-ABET - Outcome a - An appropriate mastery of the knowledge,											
techniques, skills, and modern tools of their discipl											
CCET 4884 - Fall 2017											
Final Design Project											
	Metrics										
	1	2	3	4	5	6	7	8	9		Total
Team											
Team 1 (BMW)											
Evaluator 1	3	3	3	3	3	3	3	3	3		27
Evaluator 2	3	3	3	3	3	3	3	3	3		27
Evaluator 3	3	3	3	3	3	3	3	3	3		27
Evaluator 4	3	3	3	3	3	2	3	3	3		26
Evaluator 5	3	3	3	3	2	2	2	2	2		22
Evaluator 6	3	3	3	3	3	2	3	3	2		25
Average (normalized)	**3.00**	**3.00**	**3.00**	**3.00**	**2.83**	**2.50**	**2.83**	**2.83**	**2.67**		**2.85**
Team 2 (Construct-it)											
Evaluator 1	2	2	3	3	2	2	3	3	3		23
Evaluator 2	3	2	3	3	3	2	2	3	3		24
Evaluator 3	3	3	3	3	3	3	3	3	3		27
Evaluator 4	3	2	3	3	2	2	2	3	2		22
Evaluator 5	2	3	2	2	2	2	2	2	2		19
Evaluator 6	3	3	3	3	3	3	3	3	3		27
Average (normalized)	**2.67**	**2.50**	**2.83**	**2.83**	**2.50**	**2.33**	**2.50**	**2.83**	**2.67**		**2.63**
Team 3 (Phoenix)											
Evaluator 1	3	3	3	3	2	3	3	3	3		26
Evaluator 2	3	3	3	3	2	2	2	3	3		24
Evaluator 3	3	3	3	3	3	4	4	4	4		31
Evaluator 4	2	3	3	3	3	2	2	3	1		22
Evaluator 5	4	4	4	4	4	4	4	4	4		36
Evaluator 6	3	3	3	3	3	3	3	3	3		27
Average (normalized)	**3.00**	**3.17**	**3.17**	**3.17**	**2.83**	**3.00**	**3.00**	**3.33**	**3.00**		**3.07**
Class Average =	**2.85**										

TAC-ABET - Outcome a - An appropriate mastery of the knowledge,											
techniques, skills, and modern tools of their discipl											
CCET 4884 - Fall 2018											
Final Design Project											
	Metrics										
	1	2	3	4	5	6	7	8	9		Total
Team											
Team 1 (DR3)											
Evaluator 1	2	2	2	2	2	2	2	2	2		18
Evaluator 2	4	3	3	3	3	3	3	2	2		26
Evaluator 3	3	1	3	3	2	1	2	3	1		19
Evaluator 4	3	2	3	3	2	1	2	3	2		21
Evaluator 5	3	3	3	3	3	3	3	3	3		27
Evaluator 6	3	2	2	2	1	2	4	4	1		21
Average (normalized)	3.00	2.17	2.67	2.67	2.17	2.00	2.67	2.83	1.83		2.44
Team 2 (Damn Near Eng.)											
Evaluator 1	3	3	3	3	2	3	3	3	3		26
Evaluator 2	4	3	4	3	3	3	3	3	4		30
Evaluator 3	3	2	3	3	2	2	3	3	2		23
Evaluator 4	4	3	3	3	3	4	3	3	4		30
Evaluator 5	3	3	3	3	3	3	3	3	3		27
Evaluator 6	3	3	3	3	4	4	4	4	3		31
Average (normalized)	3.33	2.83	3.17	3.00	2.83	3.17	3.17	3.17	3.17		3.09

Class Average =	2.77

7. Conclusions/Data Analysis

Comparing the AAS capstone data with the BSAS data reveals the following:

- The AAS data was gathered by student evaluations of themselves and the other members of their team, which tends to garner higher values.
- Using much more stringent criteria in the BSAS portion lent itself to a lower class average. This is due to the students plans and calculations are graded and judged by a panel of industry professionals instead of by themselves.
- A level of at least 2.5 is considered the benchmark of a good score (all scores normalized to 4). In each case the class average exceeds that figure.
- The professional panel written evaluations have, since the development of the AAS capstone, consistently improved, indicating the completeness and accuracy of the student work has improved.

References

[1] Kotys-Schwartz, Knigh, Pawlas. *First – Year and Capstone Design Projects: Is The Bookend Curriculum Approach Effective for Skill Gain?* 2010 ASEE Annual Conference & Exposition, June 2010.

Biographical Information

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