



Project based capstone course in an undergraduate

Dr. George D Ford, Western Carolina University

Dr George Ford P.E. is an associate professor in the Construction Management Department at Western Carolina University.

Dr. Aaron K. Ball, Western Carolina University

Dr. Aaron K. Ball

Dr. Aaron K. Ball is currently a full Professor of Engineering Technology at Western Carolina University in Cullowhee, North Carolina. Dr. Ball holds a B.S. and an M.S. from Appalachian State University, and earned his doctorate from Virginia Polytechnic Institute and State University. Prior to his arrival at Western Carolina University, Dr. Ball worked in production engineering at Chicago Telephone Supply and Vermont American Corporation. He has been active in working with manufacturers and distributors in developing automation and training programs in fluid power, quality, and automation. Dr. Ball teaches Design of Experiments (DOE) and Advanced Quality Design and Control in the Master of Science in Technology program. He also directs graduate students working on thesis and Automation, Fluid Power, Reverse Engineering and Quality Control at the undergraduate level.

Prof. Sungho Tae, School of Architecture & Architectural Eng., Hanyang Univ., Ansan, Korea

Dr. Sungho Tae is an associate professor at Hanyang University, Korea. He received his Ph.D from University of Tokyo in 2005. Dr. Tae has focused his research on development of sustainable building materials, building LCA program, development of sustainable durability design system and building optimum design technology. He was a research professor of Sustainable Building Research Center (ERC). He is a board member of the International Sustainability Council (ISC). And he is also a member of Journal Editorial Committee of Korea Concrete Institute, Committee of Korea Industrial Standards Commission (ISO TC 184/SC 5), ISO/Fairness Committee, Journal Editorial Committee of Architectural Institute Korea, Green Store Institution Committee and Green Building Certificate Deliberation Committee of Korea Environmental Industry Technology Institute.

Michael E. Smith Ph.D., Western Carolina University

Michael Smith is Department Head and Joe W. Kimmel Distinguished Professor of Construction Management at Western Carolina University.

A project based capstone course in an undergraduate construction management program

Abstract: The undergraduate Construction Management program in the College of Engineering and Technology at Western Carolina University is 124 credit hours in duration and is accredited by the American Council for Construction Education (ACCE). The program currently has 138 students enrolled as majors and emphasizes estimating and scheduling skills. The program includes a construction capstone project course which students complete in their last semester. This paper discusses the evolution of the Capstone course at Western Carolina University, the positive contributions of the course to the program, and lessons learned from past offerings.

The capstone course serves many purposes for the Construction Management program and students. The course is a simulation of a general contracting construction project from obtaining work through the estimating, bidding, scheduling, and cash flow projections using plans and specifications provided by an Advisory Committee company. The learning objectives are to:

1. Develop managerial and ethical skills as they relate to an actual project.
2. Prepare complete detailed estimate and specification analysis.
3. Prepare complete detailed construction schedule.
4. Prepare construction contracts, project manuals and project administration documentation.
5. Develop work package and project start-up procedures.
6. Understand and utilize construction resources & databases.
7. Prepare and deliver a professional presentation.
8. Provide an independent assessment of individual student skills and knowledge.

A project binder is completed by each student during the last week of the semester which provides a summary of their work for grading.

In addition to the educational objectives of the course, there are other, non-curriculum goals. All Advisory Committee members are invited to the final group presentations. Advisory companies are interested in recruiting the best students. The presentations provide an opportunity for these companies to scout the graduating class for potential hires. In turn, students often obtain jobs, a win for both parties. All capstone students are also required to sit for the American Institute of Constructors (AIC) Associate Constructor (AC) exam providing a benchmark for program assessment. Lastly, all Capstone students are provided exit interview forms which provide additional program assessment data plus potential alumni information.

Background

Western Carolina University (WCU) is located in western North Carolina near the border with Tennessee. The campus is in a rural, mountain setting. Outdoor activities are a favorite pastime of many students who attend WCU. Currently a little more than 10,000 students are enrolled at the University. The Construction Management (CM) program is housed in the College of Engineering and Technology. The program currently has 138 students enrolled as majors and emphasizes estimating and scheduling skills. Twenty-five to thirty students graduate from the program annually. The program is a relatively young one, started in 2001. The CM program is 124 credits hours in duration and is accredited by the American Council for Construction

Education (ACCE). Senior students enroll in the Construction Capstone course, CM-452, in their last semester before graduation.

In a time of governmental spending cuts, technology program administrators need to synergize their efforts to serve several purposes. The capstone course at WCU provides for student learning, student employment and program assessment. The literature contains a multitude of articles about technology capstone courses, specifically student learning, employer involvement, outcomes and assessment. Purdue recently included team formation activities and practitioner participation in their civil engineering capstone courses (Barry, Drnevich, Irfanoglu and Bullock, 2012). Green design and sustainability are also mentioned in the literature (Wolcott, Brown, King, Barnstone, Beyreuther and Olsen, 2011). The current WCU capstone does not provide specific sustainability and green building assignments but will need to include sustainability as it is one of the 20 new ACCE learning objectives. Learning outcomes development (Thambyah, 2011) and best practices (Dougherty and Parfitt, 2013) are other areas recently reported in the literature.

The Capstone course in the CM program at Western has been a part of the program for many years, and for many years was stagnant. The same project was used for several semesters continuously. Students often worked little on their project until the last weeks of the semester because assignments were all due at the end of the semester. A strategic integration of the course into the assessment process was not done. Advisory Committee members were not routinely involved with students and the program. The following sections describe the evolution of the course, and demonstrates the need to continuously improve delivered programming.

Discussion

The current capstone course is a simulation of one general contracting construction company project from obtaining work through the estimating, bidding, scheduling, and projecting cash flow functions associated with a typical commercial construction project using plans and specifications provided by an Advisory Committee company. All students work on one assigned building project individually. The learning objectives of the Capstone course are to:

1. Develop managerial and ethical skills as they relate to an actual project.
2. Prepare complete detailed estimate and specification analysis.
3. Prepare complete detailed construction schedule.
4. Prepare construction contracts, project manuals and project administration documentation.
5. Develop work package and project start-up procedures.
6. Understand and utilize construction resources & databases.
7. Prepare and deliver a professional presentation.
8. Provide an independent assessment of individual student skills and knowledge.

Student course evaluations have been used to adjust various aspects of the course to ensure learning objectives are met each semester. For instance, in one semester, construction plans were provided to students in an electronic format (.PDFs) instead of traditional paper plans. Course surveys indicated that electronic format only was unaccepted, and that paper plans would better assist successful completion of estimating assignments.

A project binder describing the chosen project is completed by each student during the last week of the semester which provides a summary of their work for grading. A course schedule is shown in the Appendix. All weekly assignments are added to the students' project binders. Grading is completed as the assignments are submitted by students, so that student progress may be monitored by the course instructor.

In addition to the educational objectives of the course, there are other, non-curriculum goals. All Advisory Committee members are invited to the final group presentations. Advisory companies are interested in recruiting the best students. The presentations provide an opportunity for these companies to scout the graduating class for potential hires. In turn, students often obtain jobs, a win for both parties. All Capstone students are also required to sit for the American Institute of Constructors (AIC) level 1 Associate Constructor (AC) exam providing a benchmark for program assessment. Lastly, all Capstone students are provided exit interview forms which provide additional program assessment data plus potential alumni information.

The capstone project has been developed, revised and modified over the years. Faculty and program administration turnover resulted in an inconsistently administered, but generally effective end of program course. Initially the course was more oriented to project management and presentation skills. After benchmarking several Associated Schools of Construction (ASC) programs, the faculty decided to include estimating and scheduling assignments and eventually to include AC exam materials. Most recently, Advisory Committee members have been asked to provide projects for the course, and to participate in the student final proposal presentations to enhance the experience for students by acting as potential customers for the subject project.

Accreditation

The CM program is accredited by the ACCE. Re-accreditation was achieved during 2014. The capstone course has been used to close the loop in assessment for the program through a Senior Exit Survey of capstone students in addition to the end of course survey. The Senior Exit Survey measures the perception of each student of the degree to which program learning objectives had been met. The same survey was used for five years, and the measured student perceptions suggested program objectives were met. The survey will require revision to adopt the new ACCE accreditation program outcome criteria:

“Upon graduation from an accredited ACCE Bachelor Degree program, a graduate shall be able to:

1. Create written communications appropriate to the construction discipline.
2. Create oral presentations appropriate to the construction discipline.
3. Create a construction project safety plan.
4. Create construction project cost estimates.
5. Create construction project schedules.
6. Analyze professional decisions based on ethical principles.
7. Analyze construction documents for planning and management of construction processes.
8. Analyze methods, materials, and equipment used to construct projects.
9. Apply construction management skills as a member of a multi-disciplinary team.
10. Apply electronic-based technology to manage the construction process.
11. Apply basic surveying techniques for construction layout and control.

12. Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
 13. Understand construction risk management.
 14. Understand construction accounting and cost control.
 15. Understand construction quality assurance and control.
 16. Understand construction project control processes.
 17. Understand the legal implications of contract, common, and regulatory law to manage a construction project.
 18. Understand the basic principles of sustainable construction.
 19. Understand the basic principles of structural behavior.
 20. Understand the basic principles of mechanical, electrical and piping systems.”
- (ACCE, 2015)

The new Senior Exit Survey will be administered online using Qualtrics in the fall semester of 2015. A Likert scale (1-5) will be used to measure student perceptions from “Fully Met” to “Not Met”. Statistics will be generated each semester to establish an artifact to support the ongoing assessment program.

Presentations

Students must individually assemble their project proposal binders, but are formed into teams to give presentations during the final week of class to simulate a formal project proposal. The presentations are used (or will be used) by program administration to demonstrate achievement of several educational objectives. A rubric (obtained from Business College faculty) is provided to the Capstone students and also posted on the Blackboard website. An example is provided at the conclusion of this paper. It was decided last year (2014) to videotape the presentations on a digital video recorder to create another assessment artifact. These recordings are kept on a mainframe network for archival storage. In addition, Advisory Committee representatives and the CM student body have been invited to the presentations adding to the realism of the presentations.

The rubric, expanded audience, and videotaping of the presentations have improved the presentation experience for capstone students. In the past, many students felt that the presentations were unimportant to graduation. They only count 10% of their final grades. Their attitude was that they would not be failed for poor presentation performance, and they were, to a large extent, correct. The thought of embarrassing themselves in front of their underclass peers or potential employers has substantially increased the quality of the presentations in the instructor’s and program faculty’s opinions.

American Institute of Constructors Exam

The American Institute of Constructors (AIC) Associate Constructors Exam has been administered to all graduating seniors in their last semester since about 2008. The average pass rate for WCU CM seniors is about 23%. In order to pass, a score of 210 out of 300 points must be achieved. The WCU CM faculty hopes to increase the pass rate of capstone students on the AC exam to 33% and improve the average score of all students to 195. Previous study of WCU student performance indicated that potentially a 40% increase in the average WCU student AC scores is possible (Ford, Kinard and Sims, 2012).

There are programs like the Weber University in Ogden, Utah which require students to score a minimum score on the AC Exam as graduation requirement (Weber State, 2015). The CM faculty at WCU do not require students to pass the exam prior to graduation. In the last few years, several students have registered for the exam, which is required, but did not actually sit for the exam. The AC exam score was recently given grade weight in the capstone syllabus, and during the current semester will count as much as 50% of students' grades. The formal objective is to show improvement in students' scores, not necessarily increase the pass rate, although the hope is to improve pass rates.

Student evaluations

All capstone students are required to complete a final exit interview form in addition to a course evaluation. The form has changed over the years, and for 2013 was shortened to a basic employment survey to address previous ACCE recommendations produced during the most recent assessment cycle. The exit surveys from the fall semester 2011 through the fall semester 2014 were reviewed for inclusion in this paper. One hundred and seven students completed surveys during the review period. Forty-five percent of the 107 students reported that they had at least one job offer before graduation. During 2014, all graduating seniors had at least one job offer before graduation. The construction job market seems to be improving.

Prior to the fall semester, 2013, when the exit survey was administered in person, it was seven pages and included Likert scale rated questions on employment, course satisfaction, faculty, student advising, facilities, and program outcomes. Space was provided on the survey for open ended questions in each area. Review of the Likert ratings did not reveal any significant trends. Ratings generally reflected students were satisfied with the courses taken, faculty, advising, facilities and program outcomes. However, qualitative answers to the open ended questions indicated strong opinions toward:

1. Professor instructional quality. 78% of graduating seniors included comments about instructional quality. Most seniors were very pleased with instructional quality. There were negative comments about instructional quality by 12% of the seniors.
2. Career advising and career fairs were mentioned by 25% of graduating seniors as effective and important.
3. The WCU student Construction Management Club was rated as important by nearly all respondents in the sample.

One notable finding was that many of the students attended Western due to the cheap tuition. Western is currently among the lowest priced universities in the University of North Carolina System. Several students (20%) also mentioned a need for an AIC exam preparation course and also for a building information modelling (BIM) course (5%).

The current exit survey will need to be expanded to address learning objectives as discussed previously, instructional quality, and student advising to meet the new ACCE standards. The online formatted exit survey in Qualtrics provides ready statistics and artifacts which will support re-accreditation.

Lessons learned

The primary objective of the capstone course is to provide an exceptional learning experience for students. The course content includes several elements as discussed previously, but the emphasis is on estimating and scheduling. Spreadsheets are currently provided to students to provide pricing and duration guidance. Final project pricing and schedules are submitted by the student on an Excel spreadsheet. In the past, all manner of software was used by the students such as Microsoft Project and ProEst, but students were not proficient with the software they used. As a result, a great amount of time was spent troubleshooting software and providing instruction to students, so that student proficiency in estimating jobs was never really determined. Even when a specific software was stipulated to be used, electronic aged students depended too much on software to do an estimate. They did not understand the program inputs in many cases. Ensuring that each student performed their own estimates was also challenging. Using a standard costing spreadsheet and a standard duration spreadsheet reduces grading time and encourages each student to do their own work.

Another lesson learned concerned the Associate Constructor exam. Students did not put significant effort into preparation for the exam. The current grading scheme weights the exam score more heavily than in the past. In the currently running course, the AC exam will count up to 50% of students' grades. Improving student scores on the AC exam is consistent with providing enhanced learning experiences for students because many parts of the exam are not formally covered in classes, and program assessment may be continuously monitored using the standardized exam.

In the past, binders were assembled by each student using materials they presumably produced during the semester. No assignments were graded until the end of the semester. As a consequence, many students were not able to complete an acceptable proposal binder, and copying between students was an issue. In addition, the same project would be used for several semesters, so students needed only to find a binder completed in a previous semester to copy. Different projects are now chosen each semester which cuts down on unauthorized group work, but consumes a huge amount of instructor's class preparation time, and each week assignments are graded, so students' progress may be monitored.

Industrial Advisory Committee members are invited to speak to classes speaking on the subjects taught reinforcing the instructional material provided. Students respond well to individuals they feel may be potential employers. In addition, instructors are given a chance to update themselves through professionals presenting to their classes.

Conclusion

This paper discussed the evolution of the Capstone course at Western Carolina University, the positive contributions to the program, and lessons learned from past offerings. Near future employment forecasts are favorable to construction managers as there could be a shortage of civil engineers according to recent research (Ford and Ball, 2011), so students will hopefully desire attending WCU's CM program. Recent placement of graduating Capstone students has been nearly 100%. The course will continually evolve based upon Industrial Advisory Committee and faculty recommendations, student evaluations and assessment needs.

Administrators and faculty who provide programming for construction and building students and who do not have a capstone project might consider adding a project oriented capstone course to their programs. A set of drawings of a real project, the project specifications and a detailed quantity and pricing take-off are needed as a minimum. An original schedule and the final as-built schedule of the project is also helpful. Industrial advisory committees are a good source for these materials. The project should be one which represents the program. Programs containing commercial building emphasis should provide a commercial building capstone projects, residential programs should provide residential projects, for instance. Student response to the Capstone course has been generally positive, the program's Industrial Advisory Committee is more involved with the program, and the Capstone course has been integrated into the program assessment processes to meet the new ACCE objectives based criteria. Additional benefits may be realized.

Bibliography

American Council for Construction Education, (2015). Document 103, Standards and Criteria for Accreditation of Postsecondary Construction Education Degree Programs. Retrieved on January 24, 2015 from: http://www.acce-hq.org/images/uploads/Doc_103_OBS_final_103114.pdf

Barry, B., Drnevich, V., Irfanoglu, A., and Bullock, D. (2012). Summary of developments in the civil engineering capstone course at Purdue University. *Journal of Professional Issues in Engineering Education & Practice*, 12(1), pp 95-98.

Dougherty, J., and Parfitt, M. (2013). Student and practitioner collaboration in an online knowledge community: Best practices from a capstone course implementation. *Journal of Architectural Engineering*, 19(1), pp 12-20.

Ford, G. and Ball, A., (2011). The evolution of engineering and engineering technology educational programs in the United States. Conference proceedings of the American Society of Engineering Educators. Vancouver, BC, Canada .

Ford, G., Kinard, C., and Sims, B. (2012). Measuring educational program effectiveness using the Associate Constructor Exam. *Journal of Technology, Management and Applied Engineering*, 28(1), pp 2-7.

Thambyah, A. (2011). On the design of learning outcomes for the undergraduate engineer's final year project. *European Journal of Engineering Education*, 36(1), pp 35-46.

Weber State University website, (2015). Retrieved on January 24, 2015 from: http://www.weber.edu/CMT/CMT_Sidebar/ACCE_Accreditation.html

Wolcott, M., Brown, S., King, M., Barnstone, D., Beyreather, T., and Olsen, K. (2011). *Journal of Professional Issues in Engineering Education & Practice*, 11(4), pp 94-101.

Appendix

Construction Capstone Course Schedule CM-452 Spring 2015

| Date | Topic | Assignment(s) |
|------------------|------------------|---------------------|
| Week 1, Jan 14 | Business Plan | Business Plan |
| Week 2 | Spec Takeoff | Spec Takeoff |
| Week 3 | Quantity Takeoff | Quantity Takeoff |
| Week 4 | Quantity Takeoff | Quantity Takeoff |
| Week 5 | Quantity Takeoff | Quantity Takeoff |
| Week 6 | Quantity Takeoff | Quantity Takeoff |
| Week 7 | QT/Start Pricing | QT/Pricing/Advising |
| Week 8 | Pricing | Pricing |
| Week 9, March 11 | Spring Break | Spring Break |
| Week 10 | Pricing | Pricing |
| Week 11 | Scheduling | AIC |
| Week 12, April 1 | No Class | Scheduling |
| Week 13 | Documents | Documents |
| Week 14 | Documents | Documents |
| Week 15 | Presentations | Presentations |
| Week 16 | Binders Due | Presentations |
| Week 17, May 6 | Final Exam Week | |

CM-452, Construction Capstone, Presentation Rubric

Name: _____

| | Unacceptable [6] | Acceptable [8] | Exemplary [10] | Score (1-10) |
|---|---|---|---|-------------------------|
| Organization | Weak or no introductory statement | Adequate introductory statement | Strong introductory statement | |
| | Weak or no logical progression | Adequate logical progression | Strong logical progression | |
| | Weak or no concluding statement | Adequate concluding statement | Strong concluding statement | |
| Projection | Barely audible or inaudible | Mostly audible | Consistently audible | |
| Delivery | Little or no energy and enthusiasm | Some energy and enthusiasm | Considerable energy and enthusiasm | |
| Eye Contact | Makes little or no eye contact with the audience | Makes eye contact with limited group of the audience | Makes eye contact with all the audience | |
| Gestures | Rarely uses gestures or uses gestures that distract from the verbal message | Sometimes uses gestures to reinforce verbal message | Consistently uses gestures to reinforce verbal message | |
| Pace | Consistently too fast or too slow | Fairly consistent with some portions too fast or too slow | Consistent pace, not too fast or too slow | |
| Gap fillers (“um” “uh” “like” “you know” etc.) and distractions (such as gum chewing, pen tapping, playing with hair or clothing) | Gap fillers interfere with message | Some gap fillers but minimum interference with message | Very few gap fillers | |
| Appearance | Presenter looks as if s/he just rolled out of bed. | Clothing is “college casual” – jeans or athletic wear, T-shirts, flip-flops, etc., but clean and free of rips or tears; | Presenter is dressed in professional business attire and well-groomed | |
| TOTAL | | | | |

