

Re-engineering Bowling Green State University's Construction Management Capstone

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Abstract

An internal review of Bowling Green State University's Construction Management program revealed shortcomings which were inconsistent with the University's aim for high student engagement. After interviewing faculty and industry partners, analyzing students' historical performance on a third-party skills test, and reviewing student feedback, instructional methods were revised for the capstone course. Revised instruction methods focused on lectures and discussions, problem based learning assignments, and testing and were intended to 1) better prepare students for their transition to industry, 2) instill life-long learning principles and 3) incorporate an objective measure of student performance into the program's curriculum development process. Currently in their second cycle, the revised instructional methods for the capstone course also were designed to increase student-instructor interaction and student engagement, and focus on students' preferred learning styles. The revised methods have resulted in an increased breadth and complexity of problem-based learning assignments and an apparent improvement in third-party test results. This paper is believed to offer a new perspective on an integrated instructional approach and the use of third-party testing as an objective measure in the program's curriculum development process

Introduction

Bowling Green State University (BGSU) is among the top universities and colleges in the United States for student engagement, according to rankings by the Wall Street Journal and Times Higher Education (Belkin, 2016). A recent internal review in the BGSU Construction Management program indicated that student engagement did not quite meet BGSU's high standards. In 2006, the Bowling Green State University (BGSU) Construction Management program began participating in the American Institute of Constructors' (AIC) skills testing, which provides objective assessments of students' construction management skill sets. Over the last ten years, BGSU students' performance on the AIC examination has been erratic, ranging from near to below national averages. In recent years (2013- 2016), BGSU's performance fell consistently below the national average. The reasons for this decline, according to program

faculty, staff, and students, included marginalization of the capstone course in the curriculum, lax enforcement of course prerequisites, inconsistent exam weighting, and student apathy. The substandard results appeared not to be due to insufficient student engagement outside of the classroom, given that the program offers three cooperative education opportunities, inter-collegiate student academic competitions, and an active industry advisory board. Rather, it seemed that there was room for improving student engagement in program coursework.

Student engagement is associated with student retention (Astin 1993, 1999) and may help instill students' drive to gain new knowledge (Kuh, 2007). Astin (1993, 1999) found that frequent student-faculty interaction is more strongly related to student satisfaction in college than any other type of involvement. Lin and Tsai (2009) and Holt et al. (2007) observed that engineering students valued a learning environment that was student-centered, peer-interactive, and teacher-facilitated, and favored both classroom and laboratory instruction. Chen et al. (2008) echoed Astin's (1999) call for educators to be more focused on student engagement, advocating high levels of faculty engagement in the design, revision, and improvement of undergraduate engineering programs, and teaching that effectively addresses students' cognitive and affective states of mind. Kolb's (2015) life-long learning concepts have transformed the traditional structure of the classroom through "real world" experiential learning methods which compliments and enhances project-based learning (PBL) with the perspective that "all learning is relearning" (Kolb and Kolb 2005).

Capstone courses that include term-length, group PBL assignments have long been a staple of many construction management programs, including BGSU's (Todd et al. 1995, Dutson et al. 1997, McKensie 2004, Howe and Wilbarger 2006 and Pembridge and Parretti 2010). While the

details of these courses vary, a common goal of each is to prepare students to assume construction engineering and management responsibilities in real-world situations. A second common element is that each includes open-ended, collaborative, PBL assignments that are meant to mimic real-world conditions. Many of these programs have been in place and evolved for decades, in some cases more than 50 years (Drnevich 2001). Capstone courses are seen as a means to address what many report are deficiencies in new graduates' soft skills of critical thinking, problem solving, and teamwork (Mahasneh and Thabet 2015, Barlow 2011). While capstone courses offer many benefits to students, they also require a greater level of effort and commitment from faculty than do other construction management courses (Todd 1993, Dutson et al. 1997, McKenzie 2004, Howe and Wilbarger 2006, Jonassen et al. 2006, Abdelhamid, 2003, Hanna and Sullivan 2005).

BGSU's construction management program has included a senior-level capstone course since near the beginning of the program in 1976. The BGSU capstone course has involved holistic PBL assignments that mimic real-world circumstances and require students to draw upon the skills and knowledge from their academic training. The student learning objectives for the capstone course include most of the program's twenty American Council for Construction Education accreditation learning objectives, which, in addition to topics covered in the AIC examination, include written and oral communication, ethics, legal issues, engagement in multi-disciplinary teams, employment of electronic based technology, project delivery methods, sustainability, and risk management. BGSU's capstone course is reserved for graduating seniors, with class sizes typically ranging from 12 to 32 students. Prior to enrollment, students should have completed the bulk of their coursework, including planning and scheduling and estimating and cost control.

This paper outlines an assessment of the program's previous instructional approach, describes the development and implementation of instructional improvements, and reports on results to date. This case study may serve as a useful example for other programs in their efforts to advance student achievement.

Assessment of Instructional Approach

Instructional practices in the BGSU program over the past ten years were explored through: 1) interviews with current and former faculty members to identify strengths and weaknesses and to generate ideas for program development; 2) discussions with members of the construction management industry advisory board and cooperative education organizations about relevant projects that might serve as good PBL assignments and the assets and deficiencies of recent BGSU graduates and; and 3) examination of test results from the AIC Associate Constructor Exam for graduating seniors.

Current and former faculty highlighted a need for redesigning PBL small groups in the capstone course to overcome students' silo mentalities, prevent free riders, and promote student persistence. Faculty also recommended expanding program emphasis on particular topics, such as budgeting and job cost management. The industry advisory board indicated that new graduates' communications skills and readiness for industry roles could be improved and raised questions about the extent to which real world conditions were reflected in coursework. During the decade of AIC testing, graduating seniors showed erratic performance and had relatively low scores in communications, job cost management, and planning and scheduling. The three strands

of assessment together suggested improvements for revising the capstone course and developing the program curriculum.

Development of Instructional Improvements

Instructional methods for the capstone course were redesigned to increase student engagement and persistence. Faculty workshops conducted by BGSU's Center for Faculty Excellence and the literature provided ideas on new approaches to adopt. Two priorities guided the redesign: student success in the PBL assignments and third-party skills testing. The latter allowed students to display the expertise they acquired and the program to measure its effectiveness objectively. Changes to the course focused on lectures and discussions, PBL assignments, third-party testing, and evaluations. These changes were introduced in the Fall 2016 and Spring 2017 semesters.

Lectures and discussions

Class periods were split between formal lectures and weekly small group work/progress sessions. This approach was hoped to instill beneficial lifelong learning practices. Formal lectures were sequenced according to the stages of construction projects (prequalification, the bid process, construction planning, execution, and project closeouts). The AIC study guides, recognized construction management texts, and industry examples were used as a foundation for these lectures.

During formal lectures, the instructor sought to stimulate student discussion, soliciting examples from the students' cooperative education experiences and prior knowledge, and liberally offering industry examples. Students' cooperative education experiences, such as time coding time cards, were helpful in illustrating the benefits of job cost controls and estimating future work. Industry

case studies and photos were particularly useful in bringing the real-world challenges to the classroom. Class discussions and debates both revealed students' strengths and weaknesses and facilitated their understanding of construction management practices. To jump start the PBL assignment, the class was engaged in planning charrettes employing the Gilbane Card Trick (Associated General Contractors, 1994), where students in small groups played the roles of owner, engineer, contractor, key subcontractors, and other stakeholders for the development of a schedule - identifying work activities, estimating construction durations, and defining the sequence of activities and their schedule. Active class discussions explored a variety of topics, such as the contractor's engineering responsibilities, ethics, fast-tracking, the competitive low-bid process, and whether ownership of "float" resided with the contractor or owner.

One class period each week was dedicated to small group discussions in a "flipped" classroom where students were encouraged to take ownership in developing their construction management skills. The discussion sessions included short progress meetings on each group's efforts on their project-based assignments where the instructor served as a coach, subject matter resource, or task master, as needed, to ensure the timely and complete delivery of the PBL submission. Working sessions afforded students the opportunity to provide informal submissions of portions of their PBL assignments for discussion and cursory reviews. The small group working sessions also served as a means for the instructor to assess student learning and amend instructional approaches, as needed. Students were encouraged to provide agendas and document high points of each discussion.

Project-based Learning Assignments

The literature on PBL assignments in engineering education suggested several features to adopt. Instructors often select and monitor PBL projects in concert with industry contacts (Anderson and Mourgues 2014, Al-Tabtabi 2014), and the assignments typically involve written and oral communication components, in addition to the basic deliverables of cost estimates, plans, schedules, project controls, and guidelines for safety and ethics. Other PBL assignment objectives and evaluation criteria include teamwork (Achor and Achor 2000, Brickell et al.1994, Hackbert 2004, Pocock 2016), leadership (Mills and Beliveau 1999, Barlow 2011), and creative problem solving (Jonassen 2006, 2011, Williams and Pender 2002). Anderson and Mourgues (2014) recommended that projects should be broad, with architectural, environmental, structural, equipment, legal, estimating, planning and scheduling, and management components. Pournaghshband (1990) cautioned that projects must be sufficiently complicated that a group effort is required.

The earlier version of the BGSU capstone course involved a single PBL assignment. However, given the diversity of students' career interests, the revised version of the course now has two PBL assignments: a design-bid-build heavy civil project and a concept level, design-build mixed use commercial development (which involved electrical, mechanical, and heating, ventilation, and air conditioning components). The facilitating or coaching role of the instructor enabled students to handle two complex projects in the course.

The first PBL assignment was an Ohio Department of Transportation (ODOT) bridge project selected in consultation with ODOT's regional office. The instructor formed project teams of 3-5 students largely based on the students' self-assessments and interests, while being sensitive to the needs of under-represented groups in the construction industry. This size of teams approximates

the optimal project group size for addressing the needs of the assignment and preventing “free riders,” and maximizing team effectiveness (Griffin et al., 2004). The student’s self-assessments and interests were gauged both to balance the group based on skill levels and special interest (e.g., employment with mechanical and electrical subcontractors). Members of underrepresented groups in construction, such as women, were teamed in a manner so their voices would be heard (Borrego et al. 2013, Paretto et al., 2011).

Teams had about eight weeks to submit a prequalification statement, bid submission, baseline schedule, risk analysis, job hazard analysis, and detailed work plan, which included their equipment selection. Students were also required to provide an “escrow bid document” as a narrative explanation of the group’s assumptions and basis for their bid and schedule submissions. The ODOT project allowed students to display their skills in communication, cost estimation, safety, construction engineering, planning and scheduling, and project administration, as well as their attention to detail for the prescribed submission requirements. The “flipped” classroom coaching sessions revealed some shortcomings in groups’ communications and understanding of responsibilities (including silo mentalities). These issues were subsequently discussed in weekly class periods – with an emphasis on students’ checking their teammates’ work prior to submission. In the case of risk management, a Construction Industry Institute implementation tool (CII IR 280) was introduced and shared with students for their use (Construction Industry Institute 2012).

The second PBL assignment was a concept-level, mixed-use development project. A local developer provided representative project plans, and information was also shared on locations adjacent to the proposed development. The project involved new construction on a site that first

required demolition of an abandoned building. The project also entailed addressing a number of high-level design considerations ranging from the campus architectural design requirement, Leadership in Energy and Environmental Design (LEED), emergency power, fire protection, and sound proofing measures. The size of the development was left to the students' discretion based on the prevailing zoning requirement and experiences of a nearby comparable development. Deliverables for this assignment were similar to those of the first PBL assignment.

Third-Party Skills Testing

The AIC, Level I - Associate Constructors Examination addresses ten topical areas, including 1) communications, 2) engineering concepts, 3) management concepts, 4) materials, methods, and project modeling and visualization, 5) bidding and estimation, 6) budgeting, cost, and control, 7) planning and scheduling, 8) safety, 9) geomatics (surveying), and 10) project administration. In prior capstone courses, instructors offered review sessions of each of the topical areas and offered an in-class practice quiz a few weeks prior to the AIC exam. In the revised course, the PBL assignments were used to underline fundamentals of the AIC exam. The AIC's examination study guides were also provided to each student with the intent that students would prepare for the examination outside of class time.

Like other millennials, BGSU students challenged the relevance of the third-party testing to their academic program, questioning why they should invest the time to prepare for the examination which they perceived had limited industry recognition and historically played an uncertain part of their grade. In the re-energized capstone class, it was emphasized that the exam's ten topical areas were extremely relevant to prospective employers. The AIC exam itself was scheduled to occur between the two PBL projects, which made the test a sort of "recess exercise."

In the initial revised class in Fall 2016, weeks before the scheduled examination, a practice quiz was given with sixty-five multiple choice questions taken from the AIC study guide and recognized construction management texts. In the Spring 2017 course, a 94 question on-line sample AIC quiz was give. In both cases, the results showed that several students were not adequately prepared for their upcoming examination. It also revealed additional areas in need of improvement, particularly planning and scheduling and project cost controls. These shortcomings were addressed in class discussions and a series of electronic based practice quizzes, where the correct responses were provided at the completion of each test module to aid students in their preparation process. Students were also counseled on test-taking strategies, including the need to read carefully each question and corresponding response choices. Students cited these electronic quizzes as one of their best tools in preparing for the examination. Many of the quizzes' prescribed "best answer" responses generated periodic lively discussions in class. Students also mentioned these "debates" as being of significant value for exam preparation. Similar on-line testing tools have been developed by AIC and other sources. Although there are over sixty schools that participate in the AIC third party testing, including some that link testing to construction management capstone courses, the author, in consultation with the AIC, was unable to identify any related writings (Sapp 2017).

Evaluations

Student performance was evaluated on the two PBL assignments (25% each), skills assessments (primarily the AIC test) (40%), and class participation (10%). Although the assessment of PBL assignments was potentially subjective, the comparison of BGSU's performance on the AIC examination was indexed to the national averages and served as an objective measure. Grading

criteria for the PBL assignments were based on 1) an assessment of the group submission and individual efforts, 2) preparedness and discussions in weekly progress meetings, and 3) students' self-, peer- and team-assessments. Student assessments focused on the student's and each teammate's contributions to the deliverables, a student's understanding of the assignment, a student's strengths, and lessons learned. Feedback was also sought on how the PBL and class discussions could be improved. Skills assessments were indexed to the national average of the participants from sixty universities who took the same examination. Class participation was based on a student's overall engagement, including attendance and active participation in class and PBL group discussions.

Results to Date

The AIC Level 1 examination has been administered since 1996 nationwide and since 2006 at BGSU. In 2016, 1,546 students from 60 universities sat for the examination (Sapp 2017). The shift to a more active, project-based learning approach coincided with a marked improvement in BGSU students' scoring on the AIC exam as illustrated in Figure 1.

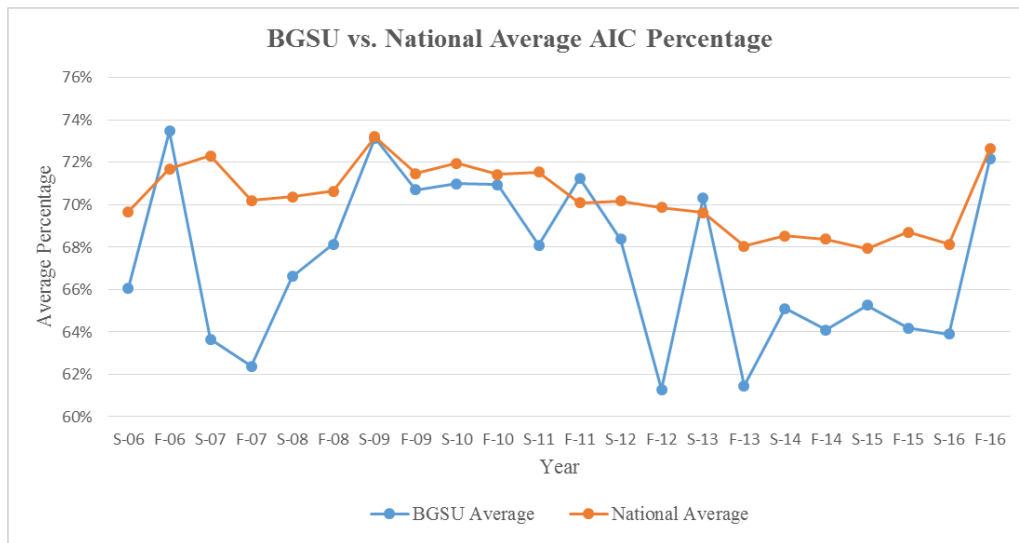


Figure 1 – Comparison of BGSU Construction Management students' historical performance (average score) on the American Institute of Constructors, Associate Constructors Exam to the national average of students from 60 participating universities.

BGSU's average scoring increased by 8.2% with gains in nine of the ten AIC subject areas. Gains in excess of 10% were recorded in six of the ten areas, including Bidding and Estimation (21.8%), Geomatics (Surveying) (18.2%), Material Methods and Project Modeling and Visualization (14.1%), Communications (11.6%), Engineering Concepts (10.7%), and Budgeting, Cost, and Control (10.2%). The sole area where BGSU students did not record an improved score was safety (-3.2%), mirroring a decline in the safety section's national average. Although the national average also increased in nine of the ten subject areas, BGSU scores outpaced the national averages by roughly 5% in each area. This improvement is reflected by an increase of more than 25% in the 3-year floating average. In two scoring areas, Communications and Planning and Scheduling, the 2016 class had the highest scores recorded since BGSU began participating in the examination. In six other subject areas BGSU students recorded their highest scores since 2011 or earlier. The Fall 2016 results reflect just the first AIC exam since the course revision. The improvement observed in this term might reflect the fairly wide natural variation in performance from term to term, so it remains to be seen whether the improvement is reliable and sustained. The exam scores will continue to be monitored and instructional approaches for the capstone course will be further modified as necessary.

The revised capstone format is in its second term of implementation and includes improvements based on the experiences from the first term. In response to the success of the fall semester, the breadth of the PBL assignment has been expanded and the students now have the opportunity to explore a PBL assignment of their own design for their second project. In their evaluations of the capstone course in Fall 2016, students noted that the engagement of the instructor in a "flipped" classroom environment, open dialogue, and web-based skills testing were among the most beneficial learning techniques. Student evaluations of the course were positive, including

commentaries on the value of new information or new perspectives being offered that were not captured in their earlier coursework.

Conclusion

As a consequence of revising the capstone course and improvements in the students' AIC exam scores, the program now includes the graduating seniors' AIC test results as part of the program's curriculum evaluation process. Possible future steps include:

- revisiting the capstone courses prerequisite requirements;
- expanding the interdisciplinary participation of the PBL to include BGSU's Department of Architecture and Environmental Design and perhaps other departments;
- involving BGSU's industry advisory board and the community in the identification and evaluation of the PBL assignments and other improvements to the course; and
- expanding a graduating senior exit survey to gauge the importance and value added of the capstone and other required coursework and integrating that information into the BGSU curriculum development process.

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