



Capstone = Team Teaching + Team Learning + Industry

Dr. James W. Jones, Ball State University

Dr. James W. Jones is the Construction Management Program Director and an Associate Professor in Ball State University's Department of Technology. He has taught in the areas of leadership and construction management for more than 10 years and has more than a decade of experience managing construction projects in both field and office environments.

Mr. Mike Mezo, Ball State University

Mr. Mike Mezo, AIA, is an Assistant Professor in Ball State University's Department of Technology. He has taught courses from the introductory cornerstone class to the senior-level capstone course in the construction management program.

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Abstract

The capstone course in construction engineering and management curricula should provide students with a realistic, challenging simulation of a construction scenario. Within this scenario, students have the opportunity to integrate their prior coursework and internship experiences into a comprehensive demonstration of their learning. This paper provides the capstone process used by one program as a case study for the use by other construction engineering programs that are considering enhancing or revising their own capstone courses. The three major distinctive features of the program under examination include the following: team teaching, team learning, and significant industry involvement.

Introduction

Students enrolled in construction engineering and construction management curricula spend years studying various specialized topics, from scientific and technical aspects to “soft” leadership, managerial, and communication skills. These topics then come together in a capstone course, where students are offered the opportunity to demonstrate their problem-solving abilities in both the parts as well as the whole. As described by McIntyre, students in problem-based learning environments “are challenged to ‘learn to learn’ so that they can achieve their highest potential in their chosen professions.”¹ Just as a capstone completes a building or archway, the capstone course finishes off the students’ learning as they prepare to graduate and enter the workforce.

This paper describes the process used by the construction management program in Ball State University’s capstone in construction course. This course, jointly created and refined by the program’s faculty, utilizes three major distinctive features: team teaching, team learning, and significant industry involvement. By describing how these features have evolved over the years, the authors provide their course as a case study for other construction engineering and management programs considering enhancing or revising their own capstone courses.

Capstone course overview

A well-designed construction engineering and management curriculum should build upon itself in an interconnected and integrated process². The capstone course in a construction program is where a student’s prior coursework is wrapped up in a single, comprehensive course³. The authors’ intent when creating this course was to provide as much of a realistic, team-based simulation of managing the construction process as was possible within a college classroom environment.

To that end, a common project of approximately \$1-7 million is used by all students, who work together on teams of 3-5 members each. While this does limit the ability of teams that have interests in specific types of construction (residential, heavy/highway, etc.), it provides for several advantages, including allowing faculty to become more familiar with the project, common clarifications and changes during the simulation, and increased grading standardization.

The relatively small dollar value of the project allows for additional detail in aspects such as estimating and scheduling, but is still large enough to challenge a small team of students. Projects are selected that are on or near campus and underway during the semester the capstone course is offered (spring only) and have included a youth center, fraternity house, state fair pavilion, dormitory, and planetarium, among others. Students and faculty typically meet with the designers and constructors and tour the ongoing project during the semester.

Course requirements are centered on six major assignments that are due throughout the term. The assignments simulate the construction process, from responding to an RFQ (Request For Qualifications) to a simulated bidding exercise to detailed estimates and site logistics planning, three oral presentations, written document submissions, and a reception for industry members. Students are graded on assignments as a team, but also conduct internal evaluations to identify any students who do not contribute adequately. Teams are also required to have industry mentors which play important roles throughout the process.

Team teaching

Although a single faculty member is assigned as the instructor of record, the entire program faculty participates in team teaching the capstone course. The advantage of this approach includes the ability to bring the breadth and depth of all faculty members directly into a single course that would not otherwise be available, and it also clearly models to the students the “team” approach that has been emphasized as being necessary in industry after graduation^{4, 5}. This approach allows for the integration of various disciplines within the faculty team to be demonstrated, from design through preconstruction to project closeout⁶.

The process serves an additional role of fostering dialogue among the program faculty. Faculty members can discuss strengths and weaknesses in particular areas and how to best supplement or correct them within particular courses in the program curriculum. Team teaching also helps to assimilate and integrate new faculty members into the team⁷. This serves as a type of mentoring internship for new faculty instructors, allowing them to see the more senior members in an actual teaching environment⁸.

However, this approach also brings significant challenges. Faculty loading only allows a single instructor to be assigned to the course, leaving the others to participate voluntarily to benefit the program and students overall. Some departments might view this voluntary participation as service to the department or university during salary, merit, and/or tenure deliberations. The position of “lead” faculty member has also rotated among professors, allowing for assignment credit and slightly different emphases, although the overall format has remained unchanged. However, for the last four years the lead faculty member has remained unchanged in the program under examination. While the lead faculty member is in the classroom or available during every class period, the remainder of the faculty team is typically only present at key events (presentations, bid exercises, etc.) or when requested by a student team for a particular issue, minimizing faculty time in the classroom to when it is most critical.

When the course outgrew its single section several years ago, a second section was added. Naturally, the increased time commitment caused additional conflicts, and it is difficult to have

time for both sections blocked out of every faculty member's schedule. In order to combat this, presentations are recorded so all faculty members can view (and grade) them, and at times graduate assistants are employed to teach classes so faculty can attend key course events.

Every faculty member normally grades every assignment as long as they are comfortable doing so. In practice, all of the faculty members typically grade the oral presentations, and a majority of the faculty team grades the remainder of the assignments. For example, most of the faculty members are familiar with quantity takeoff and estimating, so they are comfortable grading them using rubrics developed by the lead faculty member. Fewer faculty members have expertise in site layout and logistics planning, so only those with skills in this area grade those portions. Faculty grades are then averaged and, after any needed discussion, assigned to the student teams by the lead instructor.

Since this team teaching approach has been used since the course's inception, participation by all faculty members has become an expectation and continues to be successfully utilized. It is discussed when new faculty candidates are interviewed and is considered one of the distinctive features of the program, and a little peer pressure sometimes helps motivate participation. However, the authors acknowledge that it might be much more difficult to implement a team teaching approach in an existing program that did not have this kind of expectation from the beginning, or in programs that have specialized tracks (e.g. electrical construction engineering, mechanical construction management, etc.). Additionally, this does present an additional time commitment for faculty members not officially assigned to the course, particularly for junior faculty⁹.

Team learning

Just as the faculty teaches as a team, the students engineer their solutions as members of a team. This accurately replicates how real construction challenges are solved and also is one method available to put students into controlled leadership and managerial positions within a construction scenario. Just as in industry, student teams excel together at times and fail together at others, but hopefully do so in a safe environment that provides lessons of how to improve next time. Others have demonstrated that well-structured team processes can result in team learning in capstone courses that is greater than learning as an individual student¹⁰.

For any course that utilizes student teams, team formation is one of the first issues to be addressed. The authors have tried several approaches, including assigning teams (in an attempt to balance them), random assignment (picking names out of a hard hat), and allowing students to form their own. While each approach has potential benefits and drawbacks, allowing students to form their own teams has proven to be most satisfactory to both students and faculty. Teams are to be formed prior to the start of class, and this is well-advertised to all potential students the semester prior to the course. Some teams form as early as a year ahead of time, but usually teams are more or less set by the end of the fall semester, ready to start the capstone course in the spring. For those students who have difficulty forming or joining a team, faculty members help them solicit and team with others prior to the start of the class. Student selection of members emphasizes the importance of teamwork and its relationship to successful outcomes (grades) for each assignment¹¹.

Allowing students to form their own teams allows them to find others that they believe allow for their best chance of success, and it also forces teams to deal with individual schedules (including classes, work, and other activities) internally without having a faculty member mediate. Students have been observed taking advantage of the team structure and contributing less than their fair shares (social loafing), thereby unfairly burdening other team members¹². In order to combat this, student teams must designate a different project manager (PM) for each deliverable and must also internally evaluate themselves for each major assignment. This allows for faculty to help to resolve internal conflicts and mitigate problems throughout the semester rather than just at the end and can differentially assign grades based on partially on participation and contribution. After their presentations are completed, teams are allowed to sit in on other team's presentations, allowing for inter-team as well as intra-team learning¹³.

Industry involvement

The program also relies heavily on industry involvement within the capstone course framework. Projects selected for the course are typically actual jobs the industry advisory board members are working on and provide access to, both physical (site access) and virtual (documents, models, etc.). This allows a greater level of involvement for students and a more compelling, realistic construction simulation. Using actual construction projects and involving industry members provides advantages in both professional experience and student learning¹⁴.

Additionally, every student team is required to engage an industry mentor (or mentors) for assisting them throughout the semester. When properly utilized, these industry mentors provide realistic perspectives on students' approaches, work, and solutions. Industry involvement in capstone courses in construction has been shown to enrich students' experiences and even result in job interviews on occasion¹⁵. Industry involvement in capstone projects has also been noted to keep students continually motivated throughout the course¹⁶. In the authors' experience, teams that fully utilize their industry mentor typically outperform those that do not.

Students are allowed to recruit their mentors from anyone in the construction industry. Some of the students use contacts from their previous internships, such as their former direct supervisors. This can help to build upon an already existing relationship and offers the student additional exposure to the organization, hopefully keeping that successful student in the organization's sights when it comes to hiring time. However, this can also be a risky approach, for a team that does not adequately involve their mentor or performs below expectation now has that experience visible to potential employers. Advisory board members are frequent and enthusiastic mentors and are recruited directly by students or are made known to the students as possible volunteers. Other student teams have utilized family members or even facilities personnel from the university as their mentors, allowing a broad range of industry perspectives to be involved.

In the past, student teams were required to have a mentor, but some did so in name only. A mentor agreement/contract is now utilized, where the student team and mentor must develop an understanding of exactly what will be expected from each party. This has helped to alleviate "ghost" mentors and also decreases the trepidation of new mentors as to exactly what will be expected from them. At the same time, it helps the student team understand that in order to get

the most from the mentoring relationship, communication and planning must be increased. For example, if a team wants their mentor to review their detailed concrete estimate before turning it in to the faculty, they will have to complete it early in time for the mentor review and (possible) revision, all of which must be coordinated around a professional's busy schedule. Those student teams that make the effort are typically rewarded, and those that either do not involve their mentors or make only a half-hearted or late effort are stuck with having the grading as their first review.

Industry mentors, advisory board members, and other industry professionals participate as evaluators for student teams' final presentations, providing feedback and input on assessment and grading. Students are clearly the primary beneficiaries of this industry involvement, but it also helps to build faculty relationships with industry and strengthens advisory board involvement¹⁷. Advisory board members get to see how the students perform in a realistic simulation, as well as how the program's faculty team interacts, allowing for more informed advice and suggestions on program improvement.

Conclusion

Ball State University's capstone in construction course and integrates team teaching, team learning, and industry involvement. These three approaches have been utilized continuously throughout the course's existence, but continue to be refined and experiments taken with variations on these methods with the intent of continually improving the students' learning experience. Construction engineering and management educators considering new approaches for their own capstone classes have the opportunity to consider whether any or all of these approaches might be applicable to their programs. The authors continue to refine and develop their program's capstone course towards the goal of being as realistic of a construction simulation as can be developed in a classroom setting.

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