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Synergizing Case-Based Learning and Industry Involvement in a CEM Course – A Case Study

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This paper synthesizes the lessons learned from the experience of developing and teaching a Case-Based Learning (CBL) course in Construction Engineering and Management (CEM) with a diverse group of industry partners. The authors analyzed and compared the participants' reflections on their experiences throughout the course to identify: 1) the factors that may foster and hinder students' learning and 2) potential opportunities and challenges of interacting with industry practitioners when using CBL as the core teaching strategy in a CEM course. While structuring the course, instructors should invest time in increasing the navigability of practitioners' supplemental material and guiding students through it. Case order matters –complexity and uncertainty should increase as students gain confidence with CBL—and including deliberate team preparation time was highly welcomed by students. Practitioners' presence in the classroom increased case credibility, which resulted in more self-reported student engagement. Welcoming more actors allows students to analyze the cases from diverse points of view. Instructors should act as discussion facilitators. Looking forward, practitioners should start documenting the alternatives considered beyond the definitive solution of a case to enrich the case's contents. These outcomes provide instructors interested in implementing CBL in their engineering courses with insights grounded in experience that will ease the process from ideation to delivery.

Key Words: Case-Based Course, Industry Practitioners, CEM Education, Academy-Industry Partnership

Introduction

Higher-education programs in Construction Engineering and Management (CEM) face the challenge of helping students prepare for careers in a demanding industry that requires that they make accurate decisions and offer innovative solutions to problems embedded in real-world scenarios from day one. However, typical teaching strategies in CEM often fail to portray the actual conditions in which such problems occur, and such decisions must be made. Therefore, new CEM professionals regularly find it difficult to navigate the interdisciplinarity, complexity, and uncertainty that characterizes CEM practice. Consequently, they constantly express that much of the knowledge they gained during their studies lacks direct applicability.

Case-based learning (CBL) emerged as an alternative to address this educational challenge. CBL aims to provide students with faithful representations of the contexts and situations in which professional practice occurs (the cases). It emphasizes critical analysis and judgment of contextual information and its integration with theory for problem-solving and decision-making (Safapour et al., 2019). In other words, CBL allows students to apply their prior knowledge and skills to real-life problems. CBL has been extensively used across academic fields such as law, business, accounting, and the health sciences, where empirical evidence of its benefits supports the method's popularity (Martin et al., 2019).

But regardless of its potential for addressing the industry's educational needs, CBL is rarely used as the core instructional approach in engineering courses beyond ethics (Martin et al., 2021). Instead, CBL is often relegated to a secondary role after other more common teaching strategies in engineering (e.g., Problem-Based Learning). In such instances, cases are often used to illustrate course contents, practice specific disciplinary methods, and expose students to a specific project (Jiménez et al., 2011; Korkmaz, 2011; Damnjanovic and Rispoli, 2014). We argue that useful as they might be, such implementations of CBL in CEM neglect the strategy's key strengths, which lie in its ability to exercise students' situational judgment, holistic thinking, and uncertainty management amid both typical and unique construction project situations (Fulk et al., 2017).

One of the factors that could explain the scarce use of CBL as the core instructional approach in CEM courses is that, in contrast to the disciplines that deploy their full potential, CEM faculty typically develop their whole professional careers in academia. Hence, they often lack relevant job site experience in construction-related working environments and are rarely active construction practitioners. This condition might limit their contextual situatedness and undermine their perspective-taking capacity and ability to be up-to-date with the industry realities, which are key to developing convincing cases and/or conducting engaging case-based discussions.

Despite this limitation, CEM faculty usually know the importance of course practicability and credibility for student learning and engagement. So, they frequently invite active industry practitioners as guest speakers and project evaluators to enrich their classes with real-world experiences. They also seek practitioners as liaisons for hosting construction site visits and as sources of documented cases, with varying success.

We argue that both practices (CBL and guest industry practitioners) contribute to student learning differently and that integrating active practitioners into a CEM course that uses CBL as the core teaching strategy might help deploy CBL's full potential. However, the synergies between CBL and Industry Practitioner integration have not been deeply explored in CEM education. Hence, there is scarce guidance on how CEM instructors can structure and implement a course in collaboration with CEM practicing professionals.

To fill this gap, we co-created, co-developed, and co-conducted a case-based CEM course in tandem with industry partners — formed by six major US construction companies, one design firm, and the University Facilities Management Department. The course was called "Construction industry workshop: Bringing theory to practice." Rather than emphasizing topics to be studied, the course comprised six typical CEM situations (the cases) to be addressed (See Appendix A), aiming to enhance student practical judgment and decision-making criteria. The industry partners participated in the identification of project experiences (which were relevant to a set of CEM learning goals), the development of teaching materials from these experiences, and the delivery and discussion of the cases during the academic semester.

We systematically gathered the cases' post-reflections and feedback from students, instructors, and practitioners in the course evaluations and conducted bottom-up thematic analysis (Fereday & Muir-Cochrane, (2006) to identify the emerging key lessons learned that may serve as guidance for the creation and implementation of similar CBL course initiatives in CEM. This paper describes the course resulting from that experience and shares the lessons learned.

The Case

Course Structure

The in-person course was designed to meet once per week for two-and-a-half hours. It was open to undergraduate civil engineering students who had already taken (or were currently enrolled in) the introductory course to CEM. The enrollment cap was set to 15 students. Every two weeks, self-selected teams of three students had to analyze a different case. The cases were designed and written by their real actors and the instructor before the semester began. Companies that had completed construction projects on grounds opted to select one of those projects as a case to attract students' interest, and the others opted to select a challenging one.

The selected projects spotlighted contending interests between the multiple actors and construction topics such as phasing, owner requirements, resource constraints, estimating, systems procurement, prefabrication, traffic and maintenance, CEM technology, contracts, commissioning, designer-builder collaboration, constructability reviews, site logistics, among others (see **Appendix A**).

The instructor scheduled monthly online meetings with some industry practitioners involved in each project to gather the information required to define the case learning goals and understand the project, e.g., context, complexity, constraints, stakeholders, conflicting interests, issues, challenges, and proposed solutions. The instructor wrote each case (six in total) based on the information provided by the practitioners and returned a draft to them, so they could fill out the missing information, improve the authenticity and accuracy, and provide the supplemental files needed to tackle the case. The cases ranged from five to eight pages, excluding any supplemental material.

The supplemental files sought to enhance students' case understanding and served as evidence to support their analysis and recommended actions. These included, among others, architectural and civil drawings, Requests for Proposals (RFP), Requests for Information (RFI), Baseline/Master Schedules, 4-D modeling videos, design drawings, contracts, commissioning plans, vendor bid proposals, site utility plans, and geotechnical reports.

The cases had two types of questions, open-ended and problem-solving. The open-ended questions sought to help each team understand the case and ignite class discussion. These questions focused on asking students to make an informed decision. On the other hand, the problem-solving questions asked students to evaluate two or three alternative solutions for the problem and recommend a course of action or propose a solution plan (see **Appendix A**).

Depending on the case questions, each team must submit either a written response, a PowerPoint presentation or both. In the written response, students addressed and discussed most of the open-ended questions and explained the reasons for any recommendation. In the PowerPoint submission, students addressed the problem-solving questions showing and explaining how and why a solution or approach was chosen over the others.

Furthermore, the following two assessment tools were used to monitor students' progress and learning and identify improvement areas after each case.

- **Post Reflections.** Acknowledging that real learning comes after thinking about what people saw and experienced, post-reflections were incorporated as an assessment tool to monitor students' learning process. The post-reflection form, which students must answer after each case discussion, was adapted from the one proposed by Golich et al. (2000). Some of the questions included were: What overall lessons do you take from this case? If any, which CEM technical or managerial skills have you learned or improved with this case? If any, what were the most challenging aspects of this case study? What helped to improve your learning, and what hindered it? What is your goal for the next case?

- **Self-Evaluations.** Two self-evaluations were used to assess students' participation during i) case preparation and ii) class discussion. The former was included, given the importance of being an effective team member in the workplace, and the latter, to motivate the interactions between the student groups and between students and industry practitioners. The two forms were taken from the ones Golich et al. (2000) proposed.

Course Implementation

The cases were released to students every two weeks during class time. Despite the course being set to meet once per week, the instructor met with the students every two weeks when the practitioners came to the classroom — the day a case was released, there was no whole-class meeting scheduled (see Figure 1). Instead, students were encouraged to meet with their teams to review the case materials, post any questions, or request additional project documents they may need moving forward with the analysis. This means students had one week to read, assess, and discuss the case study with their teams before the class discussion.

The following week after receiving the case, all teams met (in person) with the industry practitioners and the instructor to discuss their analyses and responses to the case and hear how the real actors tackled the project challenges along with "the rest of the story." The class flow (sequence) varied depending on the combination of the case questions, as outlined below:

- **A case including open-ended and problem-solving questions**. First, students discussed the open-ended questions with the case's real actors at a round table for about 50 to 60 minutes. The discussion atmosphere was informal and relaxed. The instructor moderated the discussion by fostering a candid conversation between students and practitioners while addressing the open-ended questions. Then, each team presented its solution plan or recommended action to the practitioners within 15 minutes. After each presentation, practitioners gave feedback to the students and asked them questions about their proposed solutions. Finally, in the last 30 minutes of the class, the case's real actors presented their approach to solving the problem, shared some lessons learned, and addressed any last-minute questions students may have.

- **A case including only open-ended questions.** Most of the class time was devoted to discussing students' insights about the case questions with the case's real actors in an informal setting like the one described above. The informative discussion lasted about 80 minutes, and either the instructor, practitioners, or students asked to follow–up questions. Then, in the last 30 minutes of the class, the practitioners highlighted parts of the case that were particularly challenging during the project. Some guests prepared a presentation for the students, and others opted to continue the informal discussion.

- **A case including only problem-solving questions.** Most of the class time was devoted to students' presentations (20 – 25 minutes per team). Each team presented its solution plan to the case's real actors and recommended a course of action. Once all teams presented, the practitioners gave each team feedback highlighting any additional constraints/technical details that students did not realize would be problematic when analyzing the case. Then, in the last 40 minutes of the class, the guests explained how they handled the problem, established priorities, made tradeoffs and decisions, and addressed any last questions. Given the need to use visual aids, all guests prepared a PowerPoint presentation, so students had a better grasp of the complexities of the case.

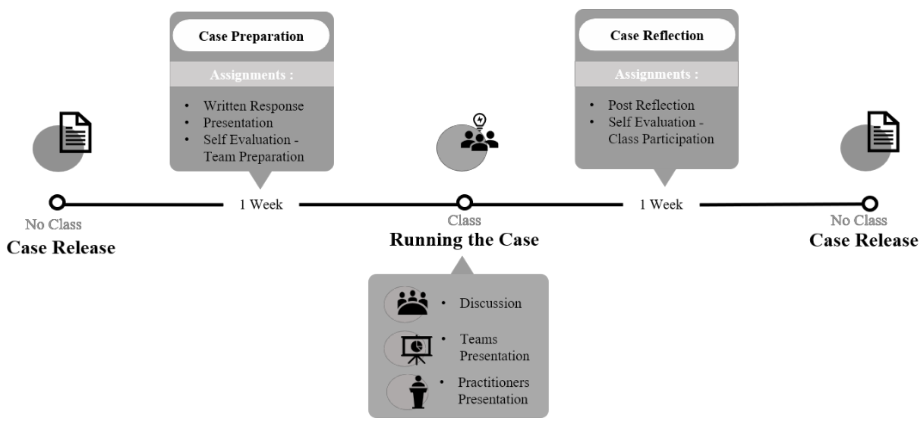

Figure 1**.** Course Flow

Since the class flow differed for each case, the instructor sent the practitioners an agenda outlining the class's main moments. Additionally, the instructor met with the industry practitioners before the case discussion to go over the class logistics. It was essential to clarify their roles in the class discussion since students should have the space to express their thoughts and analysis without the guests giving them all the answers at first. The instructor printed a copy of the agenda and case for each guest and gave them an additional blank sheet to take notes; meanwhile, students made their interventions in the class.

Lessons Learned

Structuring the Course

Avoid monotony by design. A 2.5-hour encounter proved to be sufficient to achieve the learning goals of each case. However, it can turn monotonous if you do not plan to incorporate different moments or short-sprint activities into each class session. Students reported being more engaged when having different activities (e.g., 2-way presentations, discussion time, Q/As, and intra-group and whole-group activities) in one session.

Build students' confidence by planning the cases' order. Students reported feeling overwhelmed in the first couple of cases when they had to make complex decisions with insufficient information and limited experience. Consider adjusting the difficulty of the cases incrementally to match their learning curve.

Opt for smaller class sections and student teams. Instructors and co-instructors agreed that a small class size was vital in ensuring that all students could voice their opinion and boosting social safety so that everyone (including industry practitioners) could feel comfortable presenting and participating in the discussion. From the student perspective, having a team of three students balanced individual workloads and promoted equal contribution, preventing "one or two hide and don't do their share."

Include team preparation time deliberately in the formal class schedule. When students' schedules conflict, they tend to rely on individual preparation only, and team preparation time is at risk. Students applauded the use of synchronous class time to allow teams can meet consistently.

Release case materials as early as possible. This practice allowed students to review the material individually and then meet with their team during class. They were also able to "understand the situation first," identify the technicalities they are unfamiliar with, and then "invest more time brainstorming alternatives, agreeing, developing the selected solution, and finding the best way to communicate it with their team members."

Prepare to switch teams occasionally. Although student participants did not experience this directly, many suggested that changing teams in future course iterations would benefit their learning experience. They were interested in learning from others' "industry experience and knowledge." Plus, this is how it happens in real CEM projects.

Start by focusing on cases with a documented "path of solution." The availability of construction documentation and visual aids is a restrictive factor in deciding whether to use a project for a case. Most partners kept a record of the "definitive solution" of their projects but not of the alternatives considered nor iterations conducted. Remember that construction documents are not usually readily available for didactic application. Presentations made for clients proved to be effective communicators of the project situations to students.

Prefer projects that are familiar to students. Credibility turns out to be the most engaging factor for students. The more "real" the situation is perceived, the more engaging the case. Moreover, students are more engaged, intrigued, and invested when the cases are based on campus projects since it is easier for them to relate to the context.

Incorporate tasks that resemble actual construction tasks. The more CEM-representative the task, the more valuable the students perceive it. That being said, avoid asking for repetitive tasks even if they resemble actual CEM practice (e.g., checking all geotechnical borings in case #5). Students are more engaged when cases incorporate open-ended questions and unique problems since they allow them to explore different routes and cultivate more discussion within their groups. Having open-ended problems guarantees that every group will propose something different, and they can learn from what other groups considered and did not.

Help students navigate the supplemental material. As discussed before, achieving credibility often requires using actual construction documents. However, students get overwhelmed if they are required to face extensive pieces of data without knowing where to start or to focus. Cultivate data literacy by helping students navigate the supplemental material. To do so, deliberately include cues in the narrative or notes pointing to a specific section or resource.

Invest time in adapting or developing resources that help students visualize the case situations. Helping students get a clear picture of what is going on in the project is of paramount importance for the case's success — especially with an inductive approach, not only as understanding the situation is the basis for a good analysis but also to avoid students overwhelming and frustration, given their lack of experience and exposure to construction day to day issues. Hence, make sure you devote a significant portion of your preparation time to developing, in partnership with industry practitioners, visual aids to increase clarity and student understanding. Take advantage of the BIM and 4D simulations available for the case since these can be useful to illustrate initial project conditions or construction sequences.

Course Implementation

Get used to your new facilitator role. The role of the CBL instructor is to be a facilitator or mediator of the interaction between students and industry practitioners. The instructor must empower both to participate in the discussion actively, provide feedback and ask follow-up questions. Although this role may be diminished during the class, the instructor is the real architect behind orchestrating a meaningful adequate teaching-learning environment for all the case participants.

Open discussions with factual questions. It is difficult for students to understand what happens in a construction project when they are unfamiliar with specific construction means and methods and have not spent much time at a job site. Therefore, students must have the chance to clarify the case context and situation with the industry practitioners before starting the case discussion.

Bring different perspectives and voices. Hearing the points of view of the case from different stakeholders (owner, designers, subcontractors, and contractor) allows students to gather more insight into real-life scenarios that these industry practitioners face daily. The different perspectives help students to solidify and reaffirm their thoughts about the case, clarify some predetermined misconceptions, and identify challenges they did not realize would have been problematic. The presence of the cases' real actors also motivates students to perform at a higher standard.

Share first-hand experiences and memorable facts and stories. Students learn better when the practitioners give them first-hand experience in handling problems in the construction industry and provide them with feedback. Additionally, humor and curious facts about the case exhibited during the discussion by the practitioners improved students' memorability and learning.

Foster a networking space. The class setup offers students a great opportunity not only to get some construction industry experience but also to network with potential future employers. Encourage students to learn more about the company and practitioners participating in each case and prepare questions for them in advance to interact more with them after the class discussion. Noteworthy, when applying for engineering roles with general contracting companies, some of whom were guests in the class, students felt much more comfortable and informed going into these interviews.

Use reflections as a learning tool. After listening to the train of thought and seeing how practitioners reached the best approach for all the stakeholders, the post-case reflections forced students to continue thinking about the case, as often, after a project is over, they will just put it out of their minds. By reflecting on how they can improve their case analysis, students clear up their learning, reaffirm the main takeaways/lessons learned from the case, and prompt them to think about how they can do better in the following case.

Conclusion

This paper analyzed the experience of developing and teaching a CBL course in CEM with a diverse group of industry practitioners and synthesized 17 lessons learned (11 relative to course structure and 6 to implementation). These lessons may guide those interested in fully exploiting CBL through the involvement of the cases' real actors (active industry practitioners) to build students' ability to make decisions in real-world CEM scenarios. It also explored the potential synergies of CBL and the typical teaching practice of bringing industry practitioners to CEM courses: The classroom power distribution became more balanced since the "instructor" needed to transition to a discussion "moderator /facilitator" role. This empowered students to become more active learners and practitioners to become true agents of students' education. The presence of the cases' real actors (industry practitioners) in the CBL classroom increased the cases' credibility, students' confidence in the applicability of the knowledge that was being constructed, introduced them to a variety of construction-related topics that go beyond the traditional CEM curriculum, increased the understanding of actual CEM practice and the different career paths available, provided opportunities to expand students' professional network, and motivated students to do their best to make a good impression. Students had the opportunity to contrast their proposed approaches and solutions with the ones proposed by those with first-hand experience and in the exact situation under consideration. Thus, similarities gave students confidence in their problem-solving approaches, whereas differences proved to be a source of further discussion and direct feedback. Although the implementation in the classroom of CBL combined with industry practitioner involvement may require significant planning on the instructor's side, the reported benefits make the effort worth it.

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Appendix A

Case	Problem	Examples of Question Types		Case Practitioners Participants
#1	A significant delay in an enabling project before the start of construction led the team to reconsider their phasing approach to completing the project since the schedule and budget needed to remain on track.	Open-Ended	○ Who bears the responsibility of solving this issue and why? ○ How will this issue impact the project scope, schedule, and budget?	Owner (FM)*: ○ Supervisory Team Leader Contractor: ○ Senior VP**, Project Executive, Project Manager
		Problem-Solving	○ Analyze emerging solution alternatives, evaluate how they impact the project schedule and budget, and recommend a preferred solution pathway.	
#2	In a multi-prime contract, a disagreement between the designer and the mechanical contractor arose because of fluctuating owner requirements and the ultimate effects these changes had on the design and construction of the building's HVAC system and the Net-Zero goal.	Open-Ended	○ How did the multi-prime contract benefit or affect this project's bid and design phases? ○ Do you agree with the owner's decision to have the firm as the designer and commissioning agent of the project?	Design Firm: ○ VP, Project Engineer, Commissioning Agent
#3	Because the project was a partial renovation with an existing structure, the overall construction schedule was compressed. Envelope and finish materials were needed sooner after the commencement of construction.	Open-Ended	○ How should the owner weigh early commitment of funds and early decisions against a potentially longer overall construction schedule?	Contractor: ○ Preconstruction Leader
		Problem-Solving	○ Evaluate different bid proposals and recommend the contractor a trade partner for completing the curtain wall system. ○ Perform a cost-benefit analysis of bathroom pods vs. field build.	
#4	Because the number of available beds during the renovation of six four-story buildings directly impacts the owner's revenue, the client wants the contractor to finish the project one year sooner than the RFP timeline.	Problem-Solving	○ Recommend the contractor how to best pair up the buildings to finish one year sooner than the RFP timeline keeping in mind the owner, client, and contractor constraints.	Owner (FM): ○ Senior PM*** Contractor: ○ Senior VP, PM, Project Engineer
#5	During a preconstruction site walk, the owner team noticed the presence of surface rocks on the site. The contractor has now to review the geotechnical report and analyze the risks associated with installing the structural foundations and utilities, given the presence of rock and groundwater.	Open-Ended	○ If the team had to hit the rock, what would be the best procedure to remove it (with the neighbors and budget in mind)?	Contractor: ○ VP, Project Manager
		Problem-Solving	○ Develop a preliminary site logistics plan addressing staging and potential impacts on surrounding neighborhoods and businesses.	
#6	Given the county constraints regarding installing a pedestrian walkway over one of the county's busiest thoroughfares, the contractor had to propose the prefabrication, transportation, and installation of the complex structure in one week.	Open-Ended	○ How would you sell the idea to the county, highlighting the benefits to the public? ○ How can VDC models and reality capture identify conflicts and prevent risks regarding the installation of the bridge?	Contractor: ○ VP, VDC Leader ○ Construction Executive
		Problem-Solving	○ Develop a Maintenance of Traffic plan for the move and installation of the bridge.	

* FM: Facilities Management; ** VP: Vice President, *** PM: Project Manager