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Developing a Simulated Experience to Capture the Bidding Process in a Cost-Estimating Course

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Introduction

Thriving construction companies have mastered the bidding process earning jobs that keep their employees working while maintaining a reasonable profit. Like many skills, it takes a considerable amount of time and practice to become adept at compiling an effective bid. Assembling costs is just one element of the bidding process that in and of itself does not always reflect the many nuances associated with submitting a completed bid on time that meets all the requirements. Graduates entering the workforce need to present with both soft skills and technical skills to perform their job responsibilities successfully. Integrating a simulated experience within a construction cost estimating course provides an active learning environment where students can better understand the full extent of the bidding process as a whole including the soft skills that drive and connect decision-making and the application of technical skills. Salas et al. [1] define simulation-based training as any synthetic practice environment that is created in order to impart competencies (i.e., attitudes, concepts, knowledge, rules, or skills) that will improve a trainee's performance. The study [1] goes on to discuss the advantages of simulation-based training and its ability to provide a more complex and realistic learning environment. Gaba [2] states that "simulation is a technique, not a technology, to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion."

It speaks volumes, the large number of textbooks available to support quantity take-off procedures while costing principles and the bidding process are limited to data pools or a few high-level chapters of the text. Trying to demonstrate every possible scenario that students may experience in the field can be overwhelming but establishing a baseline of relevant context for the bidding process is essential to student learning.

Purpose

To prepare students entering the workforce, a simulated experience targeting the construction bidding process has been adopted as a culminating project in a construction cost estimating course. This paper will discuss student preparation throughout the semester and the integration of the simulated experience, its format, interactions, and use of technology. The reflective nature of the report will provide a detailed examination of the impact the intervention had on student learning using direct and indirect measures currently within the course as well as identify future assessments through subsequent coursework and feedback provided by program constituents. Current direct measures will include student performance in specified coursework while indirect measures will include a student survey in response to the simulated experience. Additionally, students' future performance in completing their construction capstone course will also be considered as a means of assessing the impact of the major revision along with the associated review and commentary provided by Industry Advisory Board members.

The objective is to share with other construction educational programs the effectiveness of introducing a simulated experience, as a form of active learning, within a construction program's curriculum.

Literature Review

Numerous studies [3],[4],[5], have examined the skill gap within the construction industry associated with entry-level university graduates entering the workforce. Cavanaugh et al. [6] explores the disconnect between higher education and its ability to not only produce students competent in technical skills but to close the gap, cultivating the necessary soft skills, resulting in students that are workforce-ready and positioned to meet industry demands. Defining work readiness skills can be challenging as it varies greatly depending on the chosen field and the career path within that field. Even within the construction industry and among its academic counterparts no clearly defined program exists detailing which soft skills, when combined with technical skills, are required for student success [4]. Despite the challenges, Mahasneh and Thabet [3] contend "There is a broad consensus amongst construction academia and industry that for construction school graduates to be ready to enter the workforce, they should be equipped with hard skills (technical) and soft skills (non-technical) that enable them to apply their knowledge directly in the work setting."

One study [4] identified twelve separate clusters of soft skills relevant to the construction industry were identified and include skills associated with; communications, problem-solving, conflict management, collaboration, stress management, professionalism, productivity, ethics, diversity, planning and organizing, self-awareness, and interpersonal relationships. Another study [7] reported that the most important soft skills for job seeking, as identified by students, were positive attitude, oral communication, self-motivation and self-direction, problem-solving, and critical thinking, while employers attached the highest importance to skills related to positive attitude, teamwork, good work ethics, problem-solving, and self-motivation and self-direction.

These skills don't develop in isolation but require student engagement and participation in an interactive environment. Both students and employers agree that soft skills training should be embedded in the program curriculum and not developed as standalone coursework [8]. Active learning activities increase student engagement and performance because these approaches provide mastery experiences that increase student familiarity with professional activities and positively affect student attitudes and motivation [9]. One meta-analysis [10], targeting undergraduate STEM programs, reported a significant increase in student performance and reduced failure rates as a result of utilizing an active learning approach in the classroom. In fact, the same study [10] reported that students participating in traditional lectures were 1.5 times more likely to fail when compared to students engaged in courses integrating an active learning approach. Another study [11] concluded that active learning facilitates students' growth in professional competencies.

Identified as one of many forms of active learning, Zayapragassarazan and Kumar [12] contend that simulated experiences may provide students with their first opportunity to realize what they have learned and the attitudes they have connected to learning. Becker and Parker [13] describe non-digital educational simulations as live face-to-face learning situations where instructors guide learners through a process that is often built around project-based activities. This approach to delivering a simulated experience, though absent of any virtual reality technology or digital environment, can still embrace the use of technology and processes associated with industry-specific real-world applications. “Simulation-based learning offers a wide range of opportunities to practice complex skills in higher education and to implement different types of scaffolding to facilitate effective learning [14].” “Simulation-based training techniques, tools, and strategies can be applied in designing structured learning experiences, as well as be used as a measurement tool linked to targeted teamwork competencies and learning objectives [15].” The fidelity of any simulation is critical to the expected success of the learning intervention and its impact on producing the necessary skills for employment. Students must obtain the prerequisite knowledge to engage with the simulation and the simulation must emulate a close approximation of real-world responses and actions. Without these structural guidelines, Scidel et al. [16] argues “It is unlikely that a simulation-based learning environment or any kind or combination of instructional support could have equally positive effects for all learners regardless of their learning prerequisites.” Echoing this caution, Chernikova et al. [14] reported that if learning prerequisites are not considered, the subsequent instructional scaffolding does not provide a significant impact on the learner. Additionally, the study [14], found that simulations designed with overall high authenticity have a greater influence when compared with simulations with low authenticity. Demonstrating successful implementation, one study [17] reported that simulation-based interventions used to improve statistical skills resulted in quantifiable learning gains for students resulting in a transfer of knowledge and situational awareness.

It is imperative that the approach to learning in the classroom provides authentic context allowing students to interact in an environment that reflects real-world scenarios and expectations. Developing authentic simulated activities within the cost estimating class will strengthen core technical skills while promoting the development of soft skills associated with work readiness.

Course Intervention:

The construction cost estimating course is a junior-level, 3 credit-hour course that meets for 16 weeks, one day per week for a total of 3 hours of back-to-back lecture/lab, The majority of the course time is spent engaged in active learning utilizing demonstrations, problem-solving, discussions, and scenario or case-based learning activities. Lectures and labs were designed to mirror the expectations for the simulated experience to bolster student understanding and provide the requisite knowledge to successfully execute the bidding process tasks. To assess the effectiveness of current practices, student preparedness, and use of simulation-based training techniques, this course underwent an intervention assessment.

Prior to taking any corrective action, industry partners were consulted in an effort to ensure existing coursework and the intervention reflected current industry processes and standards. Four separate general contractors provided detailed accounts demonstrating their approaches to bidding and the preconstruction process, originating with receiving the bid documents and concluding with the bid submittal. The collected information was then examined and paired with associated course material to make improvements or fill existing gaps in the subject matter. Specific steps within the bidding process were identified and included in the scope of the simulation to increase decision-making opportunities, increase interaction, and further the real-world experience.

Two separate construction projects with similar but not exact features were selected for the course. One project was designated for the lab and the additional project was held for use in the simulation. Labs were intentionally designed to provide students with an opportunity to hone their quantity takeoff and cost-estimating skills across a single project throughout the semester, providing a broader understanding of the project as opposed to a single activity. The labs also provided an introduction to on-screen takeoff software. Lectures were further developed to include more exposure to steps within the bidding process, such as scope and legal review of the bid documents, Disadvantaged Business Enterprise (DBE) requirements, and bid leveling associated with subcontractor selection.

The simulation was introduced in week 10 of the semester, allowing students 5 full weeks to complete and submit their bids. A traditional design-bid-build project with a lump sum agreement was selected to provide some uniformity to the project. The selected project is a 3,200 square feet single-story commercial building, with masonry walls and steel joist roof framing. The structural elements of the building are similar to the lab project completed throughout the semester. During the simulation, student teams are required to complete the bid process composed of the following required elements:

- Bonding requirements and cost based on valuation of the project
- Prepare quantity takeoffs and cost estimates using RS Means data for self-performed work along with vendor and subcontractor quotes
- Review subcontractor quotes utilizing bid leveling (multiple subcontractor quotes, including certified DBE's, were developed and included in the simulation for 4 divisions of work)
- Consider DBE requirements based on a required % of the overall project
- Communicate with the Owner/Architect using RFI's
- Addenda (addenda are provided during the bid process requiring students to adapt their bids)
- Schedule of Values

Not all elements are provided in the bid package at once. Subcontractor quotes and addenda are released throughout the simulated experience forcing students to manage their time appropriately and request additional information throughout the process.

Methodology

This study seeks to examine the implementation of a simulation-based learning approach to the construction bidding process and its impact on student achievement. A mixed-method approach was used to collect both quantitative and qualitative results. An end-of-semester survey was developed and delivered using the Canvas survey tool (https://www.instructure.com/canvas) targeting the use of a simulation-based learning approach in a construction cost estimating course as an indirect form of assessment. The student survey consisted of 14 questions supporting responses to course instruction and interaction using a 4-point Likert scale (1-strongly agree, 2-

agree, 3- disagree, and 4-strongly disagree). A 4-point scale was selected to remove the neutral dumping ground and require students to select a side. 7 of the 14 questions were directed specifically at the simulated project experience with two additional open-ended questions for student responses.

The institutional review board (IRB) approved the study prior to solicitation. An email was sent out to inform each student of the survey subject matter, the format, the approximate time to complete the survey, and provided an anonymous link employing Qualtrics. The email also disclosed that participation was voluntary but if 90% participation was achieved students would earn 25 points of credit toward lab work. Once published, the surveys remained open for 2 weeks. The goal of the survey was to identify students' perception of the implemented flipped learning approach in a construction cost estimating course as a form of indirect assessment. In the Fall of 2022 at the time of their enrollment in the course, a total of 17 undergraduate students within the Construction Management program were solicited to participate in the survey.. A 94% response rate was achieved for a total of 16 participants.

In addition to the Fall 2021 student survey, Fall of 2021 and Fall of 2022 student scores were collected and used to compare pre and post-intervention and as a direct form of assessment including labs, exams, simulated bid submittal, and final course grade. All identifiers were removed, and data was collected based on 22 students participating in the Fall 2021 construction cost estimating course and 17 students participating in the Fall of 2022. Supplementary direct and indirect assessment data will also be assessed when students complete their senior capstone project at a later date.

Results

Fall 2022 Canvas Survey Responses– Simulation-Based Learning				N=16
Survey Questions	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
The course material prepared me for the final project.	50.00%	50.00%	0%	0%
The instructor provided an appropriate amount of class time to work on the final. project.	43.75%	56.25%	0%	0%
The final project was a good representation of everything students learned in the course.	25.00%	75.00%	0%	0%
The final project was relevant to industry.	37.50%	62.50%	0%	0%
The final project has made me confident in my ability to produce a construction bid.	25.00%	50.00%	25.00%	0%
Based on my own experiences, I felt that this course provided an accurate representation of what construction cost estimating is.	43.75%	56.25%	0%	0%
Based on my own experiences, I felt that the final project provided an accurate representation of what the construction bidding process looks like for the construction industry.	37.50%	56.25%	6.25%	0%
I am able to use what I have learned in class at my current job.	31.25%	37.50%	31.25%	0%

Table 1 Canvas Survey Responses -Simulation-Based Learning

Student Responses to Open-Ended Survey Questions Specific to Simulated Project Fall 2022	N=16
Describe what you liked most about the course, lecture, lab, and final project.	
I really enjoyed everything about the class, all the lectures and labs, and even the final project was helpful and made me feel as though I was really putting together all the course content into one project	
I liked that the class seemed to be all in preparation for the final project. The labs and assignments were very helpful to understand what was expected during the final project. The flipped classroom made the class more enjoyable because the lecture was shortened giving us more time to work together on the assignments.	
I liked seeing how it actually applies to the real world and how the whole process works	
I liked the final project due to the fact it made us use all of our knowledge learned throughout the course.	
Describe what you would do to improve the course, lecture, lab, and final project.	
I would make the class much less based only on excel. Due to everything being on excel, I felt like I was more focused on how to link things on excel and how to do things the way that it was set up on excel. I think it should be more focused on the concepts and actual understanding rather than trying to figure out how to follow new excel setups every week.	
If I were to improve on anything in the course, I would move Masonry near the end of the course time and move HVAC, Plumbing, and Electrical near the beginning of the course. I feel as though the masonry is really important and should be closer to the final project or even made as an assignment for the final project and reviewed by the instructor so there can be feedback when finishing the final project, like the HVAC, Plumbing, and Electrical. I believe that would benefit us more and more in the real industry due to Masonry being something that should not be overlooked by us	
Nothing really, everything went smoothly.	
There is not anything I can think of to improve the course. I believe the course went very smoothly and there was nothing I would change.	

Table 2 Student Responses to Open-Ended Survey Questions Specific to Simulated Project Fall 2022

Pre/Post Intervention Achievement (Direct Assessment)					N (FA21) =22 N (FA22) =17	
Fall 2021						
Midterm Exam Points	Midterm Exam %	Final Exam Points	Final Exam %	Final Project Points	Final Project %	Final Grade %
115/150	76.67	75.94/100	75.94	120.87/150	80.58	81.97
Fall 2022						
Midterm Exam Points	Midterm Exam %	Final Exam Points	Final Exam %	Final Project Points	Final Project %	Final Grade %
120/150	80.35	84.05/100	84.05	124.59/150	82.98	85.22

Table 3 Pre/Post Intervention Achievement (Direct Assessment)

Discussion

The results of this study establish a strong positive correlation between simulation-based learning and students' perception of obtaining real-world knowledge and practical experience. The study also recognized improved student performance in regard to course exams, the project, and overall course achievement (Table 3). The authors believe that the increased overall performance was due in large part to the efforts to improve requisite knowledge prior to the start of the simulation-based experience along with the instructional scaffolding provided throughout the project. The student survey reports that 100% of the students (Table 1) believed that they were well prepared to successfully complete the simulated project and that they were provided an appropriate amount of time in class dedicated to the project over the 5 weeks. 100% of the students (Table 1) also believed that the simulated project was a good representation of everything they had learned in class and that the project was relevant to industry. Since this course is taught at the junior level, a large majority of the construction students, if not all, have relevant work experience in the construction industry providing them with a background to formulate an opinion.

Students also agreed that the project provided them with an accurate representation of cost estimating, but 6.25% of the students felt that the simulated experience fell short of replicating the construction bidding process (Table 1). Additionally, 75% of the students reported that the project made them confident in their ability to produce a construction bid, while 25% disagreed (Table 1). While 69% of the students could apply what they have learned through the project and in the course to their current job responsibilities, 31% disagreed (Table 1). The authors hypothesize that students that disagreed are not currently working in the industry or working in a part of the industry where the knowledge gained has not become relevant to their current work responsibilities. Additional data, identifying work history, collected during the survey to further stratify the results would have been beneficial in determining the exact cause of the results.

Student open-ended responses to survey questions (Table 2) suggest that the simulated project was a success and offered a form of real-world experience that provided an understanding of the process as a whole. Feedback for improvement targeted software or estimating tools used in the classroom and sequence of material covered within the course.

Conclusion

The direct and indirect data in this study provide initial support for the implementation of a simulated experience in a construction cost estimating course. Additional data will need to be collected upon the students' completion of their capstone coursework. The cost estimate course and the ability to successfully submit an effective bid are prerequisites for the capstone course where student achievement will be directly assessed by faculty and through industry partners' review of student work. The authors believe that the data provided here reveals a positive impact on student success by utilizing a simulation-based learning approach as another tool to aid in student learning and foster work readiness through real-world application. Instructors attempting to implement simulated experiences should ensure that students are afforded the opportunity to gain the requisite knowledge for successful engagement with the simulation as well as provide the necessary instructional scaffolding to avoid student frustration.

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