Using Mock Bid Simulations to Enhance Construction Engineering and Management Education

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Abstract

In the engineering and construction industry, many companies rely on competitive bidding to obtain work. Students can read about how a general contractor assembles a competitive bid and they can listen to an instructor relay this information, but they do not understand how hectic and demanding the process can be. Students need to understand the importance of analyzing a subcontractor quotation quickly and accurately and the difficulties encountered when compiling a final bid price under the pressure of a time constraint. Learning objectives for most construction estimating course include educating students on the common practices of quantity take off and surveys, material costing, evaluation of specialty and subcontractor quotations, overhead pricing and the compilation of a final cost estimate. However, most students do not understand the difficulty that a construction engineers undertake assembling competitive bid proposals on bid day. This paper will present a class exercise that can be used to simulate the competitive bid day environment.

Introduction

The instructional objectives of the competitive bid exercise are for the students to evaluate subcontractor bids and select the responsible low bid in each category, and for the group to calculate a final competitive bid price within the allotted time frame. These instructional objectives allow the student to understand and appreciate the complexity faced by a contractor in assembling a successful competitive bid. The Mock Bid exercise is designed to provide students with a realistic experience of bid day conditions using a real project that they are likely to work on upon graduation.

Background

Beginning in the autumn quarter of 2008, the Construction Management Department at California Polytechnic State University, San Luis Obispo (Cal Poly) launched an integrated project based construction management curriculum. The basis behind the integrated curriculum was to create a series of practice courses, similar to an architecture studio model; however, each course would focus on a specific sector of the construction industry - Heavy Civil, Residential, Commercial, and Specialty Construction[8]. The concept behind the seminars was to integrate project controls, construction estimating and construction contracts and law into each of these courses and combine them with the construction methods topics pertinent to each industry sector. The integrated curriculum that the Cal Poly construction management faculty settled on led to the development of seven (7) project-based courses.

They are as follows:

- Fundamentals of Construction Management
- Residential Construction Management
- Commercial Building Construction Management
- Heavy Civil Construction Management
- Specialty Contracting Construction Management
- Jobsite Construction Management
- Integrated Services Construction Management

Each of the project-based courses was based on a model of six (6) quarter-hours of laboratory credit total of sixteen (16) scheduled contact hours per week and an additional two (2) hours per week to be arranged for by the instructor. Based on a ten (10) week quarter system, students would receive a total of one-hundred eighty (180) hours of instruction[10]. Similar to courses offered through an architecture program, their concept was teach each course in a dedicated space equipped with models, samples, contracts, marketing documents, specifications, estimating guides, computer references, and other tools appropriate to that construction industry sector. In addition, the laboratory would be furnished with work stations for twenty-six (26) students who would have twenty-four (24) hour/seven (7) days of week access to the space[1].

The concept for the commercial building construction management course was to focus on the work performed by a commercial building contractor who may self-perform various work items required for the construction of a commercial building and who procures contracts for and manages the work of subcontractors who fabricate and install the remainder of the work items[3]. Typical work items include structural insulated panel system, structural steel, light-gauge steel construction, concrete formwork and reinforcement, site-cast and precast concrete framing systems, foundation and basements, masonry (concrete masonry units, natural stone, and glass masonry units), exterior wall cladding, windows and doors, roofing, and wall and floor coverings[4]. As one can imagine, the work of a commercial building contractor involves coordinating the multiple trades, to fabricate and install the work items mentioned above. Therefore, learning objectives focus on students understanding the construction methods for numerous work items.

In addition to the learning objectives related to construction methods for the work items mentioned above, students are provided an educational background on topics related to the building delivery process, governmental constraints on construction, loads on buildings, load resistance, structural properties of materials, thermal properties of materials, air leakage and water vapor control, fire-related properties, acoustical properties of materials, principles of joints and sealants, and principles of sustainable construction.

New Facility creates Opportunity for Experiential Learning

Since 1990, the Construction Management Department at Cal Poly had been soliciting donations for the construction of the Construction Innovations Center (CIC) on the Cal Poly campus. As part of the fundraising effort for the new $33 million, 30,000 square foot building which includes seven (7) dedicated labs, twelve (12) classrooms and lecture halls, and faculty offices, which was dedicated in October 2008, it was the goal of the College of Architecture and Environmental

Design (CAED) to create an interdisciplinary learning laboratory for the CAED where students across the college would be able to design, build, and test a variety of building components. The result was a privately funded laboratory 5,000-square-foot lab named the Simpson Strong-Tie (SST) Materials Demonstration Lab for the donors to the laboratory which was dedicated in October 2010.

The integrated curriculum model described by Hauck and Jackson provides tremendous opportunities to engage teaching strategies far beyond the common lecture approach typically utilized in many single subject courses[3]. They proposed that various methodologies, such as cooperative learning, could be utilized in an integrated learning lab environment. Furthermore, they proposed a teaching approach for construction management education which requires students to be active participants in their own education. Students learn far more by doing something active rather than by simply watching and listening[2]. Therefore, to take advantage of the studio-laboratory format of the course proposed in the new curriculum, the faculty was challenged with developing experiential learning experiences to enhance student learning.

Experiential Learning

Experiential learning is learning through reflection on doing, which is often contrasted with didactic learning. Experiential learning is related to, but not synonymous with, experiential education, action learning, adventure learning, free choice learning, cooperative learning, and service learning. While there are relationships and connections between all these theories of education, there are also separate terms with separate meanings[3].

Experiential learning focuses on the learning process for the individual (unlike experiential education, which focuses on the transactive process between teacher and learner). An example of experiential learning is going to the zoo and learning through observation and interaction with the zoo environment, as opposed to reading about animals from a book. Thus, one makes discoveries and experiments with knowledge firsthand, instead of hearing or reading about others' experiences.

Experiential learning requires no teacher and relates solely to the meaning-making process of the individual's direct experience[7]. However, though the gaining of knowledge is an inherent process that occurs naturally, for a genuine learning experience to occur, certain elements must exist. According to David A. Kolb, an American educational theorist, knowledge is continuously gained through both personal and environmental experiences. He states that in order to gain genuine knowledge from an experience, certain abilities are required[9]:

- the learner must be willing to be actively involved in the experience;
- the learner must be able to reflect on the experience;
- the learner must possess and use analytical skills to conceptualize the experience; and
- the learner must possess decision making and problem solving skills in order to use the new ideas gained from the experience.

Course Approach, Learning Objectives, and Delivery Method

The commercial construction management course described above was designed to introduce

students to the construction methods for various work items common to commercial building construction. Therefore the course was developed and delivered with the following goals:

- Understanding the types of materials used in commercial buildings
- Understanding how to read commercial building project plans and specifications
- Knowing the different types of equipment and materials used in commercial building projects
- Comprehend the design intent and constructability issues in commercial building projects
- Synthesizing the knowledge gained through class readings and exercises by participating in a construction site visit

The class was divided into several key methods of delivering course content: lectures, lab exercises, construction site visits, plan reading and material take-offs, and the use of interactive learning stations. Introductory lectures were given on each subject matter. Following the introductory lecture and an assigned reading, an in-class lab exercise was given for students to work on. Lab assignments varied by subject matter but primarily included construction document reading, preparation of cost proposals, and estimating and scheduling exercises.

The plan reading and material take-off exercises required the students to work within their four (4) person teams and review a set of commercial building drawings and specifications for an instructor-selected building located on campus. In addition, several construction projects were visited during the course, including commercial and institutional sites, varying between 30% and 90% construction completion. Following each site tour, students were required to submit a field trip report focusing on a particular aspect of the commercial building. Finally, throughout the class, a common experiential learning exercise was developed which allowed students to perform "hands-on" framing exercises using light-gauge steel. The following section discusses the design and implementation of the experiential learning exercise, including the learning objectives and outcomes assessments.

The Mock Bid Exercise

The mock bid exercise was based on the competitive bid process for an actual project. The project chosen for the exercise incorporates the need for the groups to evaluate subcontractor bids that they receive during the exercise. This exercise was set up so the students the entire term on the project culminating with a final submission at the end of the quarter/semester in the course. Throughout the course, the students are educated on how to perform a quantity take off, estimate the cost of work items, and how to evaluate subcontractor proposals. Additionally, they taught how calculate and assemble a final bid estimate for their proposal.

For large competitive bids, many contractors will assign the analysis of specific divisions of work to bid team members. Therefore, for the exercise, it recommended that each group divide up the work items within their group and each team member are then responsible for that section of the proposal, with the other group members responsible for cross checking each other's. For example, one person may be assigned the task of evaluating the Division 16 Electrical bids. Each team consists of a maximum of four (4) participants. The student teams are tasked with analyzing the following divisions of work: electrical, mechanical, finishes, specialties, and thermal and moisture protection.

At the beginning of the mock bid exercise, the groups are told that they will be required to complete the exercise and submit their final bid with a listing of subcontractors to the instructor on a specified date and time. They are told that, as in industry, late bids will not be accepted. Each bid group is given the following documents at the beginning of the exercise:

- General instruction on how the bid exercise is to be completed. Guidelines for the bond amounts and general overhead and profit that should be applied to the bid.
- A bid form to submit final bid and subcontractor listing.
- A bid recapitulation sheet that is complete with the exception of the final bid amounts for the divisions of work that they are responsible to analyze, self-performed estimate amounts (provided with general instructions), bond costs and general overhead and profit.
- Subcontractor bids for the five divisions of work to be analyzed and a spreadsheet to aid in the bid analysis for each division of work. Each student is given approximately thirteen (13) bids to analyze during the exercise. This number of bids corresponds to the instructor's ability to evaluate the same number of bids in approximately one-third of the time that the students are given for the exercise. This may be a large number of bids, but the students need to experience the pressure of analyzing a large number of bids in a short time to simulate the competitive bid.
- A spreadsheet to aid in the bid analysis for each division of work. The following is an example of the spreadsheet for Division 15 bid analysis:

Organizing the Exercise

Listed below are the instructions given to the student teams for their in-class assignment. Each group has an assigned lead estimator. This person is in charge of assembling the final bid price. The bid has been broken down into the following areas for other individuals to evaluate:

- Division 01 — General Requirements
- Division 02 — Site Construction
- Division 03 — Concrete
- Division 04 — Masonry
- Division 05 — Metals
- Division 06 — Wood and Plastics
- Division 07 — Thermal and Moisture Protection
- Division 08 — Doors and Windows
- Division 09 — Finishes
- Division 10 — Specialties
- Division 11 — Equipment
- Division 12 — Furnishings
- Division 13 — Special Construction
- Division 14 — Conveying Systems
- Division 15 — Mechanical
- Division 16 — Electrical

Each group must decide the percentage of mark-up to add to their bid. The following are the guidelines provided to the student groups to use in their assessment of the appropriate mark-up:

1. The company’s office overhead is approximately 2.5% of the project volume in dollars.

2. The company really needs the work right now, but there are three other bidding opportunities that look promising in the next three weeks.
3. The project duration is 24 months, and their firm likes to bring in approximately $10,000/month revenue on the proposed project manager and superintendent.
4. The company usually puts a 5 – 7% total margin on all projects.

Throughout the term, the teams are provided with answers to questions on their bids. Typical responses to questions that are fielded throughout the term include:

1. Bid price is for the base bid only; Student groups are not considering the pricing of the alternates unless specifically stated.
2. The evaluation of separate divisions should have a bid amount
3. A performance and payment bond is required for this project.

The first step in the Mock Bid is to prepare cost estimates for general conditions. Students then need to note that the quantity take offs and installation costs for other self-performed work that has been completed. These costs and take off quantities should then be entered into the Detail and Summary worksheets provided. Half way through the exercise, students receive bids for materials and subcontracted work. It is their responsibility for incorporating those costs into their bid and preparing a completed bid during this session. The bid opening then follows.

The student teams have been given the summary pricing sheets, some completed takeoff sheets, and the indirect job cost pricing sheet. For this exercise, they have to fill in the blanks on the estimate sheets, create a total, and distribute the indirect costs and end of bid items to each item and fill out the bid form, put it in the envelope, complete envelope, and turn it in on time.

Evaluating Student Learning

A "learn by doing" atmosphere where students are responsible for determining cost provides students an educational environment to experience tasks and the results of their decisions. In the construction industry, many employees are hired that do not have the training or coursework at the university level that provides them access to determine construction cost and produce cost estimates. New employees are often placed in a position, trained to do the daily tasks, but not enough time is available to provide them with the opportunity to experience the entire operation of the business. The mock bid exercise has many of the same decision and overview tools but in the commercial construction sector, a major area key to successful management is subcontractor management.

Conclusions

The students use the skills they have developed during the course of the class to meet the learning objectives of this exercise. All student groups are able to evaluate the subcontractor quotations, determine a final bid price, and turn in their bids by the designated time. This exercise enables the students to get a sense of the time constraints and difficult nature of the competitive bid. It also provides the students with an opportunity to pull all the pieces of information that were learned during the semester into a final concrete result. Students' comments regarding the exercise have been positive. Student groups commented that they felt pressure to complete the bid on time and had a better understanding of the pressures of compiling

a competitive bid. Any time we can simulate an industry condition in the classroom, the students get a better sense of what they will encounter following graduation.

Recommendations for Future Implementations

Possible improvements to the exercise include giving the groups an opportunity prior to the bid exercise to decide "appropriate mark-up" and review scopes for their area of responsibility. In addition, if the bid exercise could be tied to a set of plans that the students have used in estimating assignments it could enhance their learning.

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