2006-2093: USING ACTIVE CONSTRUCTION SITES AS THE CLASSROOM: A UNIQUE COURSE IN ENGINEERING AND THE CONSTRUCTION PROCESS

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Using Active Construction Sites as the Classroom: A Unique Course in Engineering and the Construction Process

Abstract

The construction industry is a $4 trillion-a-year business that employs a significant number of engineering students each year. Teaching engineering students about the construction process and building technology often involves traditional pedagogy (e.g., lectures, assignments, exams, etc.) with occasional visits to construction sites. Many times, these visits are met with some trepidation from site contractors who may view them as an interference or interruption to normal site operations. Instructors may also find site visits difficult to incorporate into the course schedule due to logistical problems; e.g., travel to and from the site, and site work schedules.

This paper describes an engineering course; presented by Linbeck Construction Inc., the site's construction manager, and the Department of Civil and Environmental Engineering at Tufts University, based on two, active, on-campus construction projects; a residence hall and a new music building. Active, problem-based learning was central to course delivery with access to real-world applications of construction processes and technology readily available. The course instructors were CEE faculty, Linbeck personnel, and numerous guest presenters ranging from architects/engineers/builders to managers of university operations and community relations. The classroom was on-site; a construction trailer converted into the Linbeck Learning Center.

Pedagogically, this arrangement changed the course dynamics from using sites as co- or extra-curricular components in course delivery to having active sites, and all their technical and non-technical activities, become the central point through which the course is delivered. Direct contact with a "living" site provided valuable insight to what the students were reading and hearing in lectures as well as immediate relevance to course assignments. It is hoped that the course becomes sustainable via a continued partnership between the department and the construction manager.

Background

In the Fall of 2003, Tufts University initiated the development of a Master Plan for its campus in Somerville/Medford, Massachusetts. The plan, which is evolving, noted a number of potential building sites for the existing campus. Two such sites are the locations for Tufts first new building construction in the past 20 years, the Sophia Gordon Residence Hall and a new Music Building. The new buildings, located across the street from in each other, started construction only months apart with the construction activities of the residence hall beginning in January 2005, and the music building construction starting during the summer of 2005. Though each building was designed by different architects, Tufts retained Linbeck Construction Inc. as the construction manager for both projects. Linbeck invited Tufts to use the construction of these projects to further its educational mission. The Department of Civil and Environmental Engineering pursued this opportunity by seeking to use the construction sites as the basis for a course on the construction process and the roles engineers have in construction. In other words, the projects were used as active learning "centers" through which students will learn and apply engineering concepts and the construction process.

Construction engineering education is not new, dating back to the 1950's [1], and industry has played in important role in the establishment of such programs. The Construction Engineering and Management degree program at Purdue University, established in 1972, has strong university-industry collaborations in program development and delivery[4]. In addition, the use of active construction sites to illustrate or reinforce course concepts is commonplace[2, 3]. A unique aspect of the course described in this paper is its use of an active construction site to not only compliment the course's delivery but to *define* it.

Course Description

The course was designed to introduce the construction process and the engineer's role in the implementation of civil projects. In other words, the courses' aim was to provide students the second level of achievement, Comprehension, as outlined in the revised Civil Engineering Body of Knowledge levels of competence [5]. The course focused on the construction of the Sophia Gordon Residence Hall (SGH) and Music Building (MB) on Tufts Medford campus. Specific topics included program conceptualization and development; project delivery methods; design drawing and specification development; site scheduling, work and review; and cost estimation. The course also examined the interactions between the various stakeholders in the construction projects including Tufts, Linbeck, various architects/engineers, and the surrounding residential communities.

The author and a key contact from Linbeck served as co-course coordinators and evaluators of student performance. As will be described below, course instruction also involved various guest presentations from people with different viewpoints of the construction process. No text book was selected for the course but a number of articles and other reference materials were distributed during the course. Course grading was based on assignments, exams (3), a course project, and class participation.

Course Components

The course consisted of four major components: lectures, assignments and exams, guest presentations, and a course project. These components are briefly discussed below.

Lectures

Two one-hour lectures periods were scheduled for each week. Lecture subjects listed in Table 1. These lectures were presented by the co-instructors with occasional input from other representatives from Linbeck. Approximately one third of the course consisted of project or construction management issues such as program development, project scheduling, estimating, and change management. Another half of the course lectures were on physical components of the construction including overview of foundation, structural elements, exterior façade, mechanical, electrical/plumbing systems and interior finishes. A special lecture was dedicated to site safety issues and was required of all students before they could visit the sites. As much as practically possible, these lecture topics were connected to events happening on the sites. The final section of the course focused on the construction business and future direction and innovations. Though the course generally followed the outline presented in Table 1, events on the site often lead to spontaneous site visits that often supplanted the proposed schedule. For example, the delivery of steel for the erection of the Music Building's frame changed a planned presentation on project schedule and control to superstructure design and construction.

Table 1
List of Lecture Topics in Order of Presentation

1. Introduction and the Building Process – an overview
2. Site Safety
3. Programming and Concept Design: Stakeholders and Relationships
4. Preconstruction Process: Preliminary Design, Bidding, Approvals, Drawings, Specifications
5. Construction Process: Approvals, Change, Close
6. Final Design: Quantity Take-off and Estimating
7. Project Schedule and Control: Procurement and Subcontracting
8. Geotechnical/Foundations/Utilities
9. Superstructure – Steel and Concrete
10. Exterior Envelope
11. Mechanical/Electrical/Plumbing
12. Interior Finishes
13. Construction Business and Innovations

Guest Presentations

A number of professionals; ranging from owner (Tufts) representatives, Linbeck representatives, architects, various engineering consultants, and a construction lawyer, provided guest presentations during the course. Table 2 presents a list of presenters and their topic areas. Some of these presentations covered general, broad themes of the construction process including project development, management, and implementation. Some presentations were open to the public for a larger audience, but most were class-only presentations that covered specific details of sites' work and construction techniques.

Table 2
List of Guest Presenters and Topic

Lecturer(s)	Affiliation	Topic
John Roberto	Tufts University Vice Present for University Facilities	Constructing a Building at Tufts University
Barbara Rubel	Tufts University, Director of Community Relations	The Importance of Community Relations as it Relates to Construction Projects
Doug Johnston	Rawn Associates – Architects	Tufts University Master Plan and the Architecture of the Sophia Gordon Residence Hall
Milton Reynard	Linbeck, Chief Estimator	Project Estimating
Bill Morash	Linbeck Chief Scheduler	Project Scheduling
Andrew Chan	Haley and Aldrich, Project Engineer	Geotechnical Foundations for the Music Building
Dennis Ingram	Linbeck, LEEDs Coordinator	LEED Overview and Its Application to the Sophia Gordon Residence Hall
Peter Cheever and Jennifer Edelmann	LeMessurier Consultants, Vice President and Project Engineer	Superstructure Design and Construction for the Sophia Gordon Residence Hall
Mike Loulakis	Wickwire Gavin, President	Construction Contracts and Risk Allocation
John Kennedy	Linbeck, Principal	Entrepreneurship in Construction
John Fisher	Linbeck, New England's Regional Office Manager	How to Succeed in A Career in Construction

Students had to provide a one-page summary of these presentations as well as state what they thought were the "take home points".

Course Projects

Student projects were done either by individual or in small groups. The focus of the project was for students to choose a topic of interest to them for further evaluation. For these projects, the students needed to provide:

- Daily logs of project events (research, material gathers, interviews, etc.)
- Bi-weekly progress reports
- A written final report (10 page maximum length with appendices if necessary)
- A 15-minute oral presentation

Though not required, it was hoped that some of the projects could be used for public demonstration of project components. The topics chosen for the projects are listed in Table 3.

Table 3
List of Course Projects

Topic	Project Description
Alphabet Book	Development of a book for teaching the ABC's to pre-K kids using images and tasks from construction
Exterior Wall Construction	Display and explanation of the exterior wall system for SGH
Sustainable Elements of SGH	Display of the LEED components of the SGH including construction recycling and solar panels
SGH Architecture	The architecture of SGH and its comparison to various architectural styles
Music Building Architecture	The interior architecture of the new Music Buildings and it implications on construction
GMP Process	How Guaranteed Maximum Price was used to deliver both the SGH and Music Building
Virtual Tour of SGH	Development of an animation of the construction and certain elements of SGH

Other Activities

Often, lectures would end with mini-site tours to allow the students to directly see how the lecture topic of the day (or previous day) was being done on one of the sites. Late in the term, an entire lecture period was spent on the sites to provide the student an extended view of not only site components, but how the sites were being constructed. Snaking around and through unfinished buildings allowed to students to see many different aspects of a buildings construction and how the different trades must coordinate their work so as not to interfere or have to re-do any of the previous work done by another trade.

One of the more enjoyable activities of the course was when the students preformed a brick/stone laying activity. The exterior façade of the SGH required both brick and quarried stone sections. The sub-contractor hired to do the façade construction provided access to and a demonstration of how the brick and stone are laid. The students then got to lay both materials onto the façade. The immediate and important lessoned learned in this activity was that while laying brick may look easy, it is not and in fact it takes some time to master. The value of the activity was that the students now knew first hand the level of craftsmanship involved, even in what looked like the simplest of tasks.

Course Outcomes

Typically, student views of the course come from the end-of-course evaluation process. In general, the course and instructors faired quite well receiving an average of 4.7 and 4.6 out of 5, respectively. A common positive comment from the evaluations was having guest speakers convey their experience and knowledge about the construction process. However, since the course was new, student input was also sought throughout. In particular, a "two-thirds" course evaluation was performed (at approximately the two-thirds point through the course) to not only evaluate how the course was progressing to date, but what else could be done or was of interest for the rest of the course. The predominant, supportive comment was with respect to seeing the non-technical aspects of construction while the area noted for improvement was the need for more site tours. In addition, the students wanted to have more opportunities to see and hear from site personnel and sub-contractors on how they do their work on the project. Attempts to address both of these issues were made in the final weeks of the course.

From the instructor's perspective, the course was an excellent opportunity for student learning. As noted by the students, the guest speakers had a significant impact on the student learning, especially those who discussed non-technical aspects of the construction process. However, areas of improvement are definitely needed. For example, two one-hour class meetings per week were insufficient to cover most of the material that had been developed for presentation. The lack of sufficient lab time greatly reduced the capability of site visits as well as opportunities to expand on the lecture material with real site examples.

Conclusions

The use of construction sites to deliver the course provided a unique opportunity to dynamically change the pedagogical paradigm from using sites to augment teaching to using sites to outline the course. The benefit of these sites were that they were local and of direct interest to the students. Direct contact with a "living" site provided valuable insight and immediate relevance to what the students were reading and hearing in lectures and doing in assignments.

From Linbeck's perspective, the course incurred slight uses of their human resources, but this use was manageable and in some cases welcomed. Linbeck received no formal compensation for their participation in the course, yet gave it their utmost attention. Similarly, the guest speakers did not receive any compensation. It is clear that the desire of practicing engineers to give back to their profession via educating the next generation of engineers is still a vibrant resource that should be tapped. It is hoped that the course becomes sustainable via a continued partnership between the CEE department, Linbeck, and area engineering professionals.

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