

Design and Implementation of an Experiential Learning Exercise for a Commercial Building Construction Management Course

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Over the past several years, the building codes that govern commercial building construction have become increasingly prescriptive in nature, specifying detailed information related to the design and installation of the systems, while offering no reasoning behind their prescriptive measures. For example, metal stud framing is commonly used in commercial building construction to create bearing walls and non-bearing partition walls. Students now read and study construction details about metal stud framing installation methods in textbooks, and using published productivity rates, they perform in-class exercises estimating quantities and scheduling their installation, but they lack the experience working with the material and understanding the challenges trade workers face in the field during installation. This paper describes the design and implementation of experiential learning exercises that allows construction management students to perform "hands-on" fit-up exercises of metal stud framing.

Key Words: Commercial Building Construction, Experiential Learning, Construction Education

Introduction

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. 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. 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.

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. 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. As one can imagine, the work of a commercial building contractor involves coordinating the multiple trades, with whom they have contracted with, 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 (Hauck and Jackson, 2005). They proposed that various methodologies, such as cooperative learning and the use of interactive learning stations, 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 (Bonwell and Eison, 1991). 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 (Bonds et. al., 1993).

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 (Felder, 1994). 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 (Kolb, 1984):

- 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.

Light Gauge Steel Experiential Learning Exercise

Over the past several years, the building codes that govern commercial building construction have become increasingly prescriptive in nature, specifying detailed information related to the design and installation of the systems, while offering no reasoning behind their prescriptive measures, i.e. metal stud framing is commonly used in commercial building construction to create bearing walls and non-bearing partition walls. Students now read about metal stud framing methods and practices in textbooks, and using published productivity rates, they perform in-class exercises estimating quantities and scheduling their installation, but they lack the experience working with the material and understanding the challenges trade workers face in the field during installation.

Planned Learning Objectives

The interactive learning station originally proposed was envisioned to be a laboratory tool that would enhance students’ understanding of light gauge steel construction systems beyond the textbook explanations by allowing students to observe how light gauge steel systems perform in addition to allowing them to gain “hands-on” experience of framing. Incorporating the experiential learning exercises allows students to test each of the many practices commonly used for installation. Laboratory exercises using the experiential learning exercise were designed to enhance student learning with the following learning outcomes and objectives:

- Name and identify the components used in the installation of the light gauge steel
- Describe and perform the installation commonly used on light gauge steel
- Explain the theory behind the prescriptive building codes
- Develop construction sequencing and installation schedules for the light gauge steel

- Perform inspections and create reports for light gauge steel

Planning and Implementation

It was conceived that students would be given architectural layouts of proposed framing layouts. Students would be required to produce diagrammatic installation drawings and then have the opportunity to fabricate, test, and analyze the performance of their system.

In a typical construction management program course, classes usually range from 20 to 26 students and it was envisioned that students would work best in groups of two (2) or three (3). Therefore, eight (8) to ten (10) stations would need to be fabricated for students use. Preliminary dimensions for the framing exercise were estimated to be 4' wide by 12'-8" long. The structure was proposed to be constructed from light gauge steel framing members; similar to what students will find in a commercial building.

So that framing sections could be reused each course offering, it was envisioned that they would be fabricated so that they would not have to be modified and that they could accommodate multiple uses. Following that reasoning, once a student group fabricated and tested an installation, they would need to be able to disassemble their fabrication so that another installation could be fabricated and installed to demonstrate another type of system. Basic information provided to the students regarding light gauge steel was provided to the students, shown in Figure 1.

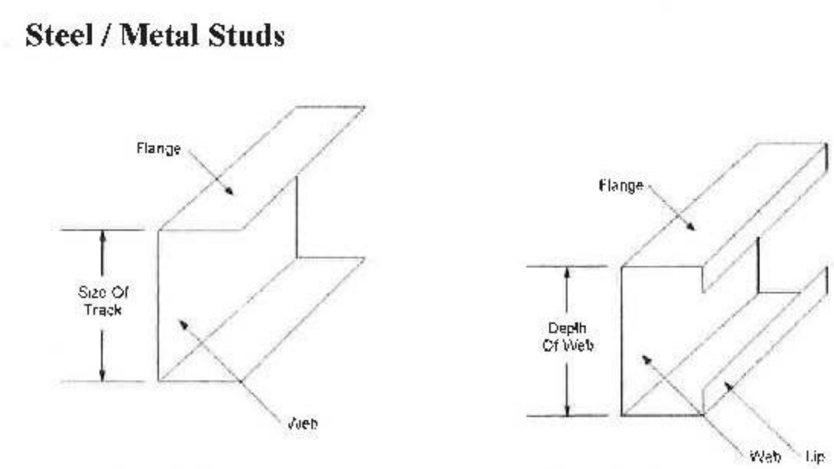


Figure 1 - Standard Light Gauge Steel Members

Prior to physically beginning work, the student groups are asked to complete a preplanning assignment, which can take form of a list of what input resources and information are needed, - schedule timing for the inputs (e.g., principles of just-in-time delivery), sketches and drawings such as concrete lift drawings and layout drawings. Basic information regarding who, what, where, when, how and why of a construction operation. This requires the student groups to study work packaging, which is concerned with breaking work down into packages that constitute work for about one week for a crew. Typically, they utilize coding schemes and a physical breakdown that corresponds to project information systems' such as schedules, cost control systems, and even drawing numbering systems. In the course, the students are introduced to the concept of breaking work tasks down at various levels in the organization by project level, area level, disciplines (e.g., pipefitters, millwrights, electricians), categories (e.g., for piping there are steam, water, air, gas systems), line numbers (e.g., for steam we may have line 1,2,3,4), isometrics (e.g., for line 6 we may have four isometric drawings).

They begin by collecting information about the work activity selected above, and develop a (set of) of preplans for it. Guidelines for the preplan(s) ask the students to describe the optimum method that a crew(s) should use to perform the activity. The students are asked to design the method considering the site constraints (e.g. allocated space, availability of tools, site conditions, etc.), but not be limited by them. As a suggestion, the groups are encouraged to meet for a "brainstorming" session to develop input for the method prior to proceeding to the design and preplan(s).

The preplan(s) should be no longer than three (3) pages in length and should include essential information about materials, labor (including optimal crew size), tools, place, equipment, information, energy, quality procedures and standards, safety, and environmental factors, and schedule requirements. While the preplans should be concise, the requirement is that they be very specific and include the following:

- types and quantities of materials
- workers
- tools
- where to set up and work
- size, type and role of equipment
- references to pertinent specifications and drawings
- quality standards and procedures
- pertinent OSHA safety regulations
- specific environmental issues and contingencies
- descriptive sketches; etc.

An example of the task planning form used is shown in figure 2 and 3 below.


Task Planning Form

Date task is to be completed: ____________ Plan prepared by: ____________
Team Leader: ____________ Task Safety Coordinator: ____________
Task to be completed: ____________ Location: ____________
Project Coordinator or Foreman in charge: ____________

Task Description

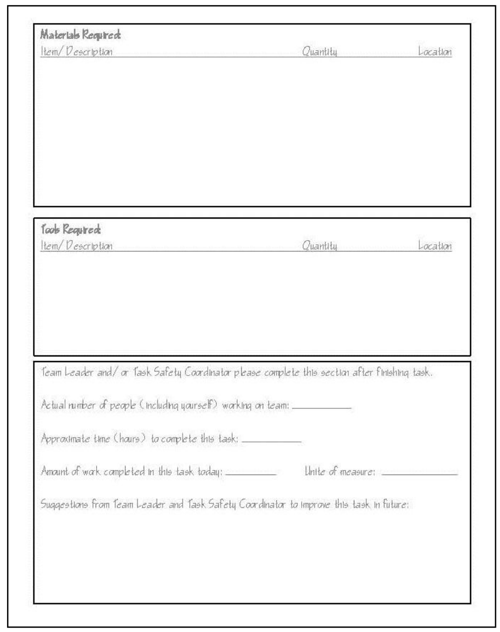
Technical requirements (e.g., patterns & spacing of fasteners, panel staggers & laps, etc.):

Safety requirements (e.g., guardrails, tie-offs, hard hats, ear plugs, safety goggles, dust mask, spotter, etc.)

Preferred Crew Size:
Suggested crew assignments:

See back of page for material and tool use lists

Figure 2 - Example of Task Planning Form (front side)


Materials Required:

Item/ Description	Quantity	Location

Tools Required:

Item/ Description	Quantity	Location

Team Leader and/ or Task Safety Coordinator please complete this section after finishing task.

Actual number of people (including yourself) working on team: ____________

Approximate time (hours) to complete this task: ____________

Amount of work completed in this task today: ____________ Units of measure: ____________

Suggestions from Team Leader and Task Safety Coordinator to improve this task in future:

Figure 3 - Example of Task Planning Form (back side)

Outcomes Assessment

As a result of implementing and using the exercise, the students were able to perform the following new and enhanced learning outcomes and objectives:

- Name and identify the components used in the installation
- Describe and perform installations
- Explain the theory behind the prescriptive building codes
- Perform installations of systems according to building codes
- Develop construction sequencing and installation schedules
- Create a “Bill of Materials” for fabrications
- Estimate fabrication and installation schedules
- Advise others on the installation techniques and practices commonly used

- Test installations
- Perform inspections and create inspection reports

Examples of assessments that were used in the laboratory where students have participated in the experiential learning exercise have included the following:

- During an examination period, students were shown an installation, constructed with the experiential learning exercise, and asked to write an inspection report and identify installation errors and/or potential problems.
- Students were asked to give an oral presentation in which they were required to give a presentation to the class on a particular system that they built using the experiential learning exercise.
- For a quiz, students were shown a particular assembly constructed with the experiential learning exercise, and then were required to use the experiential learning exercise to produce diagrammatic installation drawings.

Compared to students being taught via the traditional lecture mode, the cooperative environment provided a forum in which a deeper understanding of the material could take place and motivation could be placed on learning and achieving a common goal. Use of the interactive learning station encompasses many of the seven principles of good practice for education by encouraging contact between students and faculty, developing reciprocity and cooperation among students, encouraging active learning, giving prompt feedback, and respecting diverse talents and ways of learning.

Discussion and Recommendations for Future Implementations

Integrating the course content of commercial building construction methods for construction management students is one approach to help change students' and future constructors' thinking to look at systems as a whole, rather than as independent systems, which helps to enhance and reinforce learning by arranging content around overlapping concepts and themes. The use of the common interactive learning station for the systems further helped to reinforce connection points between the multiple systems. Future laboratory experiential learning exercises may include fabricating a mock-up section of an exterior wall section.

The student work performed on the experiential learning exercise also emulated the work of light gauge steel framing contractors who they may find themselves managing upon graduation. In order to install the light gauge steel systems in the interactive learning station, students were forced to consider design, construction, and operations and maintenance criteria in order to achieve proper functioning systems. Upon graduation, most graduates of construction management departments take positions with construction companies and are placed into roles as field engineers and construction managers, or take positions with owners as facilities managers, owners' representatives, and construction inspectors who perform quality control task. Often they are asked on construction jobsite "How can you manage construction if you have never performed construction yourself?" or "What qualifies you to inspect my work?" Using the experiential learning exercises allows students to qualify themselves by giving them the hands-on experience in installation and testing the systems and furthermore giving them the capability to describe the theory behind the building code and to explain the effects of improper installations rather than just citing the building code.

The experiential learning exercise allowed an enhanced level of student-faculty contact by allowing the students and faculty to work together in a fashion other than the traditional lecturer-listener relationship that is most commonly found. Use of the experiential learning exercises encouraged students to work with their peers and the faculty member to achieve the above listed learning outcomes. The experiential learning exercise also encouraged active learning by experimentation and gave students prompt feedback by allowing students to test their mock installations.

The interactive learning station also allowed students to learn in a multitude of ways by allowing students of all learning styles to develop from laboratory experiences related to the experiential learning exercise. From subjective observations, kinesthetic learners benefited from the "hands-on" fit-up exercises, visual learners benefited from being able to observe, and auditory learners benefited from working in student groups by either giving or receiving fit-up installation instructions.

It is the authors' opinion that the experiential learning exercises are innovative in the fact that it is a laboratory tool that focuses on getting "back-to-basics". As described above, the building codes that govern the design and installation of commercial building construction have become increasingly prescriptive in nature, while offering no reasoning behind their prescriptive measures.

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