AC 2012-4905: INTEGRATED PROBLEM-BASED LEARNING: FRAMING CUBE

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Integrated Problem-Based Learning – Framing Cube

Abstract

This paper examines a case study for problem-based learning in a construction techniques setting. The case compares alternative deliveries for a traditional linear instructor based training to that of computer aided, peer learning, and performance based holistic approach. Prototype ¼ scale designs are first developed. The "Framing Cube" drawings themselves are schematic but provide enough detail and notes for the students to complete the project with the aid of course material, applicable building code, and three-dimensional modeling tools. Students are divided into groups to capture and evaluate their learning experience, project execution, and problem solving experience. These student groups are divided into traditional wood framing material only and three dimensional modeling aided groups. The outcomes evaluate the use, acceptance, and perceived value of three dimensional modeling in a competitive peer reviewed environment. The findings indicate that there is perceived value to the computer aided design but that constraints are needed ensure the full benefits of three dimensional modeling occur.

Introduction

Construction is a unique industry compared to traditional assembly line industries. Typical projects involve one of a kind unique designs put together by unique design and construction teams for an individual owner in unique locations with differing project design requirements. Levels of construction drawings and details vary from project to project. Code requirements may differ from state to state within the United States. Computer aided software packages are allowing for better understanding of design intents through the use of three dimensional and building information modeling [ii]. In a construction techniques course within a engineering and construction management setting traditional modes of teaching involved demonstrations followed by replication of efforts by the students (e.g., deductive learning). The reality is that this is not the method in which they will learn beyond a university setting. Trade-programs on the other hand often provide a balance of written tests and skill or performance tests [v]. The goal of the Framing Cube lab was to develop an integrated problem-based test to evaluate its effectiveness in learning. The Framing Cube provided a cost effective way for the students to evaluate their knowledge of framing, modeling, code requirements, construction techniques and plan reading. The main outcome of the process was to evaluate the student's perceived value of integrating a computer model to assist them complete the ¼ scale wood model.

Problem-Based Learning

This study examines an attempt at problem-based learning (PBL) in a traditional hands-on construction techniques educational setting. PBL conceptually focuses on presenting a real world problem in which students need to apply lessons traditionally taught in a linear fashion in a parallel contextual based setting [vii,ix]. In the context of this program, students learn code requirements, estimating, and plan reading, and modeling in four different courses. Previous research has focused on differences and similarities of classroom, active, and teamwork settings in architecture and engineer settings [i]. Additionally the importance of peer or social interaction and review of work played a vital role in the effectiveness of the study [x]. According to Yang "In a community, meaningful learning is achieved by interaction, and people share individual resources, elicit challenging question and provide constructive feedbacks so as to enhance personal intellectual growth.[x]" This is especially true for students that go on to be part of a large construction projects. The integration of expertise and community decision making by stakeholders is critical on large construction and design projects.

Learning Frameworks

The goals for the project were developed to touch upon several learning theories or methods. While the theoretical framework for the learning cube was based on problem-based learning the way in which the students experienced the project differed based on which cohort they were in. Experiential learning theory places an emphasis on the experience of the individual in the learning process [iv]. Learning styles such as initial involvement, reflection, logical conclusion, and action were touched upon in the review of the students' experience. The uniqueness of the findings was the strategies the students choose when given an option in completing the projects.

Outcome Objectives

The goals for the project were to develop an integrated problem based learning module with peer communication aspects in a hands-on setting. Additional measurable goals included:

- Understanding of framing concepts (i.e., header, double-top plate)
- Understanding of code requirements
- Understanding of drawing notes
- Peer learning and communications
- Potential benefits of 3D modeling

Content and Rationale

The module was developed to be used in the construction techniques course. The course text is Building Construction – Principles, Materials, and Systems by Mehta [v]. In addition the students were provided the Florida Building Code 2007 [iii]. The students involved in the project were first semester juniors. Most students have had an introduction to drafting and a building materials course. All the students were co-enrolled in a design and plan reading class which utilized Revit. The students were also required to use Google SketchUp [viii] for the techniques course.

Figures 1 and 2 show the Framing Cube schematic design. Notes on drawings state the following:

1. Rafters 16" OC
2. Outlookers 2' OC
3. Balloon Wall Framing 16" OC
4. Hip End
5. 2 x 4 Ledger
6. Drop Truss
7. 1 x 4 Diagonal Brace
8. Flat Ceiling Except at Rafters
9. Studs, Headers, Rafters, Trusses Not Shown

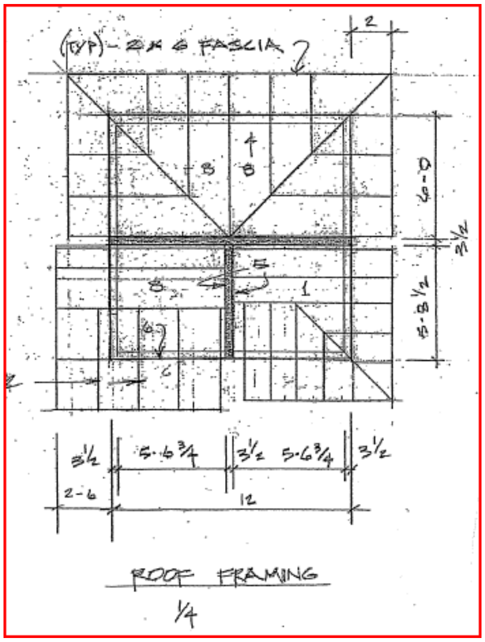

Figure 1 – Framing Cube Schematic Roof Framing Design

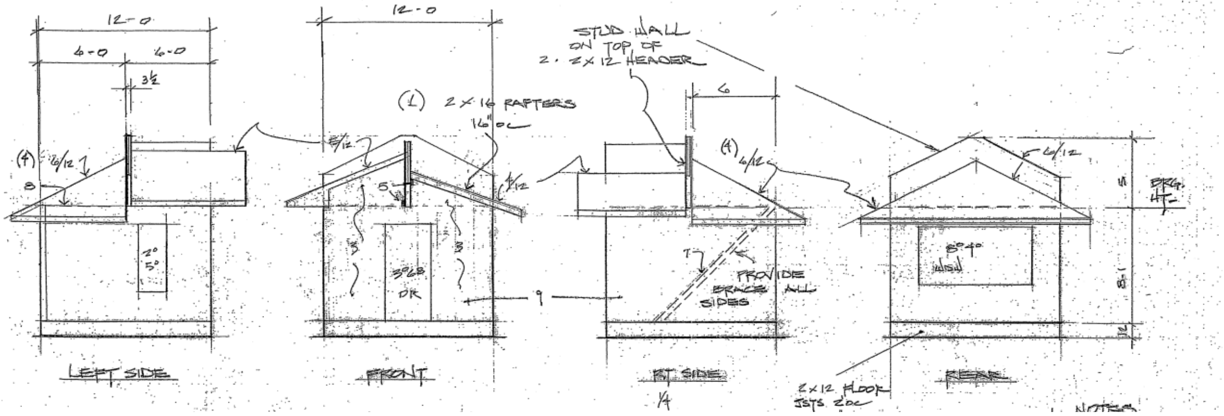

Figure 2 – Framing Cube Schematic Design

Each orientation was designed to test the students understanding and the ability to visualize the project.

Figure 3 shows an above average wood model submission. Note that project is not actually complete relative to the drawings. This will be discussed further during student evaluations.

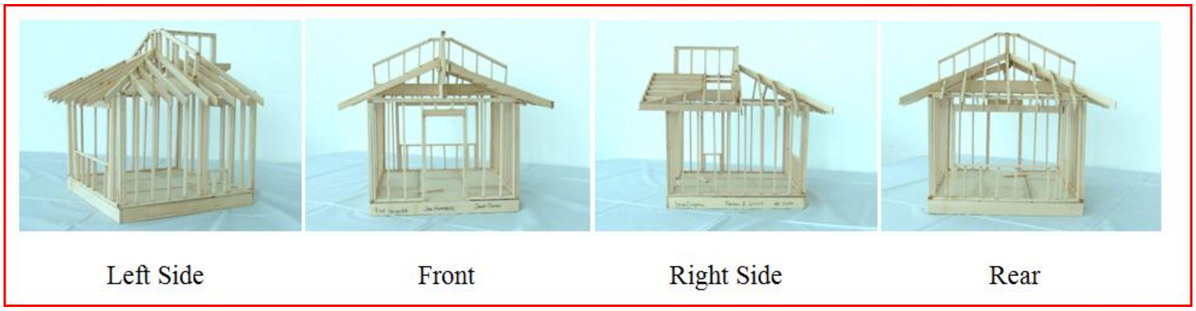
Left Side Front Right Side Rear

Figure 3 – Framing Cube Stick Build Model

Figure 4 shows an above average submittal for the SketchUp model. The groups responsible to submit their 3D model prior to their final project had a higher execution of detail.

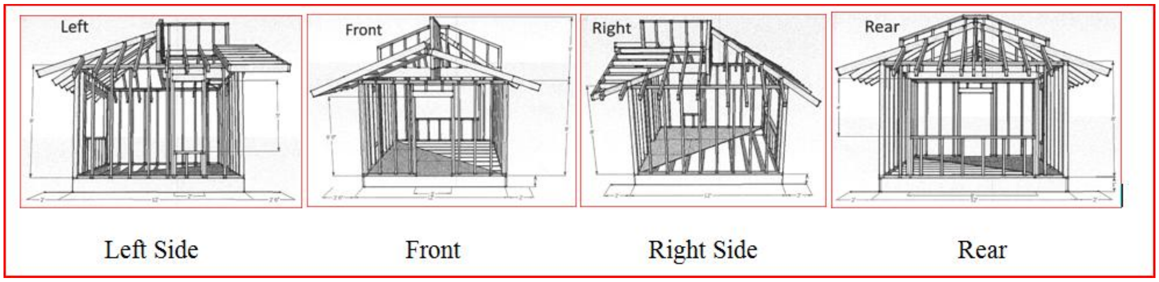

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Figure 4 – Framing Cube Google SketchUp Model

Methodology

The unique aspect of the Framing Cube and assignment is that it allows students to apply their understanding of course material on several levels. The students are provided a simple one page sketch and given material and lab space to develop their project. Framing and code requirements are discussed in class but nothing is directed specifically to building the cube. The students have assigned course material available to them. The outcome of lab was indicative to what happens on some jobsites and work crews.

The class was self-divided into groups comprising of no more than four team members. Groups were randomly divided into three categories. Table 1 shows the main difference in being the requirement for 3D modeling and the submission of work. Cohort A was not required to submit a 3D SketchUp model. Cohort B was required to complete a SketchUp model prior to starting the wood model framing. Cohort C was given the requirement to submit the completed SketchUp model at the same time as the wood model. All required cohorts submitted their models for peer review on the same day.

Table 1: Cohorts based on deliverable schedule and modeling requirements

Deliverables	Number of Groups	Cohort		
Wood Model Only	5	A		
3D Model Prior to Model	4		B	
3D Model with Wood Model	6			C

All of the above was evident when they first met as teams in the construction yard. The assignment was given handed out in class two days prior to the lab and the instructions specified the following:

- Cohort A – Submit a final wood model at the end of eight days.
- Cohort B – Submit a 3D model within 4 days for review and submit final wood model at the end of eight days.
- Cohort C – Submit both the 3D model and the wood model at the end of eight days.

None of the groups had worked out their 3D model before attending the first build session. None of the groups had done any sort of pre-planning. All of the groups in their first lab session determined that the roof system on the actual schematic design provided enough detail to build without additional explanation or sketches.

Expertise

Being that it was a group project, individuals with either framing or advanced Google SketchUp knowledge found them being looked upon as default leaders. The students as a whole found that all of them were alike in their ability to be welcomed in the program but that some of them had brought additional skills into the program or had developed their skills more quickly during their short time in the program. Teams that lacked both framing and modeling experience felt the pressure of both getting their wood and 3D models correct in a short time.

Students Evaluations and Perceptions

From a student perspective it was a great success. Our school does not promote the use of basswood models and this was a first for most of them to try their hand at such ‘mini’ mock-ups. All of the intended goals of the project were met, but some of the more interesting outcomes came out with a post-completion project evaluation. Students were asked to list time spent on each aspect of the project, what skills were needed to better succeed, and what additional training may have improved their learning experience.

Cohort A

Cohort A unanimously agreed that a computer generated 3D model would have simplified the build. Average build time for the group was 10 hours. Overall impression of the group is they missed out a greater learning experience and better quality build by not having to do the computer model. None of the groups elected to develop a computer model on their own. This is an important outcome in that had they perceived a value prior to starting the project they were free to do so – it just was not required as part of their assignment.

Cohort B

Cohort B unanimously stated that the expertise level of individuals groups determined the success of the first model submission. Only two of the four groups submitted a roughly completed model in the time period of the first four days of the project. Average build time for the group was just over eight hours. Average model time development was close to eight hours. The peer group unanimously graded Cohort B as most accurate wood models compared with the other two groups.

Cohort C

Cohort C also agreed with Cohort B regarding individual expertise facilitate the completion of the model. Cohort C's unique revelation is that each group attempted to complete the wood model prior to 'building' their SketchUp model. Essentially their 3D model was put together as an as-built. Length of time for each project consisted of six hours of model time and eight hours of build time.

Discussion

Some additional outcomes included in the peer summary sessions include the following:

- The value of pre-planning and layout
- The value of a 3D model
- Time and scheduling estimating
- Material take-off and waste-factors
- Individual expertise impacting a team process

Although the class determined that the project was a success in that students felt they learned more by doing then by reading 'how to' guidelines and code books there are obvious means to possibly improve upon the process. There are any numbers of ways to improve the lab based on desired outcome. Obviously requiring a material take-off showing the optimum utilization of their wood pieces given the provided length and cuts would have been useful. Requiring their 3D model be complete prior to lab for all cohorts would have helped with planning. Dividing skill sets, both framing and modeling, among groups would have lead to a better balanced peer learning experience. Going over in detail portions of the build that may be more difficult to comprehend would have been valuable in terms of time savings. All of these may add to the value of the process depending on the outcomes desired.

Conclusion

The lab itself was a test of the students ability to apply what they have been instructed and to use the resources at hand to fill in the necessary gaps in schematic design to successfully complete a framing project. The outcomes of the project proved this and more. This project brought in two methods of learning that were previously never joined – that of hands-on experience and computer aided modeling. Current computer modeling classes focus on full scale projects that the students will never build. Likewise current hands-on experiences tend to be simple forms that can be built from basic materials in a limited amount of time. The main outcome of the study was the self assessment of the students as to the value of computer aided modeling based on their own experience.

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