
AC 2012-4012: THE DEVELOPMENT OF AN INTEGRATED RESIDENTIAL CONSTRUCTION MANAGEMENT COURSE

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The Development of an Integrated Residential Construction Management Course

This paper presents the recent changes to different delivery methods for a residential construction management course at a major university. The project-based course was delivered similarly to a capstone course by combining Residential Methods, Estimating, Scheduling, and Contracts into one class with one overall final project. The course introduced students to land acquisition, land development, construction services, operations, finance, marketing, and sales. Information about the course's 14 different delivery methods and the recent changes is provided in this paper. The recent changes are based on a survey that was conducted to obtain the students' perspectives about the course delivery methods and combination of methods students preferred and found effective. Students also provided insight on additional delivery methods they preferred and found effective from other courses that provided insight to the recent changes. The results of the student surveys are presented and discussed. Survey results led to two alternative delivery methods that have been recently adopted in the course. These methods are: 1) providing opportunities for students to build residential assemblies outside the classroom in collaboration with industry professionals on full-scale projects by applying knowledge learned in class, and 2) new interactive electronic reading. This information may assist educators with developing the appropriate mix of delivery methods.

Introduction

The core subjects in construction management are scheduling, estimating and contracts, which are typically delivered in a lecture, format in standalone classes [1]. "The traditional segmented, topic-based approach to construction management curricula clearly has been successful at facilitating the attainment of specialized skills and concepts such as quantity surveying, estimating, or scheduling. However, the world does not always present problems that are topic specific and solved in a non-holistic manner." In the traditional construction management curriculum model, students may have difficulty "connecting the dots" between these classes "to grasp the overall process of construction management as a dynamic, synergistic engagement of subject matter and skills until they reach their final term or participate in a single capstone experience at the end of their education" [2].

Chinowsky, found the following results for students who went through their project-based learning courses:

- Students were more mature with greater communication skills and understanding of the industry.
- Students obtained the ability to form questions that extended beyond the normal boundaries of the assignment.
- Students gained a deeper understanding of the construction industry.
- Students recognized they need to address challenges and create solutions to open-ended problems [1].

The delivery system described in this paper is similar to the paper Peterson (2008) published in the Associated Schools of Construction Proceeding in 2008. The primary difference between Peterson's course and the one described in this paper was the students. Peterson's course was a capstone course for graduating seniors while the course described in this paper was for second year students. Peterson's class primarily applied knowledge gained from previous courses to the capstone project. The course described in this paper had to deliver new information to assist the students with the final project. Peterson provided the following conclusions about the project based delivery system for residential courses:

- Helps students in the transformation from "academia to industry".
- "Classroom structure and theory" is important for student motivation.
- "Smaller sized groups" helps with keeping all students involved.
- Developing a strong relationship with industry is a vital part of the project based delivery system[7]

Students have preferences for the ways they receive information [5]. Having knowledge of students' preferred method of information delivery may help the instructor customize the instruction to meet the individual student's preferences, assist instructor with overcoming the thought of treating every student in a similar way, and motivate instructors to move away from their preferred mode of information delivery to use others.

Kelting and Hauck (2010) evaluated which method or combination of teaching methods is more effective and more appealing to students in their second year. Their study was unique because it focused on all of the delivery methods utilized in the course and the students' perception of the overall impact on their learning. Kelting and Hauck (2010) included the reviewers' suggestions and recommended that an area for future research would be to study which method of information delivery (e.g. lectures, field trips, etc.) is more effective and appealing to students. A follow-up study based on their recommendation for future research was conducted and focused on students' perspectives of the entire course and its' delivery methods [3]. Based on these results, two specific delivery methods were changed in this residential construction management course. These methods are providing opportunities for students to build residential assemblies outside the classroom in collaboration with industry on full-scale projects by applying knowledge learned in class, and new interactive electronic reading. This paper presents the history of this course and the recent delivery method changes for a residential construction management course at a major university.

History

Spring 2008 was the first quarter the faculty officially implemented the delivery system described in this paper. There were many iterations of pilot studies during which the students provided the faculty with feedback that has contributed to the course's current state of development. Montoya, Kelting and Hauck (2009) discuss some of the student feedback in the areas of space utilization, ensuring individual learning when assigning work in groups as part of the project-based delivery system, and the appropriate role of industry in the classroom. Kelting and Hauck (2010) concluded, "students perceived working on a quarter long final project simulating the current market helped them better understand the course material. The most

impressive results were the students' perspective of the integration of estimating, scheduling, contracts and building methods. They felt the integration of these core subjects helped promote their understanding of the overall building process.”

The average class size was 24 students. They were divided into six teams of four for both the lab assignments and the final project. The class met 16 hours a week for a ten week quarter in the spring and 32 hours a week for a five week quarter in the summer. The course was taught in a laboratory space that was dedicated solely to homebuilding education, and primarily focused on new home construction. The class combined components of the following four classes: Residential Methods, Estimating, Scheduling, and Contracts. The following teaching methods were used in the class: lectures, lectures with a personal response system, in class activities and discussion, guest lecturers, labs, overall capstone project, peer reviews, exams, quizzes, field trips, reading assignments, homework assignments, working in teams, and student presentations.

The faculty strived to immerse students in all aspects of the homebuilding industry through lectures and interactive discussions. The lectures covered material from acquiring land through the warranty process. The instructor introduced students to the following management concepts: land acquisition, land development, construction services, operations, finance, marketing, and sales. Current market conditions were discussed in great detail, as they were vital to the success of the final project. The lectures were designed to give students the information needed to apply the skills learned in the classroom to lab assignments and their final project. The lecture material in this course was designed to be interactive by assigning pre-lecture assignments and short class assignments during the lectures. These assignments led to many great discussions in class. The lectures were delivered in PowerPoint and multi-media and many of them utilized a clicker personal response system to encourage and assess participation. Each student in the class had a personal hand held device that allowed the student to respond to multiple choice questions electronically. The instructor used the device to measure student understanding during the lecture. It worked like this: Approximately every twenty minutes during the lecture, the instructor asked the students a multiple choice question based on the lecture material previously covered. The students used their personal response system to answer the questions during lecture. The results were displayed in a graph to the students and later inputted into the grade book as part of their class participation grade. The personal response system was also used for class discussion, quizzes, and other activities. All lecture material was posted electronically so that students could refer to it.

Guest lecturers from different departments of residential building companies were brought in from industry to discuss various topics of the course, based on their experience. The faculty met with the speakers in advance of their presentation to discuss the students' project. This gave the guest speakers the ability to tie their examples to the class project. The guest speakers were also able to answer general questions students had about the project and offered insight and information that the lectures did not cover. This also strengthened the relationship between the industry and the students.

A series of labs were assigned throughout the quarter. The labs were designed to reinforce the concepts covered in class and assist the students with their final project.

The quarter consists of four lab assignments:

1. Lumber Market Lab: Groups of students tracked the lumber market weekly and created a graph. One group was randomly selected weekly to present the current state of the market.
2. Foundation Lab: Students were given two different foundation designs for all homes on the final project. Students prepared a detailed quantity takeoff and cost estimate of the two different designs. They selected a foundation to use for their final project based on their estimate, soils report, risk analysis and additional research.
3. Hand Schedule Lab: Students created a schedule by hand on butcher paper of one of their assigned homes. Students calculated the early start, early finish, late start, and late finish for 25-30 activities. In addition, they calculated the free float and total float for each activity.
4. Scope of Work Lab: Students compared two different companies' scope of work for the same trade. They provided a detailed list of similarities and differences and a detailed analysis of both scopes of work.

The students went on three field trips during the quarter, two of which were to jobsites. Depending on the stage of the project, the project manager of the jobsite walked the students through pre-drywall or post-drywall orientation of the home. One field trip was to a custom home and the other was to an active adult community. The third trip was to the local truss manufacturing facility. They met with the facility manager and area sales manager. The students were provided with information about the truss manufacturing design and process, as well as their floor joist manufacturing process. After the introduction, the students were taken on a tour of the facility to see the truss and floor systems being produced, sent through quality control and loaded onto the trucks to be delivered to the jobsites. The facility is a LEED certified building and the students learned about the different LEED components as they took their tour.

The final project was a series of assignments that were to be completed throughout the quarter and then compiled to compose a final project. The length of time for each assignment was dependent on the difficulty of the deliverables. Each group met with the instructor and presented the deliverables of each assignment at the time of its due date. The students tasked to review a developed property that was for sale and to develop a feasibility analysis for consideration of funding and acquisition or to explain why this project may be too risky for the company.

The final project consisted of seven assignments:

1. Students prepared a strategic and operational marketing analysis for the project.
2. Students completed a detailed construction estimate and budget including a quantity take-off of all labor, material, and equipment necessary to complete the project. Each student prepared a complete estimate for one home.
3. Students found creative ways to reduce costs by value engineering, purchasing strategies and changing standard amenities of the current plans and specifications.
4. Students prepared a computer generated CPM schedule for one home. The students then determined an overall project schedule based on current absorption rates.

5. The students determined their proposed project management and organization for staffing the project. The students summarized the roles they needed in their organization to make this possible.
6. Students created financial information for the project. They created cash flow projections for the proposed project based on the absorption rate determined from their marketing analysis and schedule. The students were challenged with providing different scenarios based on market fluctuation.
7. The students prepared an Executive Summary, including their recommendation for purchasing the lots.

Periodically throughout the course, students had the opportunity to review each other's work and they provided both compliments and constructive criticism. This gave students the opportunity to display their knowledge of the assignments by critically reviewing other students' work.

Students were required to conduct a professional presentation representing their solution to the problem. The students presented to a panel of instructors and peer groups of students at the end of the quarter. The reviewing peer groups of students were able to showcase their knowledge of the project by asking the presenting group questions. The presentations were 20 minutes in length and covered the main topics of the final project. In addition to the methods listed above, students were assigned to complete in-class activities, exams, reading assignments, quizzes, homework assignments, and working in teams.

Methodology

Performed over two separate quarters of the same residential construction management course at a four-year university, this paper utilizes Kelting's (2011) study that compared students' perspectives about 14 different instructional delivery methods through surveys which used ranked order, the five-point Likert scale, and open-ended questions. As a result, a forced-ranking survey method was adopted to find out which instructional delivery methods students perceive as more effective and appealing—a decision resulting from the ceiling effect generated by the five-point Likert Scale used in other research on student perspectives [4]. For example, one study used the five-point Likert Scale to rate the students' perception of how various delivery methods helped with their communication and teamwork skills while enabling their understanding of the final project [4]. The survey results led to a ceiling effect that made it difficult to pinpoint the differences between these delivery methods. To expand beyond the survey questions, qualitative questions and informal group discussions at the end of each quarter were done to allow students to share their thoughts about the different features of the interactive e-lessons [3].

An anonymous survey of the students' preferred delivery method and which method they thought was most effective was conducted during two consecutive quarters. The survey was created to obtain feedback from the students in order to find out which delivery systems were preferred and effective so the faculty could focus on methods that students ranked as the highest and improve on areas ranked the lowest. During both quarters, the class size was 24 students all 48 students answered the survey. The second quarter course had 14 construction management majors and 10 construction management minors. Two of the minors were architectural engineering majors and the other eight were architecture majors. These results may not be

generalizable to all other courses, but may be transferable to some. The questionnaire was developed based on areas for future research from Kelting and Hauck's (2010) paper. The questionnaire was put through a peer review process that customized it for the purposes of this study. The students listed the delivery method preferences on a forced ranking scale of 1 to 14 with 1 being the highest. The students were asked if there was a particular combination of delivery methods they prefer and found most effective. Students were also asked to provide other delivery methods that were not provided in the course, but may be recommended for future quarters [3]. The results from this survey were used to develop new delivery methods for this course.

Survey results

Each of the six survey items are listed in numerical order below with a discussion of the analysis of the results.

Ranking of delivery methods

1. Based on your experience in this course, please rank (in order from 1-14) the way you prefer to learn. 1 is the highest and 14 is the lowest.
2. Based on your experience in this course, please rank (in order from 1-14) the most effective way for you to learn. 1 is the highest and 14 is the lowest.

A side by side comparison of the preferred and effective ranks is provided in Table 1 and the following results were derived from the students' perspectives using the methodology stated above:

Table 1

Results of student perspectives

Preferred Rank	Delivery Method	Effective Rank	Delivery Method
1	Field Trips	1	Field Trips
2	In class activities and discussion	2	Final Project
3	Guest Lectures	3	Labs
4	Labs	4	Lectures with Personal Response Systems
5	Lectures with Personal Response Systems	5	In class activities and discussion
6	Final Project	6	Lectures
7	Working in Teams	7	Guest Lectures
8	Lectures	8	Peer Review
9	Peer Review	9	Working in Teams
10	Presentations	10	Quizzes
11	Quizzes	11	Homework Assignments
12	Homework Assignments	12	Presentations
13	Exams	13	Exams

Combinations of delivery methods

3. Based on the ranked delivery methods, is there a particular combination of delivery methods that you prefer? If yes, please describe.

Thirty students responded with a yes. Their responses were evaluated for common themes and are summarized below:

- Lecture, lab and fieldtrip in order and all on the same topics
- Lab, peer review and field trip in order and all on the same topics
- Lecture, fieldtrip and lab in that order and all on the same topics
- Lectures then working on labs in teams
- Having guest lectures on field trips
- Working in teams and peer reviews
- Working in teams on a final project

4. Based on the ranked delivery methods, is there a particular combination of delivery methods that are the most effective way for you to learn? If yes, please describe.

Sixteen students responded with a yes. Their responses were evaluated for common themes and are summarized below:

- Lectures with labs in order and all on the same topic,
- Quizzes before lecture and personal response systems during lecture,
- Reading, homework, quiz and exam in order,
- Lecture, homework, exam,
- Lecture and final project.

Other delivery methods

5. Based on your academic career, please describe any other delivery method you prefer that was not listed above.

Thirteen students responded. Their responses were evaluated for common themes and are summarized below:

- Lectures with material and assembly samples,
- Job shadowing,
- Interviewing a professional in industry,
- Providing notes for exam preparation.

6. Based on your academic career, please describe any other delivery methods that are the most effective way for you to learn.

Eleven students responded. Their responses were evaluated for common themes and are summarized below:

- Providing additional online resources,
- Providing overviews of previous classes lectures,
- Building outside the classroom with hands on projects,
- Videos,
- In person one on one teacher evaluations.

Discussion

The survey results of the delivery methods revealed the students' perception of their preferred and most effective delivery methods, and the one they found least effective. Within the top six ranked items there were five delivery methods in common. These delivery methods are field trips, in class activities and discussions, lectures with personal response systems, labs, and the final project. Field trips were ranked first on both preferred and effective delivery methods.

Five delivery methods were in common within the bottom five ranked items from the students' perspectives of both preferred and effective delivery methods. These delivery methods are reading, exams, homework assignments, quizzes, and presentations. Reading was ranked the lowest on both preferred and effective delivery methods survey results.

Students' provided additional feedback about additional delivery methods they preferred and found effective. Building outside the classroom with hands on projects was a reoccurring response.

Based on the results, two specific areas in this course were changed: the development of hands on building projects outside the classroom, and the development of new reading delivery methods. It is important to note that all delivery methods will still be used in the course.

The first area of improvement was the development of hands on building exercises. This was done in collaboration with industry and was on based on the students' suggestion of an additional effective delivery method. Two, four-hour building exercises were created in collaboration with industry. These exercises have been used to teach, demonstrate and test applications associated with best building practices. The first exercise had three groups of students assemble pre-cut flooring systems, and three different groups assemble floor systems from uncut material. Students learned advantages in both time savings and quality control when utilizing pre-cut floor systems. The second exercise had students learn about drainage planes by installing housewrap and windows and water testing them. The appropriate industry representatives assisted in facilitating both exercises.

Students' provided positive feedback about both exercises. The following quote is from one of the participating students, "I thought the hands on experience that we got during the floor framing exercise was better than almost anything that we could have done in a classroom.

Not only did we gain knowledge of some new framing technology but we also gained respect for the people in the field that are doing framing day-to-day."

The second area of improvement is new reading delivery methods. Since this study ranked reading as the lowest on the scale of preferred and effective delivery methods, new and engaging delivery methods for course reading assignments were developed. One student suggested additional on-line resources would be an effective way to learn. An interactive online course offering of 30 lessons was developed through an easy-to-manage system for the following topics: foundations, framing, structural hardware, mechanical and electrical features, plumbing, drainage planes, exterior cladding, energy efficiency and insulation, drywall, interior finishes, storm-water pollution prevention plan, jobsite safety, scheduling, estimating, and contracts. The instructor incorporated all these topics into 30 interactive e-lessons that had a deliberate organization and content aimed at creating an interactive environment for the users.

After organizing the interactive content into lessons, each considered equivalent to a chapter in a textbook, the instructor organized the lesson content into units. Each unit contained one or more topics, and each topic covered a variety of subtopics. Below is an example of the organizational structure:

Lesson 5: Constructing the Foundation

- Unit 1: Excavating the Slab Area

- Unit 2: Preliminary Stages of Foundation Construction

- Unit 3: Slab Construction

 - Topic 1: Utilities

 - Subtopic: Utility Layout

 - Subtopic: Utility Testing

 - Subtopic: Examples

 - Subtopic: Video—Locating the Placement of Piping

 - Topic 2: Pre-Slab Protection

 - Topic 3: Post Tension Layout

 - Topic 4: Slab Placement

 - Topic 5: Post Construction

- Unit 4: Basements and Crawlspace

The above organizational structure allowed for the breakdown of comprehensive content into manageable chunks of reading with the goal of making the material accessible and engaging to students. The user could access the content from multiple entry points provided through hyperlinked lesson features. The instructor also presented content in a variety of formats to promote interest, and paired with real-world content with photos or drawings to assist with increasing comprehension of important concepts. During the reading of process descriptions, students could view thumbnail sequences or see each sequence in an expanded view with short descriptions. Students had opportunities to click on "More" links throughout the content to access more in-depth information.

The instructor integrated a variety of pedagogical elements into the content. For example, the instructor established learning objectives to focus learners on the most important concepts,

identified key vocabulary, and provided definitions as hyperlinks throughout the content. A sampling of this vocabulary served as the basis for pre- and post-tests. The instructor integrated videos throughout the lesson to provide connections to the real world of construction. Lesson scenarios provided students with the opportunity to complete a task by applying what they learned in the lesson to a situation they might encounter on the job. Lesson summaries and electronic flashcards provided students with the resources to review important key terms and calculations before completing the lesson.

The online format provided assessments, flash cards, real-world scenarios as case studies, and interactive questions. The instructor offered immediate, specific feedback to reinforce learners' understanding and provide clarification as necessary. Interactive questions were embedded into the content. "What Do You Think" questions appeared at the beginning of each lesson to stimulate interest and engage students in the content of the upcoming lesson. At the beginning of each new topic, "Think About It" questions built the connection between prior knowledge and new content. The instructor integrated "Test Your Knowledge" and "Quick Check" questions throughout the content to check student understanding before the end of a lesson. Students received immediate, specific feedback. The feedback for each question included a reference back to the content. "Key Points/Make a Note" prompts encouraged students to reflect and summarize. The instructor provided a comprehensive assessment with immediate feedback at the end of each lesson. When applicable, the feedback directed the reader to the section containing the information necessary to answering each assessment question correctly.

Conclusion

This study agrees with Peterson's (2008) conclusion that developing a strong relationship with industry is a vital part of the project based delivery system. Industry relations have been important for the continued development of current material for activities, discussions, lectures, labs, final projects and continued field trips. In light of the student ranking of delivery methods indicating field trips as the highest rank, industry relationships remain important in order to provide high quality field trips for the students.

Additional surveys may be performed in order to analyze the results of future instructor's exploration of these delivery methods in this course and others. A potential area for further research would be a follow up study to determine whether students find interactive electronic reading lessons more engaging than textbooks and which aspects of these lessons are more effective and appealing. Another potential area for further research is to modify the survey of which delivery method they preferred and thought were most effective to include hands on activities. This modified survey could then be given to future courses and compared to the results of the survey presented in this paper.

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