

Hands-On Building as an Instructional Delivery Method in an Integrated Lab Curriculum

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This paper discusses students' perspectives about the instructional delivery methods students preferred and found effective in two project-based courses at a major university. A survey was conducted, and results indicated students preferred and found hands-on experiential exercises to be most effective. The results of the student surveys are presented and discussed. The hands-on experiential learning laboratories were designed to complement and enhance student learning in residential and commercial construction management courses. These courses were delivered similarly to a capstone course by combining methods, estimating, scheduling and contracts into one class with one overall final project. The hands-on experiential learning laboratory exercises provided opportunities for students to build assemblies outside the classroom on full-scale projects by applying knowledge learned in class. The hands-on experiential laboratory exercises have been designed to reinforce course comprehension by combining them with additional instructional delivery methods allowing students to "learn by doing." Each hands-on experiential exercise followed a lecture and incorporated concepts learned in class; these exercises included wood and steel stud framing, exterior systems, door and window flashing and installation, and concrete. This information may assist educational programs that are interested in developing hand-on experiential laboratory exercises to enhance other course delivery methods.

Key Words: Experiential Learning, Hands-On, Project-Based, Curricula, Construction Management

Introduction

The core subjects in construction management are scheduling, estimating and contracts, which are typically delivered in a lecture format in standalone classes (Chinowskly, Braown, Szajnman, & Realph, 2006). "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." (Montoya, Kelting, and Huack, 2009, p. 66). These lecture style classes work well to deliver management theory (Pratt, 1998), but construction educators are charged with preparing students who can lead and manage the overall construction process, not just specific, stand-alone aspects (Davis and Cline, 2009). Students must "connect the dots" between classroom theory and practical application, which some universities accomplish through a single capstone course in the student's senior year to "integrate multiple, interdisciplinary skills and abilities." (Benhart, Cabral, Hummard, Metzinger, Morgan & Santon, 2017). In contrast, other universities have developed and integrated these capstone classes across the curriculum giving students additional opportunities to solve complex problems (Benhart et al., 2017).

Students have preferences for the ways they receive information. Having knowledge of student's preferred method of information delivery may help the instructor customize instruction to meet the student's preferences, assist the instructor by 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 (Kumar, Kumar and Smart, 2004).

Kelting and Hauck (2010) evaluated which method or combination of teaching methods is more effective and appealing to students in their second year of study. Their study was unique as it focused on all the delivery methods utilized in the course and the students' perception of the overall impact on learning. Kelting and Hauck (2010) included the reviewer's 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, its delivery methods, and asked the students to describe any other delivery methods that attributes to their overall learning. A common theme that emerged from this study was students' interest in hands-on building exercises (Kelting, 2011).

Kelting and Holt (2012) discussed enhancements made to the course based off the follow-up study's recommendations and reevaluated students' perceptions of effective delivery methods. This study discussed the development on hands-on building exercises to "teach, demonstrate and test applications associated with best building practices" (Kelting and Holt, 2012) but the distributed survey did not include students ranking the hands-on building exercises as an instructional delivery method. They recommended that a potential area for future research could include a modification to the survey to focus on which delivery method the students preferred and thought most effective to include hands on activities, and then compare them to their findings.

The objective of this paper is to present the instructional delivery methods students perceive as effective, and those that they perceive as most effective for learning, as well as to determine the effectiveness of hands-on learning exercises that have been integrated into the curriculum. This paper provides a summary of the existing instructional delivery methods utilized and describes the development of hands-on building exercises and the integration and expansion of those exercises into two project-based laboratory courses. This paper also includes survey findings from both courses to gain students' perspectives on which delivery methods students preferred and found effective. The objective of this paper is

Methodology

This paper utilized Kelting's (2011) study which compared students' perspectives about 14 different instructional delivery methods through surveys which used rank order and open-ended questions. A forced ranking survey method was adopted to find out which instructional delivery methods students perceived as more effective and appealing. A forced ranking survey was used to prevent the ceiling effect generated by the five-point Likert Scale. By using the 14 rankings, respondents were not limited by a five-point scale which would not produce enough variability between the two anchors. For example, if given a five-point Likert-type scale, respondents might be inclined to use only the high end of the scale, limiting variability (Keeley, English, Irons, & Henslee, 2013). To obtain additional qualitative data, students were given the opportunity to provide written feedback on the course at the end of the survey.

The current study utilized 13 of the 14 delivery methods from the previous study (Kelting, 2011). The authors replaced one delivery method, labs, with the new category: hands-on building. In the previous study, labs included a series of assignments given throughout the quarter to reinforce the concepts covered in class, assisting the students toward the completion of the final project. These included a Lumber Market Lab, Foundation Lab, Hand Schedule Lab, and Scope of Work Lab. These assignments were still utilized in class but, to avoid confusion with the terminology, these were grouped under the heading of "homework assignments."

Anonymous surveys were conducted over two consecutive quarters in both the residential and commercial construction management courses. These surveys were created to obtain feedback from students on which delivery methods were preferred and effective so faculty could continue to focus on high-ranking areas, and make strides to improve the lower-ranking areas. Additionally, the surveys would provide feedback on whether hands-on building exercises were both effective and preferred by students. Overall, the surveys were conducted over two quarters in six separate classes, with six different instructors providing course instruction, and feedback was obtained from 124 students. The respondents were students in either their second or third year of university instruction; 105 respondents were male, 16 were female, and the remainder chose not to specify gender.

Course Formats

The hands-on building activities took place at certain points throughout the ten-week quarter and were designed to augment learning achieved by the students through reading assignments, lectures, in-class activities and discussions, and homework assignments. Each week, students attended class for 13 hours to learn different aspects of construction relevant to either residential or commercial construction. The hands-on building activities varied depending on the course – residential or commercial - and the activities for each course are described below.

Residential Construction Course

The class sizes ranged from 20 to 25 students. The students were divided into teams of four to six people for both in-class assignments leading towards the final project and for building activities. The classes met 13 hours per week for a ten-week quarter and were taught in a laboratory space dedicated to homebuilding education, specifically focusing on new-home construction in a residential tract environment. The class combined estimating, scheduling, residential methods, and contracts into one project-based class, where students worked towards the feasibility and analysis of all aspects of a new residential tract community. The following teaching methods were used in the class: reading assignments, in class activities and discussion, lectures, student presentations, quizzes, exams, homework assignments, peer review, working in a team, final project, hands-on building, field trips, and guest lectures.

The faculty strived to immerse the students in all aspects of residential construction through lectures and interactive discussions, covering topics from land acquisition to building materials, and the warranty process. Students prepared for class through reading assignments, then faculty reinforced main concepts through interactive lecture and in-class discussions and all lecture material was posted electronically. Relevant industry trends were also discussed, as well as means and methods, so students received the necessary information to work towards the completion of their final project incrementally throughout the quarter. The class was structured into weekly topic areas to reinforce the sequencing of installed components on an actual project.

For two weeks each quarter, students transitioned from the classroom to a hands-on building project to apply and reinforce their knowledge. During week four, students worked in teams to set anchor bolts and frame the floors, walls and roof of a small wood structure. This week's building expanded on the knowledge gained from the previous weeks' lectures on foundation and wood framing activities, and students were required to put into practice what they learned. During week seven, students continued work and completed the structure by applying house wrap, installing windows and a door, installing roofing materials including roof felt, flashing, and asphalt shingles, and completing exterior wood siding and trim. Again, these activities required the application of knowledge learned from the previous weeks' assignments and in-class discussions on water management, doors and windows.

These hands-on activities required resources including lumber, sheet goods, windows, one pre-hung door, house wrap, flashing tape, T-111 siding, felt paper, asphalt shingles, and framing hardware and fasteners. In addition, one or two building technicians provided additional support and quality control to assist students with building techniques. Overall, the cost of these activities averaged $2,500 per course.

Guest lectures from different departments of homebuilding companies were brought in from industry to discuss various topics of the course, based on their experience. Students also went on one field trip per quarter to tour a residential jobsite and witness the progression of a project. Each of these strengthened the relationship between industry and student.

The final project was a series of assignments that were to be completed throughout the quarter and then compiled into a comprehensive final project. For this final project, the students completed work in teams and were tasked to develop a feasibility analysis for a developed property. This feasibility analysis included funding and acquisition and required students to present a recommendation to proceed with the project or provide reasons why the project may be too risky for investors.

Commercial Construction Course

The commercial class sizes ranged from 20 to 25 students. The students were divided into teams of three to four people for the duration of the class. As a team they worked on in-class activities, final project deliverables, and hands-on lab activities. Classes met 13 hours per week for a ten-week quarter and were taught in a laboratory space dedicated to commercial education. The course focused on Type I and II construction means and methods, estimating, scheduling, and contracts. Similar to the residential class, this class worked through a commercial project for the duration of the quarter. The following teaching methods were used in the class: reading assignments, in class activities and discussion, lectures, student presentations, quizzes, exams, homework assignments, peer review, final project deliverables, hands-on building, field trips, and guest lectures.

As a project-based class, the faculty led and taught the class through exercises dealing with preconstruction, construction, and post-construction activities throughout the quarter. Prior to class, students were responsible for completing reading assignments and quizzes focusing on the means and methods of construction that tied in to the in-class discussions. As the quarter progressed, students worked through final project deliverables, including: unit cost and historical cost estimating, preconstruction sequencing, request for proposal delivery, site logistics, safety management, scopes of work, subcontracting, self-perform estimating, bid packaging, and project scheduling.

For two weeks each quarter, students transitioned from the classroom to a building project to apply and further their knowledge. During week five, students worked in teams to prepare the existing grade, complete concrete formwork, place rebar, pour a footing and slab on grade, build CMU walls, and set temporary shoring (Pro-Shore decking) for second level construction activities. This week's building expanded on the substructure and superstructure knowledge gained in previous weeks' lectures, in-class activities, and final project deliverables. During week eight, students continued work on the structure, and built pre-fab light gauge metal stud walls, installed the walls on first and second floors, installed OSHA compliant safety rails on second floor decks, installed exterior sheeting, applied waterproofing, installed a window and door frame, and applied an exterior façade system. Again, these activities required the application of knowledge learned from the previous weeks' assignments and discussions on commercial framing assemblies, exterior façades, and waterproofing.

These hands-on activities required resources including rebar, concrete, masonry blocks, light gauge metal studs, dens-glass, exterior building wrap (Tyvek or equal), flashing tape, wood framing members, and an exterior façade system. It is not required, but our hands-on lab also included a Pro-Shore concrete shoring system. This provided a 2nd floor to continue framing, as well as provided the additional hands-on activity. In addition, one or two building technicians provided additional support and quality control to assist students with building techniques. Overall, without the Pro-Shore material, the cost of these activities averaged $1,500 per course.

Guest lectures from different commercial building companies were invited to discuss various topics of the course, based on their experience. Students also went on two field trips per quarter to tour a commercial jobsite, witness the progression of a project, and view the different elements introduced through in-class lectures and activities.

The final project was a series of deliverables that were completed throughout the quarter and then compiled into a comprehensive final project. For this final project, the students prepared a request for proposal in week three presenting and delivering a project estimate, preconstruction schedule, and a management staffing plan; in week ten they presented and turned in a final packet compiled of: project buyout, subcontracting, site logistics and phasing, and a complete project schedule.

Survey Findings

The survey items are listed below, with a discussion of the analysis of the findings.

Ranking of delivery methods

Students were asked the following:

- 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.
- 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 findings were derived from the students' perspective using the methodology described above.

Table 1

Findings of Student Perspectives

Preferred Rank	Delivery Method	Effective Rank	Delivery Method
1	Hands-on Building	1	Hands-on Building
2	Working in a Team	2	In-class Activities and Discussions
3	In-Class Activities and Discussion	3	Working in a Team
4	Field Trips	4	Field Trips
5	Lectures	5	Lectures
6	Guest Lectures	6	Final Project
7	Presentations	7	Presentations
8	Final Project	8	Guest Lectures
9	Homework Assignments	9	Homework Assignments
10	Peer Review	10	Lectures with Personal Response Systems
11	Lectures with Personal Response Systems	11	Peer Review
12	Quizzes	12	Reading Assignments
13	Reading Assignments	13	Quizzes
14	Exams	14	Exams

Discussion

The survey findings of the delivery method ranking revealed the students' preferred and effective delivery methods, as well as the delivery methods they considered least effective. The top five ranked items for both effective and preferred were in common across both categories; these delivery methods were: hands-on building, working in a team, field trips, in-class activities and discussion, and lectures. Of these, hands-on building was ranked first for both effective and preferred.

The bottom five ranked items were also in common across both categories from the students' perspectives of both preferred and effective delivery methods. These delivery methods were peer review, lectures with personal response systems, quizzes, reading assignments, and exams. Exams were ranked the lowest for both student preference and effectiveness.

In reviewing the survey data, the frequency of responses for each category for both effective and preferred was also analyzed. This was done to determine if one delivery method consistently received the same ranking. For example, was the highest ranked category, hands-on building, consistently ranked number one, or did it have a representative spread across all rankings with a slight tendency towards higher rankings? In reviewing these findings, 59% of students preferred hands-on building over all other categories, and 57% of students ranked hands-on building as the most effective delivery method. Additionally, very few students ranked hands-on building with a rank of 10 or more, with 8% of students for effective, and10% of students for preferred.

When looking at working in a team, ranked second overall for preferred and third for effective, 12% of students indicated a ranking of 1, 21% ranked 2, 19% ranked 3, and 13% ranked 4, with only 12% of student ranking it in the lowest five ranking for preferred; 9% of students indicated a ranking of 1, 18% ranked 2, 13% ranked 3, and 10% ranked 4, with 14% of students ranking it in the lowest five rankings for effective.

The lowest ranked category, exams, received a high number of ranks 13 and 14, 16% for preferred and 16% for effective, and 17% for preferred and 13% for effective, respectively, but also received a consistent spread of rankings through all other categories. For preferred, 12% of student ranked exams in the top 5 rankings, and for effective, 22% of students gave it a ranking of 5 or lower. So, although exams are the lowest rated for preferred and effective, they are only slightly behind the other categories. When reviewing the lowest ranked delivery methods, under preferred delivery methods, reading assignments received the highest percentage of ranking 14 (19%), and under effective delivery methods, guest lectures received the highest percentage of ranking 14 (15%).

Figures 1 and 2 show the percentage of students who selected the corresponding rank number for each delivery method. Figure 1 shows each delivery method's effectiveness rating; items are listed in ranked order. Figure 2 shows the preferred ranking frequency for each delivery method; items are listed in ranked order.

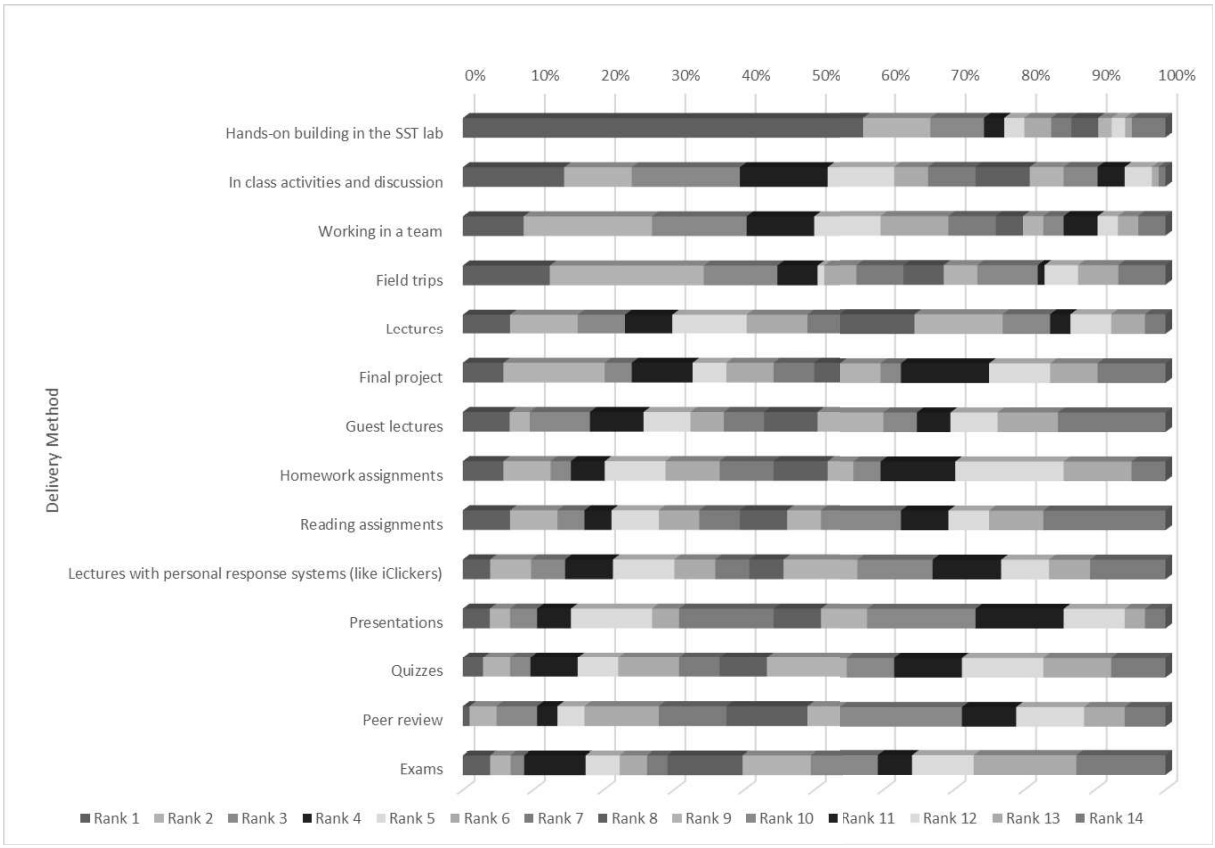

Figure 1: Delivery Method Rating Frequency – Effective Rating

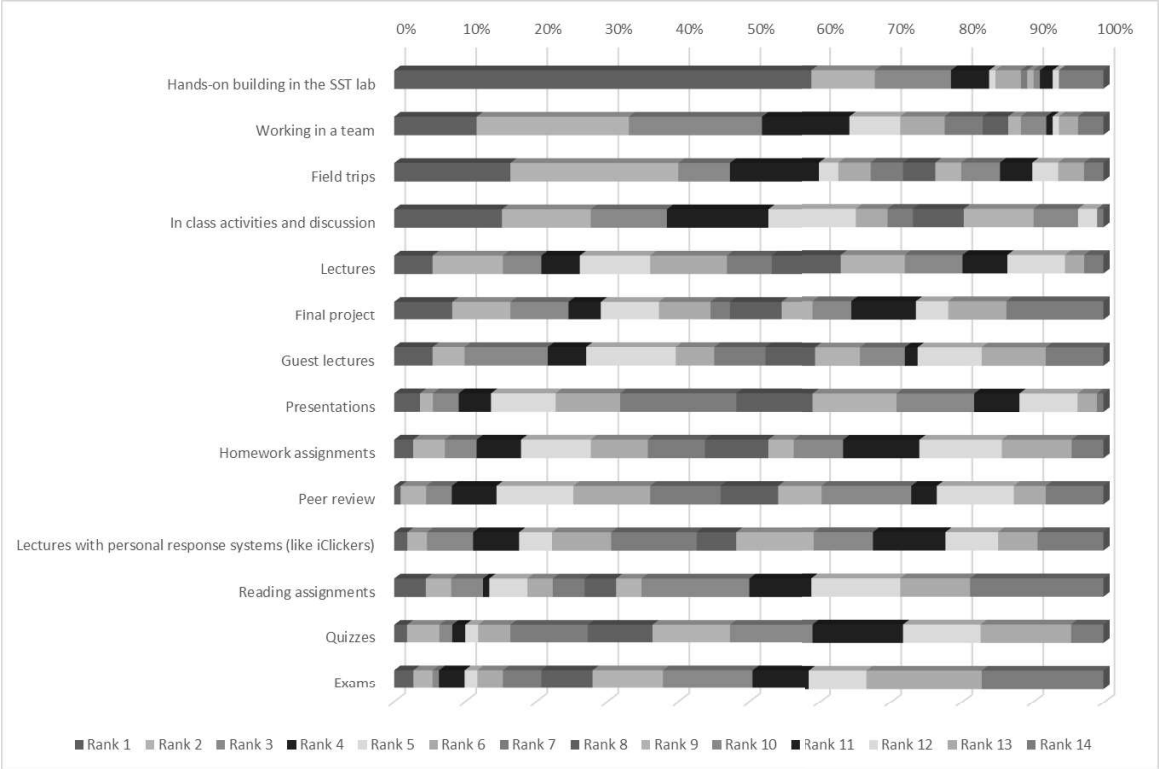

Figure 2: Delivery Method Rating Frequency – Preferred Rating

Conclusion

The instructional delivery methods identified in this paper were all included in the presented project-based courses; these courses have been designed to "connect the dots" and bridge classroom theory with real-world understanding. Although past studies reviewed which delivery methods students preferred and found effective, hands-on building activities were not included and have since been integrated into the surveyed courses.

The highest survey findings in the students' survey reinforced the faculty's decision to integrate hands-on building activities to the project-based curriculum. The most impressive findings were the students' ranking of hands-on building activities, with over half of the students giving it the top rating. According to the students surveyed, the incorporation of these activities into the course were an effective and preferred way to learn course content. In-class activities, field trips and working in a team also received high ratings, and faculty will continue to include each of these items in the curriculum.

Exams, quizzes, and reading assignments are among the lowest-ranking items, which did not come as a surprise to the faculty. Exams and quizzes were used as a summative measure to determine understanding of the course material, and reading assignments were used to deliver preliminary information to students with the highlights reinforced during lecture. The faculty will work on ways to integrate additional summative measures for material comprehension but will still rely on exams as a final determiner. The faculty will also evaluate reading assignments to ensure the reading is applicable and corresponds to the content provided in lecture; an evaluation of the text and its content will also be performed.

The authors conclude that students perceive hands-on building exercises as effective and are preferred ways to learn course material. The authors will continue to use this survey, along with student outcomes and feedback, to improve the delivery methods described in this paper.

Future Research

A potential area for further research would be a follow-up study to understand what aspects of hands-on building students find valuable, as well as the sequence or combination of delivery methods to ensure the most effective learning environment. Future research could include surveys exploring reasons why these delivery methods are preferred, their effectiveness, and the different ways these methods impact student learning. Additionally, it may be beneficial to modify the survey to include shorter ranges of one through five and have respondents rank their top five and lowest five preferred and effective activities.

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