AC 2009-1531: IMPROVING CONSTRUCTION-MANAGEMENT COURSE COMPREHENSION THROUGH EXPERIENTIAL LEARNING

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Improving Construction Management Course Comprehension through Experiential Learning

Abstract

While lectures are the most common way to teach students, they are not necessarily the best way to convey some types of information. Consider the famous quote by Confucius: "I hear and I forget. I see and I remember. I do and I understand."

This paper discusses a hands-on experiential learning laboratory, which complements the lecture in a Construction Management (CM) materials and methods course. Many CM programs avoid hands-on experiences due to the vocational/technical stigma. However, experiential learning transforms construction concepts that are often abstract and out of context for many students in an exclusively lecture course into tangible objects and processes. The hands-on laboratory reinforces and supplements material covered in lecture and improves course comprehension by allowing students to learn through discovery. The laboratory aspect of the course also improves leadership, promotes teamwork, and increases student confidence.

This paper discusses specific laboratory experiences used and their educational value, student feedback regarding the experiential labs, and lessons learned for CM programs interested in adding or expanding their hands-on learning experiences for students. The paper also provides a comparison of test and course grades from students enrolled in a lecture-only version of the course versus students enrolled in a combined lecture and laboratory version of the course.

Introduction

Construction education programs are charged with providing an education that will foster a student's ability to successfully undertake a leadership role in the management of the construction process. To manage the complex construction process requires substantial knowledge of modern management theory and practices, the ability to lead a diverse group of skilled and non-skilled personnel in daily operations, and expertise in the construction processes for which he or she is responsible [1]. Traditional transmission type teaching methodologies, requiring the teacher to "stand and deliver" information in a systematic process [2] are conducive for teaching management theory and practice. However, the effective transfer of practical leadership skills and knowledge of construction specific processes is more difficult to achieve.

When developing learning applications, it is important not to confuse education with learning [3]. Education emphasizes the educator and mainly deals with teaching methods, actions, and/or processes. The concern of education is specific learning outcomes and the process of teaching students the information needed to achieve those outcomes [4]. Learning is a focus upon the person to whom the change occurs. Learning is a process of gaining knowledge and/or skills through formal or informal means [5] and is the result of the exchange of information from educator to learner. It can be in the form of intentional transfer of information from educator to learner, as well as incidental or unplanned learning [4]. Kimble [6] contends that learning is a relatively permanent change in observable behavior that occurs as a result of reinforced practice. Individuals involved in the learning process are capable of performing afterwards in a way that they could not before being involved in the learning experience. Though it is possible that the change in behavior may not occur immediately following the learning experience, the learning process facilitates the change in behavior that results from reinforced experience or practice. It is this formal process that separates education from learning. Thus, education cannot exist without learning; learning, however, not only can exist outside the context of education, but is often found in other contexts [4].

Experiential Learning

Experiential learning is a philosophy of education based on what Dewey [7] recognized as a "theory of experience". He contended that forming a theory of experience is needed in order that education may be intelligently conducted. Based upon the work of Dewey and other educational theorists, Kolb and Kolb [8] developed an experiential leaning theory (ELT) based upon six propositions:

1. Learning is a process where the primary focus should be on engaging students in a process that best enhances their learning;
2. Learning is best facilitated by drawing on the students' prior knowledge so that more refined ideas can be examined, integrated and tested;
3. Conflict, differences, and disagreement drive the learning process. Learning takes place when the learner is required to move back and forth between reflection and action and feeling and thinking;
4. Learning is a holistic process that involves the integration of thinking, feeling, perceiving, and behaving;
5. Learning results from synergetic transactions between the person and the environment, where learning occurs through the assimilation of new experiences and existing concepts; and
6. Learning is the process of creating knowledge, which stands in contrast to the "transmission" model upon which traditional educational methodologies are based.

Terms used to describe different experiential learning methodologies include: active, collaborative, problem-based, and demonstration and simulation. Prince [9] states that active learning is an experiential form of learning that requires the learner to engage in meaningful learning activities. Collaborative learning adds a component to the active learning process that requires the learner to work in a group towards a common goal. Problem-based learning adds yet another component that requires the learner to work on "real-world" problems that are used to provide a realistic context. Galbraith's [10] book on adult learning methods contains a chapter written by Gilley that defines demonstration and simulation. Gilley states that demonstration and simulation are used to enhance the learning experience by providing a learning methodology that is more readily understood when demonstrated, or when there is need to show a process in action.

Bolstered by andragogical study on adult learning theory and research literature on experiential learning, the authors have developed experiential learning applications to effectively facilitate a student's mastery of knowledge, skills, and competencies necessary for success in the construction management field. The learning application, consisting of both lecture and lab sections, has evolved over several years through trial and error, employing multiple experiential learning theory processes including collaborative and service learning components.

Laboratory Experiences

The remainder of this paper discusses a hands-on experiential learning laboratory, which complements the lecture in a Construction Management (CM) materials and methods course at Boise State University. Students attend the lab portion of the course three hours per week. A number of different experiences are incorporated into the laboratory including:

- An OSHA 10-hour course;
- Construction jobsite layout;
- CMU wall construction under the supervision of an experienced mason;
- Concrete forming system assembly/construction for a wall, round columns, and square columns;
- Concrete testing including air entrainment, slump, and cylinder tests;
- Erection of a structural steel frame (4 columns, 8 beams, open web steel joists, and metal decking) using an overhead crane and scaffolding; and
- Light gauge steel frame construction (metal studs) for walls that include two door and two window frames.

This paper will only discuss in detail the structural steel frame erection laboratory experience and the concrete forming system assembly experience. Detailed information about other laboratory experiences is available from the authors.

Laboratory Experience: Structural Steel Frame Erection

The steel frame lab experience occurs near the end of the semester in the fall and in the middle of the semester in the spring. The order of labs changes from fall to spring so that indoor labs are done in the colder months and outdoor labs are done in the warmer months. The lecture schedule also changes each semester to reflect the order in lab.

The structural steel frame erection laboratory experience begins with safety aspects. Although the students complete the OSHA 10-hour course at the beginning of the semester, many safety requirements are reintroduced in context, including materials handling safety, crane safety, steel erection regulations, scaffolding requirements, and personal protective equipment (PPE). Throughout the structural steel frame erection (and all other laboratory experiences), students are required to demonstrate their knowledge and understanding of appropriate safety practices through their actions in the laboratory.

Once the safety aspects have been reviewed, students are given framing plans that illustrate the completed steel structure. They begin by determining the locations of the four columns, based on information on the plans. This is greatly simplified for them because they use anchor bolts that are recessed into the floor under removable cover plates, though they do have to determine the correct recessed anchor bolt locations. Pedestals, which serve as baseplates for the columns, are attached at the anchor bolt locations using a double nut application. While not completely in sync with reality, these beginning aspects are necessary given our facility layout. Students then use the skills they learned in the construction jobsite layout experience to level the pedestals (baseplates) to the correct elevation using survey equipment. At this point they also assemble a rolling scaffold that will be necessary for the remainder of the steel erection.

They next learn how to correctly use chokers, taglines, and shackles to move the steel with an overhead crane, as well as hand signals to direct the crane operator. The students erect four 17-foot high columns using the overhead crane and the scaffolding. The topics of bolts, driftpins, and spudwrenches are discovered and discussed at this point. With the columns in place, they begin to hang the wide flanges and channels that serve as beams connecting the columns. The "floor beams" are approximately four feet off the ground and the "roof beams" are approximately twelve feet off the ground. The students must wear PPE as if they were much higher above the ground, simulating a real project, but in a safe learning environment.

Due to facility constraints, the students must determine an appropriate order for hanging the upper and lower beams so that they have access to reach all connections using the rolling scaffolding. They also discover that if their columns are not true, they cannot hang all of the beams. Once all beams are in place, they proceed with the erection of open web steel joists on the lower level, followed by metal decking. Terminology learned in lecture, such as a joist seat, as well as subtleties such as the orientation of the decking, becomes apparent to the students during the experience.

Laboratory Experience: Concrete Forming System Assembly

The concrete forming system assembly lab experience occurs in the middle of the semester in the fall and near the end of the semester in the spring, as this lab is done outside. For this lab experience, students are given drawings showing a plan and elevations of an L-shaped concrete wall that is stepped in height (varies from 4 feet to 8 feet in height). They begin by cutting and tying steel reinforcing bars (rebar) according to the drawings. A concrete 'footing' is already in place for them to build the wall on top of and includes plastic inserts at 8 inch spacing to accommodate the rebar. This same footing is used in the concrete masonry lab experience as well. Discussions about bar overlap are necessary at this point, as some lengths of rebar must be spliced.

With the rebar cage tied and in place, they must determine and mark the correct locations for the formwork. This is made slightly more difficult because the L-shaped footing is not at a perfect 90 degree angle as it should be. They learn how important it is to locate and build the foundation exactly correct because of this.

The students then assemble a Symons brand forming system complete with ties, walers, bracing, bulkheads, blockouts, and an elevated working platform. Including these different aspects reinforces the vocabulary introduced in lecture. Finally, they are required to level and plumb the entire system, so that it would be ready for a concrete pour.

The students also perform similar tasks for a round column and a square column. The round column uses a sonotube as its formwork and the square column uses plywood, 2x4's and column clamps. The students also locate an anchor bolt template on the top of each column, as if a steel beam were going to be anchored to the tops of the columns.

Grading of Laboratory Experiences

The laboratory portion of the class is graded based on attendance, safety, participation, and attitude. It is more important that the students have the opportunity to try things and learn without the fear that doing something wrong will negatively affect their grade. Therefore, they are only penalized for non-attendance, unsafe behavior, non-participation, or poor attitude. The material covered in lab is included on exams the students take in the lecture portion of the course, however. Exams include pictures of items used in lab for identification by the student (vocabulary building). Safety aspects are emphasized in each exam as well, focusing on the safety practices that relate to the building materials and methods covered in a particular exam.

Educational Value of Laboratory Experiences

The hands-on laboratory reinforces and supplements material covered in lecture and improves course comprehension by allowing students to learn through discovery. The laboratory aspect of the course also improves leadership, promotes teamwork, and increases student confidence.

This course is a freshman-level course and, while many students come in with some construction background (usually wood framing), many others come with absolutely no construction experience. It is particularly important for the students with no background to practice skills in a safe environment, allowing them to build confidence before hitting a jobsite, perhaps on a summer internship.

Pratt's [2] apprenticeship perspective gives detail of why the experiential side of learning is important for the learner. He states that as we gain experience, those experiences combine with other experiences and knowledge in our mind. When this happens, the learner's personal theories expand and they increase their ability to handle problems and situations with confidence. Work-related experience is needed to educate learners because, as stated by Pratt [2], often knowledge is hidden from view, but that knowledge is the absolute key to success. Unfortunately, it is often this hidden knowledge that is not taught and yet is essential for learners to succeed. Experiential learning, such as the laboratory experiences discussed here, can bridge this gap in the education process.

A majority of the lab experiences are team projects, requiring the students to work cooperatively and collaboratively to solve problems and complete projects. It is usually very evident which students are natural leaders in the laboratory, regardless of their experience level. Those students are given the opportunity to enhance their leadership abilities. However, the other students are also expected to be in charge at times and begin to develop leadership skills. The lab experiences require the students to think at both a macro and micro perspective, exercise internal motivation, and respect the ideas of others in the group. It is this cooperative and collaborative experience that gives the students a real world understanding that is not possible in a typical lecture-only teaching style.

It is very important to note that these laboratory experiences are not to train students to be laborers or experts in any of the topics covered. Instead, the aim is to provide them with an opportunity to learn about different construction techniques and discover subtleties that are difficult to convey in a conventional lecture setting. The students also become very aware of and begin to appreciate the skill that is required in the many construction trades.

Assessment of Laboratory Experiences

An objective outcomes assessment of the effectiveness of the laboratory experiences is difficult to provide, not unlike assessing the effectiveness of any type of active learning instructional method. In the assessment process the researchers chose not to rely exclusively on a quantitative (positivism) or qualitative (interpretive / constructivism) approach. Rather, a mixed methodology (pragmatic) approach was used, combining positive attributes of the quantitative and qualitative paradigms, enhancing the ability of the researchers to understand "what is going on" [11]. In an effort to eliminate confusion, the assessment portion of this paper has been written in the same format as the study, with the quantitative portion of the study first and the qualitative portion second.

Quantitative Research Design

The design of the quantitative portion of the study consisted of the development of instruments to gather the comprehension levels of students participating in two courses with matching lecture curricula, but with only one of the courses containing a laboratory requirement. Calculations were performed on the resulting data, summing the responses and performing cross tabulations to compare the comprehension levels of the two populations. Issues concerning the pre-course comprehension levels and pre-course "hands-on" experience may present some validity issues, however, these issues were considered negligible by the researchers because of the relative homogenous student population between the two courses.

Quantitative Research Results

Aggregate comprehension levels of the two student populations indicate that students enrolled in the course with a laboratory requirement had a higher mean score or comprehension level than those students enrolled in the course without the laboratory requirement. However, the mean scores were not statistically significant. To further examine the results, students enrolled in the course with the laboratory requirement were asked to participate in the qualitative portion of the study.

Qualitative Research Design

The qualitative portion of the study was not built upon a grounded theory nor bounded system. Rather it was conducted simply to discover and understand a phenomenon, a process, and the perspective of the students involved. It was based upon concepts, models, and theories in educational psychology [12]. To collect data, an interpretive/constructivist approach was taken that employed the use of semi-structured questionnaires with the study participants. The questionnaires involved asking structured questions, and then inquiring more deeply using open-ended questions to obtain additional information [12].

Qualitative Research Results

Data from the questionnaires was organized, categories were generated, and themes and patterns were developed to critique emergent understandings and alternative explanations. Student responses indicate that the laboratory experiences are valuable and help them relate to abstract or out of context information discussed in the lecture portion of the course. They have the opportunity to touch materials and discover first-hand how they go together. They often report that this is one of their favorite courses in the curriculum. Students also indicate that it improves their leadership skills, promotes teamwork, and increases their confidence.

> **Regarding course comprehension:**
> "The hands on experience made subjects easier to understand. Physically doing something is better than reading how it's done."
> "It also has shown me that some things are not as simple as they look."
>
> **Regarding leadership:**
> "It helped to know how difficult it would be to manage 20 different ideas/personalities."
> "Taking the lead in a group of students you just met is not easy…. Through this class you learn diplomacy as well as assertive behavior required to motivate but not boss your fellow classmates."
>
> **Regarding teamwork:**
> "It forces people to work together for a common goal while reinforcing what we learn in lecture."
> "Many chiefs, not so many Indians, so we had to come to consensus often."
>
> **Regarding confidence:**
> The lab "improved my confidence remarkably. I felt I could have an educated conversation about construction activities knowing their applications not just the textbook relevance."
> "Coming into this course I was very limited in construction knowledge but after this lab I feel I have a great foundation to build on. I can now do things I had no clue how to do. So yes, it built my confidence greatly."

Lessons Learned

Although the Boise State University (BSU) program discussed here has been largely successful, there are some lessons learned that may be useful for CM programs interested in adding or expanding their hands-on learning experiences for students.

Support for the laboratory experiences is crucial to its success. There must be support from the university/college/department to provide space for the activities to occur. The BSU lab spaces include indoor and outdoor facilities which accommodate both teaching areas and material/equipment storage. Support from industry is needed for material/equipment donations, as well as expertise for demonstration and supervision of some activities. At BSU, a local mason assists in the masonry lab experience and a local concrete testing company assists in the concrete testing lab experience. Faculty knowledge must be high for labs taught without industry support.

There are costs involved in creating and running the laboratory experiences as well. Some costs are one-time and occur only when a new lab experience is introduced. For example, the structural steel erection lab experience at BSU requires an overhead crane, as well as steel columns, beams, joists, decking, bolts, tools, safety harnesses, etc. However, other than replacement of tools and safety equipment every few years due to normal wear and tear, there are virtually no additional costs of this experience. Some costs reoccur every semester however, such as the concrete used in the concrete testing lab experience. These costs must be expected and budgeted. BSU includes a lab fee (currently $25 per student per semester) that covers consumable materials. In many semesters, there is a surplus which allows for the purchase of new one-time items that improve and refine the existing lab experiences.

Faculty time is also necessary for the lab experiences to be successful. There is the obvious preparation time necessary, just as for any course, but there are some other aspects that are perhaps not as obvious. In most of the lab experiences, the students build something. At BSU, these assemblies are not permanent and must often be dismantled by faculty, with volunteer student assistance, after class is over. Sometimes this can be almost as time-consuming as the laboratory itself. The structural steel frame built in a Tuesday afternoon lab must be dismantled before the Thursday afternoon class arrives. This process can take up to two hours, although this is in part due to the slow speed of the overhead crane and the distance between the storage location and the erection location. Coordination between the lab and lecture is another aspect that can take time. At BSU, one faculty member teaches the lab and another teaches the lecture. They must coordinate the course schedule and material coverage so the students have consistent information presented in a logical order without undue duplication. To accomplish this, they must be very aware of what the other is doing during their respective class time. This often requires attending the class time of the other on a regular basis. The awareness of what the other is teaching is particularly important for consistency in evaluating the students. It takes time to establish and refine lab experiences and get them to the point where they require little advanced preparation and coordination, but with the same faculty working together over multiple semesters, over time it does get easier.

Finally, standardization is necessary for success with laboratory experiences. Each experience should be reproducible from one semester to the next so that each group of students has a comparable classroom experience with well-defined learning objectives.

Conclusion

Deviating from traditional educational methodologies used in majority of construction engineering and management curricula is not without risk. Experiential learning methodologies and can be construed as “touchy-feely”, a term that Hessler [13] identifies as a devil term in higher education, stigmatizing work as unintellectual, unsubstantial, and lacking rigorous scholarship. “Skeptical faculty regard active learning as another in a long line of educational fads. For many faculty there remain questions about what active learning is and how it differs from traditional engineering education, since this is already “active” through homework assignments and laboratories"[9]. However, Bonwell and Eison[14] conclude that experiential or active learning leads to greater knowledge retention, enhances the attitude and motivation of the learner, and improves thinking and writing skills. Based on student responses from the qualitative portion of the research at BSU, the experiential learning used in this freshman-level course on materials and methods concurs with Bonwell and Eison's findings. The experiential learning improves course comprehension, improves leadership, promotes teamwork, and increases student confidence.

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