

Development of an Integrated Project-Based Course: A Jobsite Management Class Case Study

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At universities offering professional degrees, such as construction management, some programs are moving towards and exploring alternative delivery methods for achieving the curriculum's goals and objectives. This paper describes a curriculum integrated course founded in a project-based learning environment applied to a jobsite construction management undergraduate course being taught at a major university. A course overview describing the various delivery methods used (such as lectures, reading assignments, supplemental materials, guest lecturers, lab assignments, technology, and a jobsite visit) is presented. The benefits of course integration in a construction management undergraduate curriculum are emphasized and more fully explained. The unique student learning opportunities which were created from a project-based learning environment were depicted as they specifically relate to the class. Pedagogical insights into the organization, substance, and structure of the course are also provided.

Key Words: Jobsite Management, Project-Based Learning, Integrated Course, Construction Education

Introduction

Over the years there has been a continued and growing interest in using alternative teaching and learning techniques at academic institutions which offer professional degrees (Senior, 1998). The discipline of construction management clearly fits this professional educational model. The art of construction management includes integrating the conflicting demands of clients, architects, engineers, various government entities, and end-users into a balanced and reconciled project solution which meets budget, schedule, quality, and safety prerequisite criteria. With this goal in mind, students should be encouraged by the classroom experience to utilize basic construction management skills to craft integrated construction project solutions. Non-traditional pedagogical approaches should be considered to successfully prepare students to become professionals in the construction industry (Hauck & Jackson, 2005). Of the many possible pedagogical approaches which might be used to achieve such an outcome, this paper primarily focuses on curriculum integration and project-based learning as a basis to achieve classroom success. "Great learning occurs when students are put in situations outside the curriculum norm, situations which make them a bit uncomfortable and challenge them in new ways" (Barlow, 2009, p.6). This paper seeks to share the experiences of an integrated course which leverages a project-based learning environment in an attempt to create such a learning experience for undergraduate students in a construction management course.

Integrated Curriculum

Most construction management undergraduate programs teach core subjects such as scheduling, estimating, controls, and contracts in a series of standalone courses which are typically delivered in a lecture format (Chinowsky, et al, 2006). Each course is treated as an isolated set of concepts and problem-solving strategies termed "knowledge compartmentalization" (Albano & Salazar, 1998). This segmented organization of the curriculum relies on students to "connect the dots" themselves, often struggling unsuccessfully to make the associations and functional integration required to effectively grasp the overall construction process (Hauck & Jackson, 2005; Albano & Salazar, 1998; and others). While the traditional curriculum structure may have proven successful over the years, many construction management and engineering undergraduate programs have begun to identify its limitations and question its effectiveness. The traditional approach may simplify the problems of teaching in a university environment, but it sacrifices the discussions and understanding of the interrelationships among these elements (Senior, 1998).

Over the last five years, the faculty at Cal Poly San Luis Obispo developed and recently implemented a more fully integrated curriculum based on both horizontal and vertical integration of its curriculum. Integrated "horizontally" in terms of combining previously standalone courses into one and "vertically" in terms of over the entire department curriculum as opposed to just the student's senior year. For more information on the details of this transition from a program wide perspective, see "Design and Implementation of an Integrated Construction Management Curriculum" (Hauck & Jackson, 2005) and "Pilot Study of an Integrated Construction Management Curriculum" (Montoya, Kelting, & Hauck, 2009). This paper focuses specifically on the details involving the jobsite construction management course which is one of seven core courses developed as a part of this curriculum integration spread throughout the student's undergraduate studies (Figure 1).

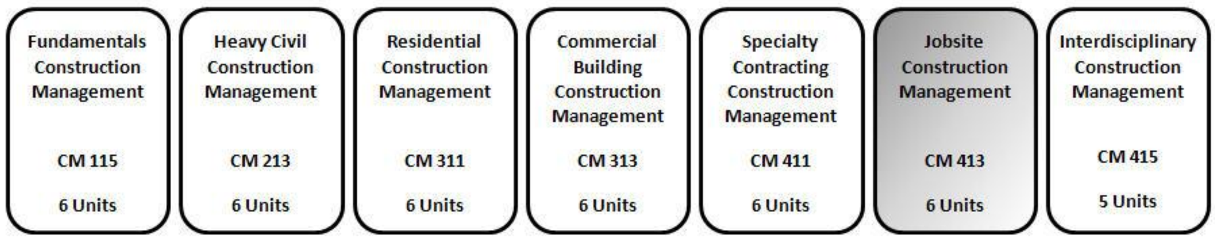

Figure 1 – Cal Poly Integrated Curriculum Core Courses

Project-Based Learning (PBL)

The "traditional" approach to teaching (lecturing, assigned readings, intermittent homework, and summary testing) are not abandoned by a more project-based learning (PBL) approach, they are deemphasized, supplemented, combined, and in the end enhanced by it. PBL requires students to become active (versus passive) learners, empowering them to learn outside the traditional classroom environment. Combining practical elements into the curriculum of a professional discipline has long been recognized as critically important to student learning.

PBL emphasizes the critically important "soft skills" of construction management which are often built "on top of" the technical skills developed in traditional individual classes. Thamhain (1992) acknowledged thirty potential problems which might inhibit a construction project from being successful, none of which could be classified as technical incompetence. Thamhian concluded that the lack of soft skills such as teamwork, leadership, communication, conflict resolution, and upper management involvement were the main cause of poor project performance. This contention was confirmed by several other studies which question the value of technical and cognitive skills over emotional intelligence and business-related skill sets (Odusami, 2002). Gunderson, Barlow, and Hauck (2007) conducted a study on construction superintendent skill sets to help guide the development of postsecondary curricula. Their study stressed the importance of people skills such as communication, trust, and dealing with various personality types. These attributes ranked highest amongst the respondents. Linking the development and enhancement of these critical soft skills in construction management undergraduate students through project-based learning is beginning to come into focus. Sirotiak and Walters (2009) concluded from their research that students through a PBL class experience demonstrated a measureable enhancement in their soft skills relating to confidence and stress coping. The evidence is building that project-based learning is an exceptional and unique tool to help students grasp the important non-technical skills needed to succeed in the collaborative business environment of construction management.

Project-Based Learning and Integrated Curriculum (PBL/IC)

When looked at together, the lines of project-based learning and an integrated curriculum (PBL/IC) start to become blurred. The combination of these two concepts is an opportunity to reverse the trend of focusing on particular construction management skills individually. Skills such as estimating, scheduling, controls, and contracts (Chinowsky, et al, 2006) combined under a project-based learning umbrella more fully integrates the subject matter. PBL/IC allows the student to explore and draw upon all the individual technical experience they have developed, apply it to a (safe and controlled) construction project environment, and continue the development of the critical soft skills necessary for business success. An integrated curriculum taught in a project-based learning environment can reintroduce breadth and depth into the "traditional" construction management curriculum and learning mode.

This paper introduces and discusses the continued development of a construction jobsite management course which is integrated, project-based, and employs several different teaching delivery methods to achieve student learning success. The various teaching delivery methods employed are discussed as to how they were applied, refined, supported, and complemented an integrated curriculum anchored in project-based learning. The course was offered and taught during the Winter and Spring quarters of 2010 at the California Polytechnic State University of San Luis Obispo.

Jobsite Construction Management Course Development

William and Pender (2002) identified two key problems to successfully developing a project/problem-based learning environment. First, there are time limitations which exist within a typical university lecture course. Second, the significant increase in student-teacher contact time required with a more one-on-one format must be considered. To meet the time concern, the Cal Poly construction management department reformatted the entire curriculum and created seven high credit hour core courses as referenced in Figure 1. This created the class time needed not only to integrate the expanded class material, but also to immerse the students in a project-based class experience. The result is sixteen hours per week of formal teacher-student contact hours and twenty four hour student lab access to the classroom, greatly mitigating any time limitations normally encountered.

In addition to reorganizing the curriculum, the department was also successful in raising the funds necessary to construct a new building. The classroom spaces were designed and built specifically for an integrated and project-based teaching model. This non-traditional classroom space was developed to address William and Pender's second concern, student-teacher contact time. The design included a central lecture area surrounded by individual and dedicated student work spaces, encouraging students to remain and work in the classroom. This was particularly important to project-based learning as group projects and student interaction are essential to success. The classroom was also designed with a dedicated and physically attached teacher work room for each class. This allowed the professor to be present and readily accessible to students during the entire class period, thus encouraging and facilitating student-teaching contact time. With the physical classroom environment and extensive time requirements solved by the department, it was up to the individual professors of these seven core courses to properly develop (in concert with one another) a fully integrated project-based classroom experience.

Course Philosophy and Overview

The general aspirations of the jobsite management course, in addition to the very specific department goals and objectives, included challenging the students to achieve in the areas of:

- Presentation and communication skills
- Collaborative and inter-personal skills
- Creativity and forward-thinking abilities
- Teamwork and problem solving skills
- Active-learning and creative problem solving
- Self-learning and time management

The jobsite construction management course has been taught at this university for many years as a required three unit lab class during the student's third academic year. With the department's new integrated curriculum fully implemented in late 2009, the class was altered to a six unit core course. Taught in the students fourth year, this class integrated portions of the core subjects which no longer existed individually. The subjects listed below were integrated into the course in addition to its original goals and objectives.

- Estimating (generally the process of pricing changed work)
- Controls (generally the maintenance of updating of a master schedule w/ look-ahead schedules)
- Contracts (generally the affects of contract provisions on jobsite construction activities)
- Temporary Structures (generally the non-permanent elements which facilitate the construction process)

While a pilot version of this course was taught in the Summer of 2009, Winter and Spring 2010 were the first two times this course was taught as intended by the department. The average class size was 22 to 24 senior undergraduate construction management students. Because this class was listed as an optional course for minors, it consistently attracted two or three architecture and/or architectural engineering students. This was viewed positively, as the course was ideal for such students and allowed the instructor an opportunity to advance inter-disciplinary opportunities.

Student retention has been greatly enhanced when several different learning modes are combined and incorporated into the delivery of class content (Wankat & Oreovicz, 1993). Thus the next part of this paper is a description and evaluation of the several delivery methods utilized to achieve the goals and objectives of the course. These teaching delivery methods included: lectures, reading assignments with pre-quizzes, guest lecturers, supplemental material, a series of lab assignments which supported a class project, and student presentations based on a construction site field visit.

Lectures: The course was organized to first provide the tools the students needed to succeed, in order to apply those tools to the project-based aspects of the class. Because the quarter system is based on only a ten weeks session, this further hastened the need to lecture early and often in the beginning weeks of the course. To facilitate the transition from lecture to lab, topics were introduced and discussed in a project-chronological format and then directly linked with the associated project-based lab assignments. This was done so students could almost immediately apply what they had learned in lecture to the class project. The following sequences of topics were taught in the first six weeks of the course:

- Project Teams
- Construction Documents
- Computer Software Training (Prolog, Revit, & ArchiCAD)
- Progress Meetings
- Safety Management and Record Keeping
- Subcontracts and Purchase Orders
- Submittals
- Changes and Claims
- Time and Cost Control
- Jobsite Layout and Labor Relations
- Project Quality Management
- Progress Payments and Project Close-out

The lecture material was presented in power point format and posted on the course website after the lectures were completed. There are varying opinions on the subject of posting power point slides. This author found that posting slides after a lecture kept the material novel when first presented, motivated the student to pay more attention during the lecture, encouraged them to interact and discuss the subject more freely, and allowed students the opportunity to review the slides prior to an examination. Once the basic and essential jobsite management material was disseminated, the information was then utilized by the students throughout the rest of the quarter as part of their ongoing project lab assignments (described later). As it relates to lecturing, the last four weeks of the quarter are more leisurely spent exploring topics which included: jobsite temporary structures, jobsite productivity, construction learning curve, lean construction techniques, sustainable construction practices, leadership, managing people, and earned-value management.

Reading Assignments and Pre-quizzes: There was one required textbook for the class, it was written by Minks and Johnston entitled *Construction Jobsite Management*, 2nd edition, John Wiley & Sons, New York, 2004. The text book subject matter was relevant and well suited for a construction management undergraduate course. The chapters in the book, while needing some rearrangement, matched well with the topics identified in the first six weeks. The chapter reading assignment was relevant to that day's lecture topic and was due prior to class discussion. The course syllabus identified when each topic would be discussed and linked it to a chapter in the book. It was the student's responsibility to read the assigned chapter prior to attending the class lecture. This facilitated a more meaningful and in-depth discussion of the subject matter. A pre-quiz was administered at the beginning of class to reward students who complied. The format was a simple; five questions, five minutes, a multiple choice quiz which simply confirmed the student had at least scanned the material. The grade significance of the quiz was low, but enough to motivate students to pick up the book (see instructor assessment described later).

Supplemental Materials: Since the textbook only covered six tenths of the course, supplemental readings and lecture materials were developed for the remaining topics of the class. In addition, a variety of selected readings were chosen from current construction industry trade magazines (ENR, Cost Engineering, Construction Executive, etc). These articles were read, vetted, scanned, and posted to the class website for ease of access and utilization by the students. This database of material, which continually grows, allowed the students to pursue various topics of interest which also related to the goals and objectives of the course. Students were required to write a one-page summary of the readings chosen and present their findings to the rest of the class.

Guest Lecturers: Over the two quarters of Winter and Spring 2010, a number of guest lecturers from the construction industry were brought in and spoke with the class. Because of the remote location of the university, it has been traditionally difficult to persuade and consistently engage industry experts in the classroom. Guest lecturers were primarily recruited industry veterans and alumni who were already coming to campus recruiting for their company. This type of industry engagement helped strengthen the relationship between students, the department, and our construction industry partners. This kind of arrangement also made formal, structured, timely, topical, and readied material which can be directly applied to the course difficult to orchestrate. Prior to the guest lecturers' visit, extra efforts were taken by the instructor to inform and guide the topics discussed to match with what the students were currently studying. Often the field experience of the lecturer combined with assistance from the instructor brought new discussion points and a fresh perspective to class subject matter. Instructor participation and engagement was vital during an industry expert's visit to facilitate a more meaningful dialogue and assist students in making the connections to previously presented class material.

Lab Assignments supporting Project-Based Learning: The construction project utilized during these two quarters, as a foundation for project-based learning (PBL) in the class, was the Simpson Strong-Tie Building. This building was chosen because a complete set of contract documents was available, the building was relatively simple, had some interesting structural elements, and happened to be under construction during this time period. The myriad of pedagogical advantages to using an active construction site on campus need not be listed here. With a project selected, it was the task of the instructor to design the lab assignments in such a way which corresponded with the lectures and simulated the construction process (as realistically as possible) in the classroom.

The class project was compressed from a ten month construction schedule to ten weeks. Each individual student was assigned a subcontractor's role for the entire quarter. A rotating group of three students were assigned as the general contractor each week. Each general contractor group was responsible for the construction administration of the project for their assigned week. Their tasks (each week) included a subcontractor and owner progress meeting, dealing with simulated jobsite problems, and scheduling updates and maintenance. Additional assignments included a detailed three-week look-ahead, jobsite coordination and oversight, quality control of the building model, and complete document control. Each individual student subcontractor was responsible for tasks such as generating requests for information (RFI's), submittals, and physically constructing the model. This type of PBL environment required the instructor to shift from a traditional teacher role, to one of a mentor and resource, and to an all business role as a savvy owner who wanted to follow the procedures of the contract documents to the letter and get his building built.

A series of thirteen labs were assigned to the students soon after each topic was fully presented and discussed in class. Each lab required the students to perform an activity which supported the PBL goals. The (I) indentifies that the lab was performed by each individual student, assigned as a separate subcontract. The (G) was an assignment for each general contractor group, typically three to four students per group:

1. **Ethics (I):** The student identified (on-line) a "code-of-ethics" list from at least five individual construction related professional organizations and wrote a paper on the three individual codes with which the student found compliance most difficult.
2. **10 Hour OSHA (I):** Through "Click-Safety" (an online safety course), students completed the 10-hour OSHA safety class and turned in their certificate.
3. **Tool Box Talk (I):** At the beginning of each class period, a student prepared and presented a 10-15 minute CalOSHA tool box talk to the class, simulating (as closely as possible) an actual field experience.
4. **Familiarization (G):** A straight forward "Where's Waldo" exercise familiarized the students with the construction project contract documents.

5. **Subcontractor Agreement (I):** The student wrote a complete subcontract agreement using the AGC short as a template. The exercise emphasized the scope-of-work and was accompanied by an appropriate certificate of insurance.
6. **Submittal (I):** Per the contract documents, the student generated a submittal package specific to their trade. This included some type of product data, MSDS sheets for that product, and a submittal transmittal.
7. **20-Day Preliminary Notice (I):** In California a preliminary notice must be filed with the owner and the lender to protect a subcontractor's lien rights. The student filled out this form as an administrative function but had to comply with the particular time and procedural requirements.
8. **Claim (I):** Each student subcontractor submitted two RFIs -- one representing an owner credit (value engineering) and one subcontractor/contractor cost increase which was subsequently turned into a fully priced potential change order.
9. **Cost Control (I & G):** Student subcontractors created a detailed cost control budget based on their lump sum price and scope-of-work. This exercise was then extrapolated to the student general contractors.
10. **Planning (G):** Now that the student was sufficiently familiar with the project, project-specific planning was considered regarding sustainability, risk management, material handling, temporary structures, etc.
11. **Quality (I):** Again, being sufficiently familiar, students considered quality control checklists, building codes, and industry standards which apply to their particular trade.
12. **Progress Payment (G):** A pay application was generated by each student general contractor group. Formatted to the AIA G701 and G702, it included a detailed schedule of values (SOV) and a varying payment date so each group submitted a unique pay request.
13. **Project Close-out (G):** To better understand the close-out process, each student general contractor group reviewed a section of the contract document requirements for warranty, training, stock material, etc.

An interesting aspect of these labs was that many did not have set due dates. Instead many labs were due as a natural progression of the project schedule. This proved to be particularly vexing to many of the students who were used to a more structured environment. For instance, the subcontractor agreement and submittal package had to be fully executed prior to the subcontractor (student) entering the jobsite (model). This required the student to closely monitor the jobs progress, and generate their paperwork in a timely manner. They also had to account for the time and effort required to have these documents processed and fully executed by all the other parties involved.

Utilizing Technology: As with most professional disciplines, university course improvements are needed continuously (particularly in technology) to meet the demands of an ever progressing construction industry. Two years ago the jobsite construction management course progressed from excel spreadsheets and is now using Meridian Systems – Prolog Management Software to create and track the project's paperwork. Prolog has been the most widely used pre-packaged construction management software in our industry. Utilizing this software exposed students to an industry standard and added an element of realism to the project. More recently, the class went from physically building the model in a wood box of soil to now building the model virtually in both a Revit and ArchiCAD computer format (See Figure 2). Building a model with balsa wood, cardboard, and glue was not providing the students with any technical knowledge or genuine insights. Using BIM software reinforced and further developed skills learned in previous integrated classes.

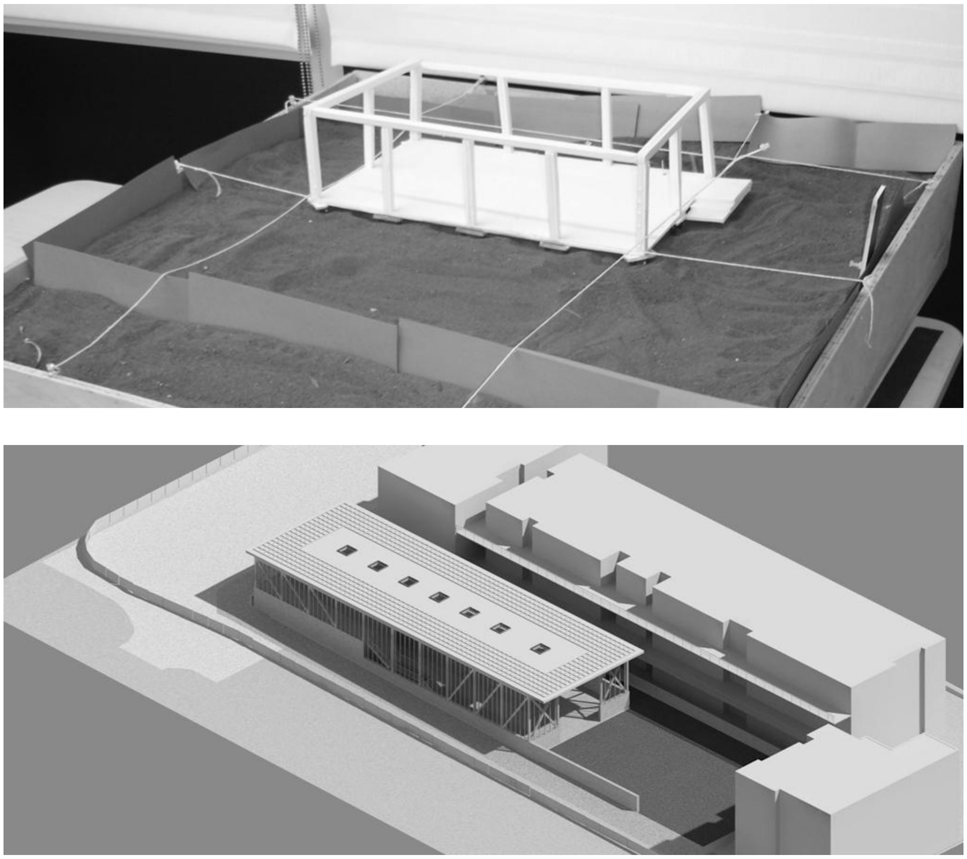

Figure 2. Example of a previous physical model and a current virtual model.

Construction Project Jobsite Visit - Student Presentations: As a final project the students were asked to pair-up, identify a "significant" active construction project, and conduct a site visit with the goal to present their findings to the class. This assignment was given to the students on the first day of class as the logistics of finding a work day which the students could visit the site has traditionally been problematic. The assignment was clearly structured and project goals clearly delineated so it matched well with the learning objectives of the class. The site visit included two interviews with the onsite superintendant and project manager, an analysis of the project team (including the owner, architect, inspector, etc.), a complete investigation of the jobsite paperwork process (contracts, document processes, etc.), and the identification and analysis of two working temporary structures. The information gathered by each team was then presented to the rest of the class in a combined power point and video format. This exercise allowed the students to affirm, on their own, the PBL assignments conducted in the class simulation.

Instructor Assessment: The following was criteria used to assess the students' performance:

- Reading (Pre-Quizzes) 10%
- Exam 1 & 2: 30%
- Lab Assignments: 30%
- Jobsite Visit - Student Presentation 20%
- Class Participation 10%

The biggest challenge for the instructor, aside the set-up time required to provide the students with a meaningful and technically accurate PBL environment, was the task of grading. The goal of swift and quality instructor feedback was important to student learning and assessment. Assessment was based on a variety of tasks and learning outcomes. While students were mostly graded individually, on occasion some group assessments were necessary. In these situations students were given the opportunity to submit self and peer evaluations to ensure that group responsibilities were equally shared. Using the various grading techniques listed above, both group and individually graded, ensured students got quality feedback on all the learning objectives of the course. Along the lines of grading, another challenge is that of proper and accurate course assessment. Outcomes assessment is often difficult to gauge when group projects and student presentations are utilized. An added layer of assessment difficulty, in an integrated curriculum, is the reliance on other core courses to achieve their goals and objectives. The building-on and revisiting of course content is crucial to achieving complete student understanding of curriculum.

Conclusions and Future Research

Being a more informative and pedagogy sharing paper, significant conclusions are not being drawn from the information presented. The success of this course was predicated on additional class time, increased teacher-student contact hours, traditional dissemination of required technical information, integration of class topics, building of student soft skills, and application of technical information under the umbrella of project-based learning. The class has continually received statistically high marks from generic university student surveys. While not statistically significant, it does anecdotally suggest that the students view the class favorably. These high marks, though, may be the result of many different factors having nothing to do with class integration or project-based learning. Class specific student surveys have been conducted for this course and are utilized in other publications.

The sharing of ideas, course content, academic theory, and best practices as they relate to construction management education should continue to be encouraged. All construction course instructors with a unique perspective and/or situation with a resulting unique solution should be perpetually encouraged to share their thoughts, experiences, successes, and failures for the benefit of everyone in our industry. This paper follows in the footsteps of many other ASC proceeding papers that accepted the risk and took the challenge to share their academic experiences with their peers for the benefit of every one in construction education.

References

Albano, L. & Salazar, G. (1998). Project-based course for integration of design and construction at WPI. *Journal of Professional Issues in Engineering Education and Practice,* October 1998, 97-104.

Barlow, P. (2009). Case study in implementing a service-learning class in a construction management curriculum. *Associated Schools of Construction International Proceedings of the 45th Annual Conference,* University of Florida - Gainesville, Florida.

Chinowsky, P., Brown, H., Szajnman, A., & Realph, A. (2006). Developing knowledge landscapes through project-based learning. *Journal of Professional Issues in Engineering Issues and Practice,* 132 (2), 118-124.

Gunderson, D., Barlow, P., & Hauck, A. (2007). Construction superintendent skill sets. *Associated Schools of Construction International Proceeding of the 42nd Annual Conference*, Northern Arizona University - Flagstaff, Arizona.

Hauck, A. & Jackson, B. (2005). Design and implementation of an integrated construction management curriculum. *Associated Schools of Construction International Proceedings of the 41st Annual Conference*, University of Cincinnati–Cincinnati, Ohio.

Montoya, M., Kelting, S., & Hauck, A. (2009). Pilot study of an integrated construction management curriculum. *Associated Schools of Construction International Proceeding of the 45th Annual Conference,* University of Florida-Gainesville, Florida.

Odusami, K. (2002). Perceptions of construction professionals concerning important skills of effective project leaders. *Journal of Management in Engineering,* April 2002, 18(2), 61-67.

Senior, B. (1998). Infusing practical components into construction education. *Journal of Construction Education*, 3(2), 92-101.

Sirotiak, T. & Walters, R. (2009). Improving student confidence and ability to cope under stress through project based learning. *Associated Schools of Construction International Proceedings of the 45th Annual Conference*, University of Florida - Gainesville, Florida.

Thamhain, H. (1992). Engineering management: Managing effectively in technology-based organizations, 1st Ed., Wiley, New York.

Wankat, P. & Oreovicz, F. (1993). Teaching Engineering. New York, NY: McGraw-Hill, Inc.

Williams, K. & Pender, G. (2002). Problem-based learning approach to construction management teaching. *Journal of Professional Issues in Engineering Education and Practice*, January 2002, 19-24.

Author Notes

The author would like to encourage anyone who is interested in project-based learning and/or curriculum integration to please contact me to share ideas or experiences at: plbarlow@calpoly.edu.