Pilot Study of an Integrated Construction Management Curriculum

Michael A. Montoya, MSCM, PE, LEEDAP
California Polytechnic State University
San Luis Obispo, California

Scott D. Kelting, MS, LEEDAP
California Polytechnic State University
San Luis Obispo, California

Allan J. Hauck, Ph.D., CPC
California Polytechnic State University
San Luis Obispo, California

A pilot study of an integrated curriculum in construction management has been conducted over the past three years at a major university. The purpose of this pilot study was to test first hand the claims made for increased student retention and involvement associated with this curricular approach. This paper describes the methodology used to conduct this pilot study and the "lessons learned" relative to four specific research questions related to space utilization, individual versus group learning, content and sequence in an integrated curriculum, and the appropriate role of practitioner educators. The authors conclude that an integrated curriculum continues to show promise for university programs in construction management, as has been demonstrated in other professional programs, but additional development work and assessment are still required.

Key Words: Integrated curriculum, interdisciplinary curriculum, construction management education, curriculum design, project based learning.

Introduction

For the past decade or more, there has been an increasing interest in developing curricula in construction management that are more integrated and more project based than ever before (Mills, Auchey, and Beliveau, 1996; Hauck and Jackson, 2005; and others). Schon (1987) and others have argued that the nature of knowledge in a profession is different than in other academic fields and, therefore, requires a more hands-on approach to learning in which students "practice" their profession and then "reflect" on their performance under the guidance and critique of professionals with extensive personal experience in the field. He defends this "reflective practice" approach to professional education as follows: The problems that professional practitioners--such as doctors, lawyers, or engineers face are rarely straightforward and clear. They are frequently complex and lack "right answers." Skillful professional practice often depends less on factual knowledge or rigid decision-making models than on the capacity to *reflect* before taking action in cases where established theories do not apply. . . . Professional education should be centered on enhancing the practitioner's ability for "reflection-in-action"--that is, learning by doing and developing the ability for continued learning and problem solving throughout the professional's career.

As they prepare students for a profession, construction management curricula can be informed by other approaches to teaching in an integrated curriculum with a heavy reliance on project based learning. Shoemaker (1991) quotes media specialist, M. Marcus, by saying, "The integrated curriculum is a great gift to experienced teachers. It's like getting a new pair of lenses that make teaching a lot more exciting and help us look forward into the next century. It is helping students take control of their own learning."

The *Dictionary of Education* (Good 1973) defines an integrated curriculum as "a curriculum organization, which cuts across subject-matter lines to focus upon comprehensive life problems or broad based areas of study that brings together the various segments of the curriculum into meaningful association." Hauck and Jackson (2005) emphasized that the goal of an integrated curriculum is "to arrange content around overlapping concepts and themes, not to help students remember isolated facts."

Bonds, Cox, and Gantt-Bonds (1993), who identify the integrated curriculum as an example of "synergistic teaching", wrote the following: Synergistic teaching goes beyond the blurring of subject area lines to a process of teaching whereby all the school subjects are related and taught in such a manner that they are almost inseparable. What is learned and applied in one area of the curriculum is related and used to reinforce, provide repetition, and expand the knowledge and skills learned in other curriculum areas. This process of synergistic teaching allows the student to quickly perceive the relationships between learning in all curriculum areas and its application throughout each of the school subjects….Synergistic teaching does more than integrate; it presents content and skills in such a manner that nearly all learning takes on new dimensions, meaning and relevance because a connection is discerned between skills and content that transcends curriculum lines. In a synergistic classroom, simultaneous teaching of concepts and skills without regard to curriculum areas would have greater effect than the sum of learning skills and concepts in individual subject areas.

According to Lipton, et al. (1993), there are numerous positive effects of curriculum integration:

- Integrated curriculum helps students apply skills.
- An integrated knowledge base leads to faster retrieval of information.
- Multiple perspectives lead to a more integrated knowledge base.
- Integrated curriculum encourages depth and breadth in learning.
- Integrated curriculum promotes positive attitudes in students.
- Integrated curriculum provides for more quality time for curriculum exploration.

An Integrated Curriculum Pilot Study in Construction Management

The faculty have conducted a series of pilot studies of three of the proposed seminars during 2005, 2006, 2007, and continuing into 2008. Seminars – each lasting an entire academic quarter – were conducted in Residential, Commercial, and Heavy/Civil Construction Practices. Each seminar was delivered by a primary faculty member with specific knowledge of that industry sector. Instruction was supplemented by other faculty "subject matter experts" and industry practitioners. Each course primarily incorporated a project based delivery that integrated the practices of each industry sector with an immersive "capstone" type project. The student projects were based on current or recently completed construction projects with involvement of the company and individuals responsible for the project. The intention was to deliver each seminar integrating various traditional construction management courses into a single active, applied learning experience.

The pilot study of this integrated curriculum model was started in 2005 and the faculty are currently completing the third round of these three seminars with the latest cohort of students. Each seminar incorporated the learning objectives from the traditional, stand-alone courses in construction practices, plus the learning objectives from the scheduling, estimating, and contracts courses in a completely integrated format. The relevance of the learning objectives to each seminar in the pilot study was evaluated primarily by a faculty committee with input from industry advisors and the students completing the courses. The goal of this evaluation was to determine the "best practices" for teaching in this format and to address specific concerns as this curriculum is being introduced to all students in the new facilities.

Research Questions

The pilot study and accompanying research was designed to address the following questions:

- How can faculty ensure individual learning when using a project based delivery system in groups?
- What is the appropriate content and sequence for an integrated curriculum?
- What is the appropriate role of industry in the class room?
- How can we assess student performance related to learning objectives and compare it to the traditional instruction model?

Methodology - Pilot Program Implementation

Twenty-four students were selected to participate in three seminars each lasting one academic quarter. They were divided into teams of four students for both the lab assignments and final project. Each seminar was worth six-credit hours and met fourteen-hours per week for each ten-week quarter. The beginning of the quarter was primarily devoted to a lecture delivery to assist the students with the knowledge they needed in order to work on their labs and the final project. Each seminar combined four classes into one: Means and Methods (appropriate to each industry sector), Estimating, Scheduling, and Contracts. The classroom was designed to simulate an office environment and was dedicated solely to this pilot study – the students had access to the space twenty-four hours a day. Each team had a work space consisting of a cubicle designed to accommodate groups of four. The classroom also had a presentation area where the students gathered to view lectures and other presentations. Each seminar was delivered using in-class lectures, laboratory exercises, guest speakers, an overall "capstone" project, and student presentations.

Lectures

The lectures consisted of presentation and interactive discussion that immersed students in all aspects of the target industry sector. The lectures covered means and methods for every phase of the building process, from entitlement to warranty, and the fundamental theory associated with the learning objectives for each course. The lectures were designed to give students necessary information to apply the skills learned in the classroom to lab assignments and their final project. The lecture material was primarily delivered using Power Point and multi-media and was designed to be interactive by including pre-lecture assignments and short in-class lab assignments during the lectures. Lectures were delivered by the primary instructor along with industry representatives and faculty "subject matter experts." Faculty members, who are proficient in specific construction management functions, such as estimating or contracts, served as these subject matter experts. Mastery of the lecture material was assessed by exams taken by each individual student.

Laboratories

Individual in-class laboratories were assigned throughout the quarter and conducted by the primary instructor and industry representatives where appropriate. The labs were designed to reinforce the concepts covered in class lecture and assist the student's understanding of fundamental concepts necessary to complete the final project. In-class laboratories included activities such as (examples form multiple seminars):

- quantity and cost evaluation of both a post tension and conventional foundation,
- evaluation of the site layout and constraints and how they may affect cost and time,
- material take-off and work breakdown structure for structural steel, and
- construction equipment productivity and work breakdown structure evaluation for mass excavation.

Guest Speakers

Guest lecturers were brought in from industry to discuss various topics in each integrated seminar. Speakers that had actually worked or were working on the assigned construction project were incorporated in an effort to make the project feel more "real-life". The guest speakers were able to answer questions students had about the project and give them insight and information that supplemented the other material covered in the lectures. The interaction clearly strengthened the relationship between the building professionals and the students and provided some opportunities for employment and information resources. Some examples of guest speakers invited to present included:

- An Area Construction Manager from a nationwide homebuilder presented construction operations, scheduling, home owner relations, and the warranty process.
- The entitlement process for commercial buildings was presented by the capstone project's Owner Representative.
- Construction contracts material was presented primarily by a local construction claims attorney in bi-weekly lectures.

- An estimating seminar was presented by the Project Manager who constructed the example project and the Estimator who prepared the original budget.
- Scheduling and equipment productivity was discussed by the Project Manager currently constructing the capstone project.

Final Project

The students worked in groups of four to complete an overall "capstone" project over the course of the quarter. At the beginning of the quarter, a set of construction documents was issued to each team with an explanation of the project. The projects were selected by the instructor with recommendations from industry advisors and included relevant structures that were currently under construction or recently completed, such as, a 97-lot residential development, a 144,000 square foot hotel, and an airport runway expansion project. The daily student work assignments were not directed by the instructor with the exception of specific milestones and periodic formal progress reviews. Each group met with the instructor and presented the deliverables for each assignment on their milestone date. This allowed the student teams to receive constructive feedback throughout the project. Generally, the final project deliverables for each of the three seminars included the following:

Residential Final Project Deliverables:

1. Complete a construction estimate and budget including a quantity take-off of all labor, material, and equipment necessary to complete the project.
2. Find creative ways to reduce costs and add marketability to the homes by value engineering the current plans and specifications.
3. Using MS Project, determine an overall CPM project schedule based on the absorption rate.
4. Complete a strategic and operational marketing analysis for the project.
5. Determine the proposed project management team.
6. Create a pro forma and cash flow projection for the proposed project.
7. Prepare an Executive Summary including a recommendation regarding purchasing the finished lots and explain reasons why or why not.

Commercial Final Project Deliverables:

1. Complete a construction estimate including a quantity take-off of all labor, material, and equipment necessary to complete the project.
2. Provide an evaluation of associated project cost topics including indirect costs, overhead determination, general condition costs, profit assessment, and value engineering.
3. Evaluate subcontractor and supplier proposals.
4. Prepare an overall project CPM schedule of construction activities, using Primavera scheduling software, indicating the critical path, milestones, and related ancillary schedule items.
5. Prepare a site layout plan (e.g., crane location) and explain how it may affect cost and time.
6. Evaluate the project contract and associated risk.
7. Determine proposed project management team and associated costs.
8. Prepare an Executive Summary including recommendations.

Heavy/Civil Final Project Deliverables:

1. Complete a quantity take-off of all materials necessary to complete the project.
2. Evaluate the equipment necessary to complete the project.
3. Determine and evaluate production cycles for equipment and determine most efficient equipment usage/cycles.
4. Determine an overall project schedule based on the proposed equipment selection/production.
5. Determine an overall project cost based on subcontractor quotes and equipment production estimates.
6. Prepare an Executive Summary of the proposed project including your proposed project staffing.

Student Presentation

Each team prepared and delivered a 20-30 minute professional presentation of their solutions to the final project. The presentations were primarily delivered with a combination of Power Point, story boards, and handouts. The presentations were delivered to a panel of 'judges" including the instructor, industry advisors, and other involved faculty. The presentation requirements generally included:

- executive summary;
- summary of project schedule and plan for completing the work;
- summary of project estimate, budget, and/or cash flow projections;
- value engineering evaluation;
- marketing analysis, general conditions cost evaluation, and/or profit assessment; and
- conclusions to address the specific scenario created by the instructor.

In addition to the presentation, each group prepared and submitted a final project report that included their solution with back-up documentation.

Results

Following the pilot study with each group of students, departmental faculty discussed the "lessons learned" and tried to determine improvements that could be incorporated into future attempts to teach in this format. In this case, they attempted to address the following questions.

How Can Faculty Ensure Individual Learning When Using a Project Based Delivery System in Groups?

The faculty's basic approach, and core to their goals in conducting the pilot studies, was to use a project based delivery with students working in groups. One of the challenges that the faculty found using this teaching method, which applied the integration of scheduling, contracts, and estimating with the means and methods content, was evaluating whether each individual was involved and engaged with each of the learning objectives associated with the final project. In each of the pilot studies, faculty tried different methods for determining the right balance between individual work and teamwork, and accessing whether each individual was practicing and retaining the learning objectives associated with the group work. To assess the results, the faculty focused primarily on how the labs were structured and how much lab work was assigned individually versus in teams. The faculty also considered other related factors, such as how groups were assigned, assessment methods, size of the project, and amount of work required.

In the first iteration, the faculty assigned only group work associated with the capstone project, and assessed individuals with peer and industry based reviews and exams. This approach allowed students to divide and assign the work tasks to the most qualified individual which was similar to how this would be approached in practice. This method produced the best overall student work results of any class. However, it was clear that by dividing the work tasks, individuals were not practicing each of the learning objectives. For example, while every student completed a quantity take-off, the schedule production may have been completed by just one of the team members. This only exposed one of the students to the schedule production, software, and CPM evaluation.

In response to the first iteration, the faculty assigned several individual laboratories that were specifically related to learning objectives and associated with the overall group project. This approach produced an improvement in individual assessments and maintained a high quality of group work. However, with the amount of time available in a quarter, it was a challenge to implement both individual lab exercises and a group project while maintaining the immersive project based delivery goal.

In the third iteration, the faculty added individual assignments that were specifically associated with the overall project. For example, each individual was required to complete an estimate for at least one house, while the overall group project required cost generation for the entire development project. The faculty also ensured individual

assessment by assigning individual exams that covered the established learning objectives. The individual credit assigned to students was in the range of 50%-70% for each course.

What is the Appropriate Content and Sequence for an Integrated Curriculum?

One of the challenges to designing this program was to evaluate which courses were best offered in a traditional format and which courses work well using this integrated approach. The initial courses as outlined in Hauck and Jackson (2005) included scheduling, estimating, contracts, and construction accounting integrated with the residential, commercial, and heavy/civil curricula. The faculty initially evaluated the learning objectives for each stand-alone class, then divided and expanded them to conform to each of the industry specific seminars. Based primarily on student assessment and feedback from industry sponsors, the faculty agreed that the topics of scheduling, estimating, and contracts worked well with the project based integrated delivery. However, the topic of construction accounting was difficult to integrate with estimating and scheduling in a project based delivery and tended to add more distraction than value. Based primarily on recommendations from the instructors and students, the faculty removed it from the third pilot study requiring these students to complete construction accounting as an individual course.

The faculty also found it challenging to introduce fundamental instruction on materials, means, and methods while allowing enough time to make the capstone project relevant. In the latest pilot study, basic materials instruction was removed from the seminars and the faculty introduced a new materials course that was taught as a prerequisite to the integrated seminars. While the faculty are still evaluating in the current iteration, it appears that this approach will help by permitting coverage of more advanced project challenges.

In the current proposed integrated model, the students will take a specialty construction seminar in which they are exposed to learning objectives related to Mechanical, Electrical, and Plumbing (MEP) systems subsequent to the industry specific seminars. However, the faculty found that the students had a difficult time assessing building costs and schedules without basic knowledge of MEP systems. In the next iteration, the faculty intends to introduce a basic discussion of MEP systems, led by faculty "subject matter experts", in each of the industry specific seminars.

What is the Appropriate Role of Industry in the Class Room? One of the primary goals for this pilot study was to include industry advisors in the course delivery. The faculty have attempted through several iterations to evaluate what is the appropriate amount of involvement and how best to include industry while maintaining an acceptable balance between theory and practice. Generally, throughout this process, the primary instructor has delivered material associated with theory. Obvious benefits from industry support, such as field trips, aside, the faculty tried to focus their assessment on what information was appropriate for industry representatives to deliver and how best to ensure that presenters were focused on the learning objectives of the course.

In the first iteration, the faculty invited industry sponsors to discuss the methods that they use for completing tasks related to the course objectives, for example, completing mass excavation quantity take-offs. The faculty did not provide specific instruction of what to cover or how to present the material, with the intention of allowing the practitioners the flexibility to guide the discussion to areas that they observe, in practice, as important for students to know. The faculty also asked them to bring company representatives who they felt were most qualified to address the topic. This worked well with some groups, but not with all. Without clear direction, several of our guest speakers used the opportunity primarily as a means to discuss their company, resulting in a recruiting information session, and deviated from the intended learning objectives often to the point of distraction.

In the second and third iterations, the speakers were organized at the beginning of the quarter and included industry practitioners selected by the instructor based primarily on a subjective evaluation of their level of expertise in the required topic. Speakers who were actually involved with the capstone project were generally preferred. Each speaker was provided with specific learning objectives and a lecture outline, and was scheduled to coincide with other relevant topics related to instructor lectures and the capstone project.

Based primarily on student and industry feedback, this approach achieved our goal of including industry advisors in the delivery of the course while maintaining a balance between theory and practice. It also allowed the instructor to

more easily ensure the delivery and retention of the learning objectives. It is clear that industry involvement helps to further engage the students and enhances the students' understanding of the material.

How Can We Assess Student Performance Related To Learning Objectives And Compare It To The Traditional Instruction Model? In order to assess the outcomes of each pilot study individual instructors, faculty, students, and industry participants were asked to provide feedback on the program. The feedback was used to make adjustments to each course and the overall program. Each iteration of the pilot study resulted in performance that prompted, compelled, and justified consecutive studies. The program evaluation conducted during each pilot study included input from faculty, industry participants, and students.

Faculty Assessment. The faculty were both the researcher and the teacher during the pilot studies. Faculty were involved with each pilot study as teachers, subject matter experts, guest lecturers, and with informal qualitative interviews for each class. Each instructor assessed student outcomes for each of the seminars and compared their performance to students in "stand-alone" courses.

During each of the pilot programs student performance was evaluated for each of the learning outcomes for the courses. Exam questions and laboratory exercises were devised to evaluate student performance related to specific learning outcomes. This assessment model was applied to the "stand alone" courses and the integrated courses for each pilot period. The outcomes evaluated were categorized by Bloom's Taxonomy: "Know, Comprehend, Apply, Analyze, Synthesize, and Evaluate." Student assessments continue to be comparable with the traditional instruction model in the Know and Comprehend categories. Student assessment and performance in the Apply, Analyze, Synthesize, Evaluate categories has steadily increased in each pilot study and currently indicates an improvement when compared to stand alone classes.

Based on the faculty involvement and observations and promising student performance results from each pilot study iteration the faculty has consensus to continue studying an integrated curriculum with the goal of changing our current curriculum. The authors would like to recognize limitations to the study due to the form of practitioner inquiry that was practiced. Most of the research data was obtained by professors who developed and instructed the courses. While the data is primarily qualitative we recognize that it is a challenge to maintain research objectivity when also developing and conducting the course.

Industry Participants Evaluation. Every class in the pilot study had some level of engagement from industry practitioners. At the end of each course the industry participants were asked to evaluate the program, many of the participants had previously graduated from the program under the existing teaching methodology. While the industry response varied widely they expressed nothing negative. Consistently industry participants indicated their observation that this model prepares students well for the challenges of our industry and that they would prefer to hire a student who has completed this program versus a traditional instruction model.

Alumni and employers who interact professionally with recent graduates from our program were interviewed to help evaluate how the program is progressing in each class in each pilot study. Several employers who have a history of recruiting our students were contacted to evaluate entry level performance of graduates of the new program as compared to historical performance. While the responses varied widely several overriding themes have emerged over the course of this pilot study. Employers and graduates agree that graduates of this program are more productive in their entry level positions when compared to graduates instructed in the traditional model.

Student Evaluation. During each pilot study course students were asked to evaluate the program using surveys, questionnaires, and an end of the quarter informal qualitative interview with faculty. The results of this survey were used to evaluate and make adjustments to each consecutive pilot study. For example, early questionnaire results helped with the evaluation and design of classroom space in our new building, and with program evaluation that led to the removal of construction accounting learning objectives from the seminars.

In each class students completed a standard survey, informal qualitative interview with faculty, and a final overall evaluation in qualitative narrative format. Most of the student's constructive criticism of the courses and program related to instructor performance and space constraints. The student's response to the curriculum and delivery were

all positive and every student indicated that they would take the class again if given the opportunity, would recommend it to other students, and felt better prepared for their future careers.

Conclusion

After completing several pilot studies of this integrated curriculum, the authors believe strongly that this synergistic method of instruction and delivery provided a more comprehensive understanding of the material and significantly improved the student's ability to practice the professional skill sets taught as they relate to each specific industry sector. While the program continues to be a work-in-progress, the authors concur with Lipton, et al. (1993) that there are numerous positive benefits to curriculum integration. 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. Rather, the everyday professional activities that occur in construction and on the job-site draw on principles and tools associated with a variety of integrated disciplines. An integrated curriculum clearly emphasizes connections, arranging content around overlapping concepts and themes, not just helping students to remember isolated facts. Most importantly, the desired learning objectives are accomplished in an immersive, project-based learning environment specific to the content of each large credit-hour seminar.

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