AC 2012-2969: LESSONS LEARNED FROM THE IMPLEMENTATION OF INTEGRATED PROJECT BASED CONSTRUCTION MANAGEMENT CURRICULUM: A FACULTY PERSPECTIVE

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Lessons Learned from the Implementation of Integrated Project Based Construction Management Curriculum: A Faculty Perspective

Abstract

Beginning in the autumn quarter of 2008, the Construction Management Department at California Polytechnic State University, San Luis Obispo (Cal Poly) launched an integrated project based construction management curriculum. The basis behind the integrated curriculum was to create a series of practice courses, similar to an architecture studio model; however, each course would focus on a specific sector of the construction industry - Heavy Civil, Residential, Commercial, and Specialty Construction. The concept behind the seminars was to integrate project controls, construction estimating and construction contracts and law into each of these courses and combine them with the construction methods topics pertinent to each industry sector. This paper covers several issues regarding the implementation of the new curriculum, including Pedagogy, Student Throughput, Faculty Workload and Teaching Assignments, and Accreditation.

Introduction and Background

Since 1990, the Construction Management Department at California Polytechnic State University, San Luis Obispo (Cal Poly) had been soliciting donations for the construction of the Construction Innovations Center (CIC) on the Cal Poly campus. As part of the fund raising effort for the new 30,000 square foot building which was to be include seven (7) dedicated labs, twelve (12) classrooms and lecture halls, and faculty offices a new curriculum was proposed to inspire interest among potential donors. The proposed curriculum was similar to that discussed by Hauck and Jackson in 2005, were project controls, construction estimating, and construction contracts and law was integrated into project based courses that focused around a specific industry of the construction market - Heavy Civil, Residential, Commercial, and Specialty Contracting[4]. Their proposal eliminated traditional stand-alone courses and integrated their content with construction methods topics pertinent to each industry sector. Their concept was to create a series of active, applied learning experiential courses. The result was a creation of the following seven (7) project-based construction management courses:

- Fundamentals of Construction Management
- Heavy Civil Construction Management
- Residential Construction Management
- Commercial Building Construction Management
- Specialty Contracting Construction Management
- Construction Jobsite Management
- Interdisciplinary Project Management

Students receive six (6) quarter-hours of lab credit for a total of sixteen (16) scheduled contact hours per week and an additional two (2) hours per week to be arranged by the instructor. Based on a ten (10) week quarter system, students would receive a total of one-hundred (180) hours of instruction[8]. Similar to a studio in an architecture studio, the concept was teach each course in a dedicated space equipped with models, samples, contracts, marketing documents, specifications, estimating guides, computer references, and other tools appropriate to that construction industry sector. In addition, the laboratory would be furnished with work stations for twenty-six (26) students who would have twenty-four (24) hour/seven (7) days of week access to the space.

Creation of the integrated project based construction management curriculum

Prior to the implementation of the new integration of the integrated curriculum students were required to complete individual courses in project controls, construction estimating, construction contracts and law, construction jobsite management, concrete formwork, and temporary structures (Table 1). The original curriculum also required students to complete a standalone course in building mechanical systems and in building electrical systems. Students were required to take an individual construction methods course in the following subject areas: residential construction, heavy civil construction, and commercial construction. The course title, delivery mode, and quarter unit values for the courses referred to above are found in the Table 1.

Table 1 – Required Courses prior to the Implementation of the Integrated Curriculum

Course Title	Course Delivery Mode	Quarter Units
CM 211 – Construction Drawings and Specifications	Laboratory	3
CM 212 – Fundamentals of Construction Management	Laboratory	3
CM 333 - Construction Contracts and Law	Lecture	1
CM 341 - Residential Construction Practices	Laboratory	3
CM 342 - Commercial Construction Practices	Laboratory	3
CM 343 - Heavy Civil Construction Practices	Laboratory	3
CM 352 - Electrical Systems for Buildings	Laboratory	3
CM 353 - Mechanical Systems for Buildings	Laboratory	3
CM 364 - Construction Jobsite Management	Laboratory	3
CM 444 - Concrete Formwork and Other Temporary Structures	Activity	3
CM 452 - Project Controls	Laboratory	3
CM 454 - Construction Estimating	Laboratory	3

When the integrated courses were created, the stand alone courses - Construction Contracts and Law Project Controls, and Construction Estimating (CM 333, CM 452, and CM 454, respectively) were eliminated and integrated with the Heavy Civil, Residential, and Commercial Construction methods courses (CM 343, CM 341, and CM 342, respectively). The content of those courses was divided and combined with the original standalone construction methods course. The specialty

contracting construction management course was created by eliminated the Mechanical and Electrical Systems for Building courses and combining their courses content. The new integrated curriculum courses which were created, the courses with which they were created, and the percentage of course content are shown in the Table 2. Figure 1 graphically displays how the integrated studio courses were created.

Table 2 – Creation of the Integrated Curriculum Courses from prior courses

Course Title	Course Delivery Mode	Quarter Units
CM 115 – Fundamentals of Construction Management CM 211 – Construction Drawings and Specifications (50%) CM 212 – Fundamentals of Construction Management (50%)	Laboratory	6
CM 213 - Heavy Civil Construction Management CM 343 - Heavy Civil Construction Practices (100%) CM 333 - Construction Contracts and Law (33%) CM 452 - Project Controls (33%) CM 454 - Construction Estimating (33%)	Laboratory	6
CM 311 - Residential Construction Management CM 341 - Residential Construction Practices (100%) CM 333 - Construction Contracts and Law (33%) CM 452 - Project Controls (33%) CM 454 - Construction Estimating (33%)	Laboratory	6
CM 313 - Commercial Construction Management CM 342 - Commercial Construction Practices (100%) CM 333 - Construction Contracts and Law (33%) CM 452 - Project Controls (33%) CM 454 - Construction Estimating (33%)	Laboratory	6
CM 413 - Jobsite Construction Management CM 364 - Construction Jobsite Management (100%) CM 444 - Concrete Formwork and Other Temporary Structures (100%)	Laboratory	6
CM 411 - Specialty Contracting Construction Management CM 352 - Electrical Systems for Buildings (100%) CM 353 - Mechanical Systems for Buildings (100%)	Laboratory	6

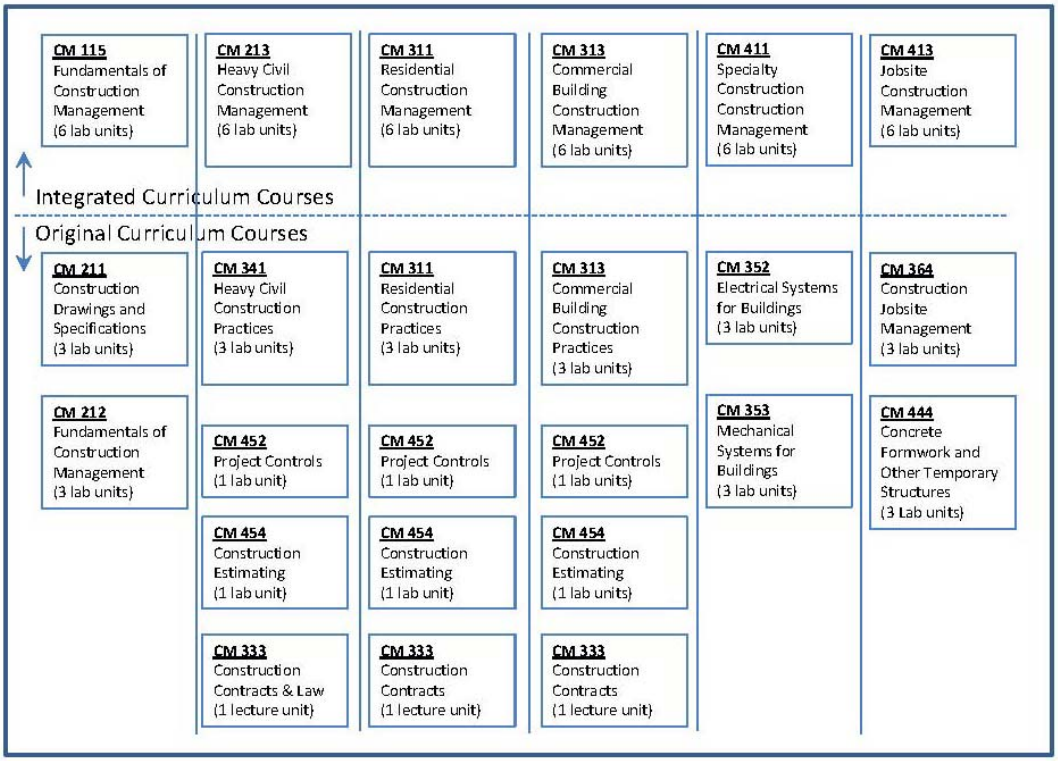

Figure 1 – Creation of Integrated Courses from Original Courses

Following the implementation of new integrated curriculum a number of concerns and discussions have surfaced through the Construction Management Curriculum Committee and through general discussions items as topics brought forth by individual faculty at department faculty meetings. These include the following: Pedagogy, Student Throughput, Faculty workload and Teaching Assignments, and Accreditation.

Pedagogy

With the implementation of integrated curriculum, the several concerns related to pedagogy surfaced relating Learning Objectives and the selection of course textbooks and implementation of project based learning.

Learning Objectives and Course Textbooks

As stated above, the concept behind the integrated curriculum was to create project based courses that focused on a specific sector of the construction industry, where educational content from project controls, construction estimating, and construction contracts and law were integrated with construction methods pertinent to an industry sector.

In order to ease financial burden on the students from purchasing multiple text books for similar subjects, the faculty course champions for the Heavy Civil, Residential, and Commercial Construction Management courses share use a common set of textbooks. No text was listed for the estimating content of the courses. Table 2 list the text books selected for use in each course.

Table 3 – Required Textbooks for the Integrated Courses

Course Title / Subject Matter	CM 213 Heavy Civil Contracting Construction Management	CM 311 Residential Contracting Construction Management	CM 313 Commercial Contracting Construction Management	CM 411 Specialty Contracting	CM 413 Jobsite Construction Management
Project Controls	Construction Planning and Scheduling – The Associated General Contractors of America	Construction Planning and Scheduling – The Associated General Contractors of America	Construction Planning and Scheduling – The Associated General Contractors of America	No textbook	No textbook
Construction Estimating	No textbook	No textbook	No textbook	No textbook	No textbook
Construction Contracts	Construction Contracting: Business and Legal Principles, 2nd ed – Bartholomew; Prentice Hall, 2001.	Construction Contracting: Business and Legal Principles, 2nd ed – Bartholomew ; Prentice Hall, 2001.	Construction Contracting: Business and Legal Principles, 2nd ed – Bartholomew; Prentice Hall, 2001.	No textbook	No textbook
Methods related textbook	Construction Planning Equipment, and Methods, 7th ed., Peurifoy, R and C. Schexnayder, 2005.	Carpentry, 4th ed. – Vogt; Delmar Cengage Learning	Building Construction: Principles, Materials and Systems - Mehta, Armpriest, Scarborough; Prentice Hall. 2008.	Mechanical & Electrical Systems for Construction Managers, 2nd ed – American Technical Publishers	Construction Jobsite Management, 3rd ed – Minks and Johnston; Delmar Cengage Learning.

Evidence supported from the chapters used throughout these courses indicated that students were only being taught the same fundamentals in project controls and construction contracts and law as they progressed throughout the curriculum. Also, it must be noted that that no construction estimating textbook was required or used in the courses. It was not until the winter quarter of 2012 that a construction estimating became a required text in the Commercial Contracting Construction Management course. The text selected was "Construction Estimating" authored by Toenjas, published by American Technical Publishers.

For CM 411 - Specialty Contracting Construction Management course no text book was used to cover project controls or construction estimating however, the argument was made that this course created from two (2) courses which focused on the fundamentals of building electrical and mechanical systems and therefore the course learning objectives did not include topics from project controls, construction estimating, or construction contracts and law.

Also, notable was that CM 413, the Jobsite Construction Management course did not include a textbook for concrete formwork/other temporary structures even through it was created by integrating the original Jobsite Construction Management and Concrete Formwork courses. Therefore, it appears as if the learning objectives related to concrete formwork may have been neglected.

During the initial discussions, prior to implementing the new curriculum, the concept was to have subject matter expects for project controls, construction estimating, construction contracts, and MEP systems. However, for the past three years, as of Fall 2011, all three (3) integrated industry sectors related studios have been taught by only one instructor. Questions among the faculty has been raised that the courses are becoming instructor specific.

Implementation of Project Based Learning

Concept for each course was to focus on one project throughout the entire ten (10) week quarter in each integrated course for Heavy Civil, Residential, and Commercial Building Construction, thus implementing a project based learning approach. A review of the course syllabi and schedules for each course found that each course was taught differently depending on the instructor. In the Heavy Civil course it was found that a number of small projects were assigned to the students rather than focusing on larger project through the quarter. In the Commercial Building course, the instructor used an approach where the first five (5) weeks of the quarter were spend covering fundamentals and the second five (5) weeks of the quarter were spent were spent working on the project culminated in a mock bid exercises. Only in the residential construction course was one project used through the entire quarter.

Student Throughput

With the implementation of integrated curriculum, the CM department has experienced several problems related to student throughout including course prerequisites, cooperative education opportunities, summer quarter course offerings, and CM minors.

Course Prerequisites

With the integrated curriculum was first proposed, the concept was that students would though the integrated curriculum in cohorts; therefore perquisites requirements were established so that students must complete one course before moving on to the next course. The sequence of courses to complete included CM 115, CM 213, CM 311, CM 313, and CM 411, and CM 413. In the original curriculum, students were permitted to take any of the three methods courses (Residential, Commercial, and Heavy Civil) in any order (or concurrently) as the only common construction management prerequisite was a construction fundamentals course. As stated above, the scheduling of the integrated courses requires students to attend class four (4) hours per day, four (4) hours per week, which are all schedule concurrently between 12:00 (noon) and 4:00PM. As result, students have noted that it has become increasing difficult to schedule other courses

outside the CM department due to the four (4) blocks that must be reserved to attend an integrated course. Essentially, their only option is take courses outside the CM department between 8:00 AM and 12:00 PM (noon).

If they are not able to register for courses during that time, they are forced to forego taking a CM integrated courses that quarter. This disrupts the cohort progression thru the CM curriculum and as a result it has become common practice that prerequisites for the sector specific integrated courses are waived in order to accommodate students need to register for courses and to balance the enrollment between the integrated courses.

Cooperative Education Opportunities

Cooperative Education opportunities consist of a student working at company for two (2) consecutive quarter and received college credit for their work since the experience is designed to involve an educational component. Prior the implementation of the integrated curriculum, CM-major and -minor students took advantage of cooperative educational opportunities offered by through the university-industry partnership throughout the academic year; however, after implementing the integrated curriculum students have primarily focused upon summer employment. It is speculated that this result of the students concentrating on trying to keep pace with their cohorts progression through the curriculum.

Summer course offerings

Prior to the implementation of the integrated curriculum, the number of course offerings were abundant and included a range of courses between the lower and upper division courses. Following the implementation of the integrated program, there has been an apparent decrease in demand for summer courses. This is most likely due to a limited number of students that may be eligible to take the subsequent course. As a result the integrated curriculum has also been detrimental for faculty who previously taught part time in the summer because each integrated course is considered a full teaching load for a faculty member; therefore, due to the limited number of courses that are able to draw enough student enrollment demand in the summer, the entire teaching load goes to only one faculty.

Construction Management Minors

Minoring in CM has been historically popular among Architecture students at Cal Poly. After the implementation of the integrated curriculum, the CM department has observed a decrease in the number of students pursing CM minors. Historically, the summer courses were popular among the CM minors who in the past took courses during the summer in order to make progress toward their minor, but now with the implementation of the integrated curriculum are ineligible to enroll in the courses due to a lack of perquisites. It is thought the integrated courses pose too much of challenge, from a scheduling perspective, to allow students to pursue a minor in CM.

Faculty Workload and Teaching Assignments

According to EP&R 76, the governing documents related to faculty workload at Cal Poly, Faculty Workload is defined as the normal workload of a full-time faculty member and consists of two components:

- 12 weighted teaching units (WTU) of direct instructional assignments, including classroom and laboratory instruction and instructional supervision (such as student thesis, project or intern supervision) equivalent to 36 hours per week, and
- 3 WTU equivalences of indirect instructional activity such as student advisement, curriculum development and improvements, and committee assignments (4 to 9 hours per week).

Thus Weighted Teaching Units are a measure of the weekly rate of faculty effort[3]. The breakdown of hours is the table below.

Table 4 – Faculty workload established by EP&R 76

Course Mode	WTU	Faculty-Student Contact Hours
1 laboratory unit	2 WTU's	3 hours
1 activity unit	1.3 WTU's	2 hours
1 lecture unit	1 WTU	1 hour

Therefore, for a six (6) unit laboratory course, faculty members are assigned 12 WTU's of teaching. The scheduling of the courses occurs in four-hour blocks. The current scheduling practice is to offer each of the integrated courses concurrently, meeting Monday, Tuesday, Wednesday, and Thursday afternoon between 12:10 PM to 4:00 PM and each integrated course constitutes a full teaching load.

Adjunct Faculty

As stated previously each course is a full teaching load, meeting four (4) times per week and scheduled in four (4) hour blocks, Monday through Thursday. Upon implementation of the integrated curriculum it has become increasing difficult to hire adjunct faculty to teach the course in event that a full-time faculty member is not available to teach one of the integrated courses. Essentially, to be able to hire an adjunct faculty member meant that you needed to find someone retired or unemployed.

Accreditation

The Construction Management Department at Cal Poly is accredited by American Council of Construction Education (ACCE). The new integrated curriculum was adopted following the department's re-accreditation in June 2007. Although the new integrated curriculum was in development during the accreditation review boards visit to Cal Poly, the prior curriculum was still being taught and therefore the CM department was evaluated on the prior curriculum. The new integrated curriculum has not been evaluated by the ACCE. In effort to design the new integrated

curriculum so that it would meet the ACCE requirements. The learning objectives for Construction Contracts and Law Project Controls, and Construction Estimating (CM 333, CM 452, and CM 454, respectively) were distributed between the new integrated courses for Heavy Civil, Residential, and Commercial Construction Management. This was done to help ensure that education content for those courses was not lost when those courses were eliminated.
The ACCE accreditation process can be considered to be prescriptive, for example the ACCE accreditation matrix requires a minimum number of instructional hours by category. Table 5 below lists the minimum number of instructional hours for selected categories of the ACCE matrix and the breakdown for the three sector specific integrated courses – Heavy Civil, Residential, and Commercial.

Table 5 – ACCE Accreditation Matrix

Category	Minimum number of instructional hours	CM 213 Heavy Civil Construction Management	CM 311 Residential Construction Management	CM 313 Commercial Construction Management
4.3 Construction Methods and Materials	90	55	60	60
5.1 Estimating	45	5	5	8
5.2 Planning and Scheduling	45	6	8	6
5.4 Construction Law	15	8	16	8

Conclusions and Future Issues

Following the implementation of the integrated curriculum, other issues have arisen. Within the curriculum committee, it has been discussed that CM311- Residential Construction Management course needed to have CM332 – Cost Evaluations as co-requisite to be able to provide a more complete depicted of the financial modeling commonly used in residential development projects. Another, issue that was brought up was that the following topics were not well represented in the curriculum. These include Building Information Modeling (BIM), Leadership in Energy Efficient Design (LEED), and Service-Learning. In addition, it has been noted that since the implementation of the integrated curriculum that technical electives were not being effectively utilized by students.

It has also been proposed to remove one (1) unit from CM213, CM311, CM313, CM411, and CM413 and reduce each of the courses to five (5) units, so that a one (1) unit co-requirement for construction accounting could be integrated into the curriculum. The one (1) unit could be taught as a module integrated into the class as the course faculty member saw fit; however, if the faculty member choose to have another faculty member teach the one (1) unit, they would be required to teach one extra class per year in addition to their core course.

In closing, discussions continue to occur regarding the implementation, yet the integrated curriculum has not been externally reviewed by an ACCE accreditation review board.

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