Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 34 - 44

1522-8150/96/$3.00/Educational Practice Manuscript

The Development of a Vertically and Horizontally Integrated Undergraduate Building Construction Curriculum for the Twenty First Century

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This paper describes a curriculum model designed to help construction education programs achieve and maintain national and international recognition as premier sources for dynamic, practical and innovative building construction knowledge. Specifically documented is an approach the Building Construction Department at a Southeastern university is exploring. This approach will to help each student master the competencies necessary to succeed in the 21st Century as a building constructor in a changing global market place. The curriculum described in this paper will meet this goal by balancing the construction education concepts of practical experience based knowledge with academic inquiry, being a dynamic, practical, applied academic model, providing a construction program that maintains a strong identity positioned between architecture and engineering, integrating people and communication skills with the pragmatic building construction skills. Strategically this task will be accomplished by weaving vertical and horizontal integration into the curriculum of the Building Construction Department at a Southeastern University.

Key Words: Curriculum, Curriculum Development, Construction Curriculum, Vertical Integration, Horizontal Integration

Introduction

The goal of many national construction education programs is to achieve and maintain national and international recognition as premier sources for dynamic, practical and innovative building construction knowledge. The cornerstone of building a strong construction education curriculum is balancing practical experience based knowledge with academic inquiry. To accomplish this goal our graduates must possess technical strength combined with the people and communication skills necessary to be successful in the global construction industry of the Twenty-First Century.

At a time when many universities including this university are being asked to do more with less, a challenge has been tendered forcing us to re-evaluate the way we do business. Faculties are smaller, student populations are growing and graduate programs are added without the benefit of added resources. No longer can universities continue with "business as usual." This environment creates an opportunity not only to examine a program's curriculum but also to implement changes that strengthen the educational mission. Strategically this will be accomplished by adjusting the current curriculum to provide for vertical and horizontal integration of the learning experiences in all Building Construction student course-work.

To meet these objectives a construction program must:

1. Balance the construction education concepts of practical experience based knowledge with academic inquiry
2. Become a dynamic, practical, applied academic model
3. Have a construction program that maintains a strong identity within the university and the industry
4. Integrate people and communication skills with pragmatic building construction skills

National Perspective

The concept of curriculum integration has been talked and written about for numerous years. L.T. Hopkins (1937) described the concept of curriculum integration as a means of fostering unity between the learning process and the learner. What occurs through "integration" is the integration of student behavior. Knowledge becomes experience and experience becomes knowledge, thus begetting wisdom. A broadened curriculum as proposed, structured to utilize horizontal and vertical integration will unify experienced based learning with the academic knowledge. The learner becomes the teacher and continues to learn long after the teacher has "gone home." Thus the true essence of education, that of self directed problem solving is accomplished.

The philosophical foundation of creative problem solving has aroused National Science Foundation and industry support. This has led to establishment of the Synthesis Coalition. This coalition includes eight national universities, working to reform engineering education. These reforms emphasize "multidisciplinary content, teamwork and communications, hands-on and laboratory experiences, open ended problem formulation and solving, and examples of 'best practices' from industry" (Synthesis Strategic Plan, 1995). Construction education at this university and many other universities has been doing this since the 1940's. While this university 's Construction Education program is not an engineering program it is excited about the prospect of engineering's shift toward a pragmatic problem-solving curriculum. "The goal of Synthesis is to develop curricular strategies and alternate modes of instruction and access that foster horizontal and vertical integration of engineering knowledge within the context of broader societal factors. This approach to curriculum structure is based on a woven fabric metaphor, ... with 'integrating threads' extending from the freshman through the senior years and across disciplines." (Synthesis Strategic Plan, 1995)

Construction education and the construction industry may be unique in that its focus has always been pragmatic problem solving in team-oriented situations. this university 's Building Construction Department has been unifying experience and academic inquiry through its senior capstone course for twenty years. Now is the time to integrate that experience across the curriculum in a vertical sense. It is noteworthy that a major component of the Synthesis Coalition's mission is to develop a multidisciplinary "Bridging the Architectural/Engineering/Construction Gap" curricular sequence. It can be suggested that they look at existing construction education models already bridging this "gap."

The National Science Foundation is also funding Project Succeed, a consortium of nine southeastern universities engineering programs. This funding is directed to developing a "system for creating transparent boundaries and methods for integration between courses, departments, schools, and colleges, and institutions within the academy." (Project Succeed Strategic Plan) This is leading to many engineering curriculums exploring integrated curriculums. The April 1995 Journal of Engineering Education devoted a third of the issue to discussion of curriculum integration.

Much of the literature discusses the concept of an integrated senior capstone course stressing participatory learning and creative problem solving. (Lonsdale, Mylrea, and Ostheimer; Lumsdaine and Lumsdaine; Wilczynski and Douglas) An example of integrating students of multiple skill and academic levels in a common capstone experience with common open-ended problem solving task is missing from the literature. Having developed and direct a participatory senior capstone course for twenty years we consider vertical integration of the experience the next logical step.

This university's Building Construction is moving in this direction. We consider this the next stage of development in creating a learning process that becomes one with the learner. We are confident that the creation of a learner that is also a teacher unifies and enhances that student's learning process. Cooperative Learning, prepared by Johnson, Johnson, and Smith lends justification to the beneficial concept of group work for both student and faculty.

Our philosophy and approach as follows, are consistent with current academic strategies to shift the paradigm of academic thinking in the technical/managerial fields to a non-linear right brain pervasiveness. (Lumsdaire and Lumsdaire) Industry is aware of the need for communicators and creative problem solvers in a long-range global society. The university educational system is responding to this charge by a shift in educational philosophy that prepares students to solve problems successfully with dynamic and less then complete information. A strategy, construction educators teach and construction professionals do on a daily basis.

Horizontal and Vertical Integration

Continuous quality improvement requires that a contemporary Building Construction program look within both the university and its own program for mechanisms to achieve its objectives in more efficient ways. One model being used to achieve these objectives is a vertically and horizontally integrated curriculum. Vertical Integration relates to the process of actively involving all building construction (BC) students in the work and experiences of BC students at all undergraduate academic levels.

Specifically, the program being developed at this university provides vertical integration by organizing and scheduling BC core major courses so that during the spring semester an opportunity is presented for all students to participate in a common lab course. In this way, first semester students learn concepts they can use in the following semester's integrated lab. In a common lab period, all freshmen, sophomores, and junior students will work in teams directed by a senior working on a capstone project. Horizontal or cross integration relates to the process

of assuring that all information presented in service courses, (engineering, communications, math, business, etc.) relate directly to skills being developed in the BC core major courses.

The concept of horizontal integration also uses the larger context of the university to provide BC service courses for undergraduates in other curriculums. The construction curriculum being revised must first examine its goals and objectives and all courses necessary to achieve these goals. Figure 1 provides a flow diagram of the curriculum investigation. This process continues by further examining the existing curriculum to determine the strengths established in the courses already being taught. It may simply be a matter of fine tuning existing course content to allow for vertical and horizontal integration. Each construction program has unique goals and objectives depending on the program's mission.

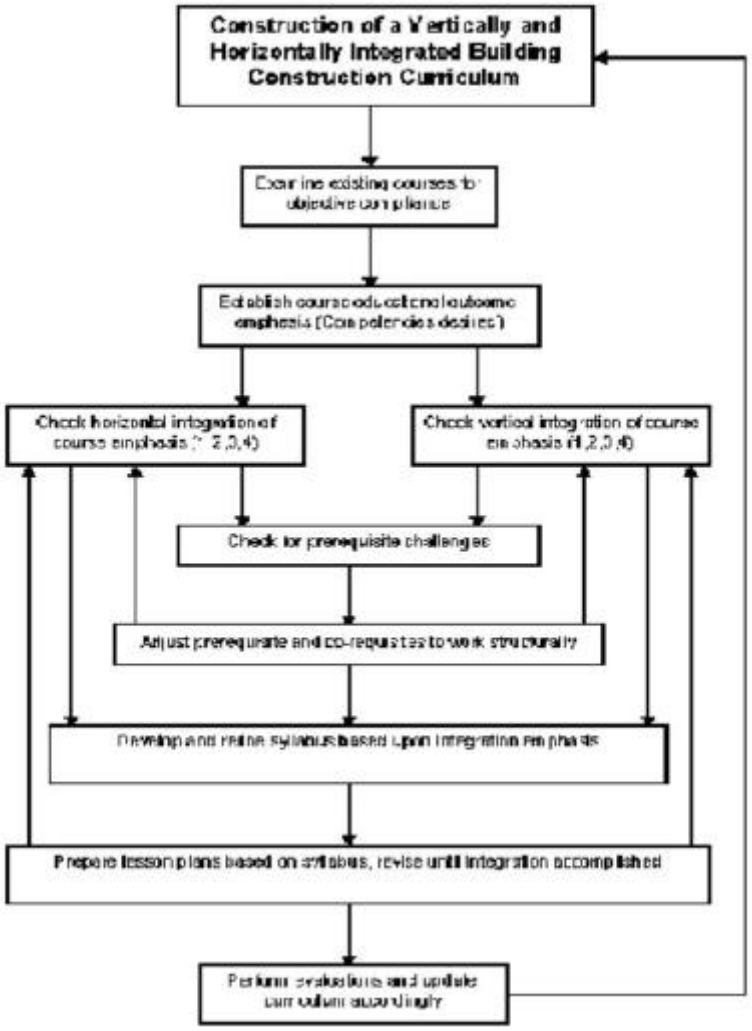

Figure 1: Flow process for implementing a fully integrated curriculum.

This university 's objective is to retain a strong technical emphasis based in engineering skills balanced by practical business and managerial skills. Horizontal integration requires close coordination and acceptance by departments outside the construction core courses. This task is accomplished by working closely with departments teaching the service courses.

In this context, BC core courses are taught by BC faculty and support courses are taught by other departments. This collaborative approach to course delivery uses facilities and faculty more efficiently, especially since this university has strong engineering and business courses. Horizontal integration provides the construction faculty with opportunities to improve the students' learning experience even as resources are diminishing.

The restructured curriculum has increased the number of courses; however the overall hours have decreased. In addition, the realignment provides an opportunity for non-BC students to participate in BC core courses. The net result of the horizontal integration opportunity is a cross integration with positive response from non-BC curriculums including, architecture, civil engineering, mechanical engineering, technology education, business management, and interior design.

A critical component of structuring a successful vertically integrated curriculum is the establishment of learning outcomes expected to be achieved within the curriculum. These competencies provide the theoretical framework used to structure the curriculum for reaching departmental program objectives. Determination of curriculum competency is essential for defining course and curriculum goals.

This university's Building Construction Department uses a Learning Outcomes Template (LOT) to enhance coordinating and focusing each course and therefore, each student's progress toward educational mastery. The "LOT" (Appendix A) is prepared for each course and coordinated as a matrix within the curriculum to confirm, verify and correct course content and focus. The curriculum competencies are organized in a systematic format that allows both lateral and vertical progressions in the student's development to a mastery level of professional constructor. Student competencies are achieved by a coordinated progression through four levels of skills acquisition:

- philosophical
- competency
- proficiency
- mastery

Four Level Progression of Competency Evaluation

Level 1 Philosophical (Preparatory Foundations)

Job Description: Beginning office work (Gopher, report writer, etc.), Beginning job site (Laborer, etc.) These courses establish "Why" and "How" the student has chosen to come into the program and chooses to stay. Components include:

- Attitudes and Ethics
- Educational Background and Assessment of Previous Knowledge (beginning skill sets)
- Personal Background and Evaluation of Commitment
- Foundation Courses in Preparation For a Career in Construction
- Communication Skills i.e. writes and speaks effectively
- Problem-Solving Skills

Level 2 Competency (Construction Course Knowledge Development)

Job Description: Continue office work with greater emphasis on the job site (after safety courses!) These courses establish the foundation for the skill sets needed for a professional constructor. Components include:

- Basic Construction Concepts (in and out of construction emphasis)
- Basic Construction Vocabulary (understanding and use)
- Using Problem-Solving as it relates to industry (beginning case studies)

Level 3 Proficiency (Practice and Application In- and Out-of-Class)

Job Description: Work closely with Mentor/Manager with greater emphasis to On-Site application. These courses apply the skill sets of a beginning project manager, who works with the contractor and sub-contractors and, possibly, owner. Components include:

- Mentorship Preparation -- Application of Theory -- Case Studies at Site
- Problem-Solving at Applications Level (Construction Case Studies)

Level 4 Mastery (Analysis, Evaluation and Controls)

Job Description: Project Manager (trainee?) These courses prepare the project manager with the skills to fully integrate his/her knowledge in a meaningful, real-life situation in order to analyze, evaluate and control 'challenges' faced daily by the construction project manager. These skills will prepare the Building Construction graduate to be productive for their employer upon graduation.

Vertical Integration

Motivation to improve this university's Building Construction curriculum grew from several facts. At present our BC students take no BC core courses in two of the eight semesters in residence. This causes the student to lose touch with the faculty, student associations, and fellow BC students for 25% of their time in the construction program. A second motivation is pressures from outside sources are insisting undergraduate program time to graduation be reduced to fewer credits. These issues coupled with our desire to provide the finest full time undergraduate construction program is best achieved using the concept of vertically integrating our undergraduate courses.

A graphical representation of an integrated curriculum is shown in Appendix B. This chart shows the central curriculum core, composed of BC courses, supported on one side by science, math and engineering courses, and the other side by communication and business courses. Course prerequisites and co-requisites are linked based on competencies. Each of the core courses is designed and developed systematically using the learning outcomes (competencies) as an organizational tool defining content and competency. The BC core courses are organized to provide BC student contact hours every semester and to provide a combined integrated lab in each spring semester. This lab is intended specifically for BC undergraduates; it occurs at a common period to allow all BC students to participate. On a team basis, varying skill levels will interact in responsible roles of interactive learning. Therefore seniors will facilitate the learning process for lower division students thus enhancing the knowledge retention of the facilitator and all students.

Opportunities and Benefits

There are many opportunities and benefits derived from a fully integrated curriculum as previously described. Principal among these is:

- Students learn by teaching each other in the team driven integrated lab.
- Conceptual and philosophical reinforcement of technical knowledge is developed in addition to the student improving in leadership, and team building skills.
- More effective utilization of faculty.
- More efficient use of equipment and facilities.
- A higher concentration of student time on task in Building Construction competency development.
- Less chance of missing or unintentionally duplicating key concepts in the overall course syllabus.
- Continual evaluation of curriculum relevancy, particularly concerning pre-requisites and co-requisites.
- Anticipating and offsetting the potential negative effects of forced curriculum hour reductions.

Attributes of the Proposed Model

Each challenge becomes a positive means of improving the integrated approach because it:

- Turns the concept of change for change sake into continuous quality improvement.
- Causes the development of problem solving skills at all levels of curriculum progression.
- Overcomes the "If it ain't broke don't fix it" resistance that some faculty, administration, and alumni might have.
- Recognizes and capitalizes on varying skill levels to teach management, leadership, and team building skills.
- Accommodates the entire undergraduate population for the integrated lab.
- Develops improved faculty team teaching and communication skills to prevent dis-jointed teaching approaches.
- Accommodates students in transition.
- Helps students learn by teaching.

Evaluation

The final piece of the game plan necessary to implement a vertically and horizontally integrated curriculum is to create mechanisms for continuous evaluation and feedback. Evaluation at this university is intended to occur both internally and externally. To make this work, the faculty will continually be asking each other, "Is it working, and how do we know it is?" Internally we will prepare, distribute, and record responses from students on how they perceive the courses to be working. Perception of the user is an important component of any evaluation. Using hierarchical levels of skills in the vertically integrated labs will encourage multiple perceptions from both novices and experienced students. One unique component of the evaluation is that it deals not only with what a student learns but also what was a student able to teach.

Externally we will be soliciting follow up responses from graduates and their employers relative to the quality of the preparation of the graduate to be successful on the job. Discussions will also be held with the ACCE accrediting team during their next campus visit.

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Appendix
Learning Outcome Template

Emphasis of where competencies are developed throughout the curriculum

Skeleton	Credits For This Course	3	(Name Course Title Here)		
draft #1	Curriculum Competencies →		*Levels Of Expectations To Be Achieved By The Student By The Conclusion of This Course*		
I	Building Sciences	0	1. Attainment Of Philosophical Foundation;		
	Be Familiar With Construction Materials		i.e. Why is this material important to the Building Construction Student?		
	Understand Const. Mech. & Elect Systems		2. Has attained a competency in this objective in this course		
	Design/Analyze Building Structures		3. Has attained a proficiency in this objective in this course		
	Understand Influence Of Bldg. Codes		4. Has attained a level of mastery of this objective in this course		
II	Means and Methods	0			
	Understand Const. Language & Methods		Note: Indicate Level Of Expectation For Students Only For		
	Be Able To Select Bldg. Sys. & Comp.		Those Objectives To Be Addressed In This Course !!!		
	Accurately Interpret Project Specifications				
	Accurately Interpret Construction Drawings				
III	Project Control	0			
	Structure and Maintain Project Control				
	Develop and Maintain Project Budgets				
	Develop and Maintain Project Schedule				
	Coordinate Overall Project Activities				
IV	Performance Improvement	0			
	Use Effective Graphical Communications				
	Communicate Well Orally & In Writing				
	Implement Continuous Quality Control				
	Applying Team Building Principles				
	Apply Value Engineering Concepts				
V	Labor Management	0			
	Understand Principles of Managing People				
	Develop and Implement A Safety Program				
	Develop and Manage Incentive Programs				
VI	Field Operations	0			
	Coordinate Project Disciplines				
	Control Material Delivery & Handling				
	Expedite Purchase Orders & Subcontracts				
	Handle Shop Drawing Procedure				
	Verify Construction Details For Accuracy				
	Close Out Project Successfully				
VII	Estimating	0			
	Compile Project Information				
	Perform Quantity Take-off				
	Perform Material Estimates Assemble and Manage The Bid Process				
	Apply Computerized Estimating				
VIII	Planning / Scheduling Develop A Project Plan & Schedule				
	Perform Computerized Scheduling				
IX	Company Operations	0			
	Understand Const. Co. Financial Mgmt.				
	Be Able To Set Up Co. Cost Control Sys.				
	Coordinate Governmental Reviews				
	Use Computerized Spreadsheets				
	Use Word Processing System				
	Use Computerized Data Base				
	Understand and Apply Professional Ethics Understand Construction Contract Law				
	Be Able To Negotiate Well				
	Total Emphasis On BC Goals In This Course	###			

Graphical Representation Of The Vertical And Horizontal Integration Of The BC Curriculum.