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Construction Management Curriculum Reform and Integration with a Broader Discipline: A Case Study

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The Construction Management (CM) curriculum reform process at Colorado State University is described through a review of the history of the program, the problems facing the program at the beginning of the reform, the process used to reform the curriculum, the results of this process, and the future of curriculum upgrades in this program. Curriculum reform on this campus resulted in a Departmental Core providing the foundational skills for three different majors. To that core, the CM program has structured upper division coursework in engineering science, general business, construction systems and techniques, and construction management practices. The need for the integration of CM programs with a broader discipline which provides a larger theoretical framework is also discussed. The curriculum reform process described here resulted in a stronger integration of this CM program with the larger discipline of technology management rather than the traditional association with the design disciplines of engineering and architecture.

Key Words: Curriculum, Curriculum Development, Construction Curriculum, Technology Management, Undergraduate Construction Education

Introduction

Construction management (CM) programs historically have emerged from and/or have been affiliated with programs representing other disciplines - predominately engineering and architecture. It is fair to say that the field has frequently struggled to find an identity of its own. Rounds (1992) recognized this struggle in an analysis of the history of construction programs during the 1970's. During this time period, "the academic discipline of construction gained even greater acceptance when programs at the Departmental level emerged, demonstrating the viability of construction as a distinct and independent academic area which could stand on its own beside its progenitors in Agriculture, Industrial Arts, Architecture, Engineering and Business" (Rounds, 1992, p.146).

However, partly as an outgrowth of this emerging independence of construction as a separate discipline, an unusual paradox has developed. It is generally believed that the strength of an individual CM program is positively correlated with its level of autonomy from other departments or disciplines, but that degree of independence leaves those autonomous programs targets in the struggle for limited resources and university recognition. Perhaps more importantly, a high level of autonomy robs a CM program of the benefits of a larger theoretical framework in which to operate. This move toward autonomy has been evident in the curricular changes at many CM programs in recent history. As an example, Virginia Tech has recently introduced a substantial reorganization of its Building Construction program (Mills, et. al., 1996)

which appears to move the curriculum further away from its roots in Architecture. This may well lead to a broader association with the National Science Foundation supported "Synthesis Coalition" which is working to reform engineering education. The mission of the Coalition is to "develop a multidisciplinary 'Bridging of the Architectural/Engineering/Construction Gap' curricular sequence" (Mills, et. al., 1996, p.20). If successful, this association might provide an example of the larger theoretical framework referenced above.

The American Council for Construction Education (ACCE), the national accrediting body, does not require or expect an administrative affiliation with any other discipline. Consequently, there are many such affiliations with engineering, architecture, technology, and business. The question program leaders and department heads must address is, "Which is the appropriate association?" Currently, many seem to be answering this question by indicating that no affiliation is best; the more autonomy the better.

The following case study relates one program's attempt to address this issue through a major curriculum reform which integrates the CM curriculum with a larger discipline. The argument is made that the larger discipline in this case - that of technology management - may provide more appropriate opportunities for integration than either of the design professions of engineering and architecture.

The History

At Colorado State University (CSU), the Construction Management program has a long history. Now celebrating its 50th Anniversary, the program started as "Light Construction and Marketing" in the General and Industrial Arts Engineering Department which was then located in the Division of Engineering. The department and the CM program was transferred to the College of Sciences and Arts in 1957. The program name was changed to Industrial Construction Management in 1959. The program was first accredited by ACCE in 1985 and the name was changed to Construction Management in 1986. CM now supports about 350 undergraduates, a Master's degree, and a joint Ph.D. program with the School of Education. The CM program applies the study of the management of technology to the construction industry.

The department changed its name to Industrial Sciences in 1970 and inaugurated a program in Industrial Technology Management (ITM) one year later. ITM applies the same emphasis on the management of technology to the manufacturing industry. The historical mission of the department - teacher education - is still seen in the third program in the department, now representing about 10% of the undergraduate population. To reflect an additional emphasis on the preparation of professional industrial trainers, this program recently changed its name to Technology Education and Training (TET).

The Department of Industrial Sciences moved to a new College of Professional Studies in 1975 and then to a consolidated College of Applied Human Sciences in 1986. After much discussion about the changed mission of the department over the last two decades, the department name was changed again in 1996 to Manufacturing Technology and Construction Management (MTCM).

About 550 students are declared majors in one of the three programs supported by the department.

During this history, these three programs had developed into completely autonomous entities sharing virtually no resources and no common courses. The only curricular overlap was in one half of one safety course required by all three programs and courses in statics and mechanics of materials required by CM and ITM and taught in the College of Engineering. The department was criticized as appearing to house three small departments which happened to be in the same building. During their respective histories, each of these programs, and the resources they represented, had been "targets of acquisition" by other departments and colleges. While program curricula had experienced minor changes and the content of courses had been modified to reflect new technology such as software applications, the fundamental base of the curricula had not been modified in many years.

The Problem

At the start of the curriculum reform process, a number of significant problems related to the historical development of the programs were noted:

- no recognition of the commonalities among disciplines represented by the three departmental programs
- no recognition of the distinct features of these commonalities which would make the department distinct from other units in the university
- a current need to support a large number of separate and diverse courses
- inadequate staffing to support this diverse base of courses and the faculty desire for an expanded emphasis on graduate programs and research.

In addition to the above, which were deemed faculty or administrative problems, a number of challenges related to student performance were also noted:

- a significant number of early, uninformed career decisions resulting from the vast majority of departmental students being internal and external transfers - creating a desire to "get on with" their new major rather than exploring other options
- inconsistent "basic skills" preparation for upper level coursework (e.g., taking a required course in Technical Writing during a student’s last semester of Senior year)
- lack of training in teamwork and group problem solving: despite the preponderance of group projects in upper level courses, students were never taught how to solve problems as a team
- lack of a required work experience (internship) as suggested by industry.

These two sets of problems - related to administrative/faculty needs and student performance - led the faculty to commit to a major curriculum reform process in 1995.

The Process

The first step in the department-wide curriculum reform was to establish a consolidated departmental mission statement which recognized the central themes of all three programs. This statement was designed to recognize the commonalities among the programs while identifying the unique features which distinguish this department from other related disciplines. First established early in 1995 as part of a strategic planning report, this departmental mission now reads as follows:

> In keeping with the land grant tradition, the Department of Manufacturing Technology and Construction Management engages in teaching, scholarly, and outreach activities to promote the development of knowledge and skills related to management, teaching, and training in manufacturing and construction. The department addresses complex issues related to the linkages between these two industries, such as: management of technical applications; materials development and market feasibility; operations and process development and improvement; design processes; environmental issues; technology transfer; human needs and resource issues; and effective pedagogical strategies.

The first major steps toward a new curriculum were taken at three days of faculty meetings in January 1996. The faculty developed and considered long lists of desired "Program Outcomes" for each of the three majors with the intent of identifying those outcomes which were common to all three. From this discussion, the following list of "key phrases of common purpose" resulted which described elements of an inclusive departmental curriculum base:

- Integration of resources
- People management
- Built environment
- Managing processes
- Graphic communication
- Regulatory agencies
- Safety
- Team/Group dynamics
- Problem solving
- Ergonomics
- Career options
- Adaptability/Flexibility
- Applied technical skills
- Cultural diversity
- Materials processing
- Scheduling
- Legal issues
- Understanding applied math and science
- Global considerations
- Environmental solutions
- Project management
- Strategic/Business planning

After much discussion and review, it was proposed that the only way to address the problems cited above and to accommodate the objective of emphasizing the "common purposes" noted for all three programs was to establish a common core of departmental requirements. (See Figure 1) This core of common coursework - primarily encompassing the Freshman and Sophomore years and providing the fundamental skills in technology management - was initially established according to the following motions passed by departmental faculty:

1. That a common core with a "gateway" (implying that pre-"gateway" students would not declare a program major) be implemented in the department.

2. That a common core should include university requirements and departmental and non-departmental coursework totaling 45-60 credit hours.
3. That part of the "internal core" should be established with departmental prefixes (9 credit hours minimum).
4. That curriculum enhancement would be achieved without jeopardizing existing program quality.
5. That the common core should not be limited to "pre-gateway" coursework alone.

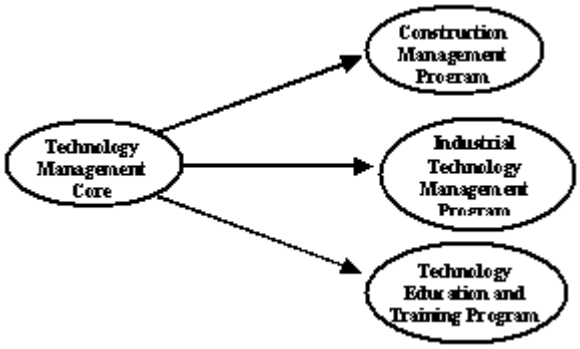

Figure 1. Relationship of the common core to the three departmental majors.

After the decision to accept the concept of a technology management core, nine areas of potential coursework were identified by the faculty which contained topics required by majors in all three programs. These curricular areas included:

1. Electronic Information Systems/Applications (Computer Literacy)
2. Electrical/Electronics/Power and Energy/Controls
3. Leadership, Motivation, and Team/Group Skills
4. Occupational Awareness
5. Materials and Basic Processes
6. Graphic Communications
7. Safety/Environment
8. Problem Solving
9. Management

Faculty discussion shifted to identify the desired outcomes/objectives to be attained in each of these areas. Two or three faculty members volunteered to work on each curricular area to further define objectives and to identify whether the outcomes for each content area could be achieved through existing coursework in other departments or whether a new departmental course(s) should be developed. Faculty in each major also worked as a group to examine the impact of a core on each program and to identify what other upper division coursework might need to be modified to attain the goals established above.

The Results

Following the January 1996 meetings at which the above decisions were made, many additional meetings were held to finalize the content and structure of the departmental core requirements.

The Departmental Core incorporates all of the faculty initiatives outlined in the previous section. Some of the features of this Core, in its current form, include the following:

- A department core requirement including six courses (16 credit hours) incorporating the common introductory knowledge required for all three program majors.
- A computer literacy requirement incorporating an examination of prerequisite computer skills given during the first semester of departmental registration. This is a two level examination: Part One measures a student's proficiency in Basic File Management and will serve as a prerequisite to some Core courses and Part Two will test End User Software proficiency and will be a prerequisite to application for a program major (beyond the "gate"). If necessary, an introductory computer course will be recommended to complete a university requirement (Logic and Critical Thinking) and to prepare for this exam.
- A verbal communication requirement including Composition, Speech, and Technical Writing which exceeds the university requirement for this area.
- A mathematics requirement including Logarithmic and Exponential Functions, Numerical Trigonometry, and Analytic Trigonometry which exceeds the university requirement for this area; if needed, College Algebra I and II will be taken in place of elective hours in the Core.
- A natural science requirement including Chemistry and a second natural science course to meet the university requirement for this area. At least one of these two courses must include a lab.
- A social science requirement including General Psychology and a second social science course to meet the university requirement for this area.

Program specific requirements scheduled for the last semester of the Sophomore year including Calculus for CM and ITM applicants and Schooling in the United States for TET applicants. Students having completed less than 60 credit hours will be registered as Manufacturing Technology and Construction Management majors without reference to a program major. When students have met all requirements of the Departmental Core (including current enrollment), they complete an application process to one or more of the three programs.

Depending on articulation agreements, transfer students with over 60 credit hours may be admitted directly into a program major, after review by the department, while they complete remaining Core requirements. Upon completion of the Core, these transfer students will have the opportunity to reconsider their selection of major.

The recommended sequence of courses in the Departmental Core is illustrated in Appendix A. Recognizing that most students in the department will continue to be transfers from other majors or from other institutions, there is no course sequence in the Core longer than two semesters. In other words, students transferring at the beginning of their Sophomore year after completing most of the general university requirements should be able to complete the Core and matriculate to the major of their choice on schedule.

There are six new courses in the Departmental Core addressing many of those areas of "common purpose" identified by the faculty. Those new courses are briefly described as follows:

MC 110 (2 Credit Hours) - Team Problem Solving and Leadership. This course explores the roles of leadership and teams in modern organizations. A combination of individual and group experiences will be utilized to give students direct experience with current and emerging tools, skills, and techniques for team based problem solving and leadership.

MC 151 (3 Credit Hours) - Introduction to Manufacturing and Construction. This course introduces the student to a wide variety of construction and manufacturing materials, processes, and systems. A combination of individual and group experiences will be applied in laboratory activities resulting in the construction of foundation, floor, wall, and roof systems commonly found in wood framed structures and the mass production of a manufactured product.

MC 251 (3 Credit Hours) - Materials Testing and Processing (Prerequisites: MC 151 and Chemistry). Students are exposed to various manufacturing and construction materials and processes through a systems approach. Separating, forming, conditioning, and joining are the focus for student laboratory experiences. A variety of research-based materials testing problems complements the laboratory component with hands-on activities related to common manufacturing and construction materials and applications.

MC 141 (2 Credit Hours) - Trends in Energy and Transportation. This course explores the ways in which our natural resources are converted into forms of energy used for transportation and environmental control and modification. Laboratory activities will be used to evaluate alternative energy sources and conservation techniques and their short- and long-term environmental ramifications.

MC 241 (3 Credit Hours) - Energy Control Systems (Prerequisites: MC 141 and Computer Literacy Examination - Part 1). This course studies the selection, application, and evaluation of electronics and fluidics based systems and devices for energy control.

MC 131 (3 Credit Hours) - Graphic Communications/Computer Aided Design (Prerequisites: MC 151 and Computer Literacy Examination - Part 1). This course emphasizes the importance of graphic communications in the visualization, design, fabrication, and construction of assemblies. Reading technical drawings, manual drafting techniques, reprographic technologies, and computer aided design applications are introduced.

The impact of this new Departmental Core on the last two years of the CM program is illustrated in Appendix B. The program builds on the Core content areas of materials and methods, energy and controls, leadership skills, and graphic communications - as well as other requirements in computer literacy, verbal communications, mathematics, and natural and social sciences - to create a course of study meeting all requirements for ongoing ACCE accreditation. (See Figure 2) A major change in the CM program which paralleled the development of the core requirements was the establishment of a required internship. The requirement is for six months of structured work experience. Many industry supporters of this program have expressed a strong preference for a minimum of six months of contiguous internship experience (e.g., January to July or June to December). To allow for this, the program requirement permits the student to complete either two three-month internships or one six-month placement. In either case, the

student must complete the internship requirement before enrolling in his or her last semester of coursework.

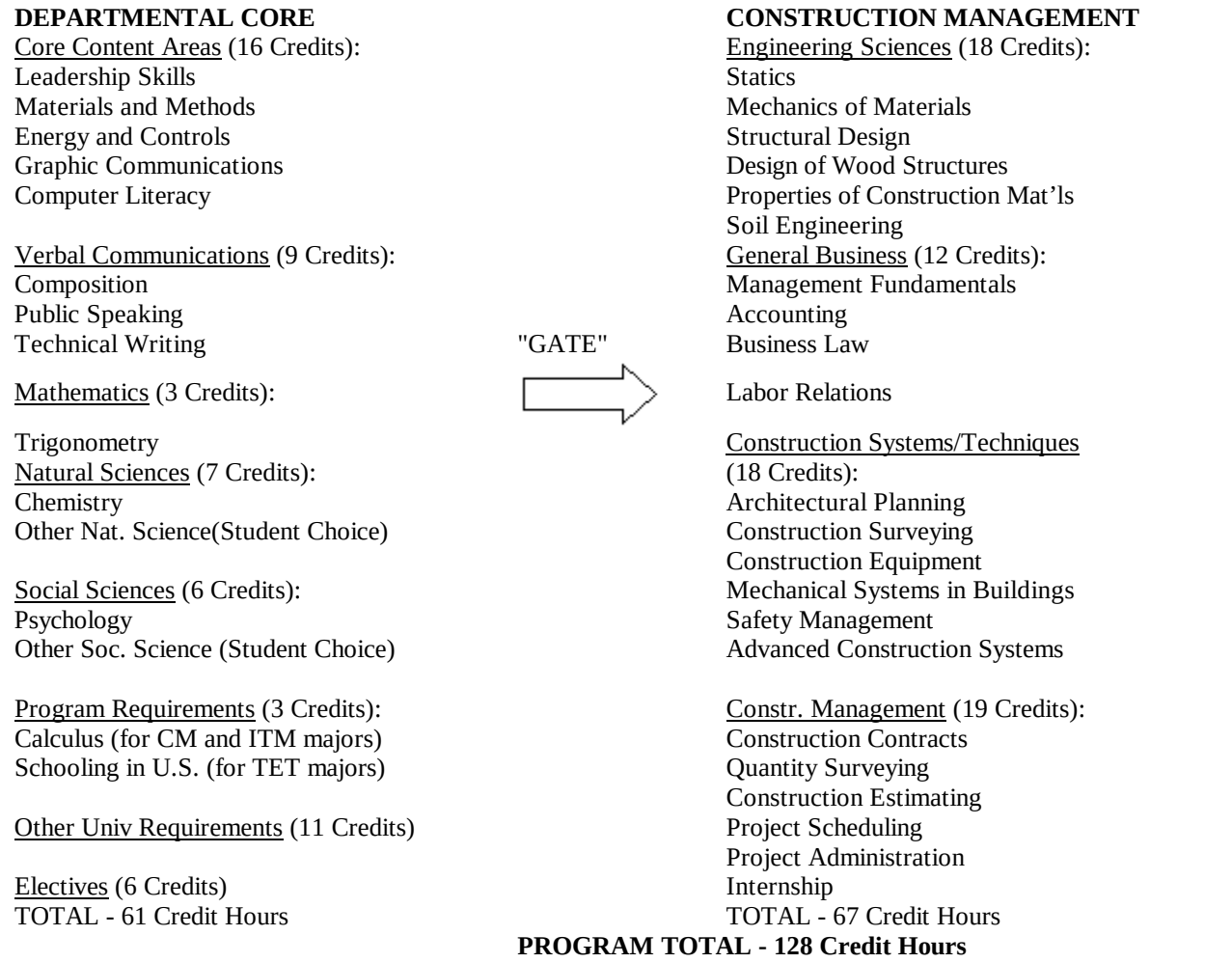

Figure 2. Conceptual relationship between departmental core and construction management program.

The Future

The faculty of the Manufacturing Technology and Construction Management Department considered many alternatives while working on this curriculum reform package. While many of these alternatives were included in the final proposal, other ideas were tabled for future development and consideration. Some do not need formal course changes as much as a shift in emphasis in existing courses. A list of some of these future plans for curriculum updates is presented below:

- Module based courses in which course content might be taught in interchangeable five-week modules for one credit hour each.
- An emphasis on a communications core which would go beyond the university requirements and which would formalize an oral and written communications component

in every departmental course. This would address a major concern expressed by our industry advisory committees.

- Formalize the role of industry internships in the department. While this will be required for CM majors and is being considered by ITM, many policy decisions are necessary to make this an integral part of the curriculum.
- An infusion of the study of human factors throughout most of the courses in the curriculum which emphasizes the management of people in addition to the management of technology.
- Increase the number of "after the gate" core courses to be taken by all or most departmental students in areas of commonality among all program majors (e.g., a joint scheduling course for ITM and CM majors).
- Review the capstone courses currently offered by each of the programs to ensure that they meet the University goals and requirements for such capstone courses.

Conclusions

Mills, et. al. (1996) have noted that the "cornerstone of building a strong construction education curriculum is balancing practical experienced 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."

This balancing of practical knowledge with academic inquiry - and of technical skills with people and communications skills - is fundamental to the definition of technology management as a discipline. This discipline of technology management provides an excellent theoretical framework in which CM programs can operate. Construction Management programs (or programs by any other names meeting ACCE accreditation standards) have never "fit" neatly within the other disciplines which have provided these programs an administrative home. CM programs share a similar technology knowledge base with the design professions of engineering and architecture, but the net result is something different. These programs also share a common management knowledge base with the disciplines represented by colleges of business, but the curricular outcome is different. Again, it is in the "balancing act" among engineering, architecture, and business that the discipline of technology management finds a home.

The faculty at CSU believe they have strengthened the CM program by establishing a Departmental Core of courses designed provide a strong foundation in the understanding of people, communications, basic materials and methods, mathematics, and science. On that foundation, upper division coursework builds a solid background in the engineering sciences, general business, construction systems and techniques, and construction management practices. To this base in "academic inquiry" the CM program adds "practical experienced based knowledge" through the requirement for six months of industry internship.

The outcome of this curriculum reform process is the integration of the CM program with the broader discipline of technology management. When examining the needs of CM graduates and the industry they serve, few writers have suggested that what is needed is a stronger background

in the design disciplines of engineering and architecture. Instead, one reads of the need for more personnel skills, better communication, stronger leadership, and a better understanding of basic business principles. Recent research completed by Mead and Gehrig (1995) attempted to identify the key skills required of constructors in the 21st century. The top three "skills" identified by this research were communication, business management, and leadership. Their "study indicates that communication, management and control, and leadership will be the pivotal skills required of future constructors. Tomorrow's marketplace will reward individuals who can manage people and paper, set and meet objectives, and lead their projects to success." (Mead and Gehrig, 1995, p. 27) How should these findings impact the future development of CM curricula? The authors encourage faculty to "emphasize people skills in construction programs. Develop specific courses or curricula at the graduate and undergraduate level which help professionals develop and strengthen these key skills. Expand role playing, simulated meetings, presentations, and team projects to foster leadership and people management. Emphasize technical writing in all courses." (Mead and Gehrig, 1995, p. 27)

These needs describe the expanding discipline of technology management rather than the traditional design disciplines associated with CM programs. Regardless of administrative affiliation on their respective campuses, construction education programs would do well to look to technology management as the broader theoretical framework in which to find a place. This association with an appropriate broader discipline beyond the construction industry itself will strengthen the position of these programs when seeking university recognition and support.

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Appendix A
DEPARTMENTAL CORE

CORE	FRESHMAN		SOPHOMORE	
	1ST SEMESTER	2ND SEMESTER	1ST SEMESTER	2ND SEMESTER
Department Core Requirements	*MC 110 (2) – Team Problem Solving and Leadership*	*MC 151 (3) - Intro. to Manufacturing and Construction*	*MC141 (2) – Energy & Transportation* *MC 251 (3) - Mat'ls Testing/Processing (prereq. - MC 151 & C 103)*	*MC241 (3) – Energy Control Systems (prereq. - MC 141 & Comp. Lit.-Pt 1)* *MC 131(3)-Graphic Comm. & CAD (prereq. - MC 151 & Comp. Lit.-Pt 1)*
Mathematics/Science	USP Cat. I.c. (3) (BD 140/1 rec. if comp. literacy test not passed) M120/1(2) –Algebra I/II (if needed)	M 124 (1) - Log. & Exp. Functions M 125 (1) -Number. Trigonometry M 126 (1) –Analytic Trigonometry C103(3 or 4 w/ Lab) Chemistry & Society	Natural Sci. elec. (3 or 4 w/ Lab)	
General	Social Sci. elec. (3) Humanities elec. (3) Physical Educ. (1) Elective (3 or 1 if M120/1 is taken)	CO 150 (3) –College Composition Elective (3)	SP 200 (3) – Public Speaking & Disc. Humanities elec. (3) Physical Educ. (1)	JT 300 or 301 (3) - Technical Writing PY100 (3) – General Psychology
Program Requirements				M 141 (3) –Calculus in Mgmt. Sciences (for ITM and CM) - OR - ED310 (3) – School in U.S. (for TET)
Credit Hours by Semester	15	15 - 16	15 -16	15
TOTAL CORE - 61 Credit Hours				

Requirements to apply for a program major at end of Sophomore year (including current enrollment):

- completion of all USP requirements (33 hours minimum including CO 150, SP 200, M 124 and 125 and 126, C 103, and PY 100)
- completion of the 16 required hours of MC core courses
- completion of Parts One and Two of the department's computer literacy examination
- completion of Cross-Cultural Awareness requirement
- completion of JT 300 or 301
- completion of M 141 (for CM and ITM applicants)
- completion of ED 310 (for TET applicants)

Legend:
Existing Courses
New Courses (Italics)
Revised Courses (Bold)

Appendix B
IMPACT OF COMMON CORE ON CONSTRUCTION MANAGEMENT PROGRAM

Given the Departmental Core described above, the faculty restructured the Junior and Senior year requirements for a degree in Construction Management (CM) as follows:

CM	JUNIOR		SENIOR		
	1ST SEMESTER	2ND SEMESTER	1ST SEMESTER	INTERN	2ND SEMESTER
Construction	MC 232(4) -Arch & Const. Planning MC366 (3) - Const.Equip & Methods MC361 (3) -Mech. Systems in Bldgs.	MC261 (3) - Const. Surveying MC 362 (2) - Const. Contracts *MC363(2) –Quantity Surveying* MC 364 (3) - Adv. Construct. Systems	MC 317 (2) –Safety Management MC365 (3) -Const. Estimating	MC487a (6) - Internship	MC461 (3) - Const. Project Scheduling & Cost Control MC464 (3) - Const. Proj. Administration (Capstone Course)
Science/ Engineering	CE 256 (3) - Statics for Non-Engineers	CE358(3) -Mech. of Mat'ls for Non-Eng.	CE350(3) -Soil Eng for Non-Engineers CE 370 (4) - Elem. Structural Design		CE364(2)-Properties of Const. Materials F 432 (3) - Design of Wood Structures
Business and Management	BG 260 (3) – Legal Envir. of Business	BN 300 (3) -Mgmt. Fundamentals	A 210 (3) - Financial Accounting		BP471(3)-Labor Rel. & Collect Bargaining
Credit Hours by Semester	16	16	15	6	14
TOTAL FOR MAJOR - 128 Credit Hours					

Note on Required Internship:

The CM program requirement is for six credit hours of MC 487a (Internship) which will be equivalent to six months of structured work experience. Many industry supporters have expressed a strong interest in and preference for a minimum of six months of contiguous internship experience (e.g., January to July or June to December). To allow for this valuable experience, the program requirement allows the student to complete either two three-month internships or one six-month internship. The Internship Director will help advise students on options available for three- and six-month placements. Please reference the Construction Management Internship Policies manual for more details on this requirement.

Legend:
Existing Courses
New Courses (Italics)
Revised Courses (Bold)