

Evolution of Construction Education in the United States: Two Case Studies

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Construction Education all over the world is constantly evolving to adapt to the changing demands of the construction educator's stakeholders; society, industry and students. The construction programs at Texas A&M University and Colorado State University are two of the more mature programs in the United States and can trace their origins back to the mid-1940s. An analysis of these two undergraduate construction curricula was undertaken to identify how each program had evolved over 60+ years. The American Council for Construction Education's core subject matter requirements were used as a basis for the analysis. The percentage of change to the number of credit hours taught in the subject matter areas of General Education; Math and Science; Business & Management; Construction Science; Construction and Other was measured over time. The results show a reduction in the number of hours of both programs from highs of 175 and 210 credit hours down to 120 credit hours for both programs. Each of the programs started out in an engineering college and the curricula contained a large number of courses offered by engineering faculty. The results from both programs show a decline in the number of courses offered by engineering faculty and an increase in the percentage of credit hours devoted to construction management topics.

Keywords: Construction Education, United States, Curriculum Development, Undergraduate Curriculum, Accreditation

Introduction

The undergraduate construction programs at Texas A&M University (TAMU) and Colorado State University (CSU) are two of the oldest programs in the nation. Each of these programs can trace their history back to the mid-1940s; CSU's program was started in 1946 and TAMU's was started in 1947. The combination of the accreditation, legal, as well as industry needs and requirements shapes the structure and evolution of any professional degree program. Construction higher education in the United States provides an exceptional example for this discussion because of its origins and dynamic nature. This paper presents a historical analysis of the construction science program curricula at Texas A&M University and Colorado State University to illustrate the evolution of each of these programs.

Methodology

In order to present the evolution of the two programs, this paper utilizes the ACCE curriculum categories as defined in their accreditation standards (ACCE, 2000). ACCE standards provide a unique opportunity for such analysis because of its prescriptive and quantitative subject matter definitions. Unlike the outcome based accreditation standards such as the standards of the Accreditation Board for Engineering (ABET, 2005) and Technology and the National Architectural Accrediting Board (NAAB, 2005), ACCE uses curriculum categories with defined

minimum contact hours and content. This paper uses the change to the number of credit hours taught in different subject matter areas as the comparison criteria.

Both programs being reviewed are accredited by ACCE. The Construction Science degree at TAMU has been accredited since 1978; the Construction Management program at CSU has been accredited since 1985. In its standards, ACCE sets out six curriculum categories: General Education; Math and Science; Business & Management; Construction Science; Construction and Other. ACCE also identifies the core subject matter that should be included within the curriculum for each of the six curriculum categories. For example, the Construction Science category includes the subject matter areas of: Design Theory; Analysis and Design of Construction Systems; Construction Materials and Methods; Construction Graphics and Construction Surveying. The standards and criteria give examples of courses for each of the subject matter areas such as statics, strength of materials, dynamics, thermodynamics, soil mechanics, hydraulics or hydrology to be included under the Fundamentals of Design Theory. This paper uses the ACCE standards and criteria to make a subjective evaluation of the content of each course to determine which of the six curriculum categories the course would fall into.

Both Texas A&M University (and its predecessor the Agricultural and Mechanical College of Texas) and Colorado State University (and its predecessor Colorado Agricultural and Mechanical College) publish academic catalogs each year that provide details all of the undergraduate programs taught at the two universities and brief descriptions of all of the courses taught as part of each program. For each undergraduate program the following information is given:

- A description of the program,
- The courses taught on a semester by semester basis,
- The name, number and number of credit hours for each course, and
- A short description of the major topic areas taught in each course.

Based on the ACCE curriculum category definitions, the undergraduate catalogs for (a) the Agricultural and Mechanical College of Texas (1947 to 1963), (b) Texas A&M University (1963 to 2007), (c) Colorado Agricultural and Mechanical College (1946-1956), and (d) Colorado State University (1957-2007) were analyzed. The following information was recorded from each catalog:

- the total number of credit hours taught,
- the number of credit hours taught in each of the six ACCE curriculum categories, and
- the major substantive changes to the curriculum

It is important to note that the assignment of credit hours to a particular ACCE curriculum category is based on the available catalog description and the authors' subjective evaluations. Actual course content variations are expected due to changes in course instructors and available materials. These variations may not have been reflected in the course descriptions in the universities' catalogs, and therefore are not reflected in this study.

Results

The results for this study are presented separately for Texas A&M University and Colorado State University.

Texas A&M University

The analysis of the historical information resulted in three distinctive eras for the construction program at TAMU, showing major differences in terms of the degrees offered and the composition of the curriculum. These eras are:

- The early years (1948–1964),
- The middle years (1965–1983), and
- The modern years (1984–2007).

TAMU: The Early Years (1948–1964)

Prior to 1947, two architecture related programs existed within the School of Engineering: (a) a four year program called “Architectural Engineering” and (b) a five year program in “Architecture”. Both programs had a common first year and were offered in the Department of Architecture. Catalogs from this period state that graduates of the department found their way into the engineering departments of construction companies. The Architectural Engineering program was a 156 hour, four year program with several construction orientated classes such as “Building Materials” and “Building Practice”. The program, however, was mainly made up of Engineering and Architecture classes. The academic catalog for the 1947-48 academic year listed only one program offered in architecture with three options: Design, Construction and Structural. All three programs were defined as five year programs, of which the first three years were common to all programs. The construction option led to a Bachelor of Architecture degree. This option was structured as a 161 hour program with more construction orientated classes than the Architectural Engineering program while keeping the engineering and architecture classes.

The origin of formal construction education at the Agricultural and Mechanical College of Texas can be traced back to the 1948-49 academic year. At that time, there were only two options offered in architecture: Design and Construction. More importantly the second option led to a *Bachelor of Science in Architectural Construction*. The Construction option was a 170 hour program and included a required 12 week Summer Practice for which students did not receive academic credit.

Between 1948 and 1963 the degree program fluctuated between 170 and 175 hours. Courses were added and removed frequently during this time. Figure 1 shows the fluctuation in the total number of credit hours for the program and the number of credit hours taught in each ACCE category from 1948-63.

In Figure 1, a significant change can be observed during the 1953-54 academic year when the general education credit hours were increased. As a result, the construction related courses were decreased to balance the total credit hours at 175 level. Also noticeable during this period, is that

the percentage of construction courses declined mainly due to the growth of general education and construction science courses.

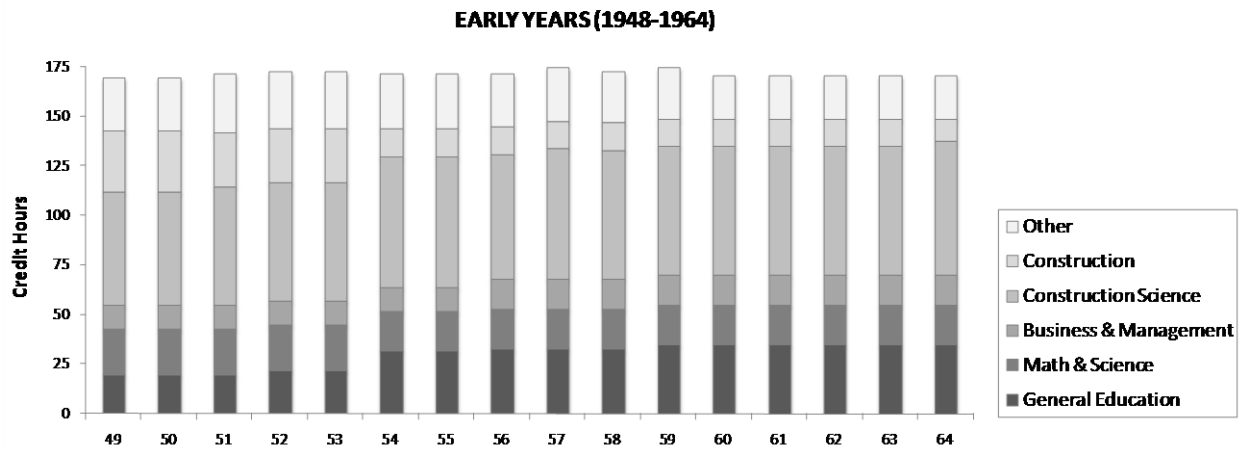


Figure 1: Texas A&M Curriculum Structure for the Early Years (1948-1964).

TAMU: The Middle Years (1965-1983).

In the 1960s, the university undertook a restructuring effort that resulted in the Texas A&M University System (TAMU) and a major reduction in credit hours for degrees offered. The undergraduate catalog for the 1964-65 academic year listed a 4-year program of only 138 hours. To reduce the program from 171 hours to 138 hours, credit hours were dropped in General Education, Business & Management, Construction Science and Other ACCE categories. The only category that showed an increase was Construction. Figure 2 shows the total number of credit hours for the program and the number of credit hours taught in each ACCE category from 1965-83

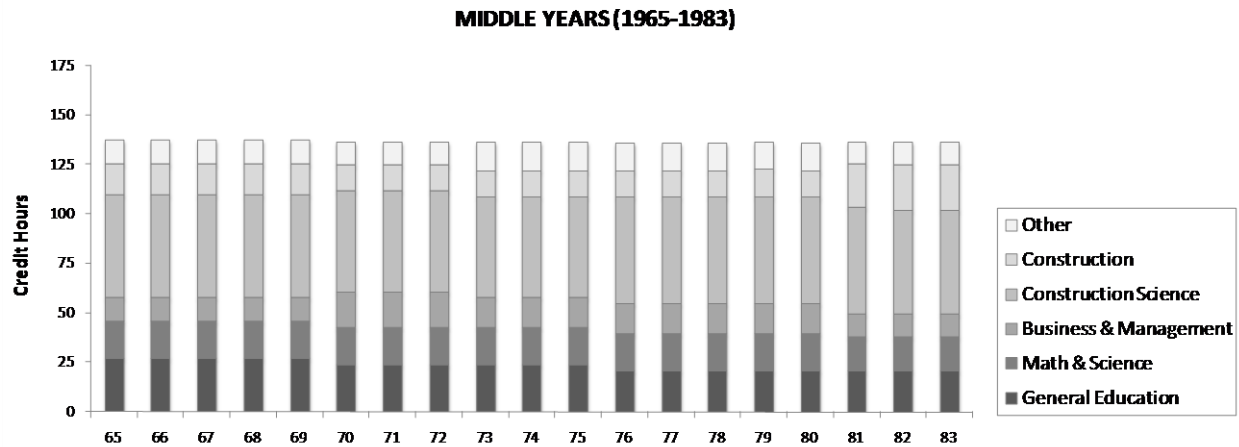


Figure 2: Texas A&M Curriculum Structure for the Middle Years (1965-1983).

As illustrated in Figure 2, the program credit hours fluctuate between 136 and 137 in this era. The construction category increased in the early 1980s, moving program toward a balance between construction science and construction.

TAMU: The Modern Years (1984–2007)

During this period, major curriculum revisions occurred, removing credit hours from the Math & Science, Construction Science and Other categories while adding courses in the Business & Management and Construction categories. Further reductions in hours occurred in 1998 when the curriculum was reduced again to 135 hours. The number of hours dedicated to free electives dropped to zero. In contrast, some of the earlier catalogs listed as many as 25 hours of free electives in the program. Figure 3 shows the total number of credit hours for the program and the number of credit hours taught in each ACCE category in the modern years.

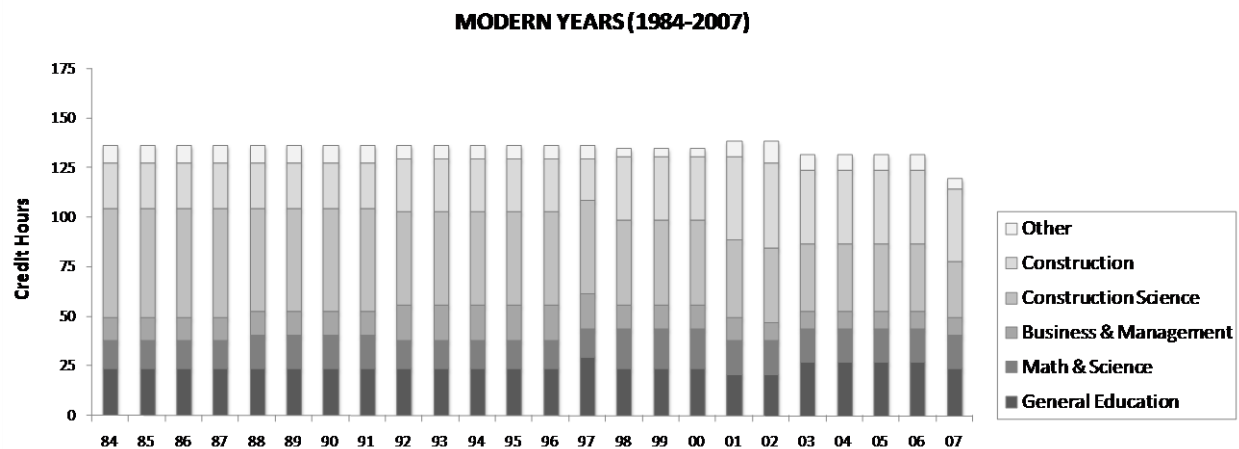


Figure 3: Texas A&M Curriculum Structure for the Modern Years (1984-2007)

In Figure 3, a curriculum change can be observed in 2001, when the program was increased to 139 hours. This increase was resulted from giving academic credit for required internships, which were now required to be completed in the spring or fall semesters as opposed to the summer semester. The curriculum was again was reduced two more times during this period. In 2003, the program was reduced to 132 hours and then to 120 hours in 2007. It can be clearly seen that in the past 25 years the percentage of credit hours taught in construction science has reduced to a point that it is now equal with construction.

The final curriculum change in 2007 saw the removal of the last course taught by the College of Engineering from the curriculum. The Plane Surveying course in the Department of Civil Engineering was replaced by a more construction specific Construction Surveying and Layout course. The only remaining course taught by the Department of Architecture is Design Communications Foundations which satisfies ACCE's construction graphics requirement. It is interesting to compare this program with the program in 1970 when classes were offered for the first time as Building Construction classes. At that time, 12 hours were taken in the Department of Architecture and 27 hours were taken in the College of Engineering.

Colorado State University

The analysis of the historical information for the construction program at Colorado State University resulted in three distinctive eras. These eras are:

- Light Construction and Marketing, The early years (1946–1958),
- Industrial-Construction Management, The middle years (1959–1986), and
- Construction Management Department, The modern years (1987–2007).

CSU: The Early Years 1946-1958

In 1937, the General and Industrial Arts Engineering program was added to Engineering. The significance of this program was that it was the first program that specifically set as its objective the “combination of business, engineering and industrial arts that today's construction management programs include” (Wagner-Renner and Grosse, 2007, p.6). This program, however, was cut in 1942 due to World War II.

The formal start of construction education at Colorado Agricultural and Mechanical College (latter renamed Colorado State University) occurred in 1946. The program was called Light Construction and Management. According to Wagner-Renner and Grosse (2007), this program was development in response to a study conducted by Johns-Manville citing an industry need for more and better trained manpower. This organization, along with other supporters, provided funding to establish the interdepartmental Light Construction and Marketing degree program in the School of Engineering. According to the 1946 general catalogue, this degree was developed to address “the shortage of housing over the country by producing men capable of entering into such a building [industry] both as builders and as salesmen for building products” (p.124). The degree program was designed to give students training in engineering, mathematics, marketing and business practices. Courses comprising the construction science and construction categories

came primarily from engineering, industrial arts, and forestry. In 1955, first course specific to construction (Building Construction and Estimating), which was taught through civil engineering, was added to the curriculum. In 1957, the Light Construction and Marketing program moved from the School of Engineering to the College of Science and Arts and the course catalogue description was written to target all students (Wagner-Renner and Grosse, 2007).

During the program's early years, it was 210 credit hours to be completed over four years. The average percentage of course hours allotted to each of the ACCE categories were as follows: 11% general education courses, 22% math and science, 16% business and management, 21% construction science, 8% construction, and 21% fell in the other category (Figure 4). Between 1955 and 1957, the number of credit hours in the Other category were increased to offset reductions in the General Education category while most of the other categories stayed relatively the same. As seen in Figure 4, in 1951, the number of construction credit hours increased 12 hours to 19 hours. This change was the result of adding civil engineering courses focusing on the engineering profession and organization. As shown in Figure 4, during this period, over twice as many credit hours were allotted for construction science courses (which averaged 44.7 hours) compare to construction courses (which averaged 17.2 hours).

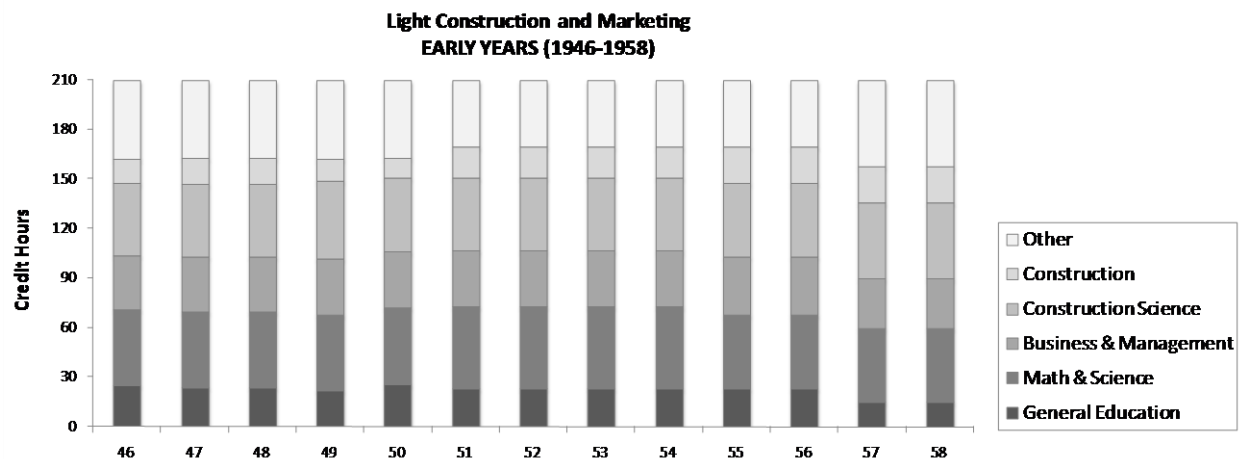


Figure 4: Distribution of courses in the Light Construction and Marketing program at Colorado State University from 1946-1958.

CSU: The Middle Years, 1959-1986

This era of construction education at Colorado State University was characterized by numerous changes to keep up with an evolving industry. In 1959, an internal advisory committee was formed for the construction program. This committee included faculty from various disciplines: Industrial Arts, Vocational Education, Civil Engineering, Business, Forest Management and Utilization, and the Colorado State Board for Vocational Education. As a result, the program goal was restated to prepare students for management careers in either (a) light or heavy construction or (b) industrial production and distribution. To meet this goal, the curriculum was revised to give students and understanding of applied science and business (Wagner-Renner and

Grosse, 2007). Another major change that occurred at this time was that the total credit hours were reduced from 210 to 192.

Combined, the program revisions and the credit hour reduction resulted in slight shifting of the percentage of credit hours for each ACCE category (Figure 5). Although all categories had changes in the percentage of credit hours allotted to them, the largest changes were in Math and Science category and the Business and Management category. These changes were reflective of the revised program goals. The credit hours for the Math and Science were cut nearly in half, while Business and Management credit hours were increased a little over a third. Additional credits were cut from the Construction Science category while the Construction credits remained relatively unchanged. As a result, the percentage of program credits from the Construction category increased slightly.

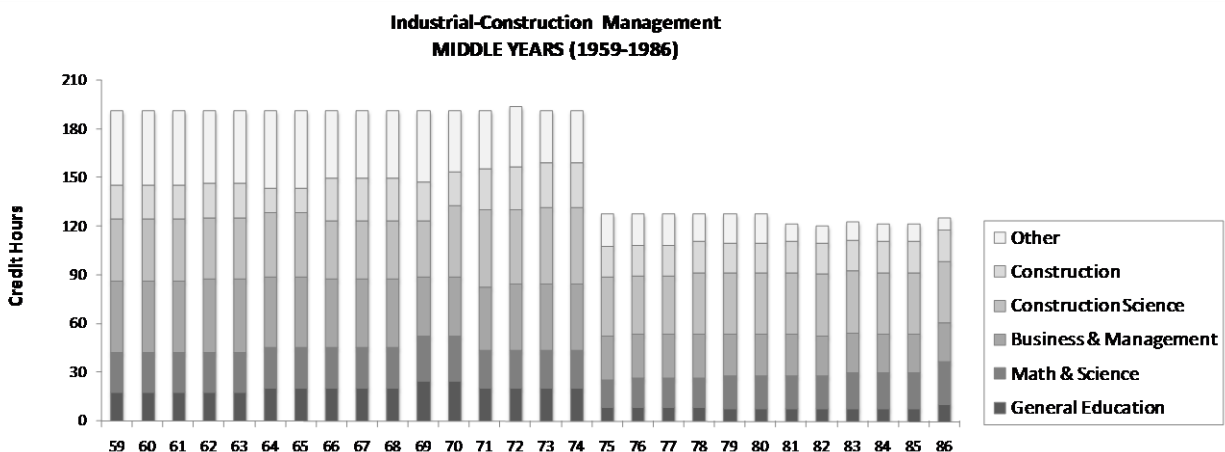


Figure 5: Distribution of classes in the Industrial-Construction Management program at Colorado State University from 1959-1986.

In 1962, the program ties with industry were strengthened as a result of Program Coordinator James Young's efforts, initiating further curriculum changes. Additionally, a course in Contracts and Specifications was added to the program. Over the next eight years, another 16 courses were developed for the construction program. Courses added in 1964, were: Construction Mechanics, Professional Opportunities, Building Materials and Equipment, and Wood Construction and Management. Courses added in 1965 were: Architectural Drawing and Estimating, Mechanical Systems for Construction, and Construction Estimates and Costs. In 1969, the program advisory committee was expanded to include industry representatives in addition to faculty. As a result, in 1970 and 1971, the following courses were added to the program: Construction Equipment, Construction Techniques, Residential Construction Planning, Mechanical Systems I and II, Architectural and Construction Materials, and Plan and Specifications. In 1971, these courses were also added to the curriculum: Construction Planning and Scheduling, and Soils Engineering and Foundations. (Wagner-Renner and Grosse, 2007)

All of the courses added between 1964 and 1971 were either Construction Management or Industrial Science courses with the exception of the Soils Engineering and Foundations course, which was taught by the Civil Engineering department. During the remainder of this period, both the Construction Science and Construction categories continued to be reduced; however, the former saw larger reductions. Credit reductions mostly were the result of reevaluating credit hours allotted to courses versus dropping courses. As a result of the changes noted above, the percentage of the program credit hours shifted away from General Education, Math and Science, and Other to Business and Management, Construction Science, and Construction. The Construction Science category increased slightly from an average of 21% during the Early Years to an average of 26% during the Middle Years. At the same time, the percentage of Construction credits more than doubled, increasing from an average of 8% in the Early Years to 14% in the Middle Years.

CSU: The Modern Years 1987-2007

The total program hours continued to fluctuate until 2000, when the program was cut to 120 hours (Figure 6). The majority of these hours were cut out of general education, resulting in the percentage of general education courses being reduced from 12% (15 credit hours) in 1999 to 5% (6 credit hours) in 2000. Other categories cut included Math and Science and Other. All other categories had increases in the number of credit hours.

During this era, the curriculum was also being reviewed through a combined effort of department faculty and Industry Advisory Board members. The resulting changes continued to increase the percentage of credit hours allotted to Construction (Figure 6). By the 2004, the percentage of credit hours for Construction had increased to 27%, while the percentage of credit hours for Construction Science remained stable at 30%. Finally, in 2007, additional curriculum revisions resulted in the percentage of Construction credits increasing to 33%, while Construction Science decreased to 25%.

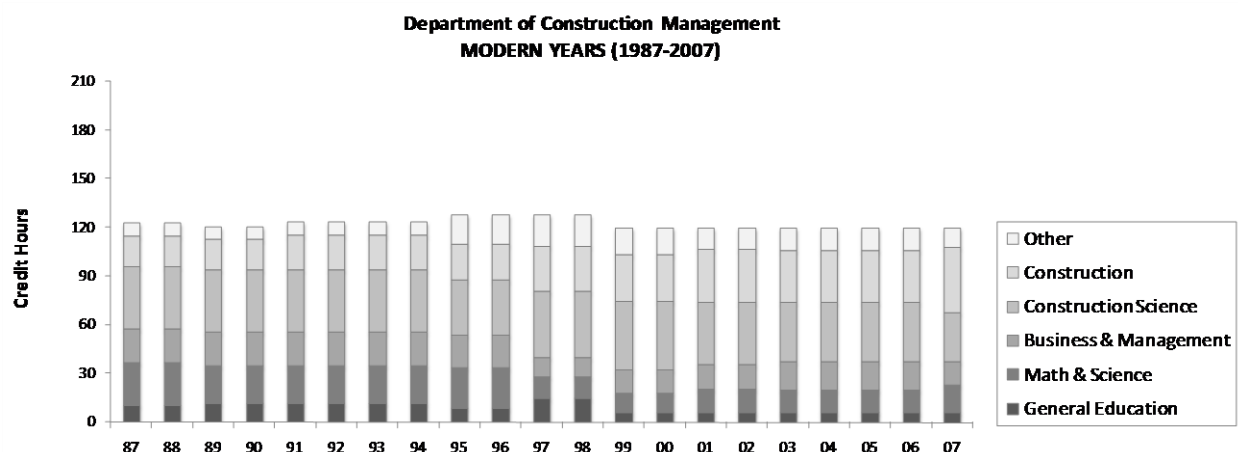


Figure 6: Distribution of classes in the Construction Management program at Colorado State University from 1987-2007.

Discussion

The evolution of the construction programs reviewed here provide a unique example for the construction programs in the United States. This analysis shows how the programs have evolved over time, highlighting (a) how the programs have grown into their own departments and (b) how program credits have shifted from a focus on Construction Science to more of a balance between Construction Science and Construction. Additionally, this analysis highlights how two programs have been successful in reducing their programs to 120 hours in response to the stakeholder's demands to qualified people out into the workforce in as short a time as possible while still meeting the minimum requirements of the accreditation agency. The results of the analysis at Texas A&M show that the curriculum has gradually removed the courses taught by its parent colleges: engineering and architecture to a point where only one course is taught in the Department of Architecture. The courses removed were mainly in the ACCE curriculum category of Construction Science.

Similar results were also observed for Colorado State University. Overall, the curriculum at Colorado State University has evolved to focus more on the ACCE curriculum categories of Construction and Construction Science. Both of these categories saw continued increases in the percentage of credit hours allotted to each category. The most recent curriculum changes have resulted in the highest percentage of credit hours being allotted to Construction. The program at Colorado State University has also seen a definite shift away from courses taught by engineering, but this process has taken longer at CSU than at TAMU.

The results imply that as construction curricula matures, it no longer needs to rely on the support of the more mature disciplines such as engineering and architecture. Both programs reviewed evolved where a more equitable balance exists between the percentage of credits allotted to construction science and construction courses, representing a shift away from the ACCE category Construction Science toward Construction, which contains the subject areas that would generally be considered *Construction Management*. Robson and Bashford (1995) argued that for Construction to become a discipline it has to be based in theory and the predominant theory in construction is *management*. Based on Robson and Bashford's observation and the results of this study, it appears that construction curriculum is moving toward a more management based curriculum.

The curriculum at both Texas A&M and Colorado State University still contains many of the subject matter areas that were previously taught through their respective Engineering Colleges such as statics, structural design, soils and surveying however these courses are now taught within the respective departments. The question raised by this study is: If the curriculum continues to evolve as it has over the past 60 years and the predominant theoretical base shifts more towards management will we see the removal of these engineering based subjects in the ACCE curriculum category of Construction Science to accommodate more courses in Construction category?

This study has also highlighted how the organizational structure and requirements of the university also play an important role in curriculum structures. General education requirements are usually defined by the universities with very little flexibility for the programs. For example,

these universities are of the few universities in the United States that require its freshman to take physical education classes. Similarly, the organizational structure plays a role in curriculum definitions where the school or college requirements have to be accommodated. The ACCE accredited construction programs in the United States are housed in a variety of colleges and schools including engineering, architecture, science and technology, agriculture and business management. The internal requirements of these organizations also help shape the program curriculums. For example, the College of Architecture at Texas A&M University requires its students to have a semester-away from the campus which creates an opportunity for a study-abroad program or a long semester internship.

Additionally, it is important to also recognize that ACCE accreditation allows individual programs to respond to industry needs and requirements in unique ways. The construction industry is dynamic and practical by its very nature and this is reflected on the program curriculums in terms of approach and content. In the recent focus group meetings with the construction industry in the State of Texas, the highest rated areas of importance were noted as business and construction management topics. Professional licensing requirements are also a part of this discussion. Although construction management students do not go through professional engineering or architectural licensure procedures, they are qualified to be certified as a professional constructor through American Institute of Constructors.

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