CONSTRUCTION ENGINEERING AND MANAGEMENT UNDERGRADUATE EDUCATION

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ABSTRACT: Construction education is not new. It was a part of the practical aspects of many early civil engineering degree programs. As early as the 1920's, specializations in construction engineering were found in a few civil engineering programs, paralleling structural engineering and other areas. However, the gradual need for more specialization than could normally be integrated in the civil engineering degree eventually led to the formation of some construction specialty degree undergraduate programs, particularly after World War II. This paper documents the historical evolution of construction education, promotes construction as a stand-alone professional engineering discipline, provides information for schools that are interested in starting an undergraduate construction engineering and management (CEM) degree program, and discusses the engineering accreditation aspects of the CEM curriculum and the role of the construction industry in the CEM curriculum development.

INTRODUCTION

The construction industry is a major player in the nation's economy, contributing over $470 billion to the national gross domestic product [Wright 1991; National Institute of Standards and Technology (NIST) 1994]. The complex nature of the construction industry, coupled with the challenges of global competitiveness and changing regulatory requirements, created the need for providing higher levels of education and experience of construction professionals (''The Challenge'' 1990; NIST 1994). Therefore, the objectives of this paper are

- To document the historical evolution of construction engineering education
- To promote construction as a stand-alone professional engineering discipline
- To provide information for schools that are interested in starting an undergraduate construction engineering and management (CEM) degree program
- To discuss the engineering accreditation aspects of the CEM curriculum
- To discuss how to involve the construction industry in the development and continued improvement of a construction engineering curriculum

CONSTRUCTION ENGINEERING EDUCATION—HISTORICAL BACKGROUND

Construction education is not new. It was a part of the practical aspects of many early civil engineering (CE) degree programs. As knowledge grew at the beginning of the twentieth century, specialty tracts within CE degrees began to be formalized. As early as the 1920s, specializations in construction engineering were found in a few CE programs, paralleling structural engineering and other areas. However, the gradual need for more specialization than could normally be integrated in the CE degree eventually led to formation of some construction specialty degree undergraduate programs, particularly after World War II. In the last half of the twentieth century, construction graduate programs have also developed within many CE departments (Oglesby 1990). Construction engineering education focuses on the entire life cycle of a physical facility, which includes conception, design, procurement, construction, operation, and maintenance (NIST 1994; Oglesby 1990). Construction, therefore, is a process that must be both designed (engineered) and managed (Johnston 1995).

Construction engineering undergraduate degrees are varied in their origin. North Carolina State University, Raleigh, N.C., established the first engineering-based construction degree in 1952. This degree evolved from a specialty that was added to the CE degree in 1923. After World War II, the construction boom and resulting demand led to the brief establishment of a bachelor of science degree (BS) in construction that was not engineering accredited but used many engineering courses. Industry and faculty desired to have a program with professional standing, so the degree was evolved in 1952 to a BS in CE—construction option, a separate degree from the CE degree. This name was used to allow accreditation under the Civil Engineering Program Criteria of the Engineers Council for Professional Development [the earlier name of the Accreditation Board for Engineering and Technology, Inc. (ABET)], because there were no accreditation criteria for construction engineering at that time. Following graduation of several classes under that degree name, accreditation was received in 1957. ABET Program Criteria for Construction Engineering were established in 1976. Subsequently the name of the North Carolina State degree was changed to a BS in CEM.

Iowa State University, Ames, Iowa, followed a similar pattern. Evolving from a nonengineering degree, a BS in construction engineering was established in 1969; however, it had to wait for development of Engineers Council for Professional Development (or ABET) Construction Engineering Program Criteria and thus became accredited in 1976. The Construction Engineering Program Criteria and initial guide were developed for ABET as a joint effort of the American Society of Civil Engineers (ASCE) and the Associated General Contractors of America. With ABET criteria available, several other major universities began to start programs successfully. Purdue University, West Lafayette, Ind., established a BS in construction engineering in 1976 and became accredited in 1984; the degree

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name was later changed to a BS in CEM. North Dakota State University, Fargo, N. Dak., established a BS in construction engineering in 1977 and became accredited in 1983. The University of New Mexico—Albuquerque, Albuquerque, N.M., established a BS in construction engineering in 1984 and became accredited in 1989. The University of Wisconsin—Madison, Madison, Wis., established a BS in CE—CEM in 1989 and became accredited in 1993. Western Michigan University, Kalamazoo, Mich., established a BS in construction engineering in 1995 and was seeking accreditation following graduation of the first class. Recently, several universities have approached the ASCE Task Committee on Construction Engineering Education with indications that they are in the process of considering or establishing a program and are seeking information.

The above programs are usually housed in, or associated, with a CE or related engineering department. The names of the programs vary somewhat, but they have in common that they are accredited as construction engineering degree programs under ABET, and they are a separate degree from the CE degree (although they may share faculty and resources and have many courses in common to the benefit of both). Most of the programs also offer graduate degrees in CE with a speciality in CEM. Combined, the above programs have produced over 4,000 graduates.

CONSTRUCTION EDUCATION

Construction graduates are currently in high demand by contractors in all types of construction including residential, commercial, industrial, highway, and heavy construction. They are also in demand by design-construction firms and by large owners who have continuing construction programs. Positions available to construction graduates include superintendent; project manager; salesperson; field, cost, schedule, design, safety, and quality control engineers; and owner representative. This section discusses current undergraduate construction educational options available to individuals who are interested in professional careers in the construction industry and discusses the need for an engineering option for construction education.

Current Construction Engineering Education Options

Individuals seeking professional engineering careers in the construction industry may generally pursue one of three undergraduate educational options: CE, CEM, and architectural engineering (AE). Each option has its own features and emphasis. The following subsections provide brief descriptions of each option. This paper will concentrate on facets of the CEM programs.

CEM

This undergraduate educational option typically leads to a BS degree in CEM. This degree is normally accredited by the Engineering Accreditation Commission (EAC) of ABET, which currently accredits over 1,550 engineering programs in the United States in all engineering disciplines. These programs are usually housed in a college of engineering. Currently, there are six ABET-accredited CEM programs in the United States and one additional program that was pursuing accreditation in 1999. (These programs are discussed in a later section.)

A CEM curriculum is also a combination of engineering, technology, construction techniques, and management. However, these programs strike a balance between the engineering, and the management and business aspects of the industry. The math and science contents are similar to any other engineering program. Engineering design is also emphasized in these programs, with a focus on design of the construction process. A curriculum in this option is planned to prepare students for engineering and management positions in the construction industry. Graduates of these programs meet the educational requirements to become registered professional engineers.

CE

This undergraduate educational option typically leads to a BS degree in CE. There are about 210 EAC ABET-accredited CE programs in the United States. Most CE programs concentrate on producing graduates for careers related to design of facilities as environmental, geotechnical, structural, transportation, or water resources engineers. However, some also offer concentration courses proving some background in construction engineering. The graduates of these programs must have breadth in four of these specialities, thus there is usually less room for depth in management aspects of construction.

AE

This undergraduate educational option leads to a BS degree in AE. These programs give graduating architectural engineers an understanding of all building systems such as architectural, structural, mechanical, lighting, electrical, and acoustical subjects, as well as project activities such as management, design, construction methods, economics, and building operations. The AE curriculum is normally dedicated to the building industry. This degree is also accredited by EAC ABET. Currently, there are 13 ABET-accredited AE programs in the United States. Graduates of these programs also may qualify for professional engineering registration. Many graduates of these programs pursue careers in building design, although some schools have options that also prepare graduates for positions in construction.

Other Construction Education Options

A number of universities offer nonengineering BS degrees in construction such as construction management, building science, building construction, and industrial technology. These degrees are normally accredited by the American Council for Construction Education. These programs may be located in a college of engineering but frequently are found in other colleges or schools such as architecture, design, business, or technology. Currently, there are over 40 American Council for Construction Engineering-accredited programs in the United States. These curricula are typically a combination of engineering technology, construction techniques, business, and management. However, the emphasis is more on the management and business and less on the math, science, and engineering content.

Need for Construction Engineering Programs

Providing formal engineering education and training to undergraduate students interested in careers in the construction industry has become necessary for addressing and overcoming the numerous challenges facing the industry today (Tener 1996, Sheehan 1991). In this respect, Tener states

> The practice of construction engineering and management in the United States increasingly demands professional engineers who are capable of solving technical, management, social, political, and leadership problems as tough as those faced in any other engineering discipline.

Therefore, many owners are beginning to demand registered engineering status for dealing with many issues at the con-

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TABLE 1. Analysis of Credit Hours in Construction Engineering Programs (Based on Old ABET Criteria)

School (1)	Credit Hours: Total curriculum (2)	Math and basic science (3)	Engineering science (4)	Engineering design (5)	Business and management (6)	Humanities and social sciences (7)
Iowa State University	134.5 (building)	33 (25)	37.5 (28)	16.5 (12)	18 (13)	16 (12)
	135.5 (mechanical)	33 (24)	39 (29)	16 (12)	18 (13)	16 (12)
	134.5 (heavy)	33 (25)	32.5 (24)	21.5 (16)	18 (13)	16 (12)
North Carolina State University	128 (general)	32 (25)	34 (27)	17 (13)	16 (13)	16 (13)
	128 (mechanical)	32 (25)	34 (27)	16 (13)	16 (13)	16 (13)
University of Wisconsin—Madison	131	38 (29)	33.5 (26)	21 (16)	22.5 (17)	16 (12)
Purdue University	134 (heavy/building)	34.5 (26)	34 (25)	16 (12)	16 (12)	18 (13)
	133 (mechanical)	34.5 (26)	32 (24)	16 (12)	16 (12)	18 (14)
	133 (electrical)	34.5 (26)	32 (24)	16 (12)	16 (12)	18 (14)
University of New Mexico—Albuquerque	131	32 (24)	32 (24)	18 (14)	16 (12)	18 (14)
North Dakota State University	139	36 (26)	36.5 (26)	16 (12)	21.5 (15)	16 (12)
Western Michigan University	132	37 (28)	40 (30)	16 (12)	22 (17)	16 (12)
ABET minimum	—	32	32	16	16	16

Note: Values in parentheses are percentages of total curriculum credit hours.
[a]Management hours may come from double counting credit hours.

struction job site, such as safety of the construction operation, and the design and engineering of construction systems and temporary structures. Increasingly, project specifications, standard specifications, local regulations, and Occupational Safety and Health Administration regulations require that a registered professional engineer must design selected aspects of the construction process. Hence, more contractors are beginning to add to their staff graduates with construction knowledge who are eligible for registration as professional engineers. These graduates are coming from CEM, CE, and AE programs that provide the necessary background in engineering that is a prerequisite to registration in most states.

KEY FEATURES OF UNDERGRADUATE CONSTRUCTION ENGINEERING PROGRAMS

Currently, six CEM undergraduate programs are accredited by EAC ABET in the United States. These are

- Iowa State University
- North Carolina State University
- North Dakota State University
- Purdue University
- University of New Mexico—Albuquerque
- University of Wisconsin—Madison

One additional program at Western Michigan University was preparing for an accreditation evaluation in the fall of 1999. A detailed analysis of the seven existing CEM programs (Tables 1 and 2) shows five main categories of courses defined by ABET under old (pre-2000) criteria that constitute a CEM curriculum:

- Math and basic science
- Engineering science
- Engineering design
- Humanities and social sciences
- Business and management

The analysis focused on courses common to most programs in each of these categories. The objective of the analysis is to study the topical contents that are common to existing CEM degree programs for the informational benefit of other schools. The following provides a discussion of the analysis as summarized in Tables 1 and 2. Note that all seven schools are on the semester system. ABET criteria minimum semester hour requirements in each category vary slightly on a sliding scale depending on the total hours in the curriculum within a range of 120 minimum to 128 maximum semester hours:

1. Math and basic science: Table 1 shows that credit hours in this category range from 24 to 29% of the total number of credit hours in the curriculum. The majority of the curricula, however, are at 25% of total credit hours. This category includes such courses as calculus, chemistry, physics, geology, and probability and statistics. A minimum of 15–16 semester hours were required.
2. Engineering science: Table 1 shows that the credit hours in this category range from 24 to 30% of the total number of credit hours in the curriculum. The majority of the curricula, however, are at 24–26% of total credit hours. Some of the sources contributing to this category have contents partially listed under engineering science and partially listed under engineering design, as indicated by Table 2. A minimum of 30–32 semester hours were required.
3. Engineering design: as shown in Table 1, the credit hours courses in this category range from 12 to 16% of the total number of credit hours in the curriculum. The majority of the curricula, however, are at 12% of total credit hours. This category includes such courses as structural design, concrete design, steel design, and senior project that are often designated as 100% design in content. Some of the courses contributing to this category have contents partially listed under engineering design and partially listed under engineering science or management (Table 2) such as scheduling, estimating, methods and equipment, transportation engineering, environmental engineering, hydraulics/hydrology, and soil and foundations. A minimum of 15–16 semester hours were required.
4. Business and management: Table 1 shows that the credit hours in this category range from 12 to 17% of the total number of credit hours in the curriculum. the majority of the curricula, however, are at 12–13% of total credit hours. Where content qualifying for other categories is also appropriate for management content, it may be counted simultaneously in both categories. For example, appropriate probability and statistics content might be listed as 100% under math and basic science and 100% under management. A minimum of 15–16 semester hours were required.

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TABLE 2. Analysis of Engineering Science, Engineering Design, and Management Topics in Construction Programs

Courses (1)	Category[a] (2)	Iowa State University (3)	North Carolina State University (4)	University of Wisconsin—Madison (5)	Purdue University (6)	University of New Mexico—Albuquerque (7)	North Dakota State University (8)	Western Michigan University (9)
Statics	ES	Course	Course	Course	Course	Course	Course	Course
Mechanics of materials	ES	Course	Course	Course	Course	Course	Course	Course
Dynamics	ES	Course	Course	Course	Course	Course	Course	Course
Surveying	ES	Course	Course	Course	Course	Course	Course	Course
Engineering economy	ES/M[b]	Course	Topic	—	Topic	Course	Course	Course
Fluid mechanics	ES	Course	Course	Course	Topic	Course	Course	Course
Thermodynamics	ES	Course	Course[c]	Course[c]	Course	Course[c]	Course	Course
Soils and foundations	ES/ED	Course	Course	Course	Course	Course	Course	Course
Structural analysis and design	ES/ED	Course	Course	Course	Course	Course	Course	Course
Codes and specifications	ES/M[b]	Course	Topic	—	Topic	Course	Course	Course
Electrical engineering	ES	Course	Course[c]	Course[c]	Course	Course[c]	Course	Course
Reinforced concrete design	ED	Course	Course	Course	Course	Course	Course	Course
Steel design	ED	Course	Course	Course	Course	—	Course	—
Transportation engineering	ES/ED	—	Course	Course	Course	Course	Course	—
Environmental engineering	ES/ED	Course	—	Course	Course	—	—	—
Hydraulics/hydrology	ES/ED	—	Course	Course	Course	—	—	—
Civil/construction materials	ES/ED	Course	Course	Course	Course	Course	Course	Course
Construction planning and scheduling	ES/ED/M[b]	Course	Topic	Course	Course	Course	Course	Course
Construction estimation and cost engineering	ES/ED/M[b]	Course	Course	Course	Course	Course	Course	Course
Construction methods and equipment	ES/ED/M[b]	Course	Course	Course	Course	Course	Course	Course
Construction project management	M	Course	Topic	Course	Course	Course	Course	Course
Engineering law/legal aspects	M	Course	Course	Course	Course	Course	Course	Topic
Senior project/capstone	ED	—	Course	Course	Course	Course	Course	Course
Statistics	M	Course	Course	Course	Course	Course	Course	Course
Technical/business communications	M	Course	Course	Course	Course	Course	Course	Course
Business courses	M	Course	Course	Course	Course	Course	—	Course

[a]ES = engineering science; ED= engineering design; M = management.
[b]Note that these courses are sometimes counted simultaneously in management category when appropriate.
[c]Electrical engineering or thermodynamics (elective).

5. Humanities and social sciences: Table 1 shows that the credit hours in this component range from 12 to 14% of the total number of credit hours in the curriculum. The majority of the curricula, however, are at 12% of total credit hours. A minimum of 15–16 semester hours were required. This category generally fulfilled both the ABET minimum requirements and contributed to the university's general education requirements.

ABET 2000 ACCREDITATION REQUIREMENTS FOR CONSTRUCTION ENGINEERING PROGRAMS

New ABET Engineering Criteria 2000 currently being implemented and required beginning in 2001 is best understood by referring to the most recent edition available. In a brief summary, the basic level criteria for all types of engineering undergraduate programs consider: students, program educational objectives, program outcomes assessment, the professional component (appropriate subject areas and minimum content in mathematics and science and in combined engineering science and engineering design), faculty, facilities, institutional support and financial resources, and program criteria. Important in this process is that institutions must have in place educational objectives that are defined and achieved, evaluated through ongoing outcomes assessment, and are improved through ongoing application of the assessment results.

Program Criteria 2000 for Construction and similarly named programs set forth additional requirements. The program must demonstrate that its graduates have

- Proficiency in mathematics through differential and integral calculus, probability and statistics, general chemistry, and calculus-based physics
- Proficiency in engineering design in a construction engineering specialty field
- An understanding of legal and professional practice issues related to the construction industry
- An understanding of construction processes, communications, methods, materials, systems, equipment, planning, scheduling, safety, cost analysis, and cost control
- An understanding of management topics such as economics, business, accounting, law, statistics, ethics, leadership, decision and optimization methods, process analysis and

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design, engineering economics, engineering management, safety, and cost engineering

The construction program criteria further address certain experience and qualifications that must be included among the faculty. It should also be noted that when a program, by virtue of its title, becomes subject to two or more sets of program criteria, then that program must satisfy each set of program criteria. An example is the title Construction Engineering and Management, which must meet both the construction engineering and the engineering management program criteria.

The required general and program content and example topics may be integrated into the curriculum in many ways. The following section attempts to organize, in ABET categories, course titles often utilized in seeking to fulfill frequently identified construction program objectives.

INFORMATION FOR DEVELOPING CONSTRUCTION ENGINEERING AND MANAGEMENT PROGRAMS

This section provides information that may be considered in developing a CEM program. First, a list of possible courses is provided based on the results of the analysis shown in Tables 1 and 2. Note that some of the schools listed in Tables 1 and 2 offer more than one CEM option (i.e., general, mechanical, and electrical). However, this section only provides information for developing a general CEM curriculum. (Contact any of the schools listed in Table 1 to obtain the relevant curriculum for the other options.) Second, this section discusses and strongly recommends the active involvement of the construction industry in the development and continuous support of the CEM program. It also provides a framework for involving the construction industry.

Example CEM Curriculum Course Contents

From the curricula of the various existing programs, it is possible to synthesize a set of courses believed to meet the needs of industry and the basic content requirements of ABET. (It is worth noting here that the total semester credit hours in existing CEM programs range from 128 to 141.) The details of credit hours in each category, course selections for each category, university general education requirements, and total curriculum credit hours are left to the individual schools. Furthermore, needed content, such as cost estimating or safety, can either be organized into specific courses or diffused throughout many parts of the curriculum in innovative ways.

The summary of typical content is broken down into the following five categories:

1. Math and basic science: A minimum of 30–32 credit hours are required by ABET. Example content for this category include
   - Calculus sequence (three or four courses)
   - Physics sequence (two courses with laboratories)
   - Chemistry (one to two courses with laboratories)
   - Probability and statistics (one course, double count under management)
   - Other appropriate science or mathematics (one course)
2. Engineering science and engineering design: A minimum of 45–48 credit hours are required by ABET. In the past, the distribution for some ABET program criteria has been 2/3 engineering science and 1/3 engineering design; however, ABET 2000 General Criteria and Construction Program 2000 Criteria no longer specify the distribution. Example content for this category includes
   - Statics
   - Dynamics
   - Mechanics of materials
   - Surveying
   - Fluid mechanics
   - Thermodynamics
   - Electrical engineering
   - Codes and specifications (may include simultaneous management content)
   - Construction materials
   - Structural analysis and design
   - Soil mechanics and foundation
   - Transportation engineering
   - Environmental engineering
   - Hydraulics/hydrology
   - Concrete design
   - Steel design
   - Construction planning and scheduling (may include simultaneous management content)
   - Construction estimating and cost engineering (may include simultaneous management content)
   - Construction methods and equipment (may include simultaneous management content)
   - Design of construction systems
   - Senior project/capstone (may include simultaneous management content)
3. Management: The ABET 2000 Construction Program Criteria does not specify a minimum amount of content. The content should be consistent with the identified program objectives. Where content qualifying for other categories is also appropriate for management content, it may be counted simultaneously in both categories. Example content for this category might include
   - Construction project management
   - Engineering economy
   - Business/technical communications
   - Engineering law/legal aspects
   - Business, management, and accounting
   - Economics
4. Humanities and social sciences: Under ABET 2000 criteria, the amount and distribution of this content is not specified, but it must complement the technical content of the curriculum and be consistent with the program and institution objectives. Thus, this category can be a valuable source of courses in support of construction management content and understanding of engineering in the context of society. Example desirable courses for this category might include
   - Ethics in engineering
   - History and impact of technology on society
   - Sociology courses related to the workplace
   - Psychology courses related to human behavior
   - Economics

Involving Construction Industry in CEM Education

As mentioned above, the construction industry is complex and fragmented, involving numerous players, skills, and technologies. As new techniques and materials are developed and implemented, the industry is in a constant state of change. For example, 10 years ago design/build was a minor player in industry. Today, it is evolving into the preferred delivery method. Because of this rate of change, it is imperative for CEM faculty and staff to stay abreast of trends to properly educate future construction professionals in the methods they will use, not only today, but tomorrow. One of the best ways to accomplish this task is to literally bring the construction industry into the classroom as guest lecturers and adjunct faculty (Table 3). The benefits of inviting industry to participate in CEM programs are explored in the following sections.

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TABLE 3. Types of Industry Participation in CEM Programs

Industry participation (1)	When to initiate (2)	What it looks like (3)
Preestablishment advisors	Program planning stage	Regional construction leaders with understanding of engineering in construction process
Site visits	Immediately	Individual courses
Internships, summer and co-op jobs	Immediately	Varies, but should be actively monitored and updated
Professional development education	Soon after establishment	Short-courses and lectures organized around faculty expertise and industry needs
On-campus recruiting	Soon after establishment	During every semester with graduating students
Program advisory board	Once program is established	Professional; broad in representing employer type; forward thinking

Why Industry in Education?

Training students to succeed in industry should be the primary goal of any engineering program. Accordingly, there is a long-standing tradition of forging industrial cooperation in engineering education. Like all other engineering disciplines, construction is an applied field, meaning that its education must center not only on theory, but on how things get done. If CEM graduates do not possess value-adding skills and the ability to self-acquire additional knowledge from day one, then the program has failed its students as well as the industry. Therefore, in concert with industry's needs, the educational mission of a CEM program should be to graduate students able to import classroom knowledge and apply it with a positive attitude to achieve the stated goals of the construction firm. Although far from definitive, rate of hire of graduates, along with the number of firms recruiting graduates are two indicators of success in CEM (Tener 1996).

To accomplish this goal, it's imperative for industry to be incorporated into CEM education. As state and federal government educational funding dwindles, institutions of higher learning must be entrepreneurial and strategic in formulating the thrust areas of their CEM programs. In an era with more public/private partnerships, industry can assist universities in securing additional state resources for instruction and research, because it has a different relationship with government. Ideally, it can also provide supplementary funding for special needs.

The construction industry, through its direct line to the ever changing market, is an invaluable resource to CEM programs. By helping faculty and staff respond appropriately to developments changing the industry, current professionals help move construction education forward. Students obtain hands-on experience with industry practices and methods and learn how to apply what they have learned in the classroom to the ''real world.'' In turn, as the industry continues to become more complex, college educated construction employees become more desirable. Thus, quality graduates enable construction firms to remain competitive, and quality input from industry enables CEM programs to stay abreast of market changes and trends. Many industry professionals are willing to help future employees gain the knowledge and skills necessary to succeed; it's in their best interest. It's up to CEM faculty and staff to seek out these industry professionals and incorporate them into the educational mission.

Who Should Participate?

Construction professionals include not only firm owners, managers, and project coordinators, but also design engineers, architects, subcontractors, surety personnel, insurance agents, bankers, accountants, attorneys, and suppliers, among others. To succeed in the twenty-first century, in addition to effectively communicating with these numerous parties, the construction professional must have a holistic perspective of the project delivery process (planning, design, procurement, construction, and operation and maintenance). Ideally, all phases of education should be supplemented with a cross section of industry. How to achieve this will be discussed shortly, but the general idea is to bring subject matter experts into the classroom to discuss their areas of expertise. By allowing practitioners to discuss how they acquire and apply their skills, students gain insight into possible career paths and expertise needed in industry. They also hear from professionals that the construction industry is relationship dependent, and that personal communication skills are essential. Furthermore, they gain first-hand experience relating positively with these professionals.

How and When to Bring Industry into Classroom

Industry involvement can take numerous forms, including guest lectures, student chapter presentations, site visits, work experiences, general donations, funded research, or even named professorships or buildings. Industry can provide data for research investigations, projects and technical expertise for capstone design experiences, and designate scholarships and graduate fellowships. While such participation is desirable, it should be apparent to the CEM educator and administrator that this inclusion represents more than a slight challenge. Successful construction personnel are necessarily busy, and coordinating meetings, lectures, and visits can be difficult. The following explores several capacities in which industry can serve, including appropriate time frames for implementation.

Guest Lectures. One of the immediate tasks of a new CEM program should be to invite industry professionals to guest lecture on their areas of expertise. Physically bringing industry players onto the campus is an effective way to showcase the program and begin cultivating a cooperative relationship that will continue to enhance educational and research efforts. The guest lecture may be part of a formal class, part of a seminar series, or a student chapter meeting program.

To be effective, guest lecturers should be given reasonable structure to narrow their comments, but plenty of room to portray their unique experiences. They should be given a specific topic, the time they have to present, and course outline, syllabus, and philosophy, along with appropriate background information on what the students already know about the topic. Because many industry professionals have never been in front of a classroom, it is important for faculty members to offer assistance and guidance. This can be a good opportunity for professionals to work on their technical presentation skills, and this fact might be worthwhile pointing out to potential speakers as incentive. Accordingly, faculty should consider offering structured input on how to improve presentation. To this end, student and faculty evaluation forms may be used.

Site Visits. Field trips are a means to augment what is taught in the classroom by allowing students to see the construction process in action. Once appropriate administrative and financial resources are in place, individual instructors should be encouraged to arrange participation at jobsites and construction professionals' offices (e.g., engineering and architect design centers). In addition to exciting students, such site visits can also serve to spark interest in industry, leading to further participation. Trips should coincide with material

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presented in class and include a guided presentation. Industry guides should be prepared in a similar manner as guest lecturers.

Internships, Summer, and Co-Op Jobs. Another good way to integrate academe and industry is to develop employment opportunities for students. This should be an immediate goal of any developing program. Variations may include part-time, school-year jobs, summer internships, and cooperative education projects. A CEM program might consider an internship requirement. It is a great way to get students to apply what they have learned, and when they are back in the classroom, to have them engage the material presented more holistically.

CEM faculty should not have difficulty finding construction firms seeking to cultivate these relationships, but a formalized plan should be presented to potential mentor firms. Also, they must be carefully monitored and constantly evaluated. An effective program matches a student's education and training with an interested firm and competent mentor. Duties should progress in complexity and responsibility as the student masters skills, and mentors must be willing to evaluate and help guide student performance.

Professional Development Education. As part of its ongoing commitment to the construction industry, a CEM program should educate professionals directly by offering lecture series and short courses, perhaps for professional development credit. Continuing education provides an opportunity to discuss industry challenges and effective working relationships in a neutral location. For example, North Carolina State University initiated a construction extension program in 1964. Presently, it averages over 75 one- to three-day short courses per year involving about 4,000 participants annually from various segments of the construction industry. At the University of Wisconsin—Madison in the past year, professional development short courses have been offered to owners, contractors, subcontractors, and design engineers. This creates value and benefit for the industry, while increasing involvement in the educational program.

On-Campus Recruiting. On-Campus recruitment can greatly help graduating students enter the workplace, while increasing rates of hire. Visits should be timed to coincide with graduation, usually twice a year. Such visits help a developing program gauge the preparedness of its graduates, as the more experience and value-adding skills they possess, the more likely their chances for gainful employment. Over time, producing quality graduates who find work will help attract more and better firms to recruit, hopefully increasing the effectiveness of the program by raising the level of prestige and industry involvement.

Program Advisory Board. The best way to coordinate industry support and participation is to form a program advisory board to provide input to the program. This forum can bring together students, faculty, administrators, and industry professionals to discuss the status, educational mission, short-term and long-term goals, and needs of the program. Faculty and students can present research and program achievements, and industry representatives learn ways to partner with faculty, students, and administrators. Granting industry a direct voice means that valuable, up-to-date industry information on methods, materials, and technologies can be incorporated into the structure of the CEM program. The advisory board can also contribute to the outcomes assessment process.

The CEM advisory board should be a diverse body representing many facets of industry. Any subfield of construction education in which the program specializes should definitely be represented (e.g., design engineering), and members may also include student representatives and faculty from related departments and other CEM programs. The key is to initiate dialogue, and there is no hard and fast law of what mix is ideal. It is important to select wisely, however, as these individuals will help direct where the program moves. Partisan bickering over turf or political issues will only serve to corrupt aims and so should be vigorously avoided. In general, people with vision for the future, interested in how the industry changes, are ideal. Accordingly, do not hesitate to interview or ask for personal statements from potential board members.

It is clear that having an advisory board can prove an invaluable resource through regularized outside consulting on the development of the program and the construction industry as a whole. Unfortunately, there is no formula for when to initiate the advisory board. A premature attempt might strain relationships with potential industry allies, not to mention sap energy from other important tasks such as acquiring accreditation. A good rule of thumb is to look toward assembling a board from day one—first approaching potential members informally. Once it appears you have a representative group, then it is time to put this resource into action.

At this time, candidates should be approached formally, which means that to initiate an advisory board, a CEM program should have an established curriculum. Terms of service should be limited but extendible (i.e., no ''tenured'' positions). Once a body has been assembled, meetings should be announced well in advance and conducted with printed agendas and materials.

SUMMARY AND CONCLUSIONS

Construction engineering has gradually become a well-developed profession. Criteria for ABET accreditation of CEM degree programs have been available for many years and continue to evolve. A number of successful programs have produced many graduates in the CEM field, and new programs are gradually being established. An analysis has been presented of the curricula course offering of these programs. Based on this analysis, information for other institutions desiring to initiate similar programs has been provided. The role of industry advisory boards in providing start-up input, frequent program and student interaction, and feedback are important to the program's success.

APPENDIX. REFERENCES

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