The First Professional Degree: A Historic Opportunity

By Jeffrey S. Russell,[1] Member, ASCE, Brewer Stouffer,[2] and Stuart G. Walesh,[3] Member, ASCE

Abstract: Historically, ASCE has worked to develop civil engineering (CE) education to ensure that the profession is continuously strengthened. Based on recent events, ASCE is poised to lead CE education into the twenty-first century. Of specific interest in this regard is the recent support shown by the Board of Direction for the master's as the first professional degree (FPD) for CE practice. To understand the ramifications of the board's policy statement, it is necessary to grasp the evolution of the FPD concept as well as undergraduate engineering curricular reform in general. Examining the shape of past debate opens a window onto the board's historic policy statement, which in turn helps illuminate the future course of action. Moreover, the writers contend that significant educational reform is necessary for CE to confront the changing, competitive global marketplace. Accordingly, three possible models to implement the FPD are explored: (1) Current master's degree programs; (2) 150-credit hour requirement used by accountancy; and (3) professional school.

INTRODUCTION

Current Context

Few civil engineers require elaboration on the significant pace and scope of change brought about by the advent of computer technology and the growing global market. As companies choose to operate 24 hours a day with offices around the world contributing to the same projects electronically, low-cost foreign design centers and engineering technologists compete with U.S. civil engineers as never before. Furthermore, the technology being employed has itself changed dramatically: the increase in the amount of information available to the human race has caused daunting advances in the ways in which we process and impart knowledge and create and apply new technology. Twenty years ago, computer-aided design was in its infancy, whereas today, it is an integral part of industry. The entire practice of engineering has irrevocably been altered in the information age, and civil engineers must confront their place in the new knowledge economy.

As intellectual capital supersedes physical capital as a measure of wealth in our economy (AOL is ''worth'' more than Time Warner), perhaps paradoxically, simply having the proper knowledge and technical know-how no longer ensures success (Walesh 1995; Edvinsson and Malone 1997; Bordogna 1998; Adamski 1999; Walesh 2000). Whereas once an understanding of engineering principles was practically sufficient to allow a career in engineering, today's competitive market, where the common currency is time, requires a blend of numerous professional skills.

In a survey of engineering deans and engineering employers conducted by the National Society of Professional Engineers in 1992, over one-third of respondents claimed that engineering bachelor's programs did not meet the employer's basic needs, whereas fully 92% indicated that new hires required more education to perform on the job. Industry leaders reported that ''technical know-how alone is no longer enough,'' citing communication and problem solving skills as the desirable characteristics distinguishing potential employees (Dahir 1993). Relating positively to people in the countless negotiations required for every project has become the crucial differentiator, yet civil engineering (CE) graduates are routinely criticized for being ineffective communicators (Florman 1996; Kersten 1996; Russell et al. 1997). As Fig. 1 demonstrates, technical comprehension is as important as ever, yet that understanding alone is insufficient. Successful CE practice now requires great breadth of professional skills as well.

Historically, 4 years of education has prepared CE graduates to successfully enter the workplace, but there is pressure on universities to produce well-rounded graduates with diminishing credit hours over that same 4-year period (Pauschke and Ingraffea 1996; ''First'' 1998; Scranton 1998). In an effort to counteract the rising costs and time commitments of college, several state legislatures, including North Carolina and Arizona, have mandated credit-hour limits for all bachelor's degrees in the mid-120s.

With a push in one direction to enhance engineering on its humanistic side and with a shove in another to keep pace with technological changes in industry, often with less credit hours, the current education system has become overly taxed. Although many undergraduate programs are certainly adequate, they do not appear to fully prepare students to manage and lead complex endeavors. In part because of these deficiencies, more and more engineers are seeking postgraduate study to gain necessary skills and understanding. For CE subfields such as environmental, structural, and geotechnical engineering, the master's degree has already become the standard degree for practice (Scranton 1998; Rainwater et al. 1999). This is not a criticism of current education so much as it is a recognition that the world is changing more rapidly than curricular improvements, particularly within a context of diminishing credit hours.

Opportunity for Change

By organizing and uniting CE, ASCE helps ensure that the built environment functions effectively, leading to improved quality of life for humankind. Central to this mission of plan-

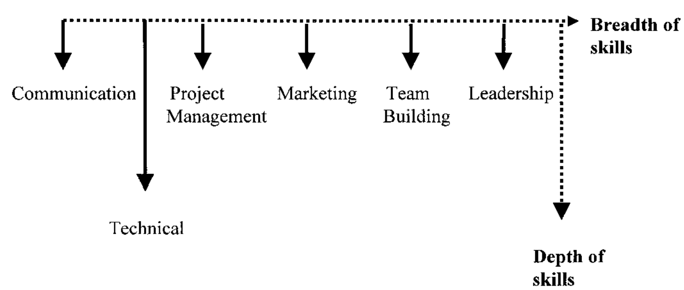

FIG. 1. Desired Skill Concentration for CE

[1]Prof., Dept. of Civ. and Envir. Engr., Univ. of Wisconsin, Madison, WI 53706. E-mail: russell@engr.wisc.edu
[2]Res. Intern, Dept. of Civ. and Envir. Engr., Univ. of Wisconsin, Madison, WI. E-mail: stouffer@facstaff.wisc.edu
[3]Mgmt. Consultant, 3006 Towne Commons Dr, Valparaiso, IN 46385. E-mail: stuwalesh@aol.com

Note. Discussion open until September 1, 2000. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on March 2, 1999. This paper is part of the ***Journal of Professional Issues in Engineering Education and Practice***, Vol. 126, No. 2, April, 2000. ©ASCE, ISSN 1052-3928/00/0002-0054–0063/$8.00 + $.50 per page. Paper No. 20363.

ning, constructing, operating, and maintaining the physical fabric of civilization is the self-evident need to evaluate, modify, and update the education of future leaders. The Board of Direction's recommendation for the master's as the first professional degree (FPD) is ASCE's response to the current untenable situation of too much to teach in too little time.

The writers' purpose in this paper to (1) explore the historical evolution of the FPD; (2) explain how the FPD can enhance the profession; and (3) describe three possible models for implementing the FPD. Through this analysis, the board's proposal is presented as a logical, proactive response to market forces firmly rooted in CE's past that will help elevate the CE profession.

EARLY EFFORTS TO RESTRUCTURE EDUCATION: ROAD TO FPD

Beginning in the early nineteenth century when engineering was first taught in this country, the French system was the leading educational theory. This system treated engineering as an applied science; thus students were taught primarily science and mathematics in the first 2 years of a 4-year degree. It was only in the last 2 years that they were taught how to apply their understanding to solve engineering problems. Although this model was effective, the rigid separation of application from knowledge became problematic, often resulting in unnecessary cramming of technical subjects to ''get it all in'' by the time students graduated. Extreme graduation requirements resulted, and at the turn of the century, it was common for a CE student to carry a semester load of 20–24 credit hours.

Reformers began calling for a more unified model on the order of Langdell's case study method for teaching law where practice and knowledge are interwoven throughout the curriculum (Pritchett 1918). Under this new educational theory, principles were to be derived from practice, rather than the other way around, and science and mechanics were to be taught simultaneously (Mann 1918). This arrangement remains the general organization of most engineering education today, though there is still room for further integration of theory and application.

Mann Report of 1918

The first systematic efforts to evaluate and improve engineering curricula began in 1907. In that year, the Society for the Promotion of Engineering Education, presently the American Society for Engineering Education (ASEE), invited several engineering societies including ASCE to help administer a ''Joint Committee on Engineering Education of the National Engineering Societies.'' Their stated purpose was to ''examine the fundamental question of the right methods of teaching and of the preparation of young men for the engineering professions'' (Pritchett 1918). In 1914, the Joint Committee on Engineering Education of the National Engineering Societies secured funding from the Carnegie Foundation for the Advancement of Teaching to hire Dr. Charles R. Mann, professor of physics at the University of Chicago, to prepare the formal report that followed in 1918.

Mann was fundamentally concerned that engineering curricula were overly broad and taxing, placing unnecessary demands on students. Along with forwarding a plan for applying the case study method, one of his primary recommendations was to decrease the student load to no more than 18 h/semester. This was intended to encourage faculty to pare down crammed courses to their essential content. Alternatively, Mann reviewed the efforts of several schools to increase the duration of undergraduate education, presumably to augment the educational experience by spreading requirements over 5 years. Instead of better-distributed curricula, however, he located at these institutions a tendency for congestion to intensify, as ''whenever a professor gets more time for instruction, he usually tries to cover more ground'' (Mann 1918).

Prefiguring several tenets of total quality management, Mann went on to state that ''the ultimate success of any organization depends on . . . the manner in which those in control coordinate and interrelate the intelligences and imaginations of men.'' He asserted that engineering education needed curricular integration and a healthy dose of managerial and ''humanistic'' courses because, ultimately, the ''conception of the professional engineer'' should be ''as the creator of machines and the interpreter of their human significance'' (Mann 1918). Mann applauded university departments that had added novel ''administrative'' (i.e., management) courses and called for further development in this direction. However, affirming the status quo, he recommended the 4-year bachelor's as the basis for professional education.

Report of Investigation of Engineering Education, 1923–1929

Beginning in 1923 and ending in 1929, the next major phase of investigation had more extensive consequences. Building on the momentum of the Mann report, ASEE inaugurated a formal investigation into the efficacy and standardization of engineering education. Again with financial assistance from the Carnegie Foundation for the Advancement of Teaching and in tandem with ASCE and other engineering societies, the Board of Investigation and Coordination (BIC) acquired the formal cooperation of over 150 colleges and universities—what amounted to almost every engineering institution of the time. The 7-year study culminated in the *Report of the Investigation of Engineering Education, 1923–1929* (Wickenden 1930). This report is noteworthy both for its unprecedented scope and because it frames the key issues of the FPD debate, including the need for a well-rounded, holistic curriculum.

In 1927, the BIC formally addressed ''The Question of a Longer Engineering Curriculum.'' In this smaller section of the longer report, it was noted that during the 1910s and 1920s over 20 institutions attempted to lengthen their curricula. This pool was significant as it represented nearly 15% of the day's engineering programs and included many prominent universities. Although most of the efforts to move beyond the standard model were short-lived—by 1927, only Dartmouth College, Columbia University, and Northwestern University still offered curricula longer than 4 years—the underlying problems necessitating the departure from the status quo remained.

Of primary concern for these institutions was to augment ''the standards of engineering education on its humanistic and scientific sides, rather than to extend the technical instruction to a more advanced level.'' A conglomeration of leading midwestern institutions added a fifth year to include ''a substantial proportion of fundamental (i.e., basic science) and humanistic subjects, omitting if necessary a sufficient amount of the more advanced technical work.'' Realizing that the half-life of specialized technical knowledge was short, whereas that of analytical abilities and professional skills was longer, faculty at these institutions wanted to ''enrich the student's conception of engineering and its place in social economy,'' a desirable outcome of CE education to this day (Wickenden 1930).

Although the BIC recognized this need ''to develop, broaden, and enrich engineering education,'' particularly considering ''the constantly enlarging responsibilities of engineers in society and the increasing exactions of professional practice,'' much like Mann, they worried about the ramifications if 5 or 6 years became the standard. In addition to the temptation for institutions to ''inflate their programs,'' adding little or no value to the profession, there was growing concern in the university engineering community over the burgeoning field of engineering technology.

Engineering had long been codified into a formal academic discipline, but for many practitioners it remained an art in the French sense of a métier, or trade, to be learned on the job. Mann estimated in 1918 that almost half of the country's engineers did not have college degrees. The onset of a third, alternate track to engineering practice, the technical institute (TI), significantly complicated the professional equation. TI graduates represented a hybrid between the university-educated engineer and the trades-route engineer. The BIC worried that TI graduates might erode the prestige of university programs by flooding the market with technically competent but less-polished personnel trained more quickly than at traditional university programs. Lengthening undergraduate education was thus undesirable, as it would increase the time differential between university and TI graduates.

Following the lead of the universities adding another year, the BIC urged engineering programs to become even more broadly based to help distance ''professional'' education from TI ''technical training.'' Rather than more education, the BIC concluded that a different kind of education more responsive to ''humanistic and scientific sides'' would best serve the profession. However, for advanced students, more schooling was considered absolutely necessary. The BIC stated quite plainly that undergraduate education did not ''constitute in itself adequate preparation for many of the higher forms of engineering activity.'' They located a ''widespread desire among educators to provide a superior preparation, beyond the possibilities of a four-year curriculum, for students who give promise of developing into leaders of engineering and industry.'' Those ''well above the average in general ability'' should be encouraged by faculty to ''extend their studies through one or more graduate years, leading to a higher degree'' (Wickenden 1930).

Although the BIC saw much benefit in encouraging future leaders of the profession to pursue additional, but not mandatory, graduate work, there appeared to be ''little demand for a longer scholastic program for the average student.'' For ''the great body of students,'' 4 years of improved education would be deemed more or less sufficient (Wickenden 1930). Ultimately, the BIC would advocate what has since become the standard discipline organization: the 4-year bachelor's of science in civil engineering (BSCE), with optional graduate school for advanced skills and methods.

Ongoing Reform: Accreditation Board for Engineering and Technology (ABET) Accreditation and National Council of Examiners for Engineering and Surveying (NCEES) Licensing

Throughout the second quarter of the twentieth century, whether through cooperative programs, summer school, or an additional year of education, there was perpetual support within the CE educational community to augment curricula. However, harnessing this support proved a challenge, in large part because there existed no central organization to coordinate educational change. As a temporary conglomeration of numerous engineering societies, the BIC was an unsuitable choice to perform this task. It would take the efforts of engineers working for a different kind of reform to establish the means to regulate and standardize the nation's curricula.

In parallel with concerns for CE education, there arose interest in licensing engineering practice. Before the turn of the century, government regulation of activities such as engineering, medicine, and dentistry was commonly considered intrusive by the practitioners, the encroachment of nonprofessionals into specialized realms of knowledge. From its inception, ASCE had preferred self-regulation to licensure, arguing that only engineers should pass judgment on other engineers. However, as issues of public safety became a leading cry of the days' reformers, licensure began to appear inevitable. After about 1910, civil engineers supported the concept of state licensing to control which aspects of practice would be regulated and to ensure that restrictions placed on professional practice would not be overly onerous. In addition, ''civils'' wanted to stay in-line with other professions such as medicine and law, which were beginning to enjoy increased public prestige and had already accepted forms of licensure (Haber 1991; Pfatteicher 1996).

As engineering licensure laws were enacted by state legislatures, the need for communication between state boards soon became acute. Accordingly, around 1920 the National Council of State Boards of Engineering Examiners, currently NCEES, was formed to work for fair licensure in every state, help enforce regulations, and ensure appropriate levels of experience and education for professional practice—roles NCEES fulfills to this day. As more and more states adopted regulations for professional practice, NCEES also became involved in the push to standardize engineering curricula. In cooperation with ASCE and ASEE, NCEES helped create the Engineers' Council for Professional Development in 1932. This body was the first permanent council consisting of multiple engineering societies and was entrusted with the responsibility of the formal accreditation of engineering curricula from 1936 up to the present, albeit under the current name ABET. If the FPD proposal is to be accepted, ABET and NCEES will play crucial roles, and, as will be discussed further below, both organizations appear willing to work with CE to define and implement the FPD.

ASCE Education Conferences: Signs of Change

Wide support for educational reform continued throughout the second half of the twentieth century, though questions of procedure continually frustrated attempts to enhance the standard curriculum. Until very recently, moving beyond the 4-year model almost always met with resistance and then disappointment. However, it was these efforts that helped lay the groundwork for CE's future.

In 1960 the first ASCE conference focusing on education was held in Ann Arbor, Mich. At that conference, the first formal articulation of the FPD circulated through the 250 participants. These conferees resolved that the standard for CE education should become 5 years. Similar support for the FPD would be shown several years later in 1968 in research conducted by ASCE in coordination with the newly named ASEE and funded by the National Science Foundation to identify the ''Goals of Engineering Education.'' The report noted that ''the increasing complexity of the technological needs of the future . . . [require] the extension of the basic engineering education to include at least one year of graduate level study'' (Wandmacher 1979). Delegates of the 1974 and 1979 conferences came to much the same conclusion (Fadum 1974; Moore 1974; Jones 1979; Nordby 1979; VanHorn 1979).

Partly in response to the excitement generated at the education conference, several universities attempted to lengthen their curricula in the 1960s and 1970s. In turn, ABET experimented with dual-level accreditation. ''Basic'' criteria applied to 4-year programs, while ''advanced'' criteria was an option for programs moving beyond the standard model. Although <10% of all engineering programs requested advanced-level accreditation during this time period, it is important to note that almost 20% of CE programs did so (Nordby 1979).

Nonetheless, administering concurrent 4- and 5-year programs proved to be extremely difficult, as institutions on the same campus could seek accreditation for different engineering programs at the basic or advanced levels, or even both simultaneously. Universities offering the 5-year programs leading to a BSCE found it difficult to compete for students because there was little incentive to prolong education for what amounted to an undifferentiated degree. In addition, few leading institutions joined the effort. Dual-accreditation was subsequently dropped by ABET, only to be reinstated in the early 1980s in a different form. Today, an institution can seek basic or advanced level accreditation in any engineering program, but not both simultaneously.

Pivotal ASCE Education Conference—1995

At the 1985 and 1990 education conferences the story was much the same: active support for the FPD but no effective follow-up linking conference findings to ASCE action (''CE education'' 1985; Meyer 1990; Parker 1990; Smith and Samson 1990). A critical shift resulted from the 1995 conference, however, as steps were finally taken to systematically bring the FPD before the ASCE Board of Direction and the wider CE community. In the summary report of the conference, four primary action areas were identified for the profession: (1) Faculty development; (2) integrated curriculum; (3) practitioner involvement; and (4) the first professional degree (Russell and Yao 1996). To investigate and respond to these action items, the Task Committee on Civil Engineering Education Initiatives (TCCEEI) was formed, reporting directly to the board.

The TCCEEI was composed of engineering practitioners, educators including the first writer, and administrators and was connected through individual members to other ASCE committees such as the Education Activities Committee's Visioning Committee and the Committee on Educator Practitioner Interface. After much consideration over several years of meetings, the TCCEEI urged the Board of Direction in April 1998 that the FPD should become the new paradigm for the education of Civil Engineers. Citing advances in competition and technology as precipitating a need for change, the TCCEEI's final report to the board noted the existence of ''innovative and diverse master's level programs.'' Whereas in the 1920s and 1930s few such programs existed, in the 1990s the educational framework appeared to be in-place to accommodate an influx of graduate-level students, should the FPD be accepted. In October 1998, the board went on to recommend the FPD at ASCE's annual convention. Fig. 2 presents this policy statement. This resolution stands as the pinnacle resolution in a debate lasting most of the century and represents a major step toward achieving multiple goals of the CE profession.

WHY FPD NOW?

Like all professional schooling, engineering education must focus on practice. As was evident to Mann in 1918, a successful engineering curriculum should instill technical proficiency in graduates, which is to say the ability to apply what's been learned to solve engineering problems, in addition to providing the additional skills necessary to perform successfully on the job. These include a grounding in the social and political systems within which work will be accomplished; an understanding of the management of resources such as time, budgets, and people; and the establishment of the professional skills necessary for life-long, ''just-in-time'' learning to stay current on evolving knowledge and techniques.

> The American Society of Civil Engineers supports the concept of the Master's degree as the First Professional Degree for the practice of Civil Engineering at a professional level. ASCE encourages institutions of higher education, government units, employers of civil engineers, and other appropriate organizations to endorse, support, and promote the concept of mandatory post-baccalaureate education for the practice of civil engineering at the professional level. The implementation of this effort should occur through establishing appropriate curricula in the formal education experience, appropriate recognition and compensation in the workplace, and congruent standards for licensure.

FIG. 2. Policy Statement 465, Approved by ASCE Board of Direction, October 18, 1998

Whereas in the 1920s only ''advanced'' engineering students required administrative training, to become gainfully employed today, every engineer must have skills and knowledge in communication, team-building, leadership, and project management principles (Walesh 1995; Florman 1996; Kersten 1996; Russell et al. 1997; ''First'' 1998). Without question further emphasis must be placed on developing these important humanistic and professional skills, yet perhaps an even greater emphasis should be placed on a holistic perspective of how projects interrelate with the natural environment, the community, and advancing technology. In the integrated world we inhabit, it is vital to understand how the profession affects and is affected by the rest of society. Curricula are full, and at what cost to technical understanding should educators strive to make engineers better communicators, managers, and leaders? There is no easy answer to this complicated question, and as mentioned above, this task has been rendered even more difficult with diminishing credit hours.

Reduction in Credit Hours and Engineering Content

In the last 75 years, not only has the number of credits comprising a BSCE degree gradually but significantly decreased, but the total credit hours of engineering content has significantly decreased in many of the nation's leading CE programs as well. Tables 1 and 2 present data collected by the writers outlining these trends at several representative institutions. These data do not represent a random sample from the population of schools offering a BSCE; rather, institutions were selected for the quality of their current CE programs, size, and geographic dispersion. The results are informative.

Table 1 reveals a striking decrease in the total number of credits required for a BSCE degree over the last 75 years. If the eliminated credits were entirely nonengineering subjects, despite the need for a more balanced education, this trend might not be significant. During the time period under investigation, physical education and Reserve Officers' Training Corps requirements once common at land-grant and some private institutions have indeed been reduced or eliminated. In addition, entering engineering freshman are more proficient in mathematics and require little or no precalculus, all of which

TABLE 1. Total Semester Credit Hours Required to Earn 4-Year BSCE or Equivalent

Name of institution (1)	1925 (2)	1950 (3)	1975 (4)	1998 (5)
University of Alabama	153	147	129	130
University of California-Berkeley	144	140	180[a]	120
Case Western	167	154	—	134
Clarkson University	143	154	120	120
Cornell	145	185[a]	126	124
University of Illinois	145	137	129	133
North Carolina State	146	152	129	127
Purdue	174.3	156	134	133
University of Texas	128	146	127	124
Texas A&M	171	—	145	128
UW-Madison	157	152	142	125
Average	152	149	133	127

[a]Denotes 5-year BSCE program weighted appropriately in average.

TABLE 2. Total Semester Credit Hours of Engineering Content in 4-Year BSCE or Equivalent

Name of institution (1)	1925 (2)	1998 (3)	Number of fewer credits (4)
University of Alabama	87	75	12
University of California-Berkeley	94	62	32
Case Western	88	64	24
Purdue	83	69	14
UW-Madison	82	68	14

explains a portion of the reduced credits. However, when Table 2 is examined, it becomes obvious that the total credit decrease stems primarily from the elimination of engineering content from some of the nation's leading CE programs, a trend that is troublesome.

In 1925, for instance, the median curriculum length of 83 CE programs surveyed by the BIC was 147 credit hours, which took 4.18 years to complete. A total of 82.6 h were dedicated to engineering content, with the median value for CE courses being 43 credit hours. Assuming 18 h/semester, CE students took an average of 2.24 years of engineering courses (John 1930). Currently, ABET criteria for basic accreditation requires only 1.5 years of engineering content, whereas ABET 2000 criteria is identical in this respect (ABET 1998a,b). Because ABET assumes 16 h/semester, this equates to a minimum of 48 credit hours of total engineering courses —over two 16-h semesters less content than in 1925 ($82.6 - 48 = 34.6$). Although many schools require more than the minimum required content, nonetheless, as Table 2 demonstrates, there has also been a noticeable reduction in engineering credits at many universities. Simply put, there is less engineering in today's CE curricula.

Changing Definition of Civil Engineer

From 1925 to the present as CE practice has evolved, components such as surveying, drafting, thermodynamics, electrical circuits, and required structural engineering courses have been reduced or deleted from many CE curricula. As these courses have been removed, others such as computer programming and applications have found their rightful place in many CE curricula alongside humanistic and professional skills courses. Yet this translates to even less technical content than before. The reason for this shift can be found in the ongoing redefinition of civil engineering education and practice, which Table 3 helps illustrate.

Up until recently, most civil engineers at some point in their careers surveyed. Proficiency in this area was deemed crucial

TABLE 3. Comparison of Curricula at UW-Madison, 1945 and 1998 (Source: Course Catalogs, UW-Madison)

1945 curriculum (1)	Credits (2)	1999 curriculum (3)	Credits (4)
(*a*) Surveying and engineering technology courses			
Drawing	3	Civil engineering graphics	2
Engineering curves	2	Engineering spatial measurements	2
Elementary surveying	4	Introduction to computer programming	1
Land surveying	3	Problem solving using computers	3
Route surveying	3		
Advanced surveying	2		
Six-week summer camp (Railway survey and topographic engineering	6		
Total credits	23	Total credits	8
(*b*) Fundamentals of engineering			
Statics, dynamics	5	Statics	3
Mechanics of materials	5	Dynamics	3
Materials of construction	4	Mechanics of materials	4
Contracts and specifications	2	Materials for constructed facilities	3
Elementary hydraulics	4	Hydroscience	3
Hydrology	2	Fluid mechanics	3
Sewerage	2	Environmental engineering	3
Water supply	3	Soil mechanics	4
Highway engineering	3	Transportation engineering	3
Total credits	30	Total credits	29
(*c*) Structural engineering			
Structural analysis	4	Structural analysis	4
Structural design	5		
Masonry	2		
Reinforced concrete	3		
Substructures	1		
Total credits	15	Total credits	4
(*d*) Mechanical and electrical engineering			
Thermodynamics	2		
Direct current machinery/laboratory	4		
Heat engine testing	2		
Total credits	8	Total credits	0
(*e*) Remainder of required curriculum			
Junior reports	2	Applied civil and environmental engineering courses	17
Senior reports	2		
Thesis	3–5	Technical/natural science courses	10
Total credits	7–9	Total credits	27
Overall total credits	83–85	Overall total credits	68

for CE practice, and accordingly, students took 23 h of surveying and drafting at the University of Wisconsin-Madison (UW) in 1945—a credit sum representing over a quarter of the CE curriculum at that time. Advances in surveying technology such as electronic distance measurement and the development of new technologies such as photogrammetry, remote sensing, and global positioning systems have enabled spatial data to be collected and analyzed more effectively and accurately. Since determining and understanding spatial measurements remain essential skills of the practicing civil engineer, it would follow that students would take a comparable set of courses to master the powerful new technologies available for these tasks. However, current students at the University of Texas, Austin, can graduate with a BSCE without having taken a single course in surveying, while UW requires only 2 h of engineering spatial measurement (Pauschke and Ingraffea 1996). Has the technology progressed so far that one course teaches all that is needed to know about this important subject? Is this the only area that is currently deficient in CE curricula?

Again using UW as the primary example, the answer to both questions is clearly no. In 1945, students took 15 h of structural engineering courses and 8 h of mechanical and electrical engineering, whereas in 1999 students are required to take just 4 h of structural analysis and no specific courses in mechanical or electrical engineering. Graduates of 1945 had a working understanding of buildings, foundations, engines, thermodynamics, and electrical circuits, but today's graduates may enter the job market possessing only fragments of this knowledge. Notice in Table 3 that a third of the 1999 CE curriculum is comprised of distributed electives in various facets of engineering. Graduates can conceivably acquire a moderate comprehension of engineering subjects, but students would have to make that choice, revealing the crux of the issue.

Clearly something major has changed in the logic of CE education. Whereas once CE comprised basically a single entity with all students taking the same distributed core of courses whether they planned to work in designing/constructing highway bridges, water treatment plants, or commercial facilities, CE today is a multifaceted discipline with numerous specialties. To accommodate today's dynamic market demanding both specialized knowledge and proficiency in many technologies, notably computers and their applications, CE curricula must be flexible and responsive. By leaving a third of the curriculum ''open'' and offering hundreds of courses, UW and many other universities allow students the opportunity to create an understanding of a particular facet of CE. The unified curriculum may be an artifact of the past, with the opportunity for specialization within subdisciplines of CE the future, but is producing specialists at the cost of a common, general understanding the ideal system? Will this help CE become the master-integrating discipline?

Given a trend to reduce credits and given the simultaneous need to further integrate professional skills into the CE curriculum, the result is an unbalanced equation. Not only is there less space in the CE curriculum to begin with, but as we uncover new knowledge with our powerful processing tools, the body of knowledge students must master to become effective civil engineers continues to grow. With less time and a larger variety of material to teach, many students receive less technical education and training than they did in the past. The FPD would allow CE programs to provide a traditional, necessary focus on engineering technology's fundamental aspects, while at the same time allowing these programs to concentrate on teaching and understanding the development of new technologies improving on design/construction processes. Providing another year for education would also open up sufficient space in the 5-year curriculum for professional skills and humanistic content, balancing current constraints on the curriculum in terms of both breadth and depth. Accordingly, the remainder of the paper outlines three possible models to transition to the FPD.

WHERE DO WE GO FROM HERE?

The recent Board of Direction's policy statement represents a significant advancement for the FPD simply by offering a concise definition and clear scope of the end goal. Yet no concept, by itself, can change a profession. The FPD proposal is intended to generate discussion among ASCE members, other professional societies, government, industry, and appropriate state licensing boards. It should be forefront on the agenda of the entire CE community until the growing needs of industry can be balanced with current educational constraints. Civil engineers should rest assured that this is part of the process: similar discussion has accompanied the acceptance of comparable educational reorganization for law, medicine, and most recently, accountancy (Haber 1991; Pfatteicher 1996; ''ASCE'' 1998; Cumming and Rankin 1999).

Encouragingly, since the FPD was circulated there has already been significant discussion in forums such as Engineering News Record, Journal of Professional Issues in Engineering Education and Practice, and throughout the 1999 ASCE Conference. The arguments for and against the adoption of the FPD remain strikingly consistent. In the face of increasing societal and market complexity, proponents cite a need to develop the complete engineer and not enough credits in the 4-year curriculum to accomplish both a sound technical and thorough humanistic education. Proponents want to ensure that advanced training in engineering methods is taught along with professional skills such as project management, teamwork, communication, and leadership, without foregoing a sufficient grounding in liberal arts and environmentally sensitive courses such as ecology, botany, and/or zoology.

On the other side, opponents of the FPD assert that any change should be accommodated within the 4-year system and with optional graduate schooling, which is to support the arrangement described by the BIC in the 1920s. Many opponents find no practical or economic benefit in increasing the educational duration, and some even point to negative consequences. Concerns include the increased costs associated with the FPD such as additional tuition, along with the lack of guarantee that salaries will rise commensurate with such costs.

The most important criticism, however, centers on feasibility. Concerns over what form the FPD will take and the kind of transition that can be expected while establishing accreditation and licensing standards must be addressed. The ASCE resolution posits the master's as the FPD for professional practice. How will the nation's existing programs accommodate an increase in students on the order called for by the ASCE proposal? Does this mean that all graduates of a bachelor's-level engineering program must be accepted into a master's program straight out of college to become practicing engineers? What will happen to those students not accepted into an FPD program? Will they still be able to become licensed professional engineers (P.E.s)? Finally, what if the BSCE degree is a 5-year degree with a required cooperative education component such as offered by the University of Cincinnati and Northeastern University?

While certainly at issue, many of these practical concerns prove less daunting when systematically analyzed. For starters, the FPD is for the future. Nothing will be retroactive, nor will any resolution be enforced abruptly. The professional standing of current civil engineers and graduates of the next few years should not be affected, as P.E.s will most assuredly receive ''grandfather'' status. Moreover, the FPD could take multiple forms, as it is unlikely that a single prescribed route or curricula would be suitable for all individuals. If existing master's

TABLE 4. Current Master's Programs for CE

Type of master's program (1)	Possible curricular focal areas (2)	Structure of program (3)	Possible degree (4)	Possible career tracks (5)
Technical/research-oriented	Structures, environmental, transportation, materials, construction, hydraulics, water resources, geographic information, and geotechnical	Course work and independent in-depth investigation into suitable topic	MS; MSCE; MEnvE	Researcher; technical expert; specialist
Project management	Human resource management, cost estimation, accounting, logistics, total quality management, and communication	Course work	MS; MSCE; MBA	Project manager; construction manager
Organizational management	Strategic planning, organization design, finance/insurance, and public policy	Course work	MS; MBA; MA in planning or public administration	Upper management for engineering construction firm or federal, state, or municipal agency

TABLE 5. Proposed Course Distribution for Structures Education [from Barnes (1999)]

Courses (1)	Semester credit hours (2)
Analysis	6
Steel design (including code application)	6
Concrete design (including code application)	6
Matrix methods	3
Timber behavior and design	3
Masonry	3
Dynamic behavior	3
Foundation mechanics/soils	3
Technical writing	3
Total	36

programs are accepted as the paradigm for the FPD—and this is just one of the options described below—there could easily be several distinct paths to this end. Current master's programs allow students to focus on different facets of CE and learn different skills, as some programs are research-oriented with a thesis or independent research component, and others consist solely of course work. The goal should always be to provide maximum flexibility to satisfy the spirit of the requirement, as this will ensure a smooth transition to a strong future. Bearing this in mind, three possible models for the FPD will be explored below with an emphasis on the feasibility of each model.

What FPD Might Look Like: Current Master's Programs as FPD Model

Three primary types of master's programs are currently offered for professional practice in CE. Table 4 details the trajectory of each of these general types, including possible focus areas and graduate degrees earned. Assuming that a core distribution had been satisfied as an undergraduate or with graduate work, the completion of one of these current master's programs could satisfy the FPD requirements by providing students with the skills and knowledge needed for practice in a wide variety of specialties.

In response to the FPD proposal for CE, the National Council of Structural Engineers Association recently provided such a core distribution to rectify what that group perceived as a gap in current structures education. Table 5 lists the specific courses structures students would have to master as a prerequisite for practice, in addition to completing a ''full academic year of formal education in structural engineering beyond Elementary Strength of Materials'' (Barnes 1999). For an example of a 5-year curriculum leading to a master's of environmental engineering, see Rainwater et al. (1999).

If current master's programs are accepted as the model for the FPD, time schedules could vary for maximum flexibility. After earning a BSCE, for instance, the graduate could immediately enter a master's program, but he or she could also obtain industry experience before returning to school to earn the FPD. BSCE graduates with low grade point averages or significant student-loan debts could choose to work in industry or public service, gaining valuable experience and understanding that would eventually allow them to gain entrance into a master's program. Alternatively, the BSCE graduate could take courses in the evening or on weekends as they worked. Advances in distance education and the virtual classroom make this a viable option even for those employed in remote locations and/or with limited time. Currently, the Georgia Institute of Technology (GT) offers a master's of science in environmental engineering taught entirely through a distance learning program. The GT program consists of 30 credits to be completed over 4–5 years, with 15 h of required courses, 6 h of concentration electives, 9 h of technical electives subject to advisor approval, and a thesis. GT students can also pursue a master's through an all-course-work program (GT 1999). Many other schools are developing similar programs.

Such a staggered entrance of students would allow graduate schools time to adjust to a vast increase in applications and matriculations that would most likely follow the institution of the FPD. As is done currently, work experience would conceivably satisfy some component of licensing requirements. Furthermore, having students ''return'' to school for the FPD could have the added benefit common in the business world of employers compensating employees for educational expenses. Informed and forward-thinking companies may even pay for education to attract and retain engineering talent.

Model of Accountancy: 150-h Rule

There is a second model for the FPD: simply requiring a fifth year of education, be it at the master's or bachelor's level. Under this plan, students would be required to complete a minimum number of semester hours over a range of topical areas. This arrangement could be a transitional form to help move to the master's as the FPD, or it could become the paradigm.

Citing an accelerating information and knowledge economy and the need for prestige in a competitive, global marketplace, the accounting profession is adopting such a program. Despite a nationwide move to reduce credits required for a bachelor's degree, the accounting profession recognized a need for more education. Ten years ago, in January 1988, the American Institute of Certified Public Accountants (AICPA) accepted a proposal to require all new accountants after the year 2000 to have completed a minimum of 150 semester hours of college education to sit for the CPA examination. Much like engineering, the previous standard had been the bachelor's degree. Several states, including Florida, Texas, and Utah, have already adopted the 150-h requirement, while in the next several years, a total of 45 states will have ratified the measure. The AICPA expects all states to have adopted the 150-h rule by 2010.

According to AICPA guidelines, students must earn either a graduate degree with a concentration in accounting from an accredited institution or a baccalaureate degree including ''at least 24 semester hours of accounting at the upper division or graduate level, including courses covering the subjects of financial accounting, auditing, taxation, and management accounting . . . and at least 24 semester hours in business courses (other than accounting courses) at the undergraduate or graduate level'' (AICPA 1999). By the time they graduate with either a master's or a 150-h bachelor's, students should have mastered both the fundamentals and advanced aspects of accountancy.

Even at first glance, it should be obvious that this 150-h requirement must not have been easy for accountancy to accept. It will take over 20 years to be fully implemented, and in the meantime, staggered adoption has led to short-term fragmentation. Early adopters like Florida and Tennessee have had to deal with an influx of graduates in the years immediately before the curricular changes took effect, as students raced through school to take the CPA examination under 4-year requirements. Neighboring states also had to accommodate an influx of 4-year bachelor's graduates looking to qualify for practice without the additional year of credits required by the 150-h states. Nonetheless, the AICPA states that the price accountancy pays now will be worth the increased rates of compensation and control over their fate in the technologically sophisticated integrated global marketplace.

Encouragingly, the early adopters have fared well. These states cite improved rates of passing for those taking the CPA examination for the first time, in addition to improved rates of compensation in the workplace. In Florida, for example, the rate of first-timers passing all parts of the CPA examination after the 150-h law took effect jumped from 15% to over 30%. Since adopting the requirement, first-year salaries of 5-year degree holders have been between 8 and 16% higher than their 4-year counterparts (Cumming and Rankin 1999). Clearly, the increased education has benefited accounting companies, as they have paid more for this added value.

The experience of accountancy offers CE a model of transition from a bachelor's to an enhanced professional standard. Instead of requiring a master's for professional practice, the 150-h requirement presents an interesting opportunity for hybridization. With this model, it would be left up to the individual whether to pursue a master's or a 5-year bachelor's with specified, advanced-level courses. The student could satisfy the requirement several ways, providing maximum flexibility when facing such concerns as acquiring financial aid and relocating to another institution for graduate work. If a student was not accepted to a master's program, he or she could conceivably continue taking courses at his or her undergraduate institution until the required credits for professional practice were satisfied, whether that number be 150 or 160. Students could also take ''fifth-year'' courses part-time while working in industry after graduation.

This model is further attractive to CE as it would provide a high level of continuity during its adoption by granting institutions time to enhance their curricula and define what constitutes the fifth year. As discussed above, structures and environmental engineering—subfields of CE where the master's is the de facto degree for professional practice—have already begun defining the fifth year (Table 5). Additionally, the 150-h model would work particularly well with existing 5-year cooperative programs. Cooperative education work experience alone would not serve as the fifth year, but credits earned in that manner could satisfy a portion of the FPD curriculum. Finally, the selection of a 150-h requirement would allow universities without existing graduate programs to compete for students, a major advantage from a feasibility standpoint.

Professional School Model

A third model satisfying the FPD proposal, albeit a more complicated alternative than the previous two, would be to institute a class of CE professional schools on the order of medicine or law. After earning a general degree as an undergraduate with a required base of engineering, science, and math courses, qualified students would then attend a 2- or 3-year professional program. The current Fundamentals of Engineering examination could be modified to serve as the entrance examination for these professional schools, much as the Law School Admissions Test serves as the entrance examination for law school. A new test could also be created, or the currently used Graduate Records Examination could be kept instead. Graduates of such a professional program would then enter industry, wherein they would acquire an acceptable amount of experience before being allowed to take the P.E. examination to qualify for professional practice in his or her specialty area. Students could earn their degree immediately following the bachelor's, or they could chose to work in industry for several years after graduation before entering a CE professional school.

J. T. P. Yao, among others, has discussed the professional school model (Meyer 1990; Schenk 1999; Yao and Roesset 1999). A short-term disadvantage of the professional school is that it would require engineering colleges to drastically alter curricula and faculty. For this reason alone, the professional school model would likely take longer to implement on a wide scale, but in the meantime, entrepreneurial and creative institutions could unilaterally create professional schools. This model would also provide CE with the unique opportunity to erect an entirely novel educational structure, more flexible in regard to incorporating technological advances, and tailor-made to the needs of the changing market. As is done with business school, this model would also provide the opportunity to involve practitioners in the educational process. Finally, pre-engineering students not admitted into a professional school would possess a general college degree applicable for jobs in fields other than engineering.

New Expectations Atmosphere

Curricula has been emphasized in the discussion of the three possible models. Though dramatic changes in the CE curriculum are necessary to strengthen the CE profession, they are far from sufficient. Attention must be given to the expectations atmosphere within CE programs.

Students respond to what is required as well as the atmosphere within which it is required. Unfortunately, the message implicit in many CE educational programs is that civil engineers are essentially doers. A de facto mission of these programs is to train graduates to work for business and law school graduates, either as doer employees or as doers in the social/political/economic structure. In accordance with expectations, CE students and practitioners perform well as doers and producers but not necessarily as leaders and managers. However, if CE education included a directing and deciding message—that is, a management and leadership theme—most CE students would respond favorably. They clearly have the ability to fulfill broader expectations. The acceptance of an FPD would allow such a positive, defining message to be integrated into the education experience of tomorrow's civil engineers—one more reason why CE needs the FPD.

IMPLEMENTATION—HOW DO WE GET FPD UP AND RUNNING?

ASCE is preparing to celebrate its sesquicentennial in 2002 with a plan of action to take civil engineering into the twenty-first century. The fate of 100 years of discussion should most likely be decided in the next few years. Even with diligence on the part of ASCE members and the CE community, 10 to 20 years will probably pass before the FPD can become a fully integrated reality, as the example of the 150-h requirement for accounting shows us. Lest any critics suppose that this push is driven by academics for academics, do not underestimate the rethinking, problem-solving, and administrative obstacles, not to mention increased teaching loads, that will follow such comprehensive curricular reform. However, the purpose of CE education is to produce competent, effective CE leaders. By accepting the FPD to elevate the profession, the future payoff will be worth any temporary struggle.

Just because ASCE is the first to recognize the possibility of a diminishing role in the future does not mean that other fields will not face the same. Eventually, all branches of engineering will have to confront the changes CE is considering because we all operate in the same integrated global economy. However, ASCE should not ''wait'' on other engineering societies before implementing the FPD. In keeping with its historic role of being the first nationwide engineering society, ASCE's leadership in the FPD seems particularly fitting. ASCE should continue to include other branches of engineering in discussions, particularly through sister societies and ASEE, in addition to forwarding the debate to appropriate industrial and governmental units.

To effect any meaningful change, ABET and NCEES must be included and integrated into any FPD proposal. Based on its recent strategic plan and accreditation criteria, ABET seems willing to assist CE in defining and implementing the FPD. ABET's sixth strategic goal is to ''Encourage and accommodate new educational paradigms,'' while specifically assisting ''engineering disciplines in defining the first degree for professional practice.'' ABET advanced level criteria currently encourages ''the development of new, innovative, and/or experimental'' programs leading to ''one or more degrees,'' whereas ABET 2000 advanced criteria specifies an additional year beyond the bachelor's level. In general, ABET 2000 guidelines allow CE programs more leeway in developing curricula, encouraging experimentation to find the right formula for basic science, technology instruction, sociocultural understanding, and project administration—an adaptable set of requirements that will blend seamlessly with the FPD (ABET 1998a,b).

Although flexible, ABET criteria is nonetheless outcome-oriented, and thus how individual programs structure their curricula remains a practical concern (Scranton 1998; ABET 1998a,b). ASCE must continue to support local experimentation and encourage dialogue on this issue, particularly with other branches of engineering. Sooner or later changes made in CE will affect mechanical, industrial, electrical, computer, and chemical engineering departments, and thus it is crucial for a feasible plan of action for engineering schools to be formulated as soon as possible. ABET can assist in this endeavor by helping coordinate efforts to institute the FPD for CE, and eventually other branches of engineering.

When the time comes, ABET can also help CE negotiate licensing and registration changes with individual states through the NCEES. According to a past president of NCEES, Steven T. Schenk, P.E., the FPD is an appropriate move for the profession. Considering that in the majority of states one can still become an engineer with only a high school education or technology degree, Schenk warns the profession not to accept the lowest common denominator for professional practice (Schenk 1999).

Although NCEES seems poised to support CE in the FPD endeavor, it will no doubt be a challenge to get the FPD passed in all 50 states. However, the more unified the discipline, the easier will this challenge become. Individual CE programs should begin reevaluating curricula and defining what the FPD could look like at their institutions. Universities should not wait for legislation requiring the FPD to establish their own programs but should proceed at once to bring about a plan of action to transition to the FPD.

CONCLUSIONS

As technology and the practice of CE continues to change in the integrated global marketplace, it is the obligation of ASCE, which represents the grand profession, to define the minimum standards for CE. By failing to act positively, we abdicate our responsibility and enable others, perhaps nonengineers, to define crucial requirements for the profession. The time has come for CE to address the limitations of the current educational system.

The FPD is a plan growing out of this need. It is for the future, offering CE a chance to proactively take control of its destiny by ''raising the bar'' and demanding more from its constituents. With an FPD, civil engineers will once again become ''the master integrators'' of society, guiding change in our technologically dependent society instead of performing only as doers (Bordogna 1998; Walesh 2000). Accepting the FPD will enhance the profession by providing civil engineers with the knowledge and skills they need to excel in the information and knowledge economy of the future. Through the additional education imparted to the individual, tomorrow's civil engineer will enter the marketplace qualified to perform at a higher level from day one and compete more successfully for leadership positions. Over time, as more and more civil engineers rise to positions of responsibility and authority, increased prestige and influence will necessarily follow because of the added value brought to clients and the public at large. CE will not have to ask for a role in the future; it will have been earned.

ACKNOWLEDGMENTS

Previous portions of this article were presented at the 1999 ASCE Annual Meeting and Conference in Charlotte, N.C., and published in the proceedings *Forming Civil Engineering's Future*. The writers would like to thank ASCE, as well as the numerous faculty and staff who helped provide the data for Tables 1 and 2.

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