ROLES OF CIVIL ENGINEERING FACULTY

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ABSTRACT: The education of civil engineers who will continue to fulfill the societal demands of the 21st century has been the subject of a number of workshops and conferences in recent years. The writers believe that the role of civil engineering faculty in the education of future engineers is extremely important. Faculty will be required to teach new topics in different ways and with different tools. Yet in a research university, teaching is often only one of four or five activities a faculty member must perform. In a typical faculty reward system for research universities, teaching is not considered as important as paper publication or research marketing. In this paper, faculty needs are outlined, the roles of faculty members are discussed, and the current faculty reward systems are critically reviewed.

INTRODUCTION

A former executive director of ASCE, W. H. Wisely (1974), said that civil engineers are ''true professionals'' who are obliged to educate current and future members of the profession. The methods used in the education of future civil engineers who will fulfill the societal demands of the 21st century have been a matter of serious concern, leading to a number of workshops and conferences in recent years. ASCE has played a major role in this effort since 1874. According to J. M. Hayes (1992), a former vice president of ASCE, trends in civil engineering education in the United States were studied in depth at least a dozen times between the years of 1874 and 1974. In addition, educational conferences were organized and conducted by ASCE at Ann Arbor, MI, in 1960; Columbus, OH, in 1974; Madison, WI, in 1979; Columbus, OH, in 1985; Las Vegas, NE, in 1990; and Denver, CO, in 1995. Since 1998, there has been a National Education Congress at each Annual ASCE Convention. At the 1995 ASCE education conference (ASCE 1994) in Denver, participants recommended the following:

- Integrating all the required skills into coursework
- Requiring a post-baccalaureate degree for practice
- Pursuing faculty development programs
- Recruiting more practicing engineers into college teaching

A special ASCE committee (Russell and Yao 1996) has begun to implement some of these recommendations. The writers are pleased to note that the ASCE Board of Direction has taken positive steps with at least two of these four recommendations. A panel of educators, practitioners, and government officials convened to discuss future civil engineering education in the 21st century at a session during the 1998 ASCE Convention in Boston (Moore et al. 1998). Given the importance that a devoted faculty will have in the successful implementation of any educational changes, it is now important and timely to discuss the roles of civil engineering faculty in the modern university as well as the faculty reward system needed for further improvement.

In this paper, the writers look at the needs for change in both the way we teach engineering and the roles of faculty members, the causes for these changes, some of the present trends and educational initiatives, and the procedures used at most research universities to evaluate faculty performance. We discuss some of our concerns with engineering education, the potential role of practitioners in this important venture, and possible actions. Although the emphasis of the paper is on undergraduate education, any major change will require simultaneous consideration of graduate and continuing (lifelong) education programs.

CAUSES FOR CHANGE

General Remarks

In the past, most civil engineers were trained to be very efficient solvers of routine problems. They performed approximate analyses (using a variety of methods and analogies), computed stresses and compared them to code formulas in design or supervised the construction process, and dealt with equipment and labor issues. The past desire of educational institutions was to produce engineers at the bachelor's level who could be of immediate use to industry, though industry was willing to conduct in-house training programs for beginning engineers. Only a few universities perceived their role as that of educating rather than training engineers. It was at the graduate level where the reasons for different formulas and approaches were explained, teaching the ''why'' instead of the 'how.'' The implication was that only a small number of engineers had to know this and that the demand was mostly for glorified technicians (Roesset and Yao 1990). This debate between education and training is still very much alive today.

Influence of Computers

With the advent of computers, the need for approximate methods of analysis diminished, though there is always a need for simple methods to check the general validity of computer results. Even the most conservative educational institutions have reluctantly phased out the teachings of clearly obsolete methodologies. For some time, however, the number of analysis packages available in practice was small. Most of the programs were developed at universities, and they often required substantial training to be used correctly. Several institutions replaced the training in hand computation with training in the use of existing software (particularly their own) in order to satisfy the immediate short-term needs of industry. The debate between developers and users of computer programs is also an ongoing one.

As user-friendly, general-purpose, extremely powerful analysis and design software, as well as virtual construction, visual computer-aided design, and three-dimensional walk-through programs become available, the traditional routine analyst/designer is becoming obsolete. The problem is compounded by the fact that international teams who communicate almost in-

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stantaneously through the Internet and/or fax may perform projects in countries that can provide services at a smaller cost. Highly trained and experienced users of the available software do not even have to be engineers. All that is necessary is to have a few supervisors who can check the reasonableness of the input models and of the results. The type of engineer that society will need in the 21st century is thus radically different from the traditional engineer of 50 or even 25 years ago. In addition, a shift from empiricism to a more theoretical basis has been occurring, necessitating a higher level of education. Pennoni (1998) stated that ‘‘U.S. civil engineers must re-tool or become obsolete except as technical processors—using the computer to meet the requirements of codes, standards, and regulations.’’ If the role of the civil engineer has changed, this means that faculty members must be able to teach new and different courses, and in order to formulate and implement a new curriculum, they must be familiar with the new topics.

University Education and R/D Practices

The organization and goals of universities have changed also. Engineering faculty used to have many years of practical experience, were devoted to teaching (with open-door policies for students with questions), and did mostly bibliographical or applied research keeping in touch with the practical side of the profession. Only a few institutions granted graduate degrees and were therefore actively involved in basic engineering research. Since the sixties, the number of institutions with graduate programs and with claims to innovative and revolutionary research capabilities has skyrocketed. As the primary role of universities has changed from undergraduate education to research, the time devoted to the former has consistently decreased, since relatively few undergraduate students can be immediately productive in research. The open-door policy of the faculty has been generally replaced by rigid office hours that are frequently canceled. The ever-increasing number of international as well as national conferences and workshops held during the academic year further aggravate the problem. Faculty members must attend these meetings to achieve visibility and/or to have a good chance at obtaining research funds. Assistant professors are now hired as soon as they complete their doctoral degrees, and sometimes even before. They have in most cases very little, if any, exposure to engineering practice. Within five years, they are required to have published a substantial number of papers in refereed journals. They must also have raised a significant amount of research funds, and they must have completed the supervision of at least one doctoral student. This leaves very little time for consultation with undergraduates or for exposure to engineering practice. As a result, it has become increasingly difficult at many universities to teach meaningful design courses and, in particular, capstone and synthesis types of design courses using only full-time faculty. This means that we must provide regular faculty members with time to get exposed to the practice of engineering and reward them for their effort. Alternatively, we must find ways to attract experienced and highly qualified practitioners to the academic life.

Technology Advances

The advances in computer technology and engineering software have caused the loss of many jobs. They have also allowed properly conceived and nontraditional design courses to include much larger and much more meaningful projects, effectively eliminating the need for cumbersome hand computations. Yet, as was pointed out correctly by Peck (personal communication, 1998), ‘‘even in complex problems there are order-of-magnitude estimates and checks that can be made; they give perspective and cultivate a sense of proportion.’’ The writers also echo his question: ‘‘Can’t this technique be taught?’’ Meanwhile, the development of user-friendly software and CAD packages has allowed students to conduct extensive parametric studies that can provide in a relatively short time part of the experience that would take years of office work in practice. The advent of the Internet and all the recent multimedia developments have allowed universities, on one hand, to facilitate and increase the communication between students and faculty and, on the other, to develop new electronic textbooks and simulation packages that can revolutionize the way we teach. There is no doubt that these are all invaluable tools that can tremendously enhance engineering education. Yet it should be remembered that these are only tools that will not replace faculty. As Brown (1996) wrote: ‘‘Perhaps people will be able to forsake the fireworks and bells of the information age and give time to developing wisdom, understanding, and knowledge.’’ Moore and Yao (1998) stated that ‘‘most of us need the discipline and the fundamental knowledge that come with it. . . . The Internet as well as all the desirable software are tools and definitely not a replacement for education.’’ This implies that faculty members must be familiar with the new technologies available for communication and transfer of information, while putting them in the proper perspective. We must not only be able to introduce our students to the new means of communication in technical communication courses but also to make use of these means in engineering subjects to improve the delivery of the material. As an example, exposure of the students through simulations to realistic environments can provide exposure that would take years of practice to acquire.

TRENDS AND INITIATIVES

Teaching Methodologies

At a time when state contributions to public universities are in some cases as low as 25% of their total budget, there is a natural interest in reducing the costs of education, particularly undergraduate education. Some of the changes in teaching styles that have been suggested are intended to achieve cost reductions by substituting faculty time with that of graduate students acting as mentors. Unfortunately, cost reduction schemes rarely result in actual improvements in quality. Others are provided, at least on paper, to improve the quality of teaching for the average student, who may no longer fit the mold of traditional engineering students. Most teaching at present is abstract (based on the mastery of basic principles before seeing their applications), verbal (with a reduced number of graphical displays and laboratory demonstrations), deductive (going from general axioms to specific applications), and sequential (proceeding in a logical order with different topics and subjects). Although this system has produced outstanding engineers worldwide through the years, many potentially great engineers may have been lost to a system that does not understand their learning needs.

Some of the new teaching approaches that have been suggested, such as active or cooperative learning, are intended to reach students who may depend more on physical observation (sensing) and visual demonstration to learn and assimilate the material; who prefer an inductive approach, going from the specific towards the general; who enjoy active participation in the classroom; and who need to see the global picture to fully understand. Although these new teaching styles are promoted as a replacement for the traditional lectures, sometimes dubbed as being ‘‘the most inefficient way to transmit information,’’ the writers believe that, instead of serving as substitutes, both methodologies should be considered complements of each other, so that a better-balanced system may be obtained. After all, the objective of education is to teach students how to think and not just to transmit information. The distinction between ‘‘information’’ that may be readily available and ‘‘knowledge’’ that must be acquired was also made by Brown (1996). Faculty members must also learn these new teaching techniques and their potential value, keeping up to date on the latest developments. More importantly, university administration must be aware of this need.

Organization and Dissemination of Knowledge Base

Among others, *Engineering* (1985), Bordogna et al. (1993), Philips (1993), and NSF (1995a) emphasized the continued need for a strong foundation in science in a broad and general engineering education. Roesset and Yao (1988, 1990) also emphasized the importance of fundamental studies such as engineering mechanics. Parker et al. (1990) reexamined the civil engineering curriculum and recommended a start from the beginning in redesigning the curriculum for the next century. Moore and Yao (1998) suggested possible ways of educating structural engineers for modern practice. The Engineering Deans Council and Corporate Roundtable (‘‘Engineering’’ 1994) recommended that universities continue teaching fundamentals and prepare students for the broadened world of engineering work by incorporating team skills, communication skills, leadership skills, system perspective, and integration of knowledge through the curriculum, as well as commitment to quality, ethnics, and other matters. Pennoni (1998) said: ‘‘There is still a need for the experienced and/or creative engineer, but not to the same degree as in the past, and this new engineer of today and the future must have much broader skills. He or she need not have the capability to solve all of the problems related to a project, but must be able to recognize all areas of concern and properly deal with the issues, i.e., legal, political, societal, aesthetic, and financial, as well as technical, economical, and environmental. . . .’’

Two important issues are the duration of a civil engineering curriculum and its relation to professional licensing. Most professional degrees (lawyers, medical doctors, etc.) require 7–10 years of education and training. Is it realistic to expect that engineers with a four-year bachelor’s degree be considered professionals of the same level and making similar salaries? Hall et al. (1988) recommended exploring the concept of a master’s degree as the entry-level professional practice degree. Ingersol (1972), Marcuson et al. (1991), Philips (1993), Moses (1994), and NSF (1995b), among others, also advocated a post-baccalaureate professional engineering degree. The desirable civil engineer that would satisfy the societal needs of the 21st century will indeed require more than four years of education (Galambos, personal communication, 1998). Recently, the ASCE Board of Direction ‘‘approved a resolution endorsing the master’s degree as the first professional degree for the practice of civil engineering’’ (ASCE 1998). The Educational Activities Committee has been charged to develop a policy and a plan for its implementation. The requirement of a master’s degree is a controversial issue that has resulted already in a number of papers and presentations for and against this requirement. Any further discussion of this topic is beyond the scope of this paper.

Recent University Initiatives

A number of initiatives are in progress to implement several of the above-mentioned changes. For instance, Louisiana Tech initiated a new program in 1997 where a group of students take together a series of courses with mathematics, physics, chemistry, and engineering topics integrated and coordinated so that the material covered finds immediate application to a practical problem. Students are exposed to design projects from the very early stages. They are also taught to work in teams, and they have a more active participation in the classroom. The students involved in this program have been enthusiastic about it. They appreciate the reduced size of their group, the relationships developed by taking the same courses and working in teams, the increased exposure to the faculty, the ability to see the practical applications of what they learn, and the faster exposure to useful computer software. Yet the success of a program of this kind depends strongly on the availability of dedicated and interested faculty, willing to accept innovation and to devote a significant amount of time to teaching. Cooperation and communication among the teachers to effect the collective learning experience is sometimes missing. There can also be some deficiencies in this system, such as: (1) stronger students may carry the weak ones; (2) team grades reflect the collective effort, which can be detrimental; and (3) less enthusiastic and less capable students tend to be parasitic to the team progress. Moreover, it requires the willingness of the college to devote substantial resources to the program and to recognize the effort of the faculty involved.

A similar program was started at the University of Maryland with support from the National Science Foundation. The National Science Foundation is also sponsoring eight engineering education coalitions involving many universities integrating engineering curricula for the first two years. Texas A&M University (TAMU) is the leading partner of the Foundation Coalition (FC), emphasizing computer technology, teamwork, and integration for the first two years. All ten departments in the College of Engineering at TAMU have participated in uniform and integrated freshman courses and adopted at least a portion of the five-course sophomore-level basic courses in engineering sciences. In the uniform FC freshman curriculum, cohorts of students participate in Inclusive Learning Communities (Caso et al. 1999). Sophomore courses emphasize the application of conservative principles in solving various problems. In this sequence, for all engineering students, the Department of Electrical Engineering successfully demanded to have their own course with only electrical applications. The other four courses are integrated in the sense that students apply the same conservation principles to solve problems in statics, dynamics, materials, and heat transfer. The Foundation Coalition also emphasizes earlier exposure (from the freshman year) to design cases of different levels of complexity and contact with professional engineers.

The Department of Civil Engineering at the Air Force Academy has a unique program called the Field Engineering and Readiness Laboratory (Swint 1993). Before they begin civil engineering studies, all sophomore students build something on campus with the supervision of experienced soldiers. From then on, each civil engineering course will use what the students built as examples. For instance, when students take the soils and foundation course, they learn why the foundation was built in a certain way and how it was sized. After they have learned the course material, the students are challenged to produce a better design.

Another innovative example is the Integrated Teaching and Learning Laboratory at the University of Colorado at Boulder (Monaghan 1998). The new $17,000,000 center serves 2,250 undergraduate and 1,200 graduate students. Students are introduced to a hands-on design approach through the use of 30 workstations and various working machines. Projects include bottle rockets powered by compressed air and water, an Archimedean screw, a fishing pole for wheelchair users, and a ski-walker. Cutaways and transparent panels in the building reveal wall construction and plumbing, and more than 250 sensors, gauges, and control panels can be used to check conditions of the foundation and structure of the building. Now, a Discovery Learning Center (DLC) is being planned as a partner to the Integrated Teaching and Learning Laboratory (Corotis et al. 1998). The DLC will host new research opportunities for undergraduate and graduate students.

FACULTY NEEDS AND RESPONSIBILITIES

Successful implementation of major curriculum revisions or educational initiatives requires the availability of willing and dedicated faculty. While computers and multimedia technology will enhance the quality of teaching and while graduate students may help with the mentoring of undergraduates, there will still be a need for lectures and the more traditional methods of instruction. In spite of the substantial pressures and demands that research universities place on young faculty members, many of them devote a significant amount of time to preparing and updating class notes, homework, and laboratory demonstrations on a continuous basis as well as personally advising students. Others, unfortunately, feel forced to repeat year after year the same lecture notes—in some cases, the ones they received when they took the course as students. Graduate students with little faculty supervision and intervention very often teach laboratories. Curriculum revisions are done in most cases in a piecemeal and incremental manner. Occasionally, a new course is created without in-depth consideration of how it affects the overall program or how it interacts with other courses. Most of the time, we add or delete material as a result of (1) a top-down mandate of reducing the total number of required hours for graduation and/or (2) horse-trading between the faculty in different subspecialties.

A comprehensive redesign of the curriculum starting from scratch, as suggested by Jester (1989) and Parker et al. (1990), is rarely done. Whenever more serious revisions are made, they are often based on the adaptation at the local level of what is done at other universities in an attempt to emulate them. Whether these changes were indeed the best ones for the place is seldom considered carefully.

The most important attributes in a teacher include a solid knowledge and clear understanding of the material to be taught (going well beyond the matter covered in the course), dedication and commitment to teaching and genuine caring for the students, and good communication skills. Individuals who possess the above-mentioned qualities are likely to become successful and respected teachers, but they may not necessarily be successful in moving upward in their academic career if their research activities are lacking.

Engineering professors are normally hired at the completion of their doctoral degrees and thrust into the classroom without any formal training as teachers, relying only on their own experience as students and their personal abilities. In some enlightened institutions, starting assistant professors are first assigned graduate courses related to the topic of their dissertation or their ongoing research. They do not teach basic undergraduate courses until they have a proven ability in teaching. However, in many (if not most) universities, the process is reversed, because the senior faculty members do not want to spend their time teaching undergraduates. There are states, in fact, where teaching a graduate course is given 50% more credit than teaching a basic undergraduate subject.

Some universities are beginning to have one- or two-day orientation programs for new faculty. In many cases, this orientation covers only administrative and bureaucratic matters. In others, however, the orientation includes valuable exposure to new teaching techniques and multimedia facilities that can be valuable tools for the faculty. In some places, the faculty orientation may take up to a week of paid time. There are also universities, such as TAMU, which have centers of teaching excellence to offer teaching workshops to the faculty. These are excellent initiatives, which should be maintained and expanded. There should also be a continuous opportunity for faculty to learn about new pedagogical techniques and developments as part of their regular duties. While most universities have some form of sabbatical programs to allow faculty to refresh their research interests and expertise, often called research leaves or research assignments, there are not many equivalent teaching leaves.

FACULTY REWARD SYSTEMS

General Remarks

The present evaluation and reward system at universities does not encourage faculty to dedicate time and effort to teaching, particularly at the undergraduate level. In most institutions, the reward system is based foremost on the amount of funding granted. Many universities will consider five aspects in evaluating faculty performance: teaching, research, publications, administrative duties, and service. The range of ratings in teaching tends to be narrow: very good and excellent. It is difficult to find anyone described by his/her colleagues as a bad teacher, though bad teachers do in fact exist. Research reflects purely the amount of funding generated. In a litigation-prone society, it has become impossible to judge quality of work on a subjective basis; therefore, evaluation must be based on counting beans. Even recommendation letters written by outside reviewers have become essentially unclear and must be read carefully to detect what is said between the lines. These letters are in the public domain and no one wants to be sued for giving a negative opinion.

Few, if any, faculty members have their papers read and evaluated by their colleagues, and therefore the quality is assumed to be implied by the fact that the papers were published in recognized journals. Clearly, faculty members who generate large amounts of funding can employ a number of full-time researchers (post-doctoral fellows, research engineers, etc.) who will write a large number of papers with the name of the overall supervisor. The number of authors per paper seems to be consistently increasing also. Supervising a large number of researchers is in itself an important administrative job, which should get proper recognition, particularly when the researchers can be assembled into any sort of formal or informal center. It is noted that informal or internal centers have proliferated in recent years. Conducting or supervising a substantial volume of research will inevitably lead to membership in a number of technical, research, and administrative committees, and thus provide the opportunity for important service activities. Generating large amounts of research funds thus guarantees high grades in four of the five evaluation categories. Within a research university, those who can come up with most research funding will always be the stars. Can we expect, then, that a bright young faculty member who wants to be successful will be willing to spend a large fraction of his/her time teaching undergraduates who usually do not contribute to the faculty member’s research record?

It should also be pointed out that use of number of publications as a measure of the quality of a faculty member’s work is becoming less and less meaningful, due to the proliferation of journals. Not so long ago, a faculty member in structures subscribed to/read only the ASCE *Journal of Structural Engineering* and/or the *Journal of Engineering Mechanics*. Today, within ASCE alone, he/she must subscribe to/read the *Journal of Architectural Engineering*, the *Journal of Bridge Engineering*, the *Journal of Composites for Construction*, the *Journal of Computing in Civil Engineering*, the *Journal of Infrastructure Systems*, the *Journal of Materials in Civil Engineering*, the *Journal of Performance of Constructed Facilities* and the *Practice Periodical on Structural Design and Construction*, in addition to the above-mentioned two journals. There are, of course, many, many other journals in structural engineering not connected with ASCE, published by other organizations and commercial publishers. Is the amount of significant research discoveries each year sufficient to fill all these journals? Or are we just facilitating the publication of the same article with minimal variation in a number of different journals? With many more journals available today, fewer people read each paper. As a result, quantity may have had a significant effect in reducing the quality. This fact has an impact on education in the following two ways:

- Administrators in academia put more emphasis on quantity of publications as an easy way out, while few people read these published papers, and thus their significance is smaller and smaller each year.
- Many authors make reference only to their own papers or those of their friends. On the other hand, papers that contain significant results for practice might not be cited frequently because the professional engineers who benefit from them seldom write journal papers where they could reference them. The index counting of the number of citations used as a measure of the value of a published paper is becoming meaningless.

The basic question here is how to change the faculty reward system to put the emphasis on the quality and significance of each paper, rather than just counting the number of publications and citations.

The George Washington University in Washington, D.C., published two comprehensive studies on faculty loads. Yuker (1984) included 217 references, and Meyer (1998) included 207 references. Yuker (1984) stated, ‘‘It should be recognized that institutions, departments, and individuals are frequently not comparable, except in general terms. . . . Rather than seeking equivalencies, we should define workloads in appropriate terms for each department.’’ Meyer (1998) said: ‘‘The reward structure, which has effectively molded faculty behavior to follow the rewards of research will require revision. . . . Changing the faculty reward structure requires substantial administrative support and leadership, as well as faculty involvement, as rewards are realigned to more nearly reflect the emerging institutional mission.’’

Evaluating Faculty Performance

The lack of appreciation for teaching in the present reward system of research universities has led to a number of papers and initiatives. Leonards and Yao (1985) explored a new way of evaluating teaching including scholarship and classroom performance. Boyer (1990) expanded the definition of scholarship to include that of creativity (basic research), integration (applying successful methods in one discipline to solve problems in another), application (solving practical problems), and teaching (writing journal articles and/or textbooks). He pointed out that many modern universities tend to be ‘‘imitative’’—aiming at becoming another MIT or UC-Berkeley, rather than trying to develop their own identity and provide their own leadership. These universities do not seem to realize it is very difficult to be recognized as a leader by following the example of others. Because of the different strengths, traditions, and resources of each institution of higher learning, it is neither realistic nor appropriate to force each and every faculty to fit the same mold. In fact, it is impractical to think that all faculty members will excel in all areas of evaluation and will do well in basic research throughout their lives. Boyer suggested, therefore, that each faculty member be allowed to decide every few years what kind of scholarship to pursue. Faculty members should be accountable for their decisions and should be able to show results of their scholarship. Recently, the Oregon State University (OSU) implemented a new faculty reward system that is similar to Boyer’s approach. Both broadened the scope of scholarship beyond research; however, the OSU model recognizes scholarship in teaching in the areas of discovery, development, integration, and artistry (Weiser 1999).

Recently, UC-Berkeley has put more emphasis on teaching, if the faculty member has a balanced record in research, teaching, and service (Langari and Tomizuka 1998). However, ‘‘people doing strong research appear to be advanced faster than others’’ still.

To implement Boyer’s ideas, the ASCE Department Heads’ Council (chaired by Vince Drnevich) established a task force that drafted a report available on the Internet (Al-Khafaji et al. 1998). This report is based on the Purdue model (Drnevich, personal communication, 1997). In the School of Civil Engineering at Purdue University, the department head and a faculty committee agreed that five things are important contributions of the faculty: teaching, mentoring, research, scholarship, and service. Any faculty member who excels in more than three of these five areas deserves to be rewarded. Teaching includes all the activities normally considered in this category except student supervision (M.S. or Ph.D. students supervised). This is a part of the reward category called mentoring that includes guidance of other faculty members, advising of student organizations, and undergraduate and graduate advising. Research includes not only the number of active grants and proposals submitted, pending, and funded, but also interdisciplinary activities, contribution to the research infrastructure, and national and international recognition and awards. Scholarship includes all the articles normally included in publications. Service is also the normal category, including both external societies and committees and administrative committees at the university. The basic difference between that policy and the more standard one is that the administration category has been assimilated into service and a new category has been created in mentoring. That change allows faculty devoted primarily to teaching to excel at least in two categories and do well at least in three. From that point of view, it represents potentially a significant improvement, but its real impact will depend on how it is implemented in practice.

Among its eight recommendations in ‘‘Chapter 9: Change Faculty Reward Systems,’’ the Boyer Commission (‘‘Reinventing’’ 1998) on Educating Undergraduates in the Research University included the following:

- ‘‘Departmental leaders should be faculty members with a demonstrated commitment to undergraduate teaching and learning as well as to traditionally defined research.’’
- ‘‘The correlation between good undergraduate teaching and good research must be recognized in promotion and tenure decisions.’’
- ‘‘A ‘culture of teaching’ within departments should be cultivated to heighten the prestige of teaching and emphasize the linkages between teaching and research.’’
- ‘‘Rewards for teaching excellence, for participation in interdisciplinary programs, and for outstanding mentorship need to be in the form of permanent salary increases rather than one-time awards.’’
- ‘‘Committee work at all levels of university life should be greatly reduced to allow more time and effort of productive student-related efforts.’’

Bean (1998) advocated for each faculty member to re-create the faculty’s role. His ideal situations included one where all the faculty and students are devoted to learning and discovering, creating, and taking risks. He said: ‘‘It is time that we take responsibility for our own work, define our role broadly, and contribute to the society that supports us.’’ As Wulf (1998) noted, ‘‘Engineering faculty are, for the most part, judged by criteria similar to the science faculty, and the practice of engineering is not one of those criteria. The faculty reward system recognizes teaching, research, and service to the profession, but it does not give the same status to delivering a marketable product or process, or designing an enduring piece of the nation's infrastructure.'' He also said, ''We have studied engineering education to death. . . . Let us get on with it! It is urgent that we do so!''

A trend towards increased recognition of teaching activities is necessary if new education initiatives are to be successful. Even with dramatic changes in the present university culture, the problem remains that new faculty have only a minor exposure to the practice of engineering. To remedy this situation, it would be necessary to promote the opportunity for faculty to spend some time in industry or to involve more practitioners in the educational process. Since a semester or a year of residence in an engineering firm will not be considered an asset in the promotion/tenure process, it is not appropriate to have junior and pretenure faculty taking advantage of opportunities of this kind. Some senior faculty members spend their sabbatical leaves or part of them in engineering firms. Nevertheless, they are normally involved in special problems where their expertise is needed. They may try to identify new potential research areas rather than participating in actual practice. Unless major changes are made in the faculty reward system, the option of placing faculty members in industry to acquire practical experience is not a realistic one.

Practitioners as Faculty

Professional engineers already participate in a number of ways in academic activities. They give seminars at meetings of the professional societies (ASCE student chapters, for instance) or at regularly scheduled classes, are parts of visiting committees for the departments, etc. ASCE created a Practitioner-in-Residence program whereby an experienced professional engineer spends a weak full-time (at his/her own expense) at a university interacting with students and faculty (Poirot and Yao 1991). It was a valuable program for several years. It is not clear to many of us, however, whether this program is still successful today.

Many universities have involved practitioners to teach design courses as adjunct professors. In such cases, the engineer has full responsibility for the course with little interaction with the faculty. While this practice has economic advantages because the practitioner is paid less than a regular full-time professor per course, it is not as effective from the educational viewpoint as where the courses are taught jointly by regular faculty and a practitioner. The best solution is to have successful professional engineers who are willing to take early retirement from industry as regular faculty members. There are a number of excellent examples of this. Yet this solution is somewhat difficult because of the reluctance of universities to hire faculty who will not fit the established criteria as typified by number of refereed publications, research accomplishments, and attainment of the Ph.D. degree. It appears that only the truly top institutions have enough self-confidence to be able to adapt and change their rules.

Practitioners can be used effectively as advisors or mentors of students in collaboration with the academic advisor. As an example, practicing engineers can advise students on their senior projects on design, cost estimation, and other practical issues. This may lead also to finding rewarding careers for the students upon their graduation.

CONCERNS

The large number of conferences, sessions at conferences, workshops, and papers dealing with engineering education indicates there is at least a perception that everything is not well within the present system and the evolution of research universities. Bright students will continue to perform well and become successful engineers irrespective of the quality of their education. They can read, think, and learn on their own. They need minor mentoring and supervision, only the opportunity to learn. The concern here is how to keep the very bright students interested while we provide education for the average student.

The writers are concerned with the continuous discussion on the problems and deficiencies of engineering education, the writing of numerous reports and recommendations, and the scarcity of action that follows up. Some of these issues have been discussed for decades, ever since the writers were students. There has been little positive change.

A second point of concern is the tendency to fragment a proud and successful profession. The awareness of the need to provide and maintain an adequate infrastructure implies an important and promising future for civil engineers. Moreover, the interest in our civil infrastructure should have served as an integrative force to bring back together a profession that was becoming too broad and disjointed. Yet the trend toward splitting the profession seems to continue. Students are being pushed into specialty areas at earlier and earlier stages. Before he passed away, Jerry Iffland (the founder of Kavanagh, Iffland, and Waterbury, P.C., of New York) made a survey and found that there are more than one hundred organizations that an American structural engineer can join. There is pressure at the same time to establish separate degree programs in environmental engineering, transportation engineering, geotechnical engineering, and structural engineering. Many departments have changed their name to Civil and Environmental Engineering implying clearly that these are two distinct programs. Why not include structural, geotechnical, or transportation in the title? Is the implication that these specialties are not as worthwhile as the environmental option? Dismembering the civil engineering profession into a number of new ones is a subject worthy of discussion. After all, even the ASCE has formed independent institutes for structural engineering and geotechnical engineering, and other institutes are being formed as well. The writers believe that it is in the best interest of students to keep the undergraduate degree broad-based in the general practice of civil engineering.

A third point of concern is the fuzzy demarcation between engineers and technicians. Many people view the civil engineers as technicians because all that is required is a four-year degree that is not very different from a technology education. In spite of calculus requirements for civil engineering students, many of our students are not required to use them in advanced undergraduate courses. In addition, many civil engineering graduates may be actually working as technicians. Even within universities there are still many that believe their primary goal is to train proficient technicians rather than to educate professionals (Roesset and Yao 1990).

Weese (personal communication, 1998) noted that some faculty members have already overemphasized their consulting activities to the detriment of undergraduate students. We believe that it is necessary for faculty members to do research, sponsored or otherwise, in order to stay at the forefront of one's specialty. Meanwhile, occasional consulting work applying their research results is desirable, but excessive consulting can be a serious problem.

DISCUSSION AND CONCLUDING REMARKS

The specific emphasis of this paper was on the roles of civil engineering faculty in undergraduate education. It would be unwise, however, to go through a complete overhaul of the undergraduate civil engineering curriculum or the definition of academic duties without simultaneous consideration of the graduate and continuing engineering education agendas. The question of the duration of the undergraduate curriculum and whether the resulting degree should be considered a professional degree or should be linked to some graduate work must be resolved first. In this regard, we are pleased to note that the ASCE Board of Direction has decided to endorse a post-baccalaureate professional degree for civil engineering practice (ASCE 1998). According to Pennoni (1998), ‘‘The engineers of the next millennium must possess a bachelor’s degree, a master’s degree in an area of specialty, experience, licensing, leadership qualities, and be bi- or multilingual. He or she must be capable of working in a team environment, be a good communicator and possess excellent people skills.’’

The role of Ph.D.s in industry, academia, or a research environment should also be considered. Finally, it is important for universities to assume a more active role in the formulation of rational continuing education programs that will provide a solid opportunity for lifelong learning, rather than providing only a handful of short-course offerings without any linking or continuity among them. While the present educational system is not broken, we need to improve it continuously. As an example, the faculty reward system in many universities should be changed so that mentoring activities as well as scholarships of discovery, integration, application, and teaching (Boyer 1990) are equally important as research funding in the evaluation criteria.

Natke (personal communication, 1997), among others, has advocated the systems approach in civil engineering education and practice. Bordogna (1998) calls the future civil engineer ‘‘the master integrator’’ because we must understand civil infrastructure as a system. In addition to possessing the up-to-date technical knowledge, civil engineers must know ‘‘how to do things right’’ and also ‘‘the right things to do.’’ Civil engineers must be able to work in teams, communicate well, work from a systems approach, and work within the context of ethical, political, international, environmental, and economical considerations. Consequently, civil engineers are required to have a broad-based undergraduate education. The writers also believe that a post-baccalaureate professional education is needed before entering practice.

Based on his many years of university teaching and administrative experience, Calhoun (personal communication, 1998) believes that ‘‘the impetus for change will have to come from pressures outside the engineering education community, primarily from the university community as a whole. . . . The underlying question becomes—What is the role of engineering education within the University? . . . Engineering education should consist of two items, for two different purposes—the undergraduate degree, unaccredited, for general technological careers, and the accredited graduate-level degree for professional preparation purposes.’’ The writers would welcome additional comments and suggestions to further improve engineering education.

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APPENDIX. REFERENCES

Al-Khafaji, A. W., et al. (1998). ‘‘The scholarship landscape in civil engineering: a bridge between rhetoric and reality.’’ 2nd Draft, Rep. of Task Force on Redefining Scholarly Work, 〈http://www.asce.org/peta/ed/redefschol.html〉.

ASCE. (1995). *Summary Rep. on 1995 Civ. Engrg. Education Conf.*, New York.

ASCE. (1998). ‘‘Board supports professional degree for civil engineers.’’ ASCE News, ASCE, 23(5), 1–2.

Bean, J. P. (1998). ‘‘Alternative models of professional roles: new languages to reimagine faculty work.’’ *J. Higher Educ.*, 69(5), 496–512.

Bordogna, J. (1998). ‘‘Tomorrow’s civil systems engineer—the master integrator.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 124(2), 48–50.

Bordogna, J., Fromm, E., and Ernst, E. W. (1993). ‘‘Engineering education: innovation through integration.’’ *J. Engrg. Educ.*, 82(1), 3–8.

Boyer, E. L. (1990). *Scholarship reconsidered: priorities of the professoriate*. The Carnegie Foundation for the Advancement of Teaching, Princeton, N.J.

Brown, C. B. (1996). ‘‘Trapped in one’s own times: the individual’s relationship to education and practice.’’ *Civ. Engrg. Sys.*, 14, 1–18.

Caso, R., Malave, C., Morgan, J., Rinehart, J., and Yao, J. T. P. (1999). ‘‘Inclusive learning communities at Texas A&M University.’’ *Conf. on Creating and Sustaining Learning Communities: Connections, Collaboration, and Crossing Borders*, University of South Florida, Tampa, Fla.

Corotis, R. B., et al. (1998). *Program Plan for Discovery Learning Center, College of Engineering and Applied Science*. Dept. of Fac. Mgmt., University of Colorado, Boulder, Colo.

Engineering education and practice in the United States. (1985). Comm. on the Educ. and Utilization of the Engr., Commission on Engrg. and Tech. Sys., National Research Council, Washington, D.C.

‘‘Engineering education for a changing world.’’ (1994). *Joint Rep. of Engrg. Deans Council and Corporate Roundtable,* 〈http://www.asee.org/pubs/html/green'report.html〉.

Epstein, H. (1992). ‘‘Why four years?’’ *CEEC’95 Position Paper No. P-4*, ASCE, New York.

Hall, W. J., Focht Jr., J. A., Michael, H. A., Paulson Jr., B. G., Saville, T., and Lowe, S. D. (1988). *Civil engineering in the 21st century: a vision and a challenge for the profession*, ASCE, New York.

Hayes, J. M. (1992). ‘‘ASCE’s responsibility in civil engineering education.’’ *CEEC’95 Position Paper No. G-1*, ASCE, New York.

Ingersoll, A. C. (1972). ‘‘The nature of continuing education.’’ *J. Engrg. Issues*, ASCE, 98(1), 113–130.

Jester, G. E. (1989). ‘‘Curriculum for future civil engineers: practitioner’s viewpoint.’’ *J. Profl. Issues in Engrg.*, ASCE, 115(4), 357–362.

Leonards, G. A., and Yao, J. T. P. (1985). ‘‘On teaching evaluation.’’ *Proc., Challenges for Civ. Engrg. Educators and Practitioners*, ASCE, New York, 370–376.

Marcuson III, W. F., Dobry, R., Nelson, J. D., Woods, R. D., and Youd, J. L. (1991). ‘‘Issues in geotechnical engineering education.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 117(1), 1–9.

Meyer, K. A. (1998). ‘‘Faculty workload studies—perspectives, needs, and future directions.’’ *ASHE-ERIC Higher Educ. Rep., Vol. 26, No. 1*, The George Washington University, Washington, D.C.

Monaghan, P. (1998). ‘‘A ‘hands-on’ approach to engineering is reflected in new facility at Colorado,’’ *Chronicle of Higher Educ.*, 44(24),

Moore Jr., W. P., Roesset, J. M., and Yao, J. T. P. (1998). ‘‘Civil engineering education in the 21st century—an introduction to the panel discussion.’’ 〈http://lohman.tamu.edu〉.

Moore Jr., W. P., and Yao, J. T. P. (1998). ‘‘On education and practice of structural engineering.’’ 〈http://lohman.tamu.edu〉.

Moses, J. (1994). ‘‘Engineering with a big E: integrative education in engineering.’’ *Long Range Plan 1994–1998*, School of Engrg., Massachusetts Institute of Technology, Cambridge, Mass.

National Science Foundation (NSF). (1995a). ‘‘Restructuring engineering education: a focus on change.’’ *Rep. of an 1994 NSF Workshop on Engrg. Educ.*, Div. Undergrad. Educ., Directorate for Education and Human Resources, Arlington, Va.

National Science Foundation (NSF). (1995b). ‘‘Systemic engineering education reform: an action agenda.’’ *Recommendations of 1995 Workshop Convened by Engrg. Directorate*, Arlington, Va.

Parker, C. E., Jester, G. E., Desai, C. S., and Yao, J. T. P. (1990). ‘‘Reexamination of CE curriculum for the 21st century.’’ *Proc., Educ. and Continuing Devel. for the Civ. Engr.*, ASCE, New York, 684–694.

Pennoni, C. R. (1998). ‘‘Managing your career in an era of change.’’ *J. Profl. Issues in Engrg. Educ. and Pract.*, ASCE, 124(3), 75–77.

Philips, W. M. (1993). ‘‘Taking the lead.’’ *Prism*, 52.

Poirot, J. W., and Yao, J. T. P. (1991). ‘‘Practitioner-in-residence: an ASCE pilot program and the CH2M Hill–Texas A&M experience.’’ *Rep. to ASCE EDAC/PAC Joint Task Comm. on Educator/Practitioner Interface*, ASCE, New York.

‘‘Reinventing undergraduate education: a blueprint for America’s research universities.’’ (1998). Boyer Commission, 〈http://notes.sunysb.edu/pres/boyer.nsf/webform〉.

Roesset, J. M., and Yao, J. T. P. (1988). ‘‘Civil engineering needs in the 21st century.’’ *J. Profl. Issues in Engrg.*, ASCE, 114(3), 248–255.

Roesset, J. M., and Yao, J. T. P. (1990). ‘‘The civil engineer: scientist or technician?’’ *Proc., Educ. and Continuing Devel. for the Civ. Engr.*, ASCE, New York, 741–749.

Russell, J., and Yao, J. T. P. (1996). ‘‘Education conference delivers initiatives.’’ *J. Mgmt. in Engrg.*, ASCE, 12(6), 17–24.

Weiser, C. J. (1999). *The value system of a university—rethinking scholarship*. College of Agric. Sci., Oregon State University, Corvallis, Oreg.

Wisely, W. H. (1974). *The American civil engineer, 1852–1974*. ASCE, New York.

Wulf, W. A. (1998). ‘‘The urgency of engineering education reform.’’ *The Bent*, Fall, 21–23.

Yao, J. T. P. (1996). ‘‘On civil infrastructure systems and engineering education.’’ *J. Infrastruct. Sys.*, ASCE, 2(1), 1–4.

Yuker, H. E. (1984). ‘‘Faculty workload: research, theory, and interpretation.’’ *ASHE-ERIC Res. Rep. 10*, The George Washington University, Washington, D.C.