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Perception Versus Reality in Civil Engineering Education Today

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Abstract
The discipline of civil engineering, and how to best teach it to aspiring engineers, has been the subject of many discussions and debates for the past few years. Between perception and reality one can find groups with opinions that vary across the spectrum. To some, the traditional field of civil engineering is considered to be one of the most important fields in engineering because it is closely attached to the needs of humans in their daily lives. To others, it is an old fashioned discipline that does not belong in a modern engineering curriculum. Colleges, universities, and educational institutions have debated the question of how to modify the civil engineering curriculum in ways that will increase its appeal to students. Some of these institutions went as far as debating the viability of existing civil engineering programs. Many of the factors that affect the direction of civil engineering education are directly related to environmental, economical, political, social, and cultural issues. Civil engineering is a discipline that mirrors the societal conditions of a community and addresses these conditions in a scientific and technical way in the classroom. Many educational institutions have come to the realization that advancements in technology should be reflected in newly structured civil engineering courses, and introduced changes in their offerings. This paper attempts to offer a global view of steps implemented by large and small institutions to modernize their engineering curricula. Changes made by institutions will be classified as light, moderate, or dramatic. The self-assessed degree of success of these changes, and the level of acceptance these newly revamped programs received will be discussed.

I. Perception and Reality

The period of the mid to late nineties showed astronomical growth in some sectors of the economy. A close look at the areas that experienced this growth would reveal that it was almost entirely confined to Internet-related stocks and bioengineering stocks that stood to benefit from the mapping of the human genome. This apparently led to a feeling on the part of some engineering educators that if they do not shift the focus of their programs to benefit from the so-called "new economy," they would be left behind. Many called for dramatic changes, and saw no light in the end of the tunnel unless these changes were implemented. Others proclaimed that conventional fields such as civil engineering were dead and it was time to ride the new wave. This hysteria was fueled by the apparent daily rise in Internet-related issues traded on the NASDAQ Market. For a time it seemed as if every one shifted focus to this new phenomenon, and who could argue otherwise if this was the place where money was being made. This came to an abrupt end when the market peaked in March 2000 and slowly deflated over the past three years. When the bubble burst, many believers thought it was a temporary pause after which the market would resume its progress. It has been a painful three years' period for those believers. Now that the dust has almost settled, people are awakening to the fact that the Internet is a great thing, and the mapping of the human genome is also a great thing, but there are basic human needs that have to be met first if we are to enjoy a quality life. Clean air and clean water are two fundamental needs for humans to sustain life on earth. Without meeting these needs first, life itself will not be possible.

In addition, the deteriorating infrastructure, the depletion of energy sources, and the explosion in human population are only the tip of the iceberg that if not countered could result in a catastrophe of titanic proportion. Environment, infrastructure, and waste management constitute serious and critical challenges to the health and continuation of humanity. Governments and international agencies know that these problems must be tackled immediately. The longer they wait, the worse these problems get. These are problems that civil engineers can and do solve. The civil engineering field may not be glamorous, but human needs for shelter, food, water, and waste disposal have been, are, and will always be critical. The civil engineering discipline will always be needed as long as there is life on earth. Furthermore, civil engineers are using the latest in technological advances to achieve the desired goals efficiently and economically. This paper is an attempt to take a look at some of the factors that resulted in civil engineering losing its luster during the nineties, and how it is regaining ground.

II. What is Engineering Anyway?

"en-gi-neer-ing, n. the planning, designing, construction, or management of machinery, roads, bridges, etc." (Compact Desk Edition, Webster's New World Dictionary of the American Language, The World Publishing Company, 1963). Webster's Dictionary's definition of engineering is interesting. It uses four actions individually or collectively to describe engineering. These actions are planning, designing, construction, or management. Using "or" rather than "and" in this definition implies that any or all of the four actions is part of the engineering process. It is also of interest that the Dictionary specifies three areas (machinery, roads, and bridges), two of which are civil engineering areas. This, however, is of minor importance because the use of etc. (et cetera) implies that any other built structure (such as a skyscraper, computer, or electrical circuit) can be considered under the general umbrella of engineering. The 1993 Edition of the Merriam-Webster Collegiate Dictionary recognized this wider umbrella in a revised definition of engineering. It stated that engineering is "the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people," and it is "the design and manufacture of complex products". These definitions clearly demonstrate that all things that are meant to be useful to humans involve engineering.

III. Role of Civil Engineers

Clough (2000) states, "Today, most of the buzz is about biotechnology and information technology, but the future of our society also rests on technologies that are more basic to its functioning. The combination of a growing world population with the human tendency to delay dealing with infrastructure and environmental needs until they have reached crisis proportions, means that our profession will become more essential than ever before." Clough acknowledges that there are emerging fields where most research money is being poured, and urges civil engineers to actively seek to understand and use technology developments from these fields to the advantage of civil engineering. He calls for a new curriculum for civil engineering students to help them develop a more entrepreneurial mindset.

Bras (1999) states, "Any industry that decides to act irresponsibly in its stewardship of the environment will not be competitive. Such industries and firms will not attract employees and will not find clients in an increasingly environmentally conscious society that will not tolerate damage to its air, water, and soil. Environmental damage is almost always the result of process inefficiency and waste. Simply put, preservation of the environment is a bottom line concern very much related to efficiency and competitiveness."

Over the last decade there have been calls by many educators for renewal and reform of the civil and environmental engineering curriculum. The ABET Engineering Criteria 2000 (AEC2000) provided a flexible framework for academic institutions to develop curricula that can best suit their needs and the needs of the profession. Some academic institutions took advantage of this flexibility to develop curricula that incorporate features that they thought important to graduate civil engineers practicing in the 21st century. Before developing these new curricula, it was necessary for academic institutions to study the needs of the marketplace and to get as much input as possible from practitioners. To address societal needs in the new curricula, the following general problems were identified:

Depletion of water resources
More than half of the world population does not have clean water to drink. This results in health problems of epidemic proportion. Falling water tables in many places in the world threaten all forms of life and the ability to produce food. Water shortage has become such a serious problem regional conflicts in some areas of the world are resulting from arguments over methods of water distribution.

Deterioration of infrastructure
This may not be a problem in many developing parts of the world. This is not because their infrastructure is in good shape, but it is because they have no infrastructure to start with. However, in the United States the basic inventory of infrastructure includes roads; bridges; and water, gas, power, and sewer systems. It is estimated that over half of the entire infrastructure of the US is currently operating beyond its design life. The Environmental Protection Agency (EPA) estimates that $300 billion will have to be spent over the next 20 years to upgrade the water system in America.

Waste disposal
It is estimated that the current annual volume of waste in the US is 500 million tons. Management of the disposal of this volume of waste has become a vital concern. Part of this waste is recycled but most of it goes to landfills. Building new containment systems has grown to be a significant sector in civil engineering. However, tight space or unavailability of land to build new systems is now forcing civil engineers to find new ways for waste disposal or treatment of the refuse using chemical or biological processes.

Transportation demands
Mobility and ease of movement are necessities for the public today. The inadequacy of transportation facilities, including roads, bridges, and airports, are a continuous source of loss for the economy. Much of the interstate highway infrastructure was constructed in the 1950s and1960s. It is now at a point where it needs to be expanded, rehabilitated or replaced – a case in point is the Tappan Zee Bridge that carries I-87 over the Hudson River. Federal, state, and local governments are all looking for ways to develop more capacity from existing transportation systems. These include increasing mass transit, high occupancy vehicles, and telecommuting.

Congestion and air pollution
Congestion lengthens travel time. For those people stuck in cars and buses it results in air pollution, loss of productive time, and aggravation of the public when they idly sit waiting for jams to clear up. Delay at airports costs consumers time and airlines revenue. All these factors, compounded on a daily basis add up and the total amounts to billions of dollars of losses to the national economy.

Growing hazard exposure and global warming
The risk of exposure to hazardous materials, the lack of proper facilities to store these materials, and in some cases the danger of transporting these materials to storage facilities can have a great influence on the quality of life. Rising levels of energy production produce green house gases that can cause global warming.

Natural disasters: storms, floods, drought and fires.
According to environmentalists the increase in intensity and frequency of natural disasters such as storms, floods, droughts and fire are the direct result of the climatic change the earth has been experiencing for the past few decades. It is argued that these changes in climate are indicative of imbalance in the earth's ecological systems.

The problems outlined above require aggressive and innovative solutions. These are serious problems that impact the daily lives of all the inhabitants of this planet. These problems will not go away on their own. The present situation cannot improve without a sincere effort to address the causes of these problems. It can only get worse, which can ultimately threaten the ability of future generations to live normal lives. Civil engineers are in the forefront leading the efforts to address these problems.

IV. Civil Engineering Emerging Growth Areas

Vaziri (2000) summarized potential civil engineering growth areas. He identified the following areas:

Pure Tech: this includes computers, wireless networks, robots, global positioning systems (GPS), and intelligent transportation systems. A variety of advanced sensing, computing and communications technologies handle tasks that range from collecting tolls to controlling traffic signals, and they are integrated into coordinated systems that manage traffic flow.

Materials Tech: this includes smart materials, self-repairing materials, lightweight concrete, high-performance steel, epoxy-coated cable strands, composite prefabricated anchorages, and fiber-reinforced polymer (FRP).

Construction Tech: this includes construction considerations for infrastructure renewal, development and dissemination of integrated sensor, measurement, simulation, and project information systems to increase construction productivity and quality.

Biotech: this includes its impact on environmental engineering, including bio-remediation to clean up waste and the potential to change the treatment of wastewater dramatically. It even raises the possibility of treating wastewater at the point of generation, significantly reducing the need for large-scale sewage infrastructures.

Green and Sustainable Tech: this includes the development and acceptance of "green" technologies that conserve energy and utilize renewable or recycled resources both in construction design and execution.

Modern Business Management E-commerce: this includes business-to-business Internet transactions which have the potential for increased productivity in civil engineering and construction by comparing suppliers and finding new sources, learning about delivery options and tracking orders, and getting technical advice. Another e-commerce trend that will change civil engineering is electronic construction management companies that use the Internet to coordinate communications, share design updates, and even hold project meetings in chat rooms.

V. Response of Academic Institutions

In response to the real need to deal with the realities of life today, civil engineering programs at many academic institutions took a fresh look at their curricula. Many programs implemented changes to make the curricula responsive to societal needs. Some programs embarked on these changes after receiving input from industrial partners and practitioners, and others studied the new forces and realities of the marketplace to introduce the changes that could make their graduates better prepared to meet the new challenges.

Table 1 shows the civil engineering areas of study at the 10 universities with the largest undergraduate enrollments (ENR, 2002). It can be seen that these programs concentrate on six major areas in civil engineering. These areas are structural, environmental, geotechnical, water resources, transportation, and construction engineering.

Table 1. Civil engineering areas of study at top 10 universities with the largest undergraduate enrollment (shown in parenthesis).

1. Polytechnic University of Puerto Rico, San Juan, PR (1205) Structural Engineering Construction Management Engineering Environmental Engineering Water Resources Engineering Geotechnical Engineering Transportation Engineering	**2. Texas A&M University, College Station, TX (832)** General Engineering Construction Engineering and Management Transportation Engineering Structural Engineering Coastal and Ocean Engineering Environmental Engineering Water Resources Engineering Geotechnical Engineering
3. University of Texas at Austin, TX (665) Construction Engineering and Project Management Environmental Engineering Geotechnical Engineering Structural Engineering Mechanics and Materials Modern Pavement Materials Transportation Engineering Water Resources Engineering	**4. Purdue University, West Lafayette, IN (544)** Computational Mechanics Construction Ecological Science Environmental Process Geomatics Geotechnical Hydraulics & Hydrology Materials Structures Transportation
5. Georgia Institute of Technology, Atlanta, GA (518) Structural Engineering and Mechanics Environmental Engineering Environmental Fluid Mechanics and Water Resources Transportation Systems Construction Management GeoSystems Engineering	**6. University of Illinois-Urbana-Champaign, Urbana, IL (500)** Construction Management Construction Materials Environmental Engineering and Science Environmental Hydrology and Hydraulic Engineering Geotechnical Engineering Structural Engineering Transportation Engineering
7. California State Polytechnique University, Pomona, CA (490) Structural Engineering Geotechnical Engineering Transportation Engineering Environmental Engineering Surveying Engineering	**8. University of Florida, Gainesville, FL (439)** Coastal & Oceanographic Construction Management Geomatics GeoSensing Systems Geotechnical Hydraulics/Hydrology/Water Resources Materials Public Works Structures Transportation

9. Michigan Technological University, Houghton, MI (427) Construction Engineering Environmental Engineering Geotechnical Engineering Structural Engineering Transportation Engineering Water Resources Engineering	**10. Brigham Young University, Provo, UT (380)** Structural Engineering Water Resources and Environmental Engineering Geotechnical Engineering Traffic and Transportation Engineering

According to the American Society of Civil Engineers (ASCE), these areas of study should prepare engineers to meet the following challenges:

Structural Engineering
Structural engineers face the challenge of designing structures that support their own weight and the loads they carry, and that resist extreme forces from wind, earthquakes, bombings, temperature and other loads. Bridges, buildings, amusement park rides and many other kinds of projects are included within this specialty. Structural engineers develop appropriate systems of steel, concrete, timber, plastic and new exotic materials. They also visit project sites to make sure work is done properly.

Environmental Engineering
The skills of environmental engineers have become increasingly important as we protect our fragile resources. Environmental engineers translate physical, chemical and biological processes into systems to destroy toxic substances, remove pollutants from water, reduce non-hazardous solid waste volumes, eliminate contaminants from the air, and develop groundwater supplies. Environmental engineers are called upon to resolve the problems of providing safe drinking water, cleaning up contaminated sites with hazardous materials, disposing of wastewater and managing solid wastes.

Geotechnical Engineering
Geotechnical engineering is required in all aspects of civil engineering because most structures require foundations that rest on the ground. A geotechnical engineer may develop projects below the ground, such as tunnels, foundations, and offshore platforms. They analyze the properties of soil and rock that support and affect the behavior of these structures. They evaluate potential settlements of buildings, the stability of slopes and fills, the seepage of ground water and the effects of earthquakes. They investigate rocks and soils at a project site and determine the best way to support a structure in the ground. They also take part in the design and construction of dams, embankments and retaining walls.

Water Resources Engineering
Water is essential to our lives, and water resources engineers deal with the physical control of water. They work with others to prevent floods; to supply water for cities, industry and agriculture; to protect beaches; or to manage and redirect rivers. They design, construct and maintain hydroelectric power facilities, canals, dams, pipelines, pumping stations, locks, seaport facilities, or even waterslides.

Transportation Engineering
The quality of a community is directly related to the quality of its transportation system. Transportation engineers work to move people, goods and materials safely and efficiently. They find ways to meet our ever-increasing travel needs on land, air and sea. They design, construct and maintain all types of transportation facilities, including airports, highways, railroads, mass transit systems, and ports. An important part of transportation engineering is improving our transportation capability by improving roadway and airport capacity, upgrading mass transit and intercity transportation systems, by introducing high-speed trains, people movers, and other intermodal transportation methods.

Construction Engineering
The construction phase of a project represents the first tangible result of a design. Using technical and management skills, construction engineers turn designs into reality, on time and within budget. They apply their knowledge of construction methods and equipment, along with the principles of financing, planning and managing, to turn the designs of other engineers into successful facilities.

It is worth noting that all the programs listed in Table 1 cover, in depth and breadth, all the areas that people so badly need today. The titles of various areas may be different but they are basically structured to serve the function of graduating engineers who can make a meaningful contribution to the society.

VI. The MIT Experience

Bras (1999) states, "Engineering is being devalued in all developed countries. Many times we are perceived as technologists offering cheap and routine service, a commodity. This perception is encouraged by the narrowness of many engineering programs and by our competitive disadvantages vis a vis sister professions (i.e., medicine, law, and business) that require broad undergraduate education followed by postgraduate work." Einstein (2002) outlined the changes made as part of a revision of the civil and environmental engineering (CEE) curricula at Massachusetts Institute of Technology (MIT). He indicated that in the early 1990s, several faculty members of MIT's CEE department came to the conclusion that the civil engineering curriculum was in need of improvement. A departmental committee on undergraduate education developed a detailed course structure in the spring of 1997. The 2001 class was the first class to graduate after the implementation of the new course structure. The sources of dissatisfaction with the old curriculum can be summarized as:

- Students were having difficulty conceptualizing and formulating problems.
- There was little exposure to ill-defined (open-ended) problems.
- Teamwork was uncommon and ineffective.
- Coherence was lacking. That is, sequels to courses did not rigorously rely on prerequisites, and this was particularly true for some of the engineering fundamentals.
- There was not enough hands-on experience, and where it did exist there was only a limited tie-in to the associated theory.
- Courses for the most part ignored the societal context of engineering problems.

- The emphasis on abstraction and analysis gave short shrift to synthesis and creativity.
- Insufficient attention was given to communication, and the writing requirements were often poorly linked to technical courses.

Three proposals were made to address the perceived problems. The first called for minor revisions that included reintroducing a capstone course and ensuring better coordination of prerequisites. The second regarded design (synthesis), coordination, and communication as major features integrated into the traditional course structure. The third, and most radical alternative would have eliminated traditional courses in favor of a design studio sequence, with engineering principles learned in the context of design project. The faculty opted for the second alternative. The structure of the curriculum after the revision is outlined in Table 2.

Table 2. The structure of the revised MIT civil and environmental engineering curriculum

General and Civil Engineering Fundamentals
Introduction to Computers and Engineering Problem Solving
Uncertainty in Engineering
Differential Equations
Project Evaluation
Solid Mechanics and Solid Mechanics Lab
Civil Engineering Materials and Civil Engineering Materials Lab
Design Course Sequence
Introduction to Civil Engineering Design
Geotechnical Engineering Design
Engineering Systems Design
Structural Engineering Design
Civil Engineering Design
Specialization Tracks
Civil Engineering Mechanics
Civil Engineering Systems
Environmental Engineering
Student-Formulated Track

Einstein (2002) concluded that the new curriculum, while not as radical and comprehensive as may have been desirable, still embodies significant changes. However, he also indicated that the new program had not been entirely satisfactory. He stated "there have been problems with the specialization tracks and there are some misgivings with regard to the theme project."

VII. The Union College Approach

Union College is a liberal arts with engineering undergraduate institution. Union College developed what it called "Converging Technologies" (CT) as a framework to a new vision in engineering education. It is a vision that "will bring biology, chemistry, physics, and ethics together with computer science, electrical engineering, and mechanical engineering." The four major areas where the Engineering Division at Union College is focusing its efforts are Bioengieering, Nantotechnology, Mechatronics, and Pervasive Computing.

The Civil Engineering (CE) Department at Union College was established in 1845. In 2000 it was ranked 8th in the nation. At the time the CT initiative was proposed, the administration indicated that the CE discipline was the "least compatible with CT". In October 2001, Union College decided to eliminate the CE department. The department is currently being phased out, and the 2005 class will be the last graduating one.

The decision to eliminate the CE department was strenuously resisted by the alumni, faculty, parents, students, and practitioners. The arguments that CE has a lot to do with all fields related to human life, and with CT itself, were apparently insufficient to avert the administration's desire to eliminate the department. Later in the debate, the administration acknowledged that CE is an important discipline and is relevant even to CT, but cited lack of resources as a reason to eliminate the department.

Interestingly, or maybe sadly, some of arguments made by civil engineering practitioners and educators concerning the need for revision and reform of the CE curriculum were used as tools to strengthen the case against the CE discipline. Clearly these arguments were taken out of context, however, they have been used to serve a function that was totally contrary to what they were intended for.

There is an important lesson one should learn out of this experience. Sometimes the motive behind harsh criticism is extreme care about the health of the CE profession. This is certainly true, but it is also true that with this continuous criticism and complete focus on what is perceived to be negatives, those reformists are unintentionally damaging the image of the CE profession and hurting its standing with the public.

VIII. Colleges and Universities Comparable with Union College

Bucknell University, Lafayette College, and Rose-Hulman Institute of Technology are three relatively small institutions with strong undergraduate civil and environmental engineering (CEE) programs. These three institutions are comparable to Union College in size and focus. Table 3 shows the major areas of study within the CEE discipline at these institutions. Based on the data derived from both Tables 1 and 3, one can conclude that, whether teaching of CEE is taking place in a large or a small setting, there seems to be a general agreement that the three areas of structural, geotechnical, and environmental engineering should be basic fixtures in civil engineering programs. The size of a given department is probably the determining factor as to how many additional areas of study can be added to the basic three. In large universities with large enrollment and numerous faculty, the tendency is to offer a wide variety of areas of studies. In small colleges, according to ABET, a minimum of four areas are required for accreditation. Different departments place emphasis on different areas depending on the student and professional population they serve. However, it is apparent that there is a strong interest in structural, geotechnical, and environmental engineering, and this interest is certainly driven by market demands.

Table 3. Civil engineering areas of study at Bucknell, Lafayette, and Rose-Hulman

Bucknell University Structural Engineering Environmental Engineering Geotechnical Engineering Transportation Engineering Water Resources Engineering
Lafayette College Environmental Engineering Structural Engineering Materials Geotechnical Engineering
Rose-Hulman Institute of Technology Structural Engineering Environmental Engineering Geotechnical Engineering Construction Engineering Water Resources Engineering

IX. Where Does ASCE Stand?

In October 2002, the Body of Knowledge Curricula Committee of ASCE released a report with a section on what should be taught and learned. The committee concluded that the 21st century civil engineer must demonstrate:

1. Ability to apply the common technical core of mathematical, scientific, and engineering knowledge underlying the role of the civil engineer as the master integrator.
2. Ability to apply knowledge in a specialized technical and/or professional area.
3. Ability to design and conduct experiments, as well as analyze and interpret field and laboratory data, in more than one of the major recognized major civil engineering areas.
4. Ability to understand the role of and to use the techniques, skills, and modern engineering tools necessary for engineering practice.
5. Ability to identify, formulate, and solve engineering problems.
6. Ability to communicate effectively, that is, to listen, observe, speak, and write.
7. Ability to participate on and lead multi-disciplinary teams.
8. Ability to understand the role of the leader and to use leadership principles.
9. Understanding the elements of building, facilities, process, and systems design.
10. Understanding of the elements of project management.
11. Understanding of the elements of asset management.
12. Understanding of the elements of construction.
13. Understanding of business fundamentals as applied to private, government, and non-profit sectors.
14. Understanding of public policy and administration fundamentals.
15. Understanding of and abiding commitment to practice according to the professional and ethical standards of the engineering profession.
16. An appreciation for culture, environment, history, and human behavior.
17. Knowledge and appreciation of the relationship of engineering to critical contemporary issues.
18. Recognition of the need for, and an ability and commitment to engage in life-long learning

for personal and professional development.

In October 1998, the American Society of Civil Engineers (ASCE) adopted a policy statement that said: "The ASCE supports the concept of the master's degree as the First Professional Degree for the practice of Civil Engineering at the professional level."

This statement has sparked lively debate. Bras (1998) summarized the arguments for and against the proposed policy. The arguments for adopting that policy are:

- Employers, particularly those looking for professional leaders, already require the master's degree.
- Future engineering practice will require a knowledge base of technical and non-technical subjects that are difficult to offer in just four years.
- The civil engineer of the future will be a master integrator managing technology and the infrastructure in a societal context like no other engineer. The ability to perform in that context requires a maturity of thought and a broad education that is best achieved over a longer period of time.

The arguments against the move are numerous and varied.

- Many people point out their success with a bachelor's degree or even less education. They argue that additional studies would have been an unnecessary obstacle.
- Another argument is that students have it easier these days, and if we were to increase the units to previous levels a professional education would be possible in four years.
- Engineering education could be delivered more efficiently.
- Many individuals who presently complete bachelor's degrees may not qualify to enter master's programs (Yao and Lutes, 1999).

A number of concerns all relate to accreditation issues:

- Who will be eligible for licensing?
- Will accreditation standards reduce the "considerable flexibility in master's degree programs with each institution capitalizing on its own particular strength"? Would accreditation force uniformity and result in the elimination of excellent programs?
- Would accreditation standards pose "particular problems to graduate programs with emphasis on analysis and behavior, rather than design?" (Yao and Lutes, 1999)

Bras (1998) argues "The debate on the First Professional Degree should not be framed within existing standards of accreditation or practice. Our deliberations must be framed within the intellectual rigor and knowledge that will be required from future civil and environmental engineers. We cannot let the debate be dominated by implementation details, no matter how difficult they may be."

Clough (2000) states, "The task will become easier if civil engineering designates the master's degree as the first professional degree, which is under serious consideration. If we take this step, it will be important to allow for a generalist's track as well as offering narrow specialties."

Bras (1998) states, “Engineering practice and education are by necessity context rich. Engineers are specialists. Their expertise, their technical expertise, is what gives them uniqueness. Engineers cannot become generalists and particularly generalists in the practice of management. The minute engineering education falls in that trap; our output will be nothing more than a poor man’s business degree. MBA’s are trained to be generalists, but engineers need a context in which they can specialize, a context that calls for planning, design, construction, and management.”

X. Society’s Perception of Engineering

Society views engineering as a field that is too technical. Unintentional statements engineers make sometimes reinforce this idea. For instance, if a physician is asked why he/she wanted to be a physician, the most likely answer is “because I wanted to help people.” If an engineer is asked why he/she wanted to be an engineer, the most likely answer is “because I was good in math and science.” Although engineering is a people-serving profession and is closely attached to the daily lives of humans, such answers lead people to think that engineers are detached from societal needs. It gives an impression that those engineers are “nerds” living in their own world. Whether engineers like it or not, in this day and age image management can make or break. It can mean the difference between success and failure. This is an area engineers can no longer afford to ignore.

XI. Where Do We Go From Here?

Niedzwecki (2000) states, “Almost all civil engineering programs are resource limited and the profession and its successful practitioners need to look more seriously at financially enabling the educational programs to address uniqueness, innovation, and an increasingly diverse student population. Scholarships for tuition and books, internships that provide income throughout the year, and funds to allow the faculty to be innovative while partnering with practitioners are issues that very much need to be addressed by the civil engineering community.”

Weingardt (2000) stresses the importance for engineers in being visible in society and reflecting a glamorous image of engineering to attract young bright people to the profession. He offers a number of suggestions that engineers can implement to be noticeable by the media, recognized as public figures, admired as heroes who build and make things run smoothly, and achieve celebrity status. He goes as far as suggesting publicity campaigns that are designed to inform the public about the nature of the profession. However he also acknowledges that “One of the difficulties in actually getting involved and becoming a societal leader is that most engineers truly enjoy just doing engineering. The work is so challenging and rewarding, many do not want to do anything but engineering. Many engineers find it distracting -- and less than interesting -- to integrate the impact of their work into broader issues. Most are not interested in politics and some even find politicians despicable -- often not without reason. But the situation will not be made better by ignoring it.”

Vijayaratnam (2000) expresses great concern about the lack of clean water on human and environmental health. He indicates that the dimensions of world environmental problems are beyond imagination. He challenges engineers and engineering educators to develop sustainable programs that ultimately eradicate poverty. He states, "Urban environment towards sustainable development in the end boils down to shaping of education at all levels, schools, colleges, universities, industries, and governments towards the new realities about to unfold in the future which is going to be challenging and interesting. Preparation must start now, and original and unconventional thinking must be encouraged for innovative solutions."

Clough (2000) believes that civil engineers must take advantage of advances in other fields such as the Internet, bioengineering, and materials. He stresses the importance of planting the entrepreneurial seed in the minds of young engineering students. He believes that tomorrow's engineers must also be good managers and leaders.

Bordogna (1998) calls the future civil engineer "the master integrator" because he/she must understand civil infrastructure as a system. In addition to possessing up-to-date technical knowledge, civil engineers must thus know "how to do things right" as well as "the right things to do."

In today's world where fast communications made it easy to shrink distances and implement globalization, one should also realize that tomorrow's graduates need exposure to different cultures, be aware of different political and social climates, be sensitive to historical and traditional customs, and be capable of listening to and accommodating opposite points of view. Civil engineering educators should ensure that tomorrow's graduate would be an integrated package of many elements. These elements constitute the character of a well-rounded engineer who is able to make an argument and build a case for his/her viewpoint.

The industry and government have roles to play. Clough (2000) states, "The industry practitioner does not operate in a vacuum, however. For many of the industry's products, the government, on both the federal and state level, is a critical factor. The government is often the sole or primary owner of the structure to be built or repaired. The government frequently participates in the financing of the project or the development of the contract. Perhaps most importantly, the government often assumes part of the risk and liability associated with the physical assets that it owns (bridges, highways, buildings, etc.). In the interest of public safety and open competitiveness, federal and local governments have developed, over time, a variety of policies. While intended for the best of reasons, many of these strategies have had the effect of reinforcing the industry's conservative inclination outlined above, thus making innovative approaches even less likely."

XII. Conclusions

- The CE discipline came under a cloud in the 1990s when its progress was judged as slow when it was compared against the explosive progress of hot new fields such as the Internet.
- Almost three years after the Internet bubble has burst, the basic human needs that only civil and environmental engineers can meet are still the same.

- The reality is that civil engineers are positioned to play a significant role in advancing the society as they take on problems related to the environment, infrastructure, and waste management. There is every indication that these problems will get worse as the human population increases.
- Large and small academic institutions have successfully pin pointed areas of study that are relevant to the need of society today.
- A survey of academic institutions showed six major areas within the discipline of civil engineering where the effort currently concentrates. These areas are structural, environmental, geotechnical, water resources, transportation, and construction engineering.
- It appears that the areas of structural, geotechnical, and environmental engineering are the basic three fixtures in most, if not all, civil engineering programs.
- Civil engineers should embrace new technologies and use them for the advancement of the civil engineering profession. The Internet, bioengineering, smart materials, and intelligent transportation systems are elements that can benefit the civil engineering profession a great deal.
- The rate of advancement and adoption of new technologies in the civil engineering area is hampered by the extent of liability engineers are willing to accept. To accelerate the rate of introduction of new technologies, government and industry should be willing to assume part of the risk and encourage the use of well-tested materials and almost-proven new techniques in various engineering projects.
- Civil engineering educators have a responsibility for graduating an engineer that will have the capability of operating in a global environment. This necessitates that the graduating engineer be well rounded, have had exposure to different cultures, and be sensitive to view points different from his/her own.
- Civil engineers should be careful not to cause unintentional damage by constantly criticizing the profession and shedding light on only the negatives. Public perception is greatly affected by these views. Positive image reflection is very important for civil engineers if they are to achieve the place they deserve in societal ranks.

Bibliography

ASCE (2002), “Civil Engineering Body of Knowledge for the 21st Century,” Preparing the Civil Engineer for the Future, Report prepared by the Body of Knowledge, Curricula Committee of the Task Committee on Academic Prerequisites for Professional Practice, American Society of Civil Engineers.

ASCE (1998), “Engineering the Future of Civil Engineering,” Report of the Task Committee on the First Professional Degree to the Executive Committee, Board of Direction, American Society of Civil Engineers.

ASCE (1998), “Board Supports Professional Degree for Civil Engineers,” ASCE NEWS, Vol. 23, No. 5, May 1998, pp. 1-2.

Bordogna, J., (1998), “Tomorrow’s Civil Systems Engineer: The Master Integrator,” Journal of Professional Issues in Engineering Education and Practice, Vol. 124, No. 2, April 1998, pp.48-50.

Bras, R. (1999). “Themes of the Future,” MIT Civil and Environmental Engineering Newsletter, Vol. 13, No. 3, Cambridge, MA.

Bras, R. (1999). “The Master’s as a First Professional Engineering Degree,” MIT Civil and Environmental Engineering Newsletter, Vol. 13, No. 4, Cambridge, MA.

Bras, R. (1998). MIT Civil and Environmental Engineering Newsletter, Vol. 13, No. 1, Cambridge, MA.

Clough, G.W. (2000). “Civil Engineering in the Next Millennium,” CEE New Millennium Colloquium, The MIT Department of Civil and Environmental Engineering, Cambridge, MA.

Einstein, H.H. (2002). “Engineering Change at MIT,” Civil Engineering, Vol. 72, No. 10, ASCE, VA.

Engineering News Record, ENR (2002). “Schools Seek New Ways to Retain A most Valuable Asset - Students,” ENR, October 21, 2002, pp. 6-23, The McGraw-Hill Companies, NY.

Niedzwecki, J.M. (2000). “Challenge: Civil Engineering Education 2000 and Beyond,” CEE New Millennium Colloquium, The MIT Department of Civil and Environmental Engineering, Cambridge, MA.

Vaziri, H. (2000). “Discussion on Future Prospects and Emerging Growth Areas in Civil Engineering,” Discussion on the Future of Civil Engineering, Civil Engineering Workshop, London on June 7, 2000 and the NSERC Civil Engineering Reallocation Program on June 8.

Vijayaratnam, K. (2000). “Engineering Education in the New Millennium: Towards Sustainable Technology, Infrastructure and Environment,” CEE New Millennium Colloquium, The MIT Department of Civil and Environmental Engineering, Cambridge, MA.

Weingardt, R. (2000). “Step Forward and Be Heard,” CEE New Millennium Colloquium, The MIT Department of Civil and Environmental Engineering, Cambridge, MA.

Yao, J. and Lutes, L. (1999). “On Professional Degree Requirement For Civil Engineering Practice”, ASEE Conference on Education, Charlotte, North Carolina.

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