Session: FD4-2

FUTURE DIRECTIONS IN ENGINEERING AND TECHNOLOGY EDUCATION

Mohammad Razani
Electrical and Telecommunications Engineering Technology Department,
New York City College of Technology-City University of New York
mrazani@citytech.cuny.edu

Abstract

The engineering and technology curricula must align themselves with the challenges graduates will face in the future workplace. Such challenges call for scientists, engineers and technologists to possess many attributes such as strong analytical skills, practical ingenuity, creativity, high ethical standards and strong sense of professionalism, leadership abilities, and to become lifelong learners. To prepare such multi-talented workforce requires enhancement of curricula flexibility such as minimizing required core courses and maximizing the non-technical elective courses. This approach is critical for training and educating engineers and technologists to be able to tackle complex and interdisciplinary problems of the future. Students of the future need to be knowledgeable in technical, legal, regulatory, economic, and business fields to give them the capability they need to conduct business globally and deal with diverse business cultures and governmental regulations.

There are several instruments in place to help achieve the goal of preparing capable engineers and technologists for the future and these instruments should be fully and objectively utilized. The role of industrial advisory commissions within the engineering and engineering technology programs are crucial in keeping the programs updated and in line with technological advancements. Co-op programs now in place in many institutions also are needed to create a perspective of how academia with industry could be integrated while still in school. Accreditations and standards set by ABET which guides the institutions to achieve the goal of creating a mechanism of closing the loop for continuous improvement is also another tool to help engineering and technology programs march successfully on the road ahead and be able to meet the challenges that lie over the horizon.

1. Introduction

Engineering is defined as the profession in which knowledge of the mathematical and natural sciences, gained by study, experience, and practice, is applied with judgment to develop ways to use, economically, the materials and forces of nature for the benefit of mankind. The main

Copyright © 2010, American Society for Engineering Education

difference between the Engineer and the Engineering Technologist is that Engineers design and manufacture machines and systems, while Engineering Technologists have the technical know-how to use and install the machines properly.
In today's economy, employers are looking for graduates who possess excellent communication skills and leadership qualities as well as having computer/technical proficiency. They are expected to have hard working attitude and be prepared for a global career. In addition, for those students who are looking to work internationally, they should be language and culturally proficient and have participated in study abroad programs.

2. Elements of Discussion

2.1 Co-Op Programs

Students with work experience, who have taken advantage of Co-Op opportunities during their school years, are often preferred over the ones lacking such qualities. Co-Ops are considered to be academic and are administered by the college. Assignments are directly related to field of study and detailed job descriptions are used to create the best possible matches. A semester in school followed by a term at work followed by a term at school and so on in Co-Op programs have several advantages for students. Some of these gained qualities for those students who participate in C0-Ops are their preferences while they are considered for employment or applying to graduate school. Improved technical skills gained during the Co-Op programs helps determine career path and students with Co-Op experience are more cost efficient for employers and many students accept full time positions with their employer. Some of the advantages for schools in accepting the students with Co-Op experience are the fact that these students have had a chance to integrate theory learned at school with the practice earned in the field. They also help in keeping faculty informed of trends in the related industry and they can be instrumental in creating relationships between schools and businesses, hence improving the schools' reputation. Other benefits are the gained communication and networking skills, self-discipline and management experience.

2.2 Market Demands and Expectations

A look at the market demands for engineers and technologists might give us a better feeling and understanding of how crucial it is now, at this juncture of our time, that educating and training such a work force is important for the future of the country. There are currently 1.3 million engineering/engineering technology jobs available in the U.S. without sufficient qualified people to fill them. According to the Federal Government the country will need 15 million engineers and technology workers by 2020. Educating such a work force for the futures comes with some potential graduation expectations. These expectations include, but are not limited to: understanding technology as a tool for problem solving, understanding the scientific process, engineering problem solving and the application of technology. Students should be well familiar

Copyright © 2010, American Society for Engineering Education

and understand the technological systems as they interface with other systems. They should be able to Use the mathematical principles in their application to problem solving and be able to communicate effectively using reading, writing, listening and speaking and demonstrating the ability to work in teams are rapidly becoming the requirements for engineers and technologists in order to secure long lasting professional jobs. This brings with it a mutual commitment to partnerships between engineering education and professional practice**.** Industries must take the lead in developing opportunities for students to practice engineering in a global context. Universities should initiate more collaborative activities with industry and increase cross-border collaboration among professional engineering organizations.

2.3 ABET Requirements

CQI, Continuous Quality Improvement, is the heart of the ABET requirements for engineering and engineering technology programs and demonstrating the mechanism with which the continuing improvement loop is closed is the crux of ABET's objectives. According to the ABET vision statement[1], ABET provides world leadership in assuring quality and in stimulating innovation in applied science, computing, engineering, and technology education. Included in ABET mission statement is serving the public through the promotion and advancement of education in applied science, computing, engineering, and technology. To achieve this goal, ABET will promote the quality and innovation in education and anticipate and prepare for the changing environment and the future needs of constituencies. In addition, ABET continuous effort is to adapt to emerging technologies, changing disciplines, and blurring among boundaries. Having ABET accreditation approval policies, help students to get the assurance that the ever evolving technologies, its integration into the curriculum and the quality of its deliverance in classroom environments are always under careful monitoring and improvement.

2.4 Advisory Commission Role

Advisory Commission is an effective industrial advising arm of each engineering or technology program. The selection and invitation of individuals who are expert in the related fields are essential to the success of such committees. Once the Commission is formed, the members will meet with the department on a regular basis. The goal is to get their advice on several fronts crucial to the future growth of the department. The advisory board should have full access to the goals and targets of the department, and in a broader scope to the college and university's goals and targets, the running curriculum, the future plans, laboratory potentials, and whatever information pertinent to the academic affairs of the department. The advisory board helps the department with the enhancement of the educational quality and assist with their strategic planning to address the future needs of the department. They provide expert opinion on new equipment and devices the department needs to be able to educate the students in such a manner that they are ready for the job market once graduated. Emerging technologies are always a challenging task that every department has to carefully, rationally, and gradually acknowledge,

Copyright © 2010, American Society for Engineering Education

plan, and implement these technologies in their curriculum. Technology is rapidly advancing and new technologies emerge at such a rate that if not considered, analyzed, and adopted, the graduating class will not be able to perform at the desired quality and will not be equipped with sufficient knowledge that he or she needs and hence might feel left behind. The advisory board helps the department to keep up with new technologies and their advice would be integrated into the curriculum that students would benefit from. After all, the students are the central focus of all educational activities and the sum total of all of the department's effort should be to improve the means in which students are educated and trained to be the future technicians, engineers and technologists in such a way that they start their career with concrete knowledge of the fields and strong confidence that are both required for success.

2.5 Engineers of the next decade

Some colleges have already defined their program outcomes such that they are in line with the industries in terms of their engineering and technological workforce requirements of the future. Such program designs call for an intricate study of the emerging technologies and a good understanding of the infrastructure of the society in 10-15years from now. One such university is Purdue University which has defined its "Engineer of 2020 Program Outcomes" based on the vision that engineers will be prepared for leadership roles in responding to the global technological, economic, and societal challenges of the 21st century. The strategy adopted by Purdue to achieve these outcomes was that educational experiences provided to develop students' technical strength, leadership, innovation, flexibility, and creativity to enable them to identify needs and construct effective solutions in an economically, socially, and culturally relevant manner. The program calls for providing the sufficient grounds to create the essential abilities that the students need to face this challenge. These abilities include leadership, teamwork, communication skills, decision-making, recognize & manage change, work effectively in diverse and multicultural environments, work effectively in the global, engineering profession, and synthesize engineering, business, and societal perspectives. The knowledge areas that provide such abilities are science & math, engineering fundamentals, analytical skills, open-ended design & problem solving skills, multidisciplinarity within and beyond engineering, and integration of analytical, problem solving, and design skills.

In the book "Educating the Engineer of 2020: Adapting Engineering Education to the New Century,"[2] the author points to the fact that engineering education must produce technically excellent and innovative graduates. That report begins with a review of the likely technological changes and challenges that will impact the world and the engineering profession by the year 2020. Noting the expansion of knowledge that is expected by 2010, the report offers exciting opportunities for engineers to develop new technologies to address the challenges faced by society of the time. Issues such as improving the quality of life through advanced technologies will be challenging tasks that the engineers and technologists have to provide answers to.

Copyright © 2010, American Society for Engineering Education

Although the engineering fundamentals will not be any different than what it is today, however the expansion of knowledge, the globalization of the economy, the growth of population, and the new demands, will shape the way engineers tackle problems that requires their understanding of not only the subject matter but also calls for their skills, practical ingenuity, creativity, and strong sense of professionalism, not to mention their leadership abilities and their high ethical standards. The economy in which we will work in 10-15 years from now will be strongly influenced by the global marketplace for engineering services. The outsourcing of engineering jobs and a growing need for interdisciplinary and system-based approaches, demands for new methods of customization and a better understanding of the global economy. The report notes that the steady integration of technology in our public infrastructures and lives will call for more involvement by engineers in the setting of public policy and in participation in the civic arena. A point that needs special attention in this report is the fact that if the United States is to maintain its economic leadership and be able to sustain its share of high-technology jobs, it must prepare for this wave of change. This change is not possible unless the higher education policy makers take this task very seriously and continuously monitor the advances in technological arena and adapt such policies that meet these new waves of technologies. Interaction of engineers in industry and academe are essential to the success of our engineers and technologists to meet the future challenges. Some of the recommendations of this report are as follows:

- The B.S. degree should be considered as a preengineering or "engineer in training" degree.
- Engineering programs should be accredited at both the B.S. and M.S. levels, so that the M.S. degree can be recognized as the engineering "professional" degree.
- Institutions should take advantage of the flexibility inherent in the EC2000 accreditation criteria of ABET, Incorporated (previously known as the Accreditation Board for Engineering and Technology) in developing curricula, and students should be introduced to the "essence" of engineering early in their undergraduate careers.
- Colleges and universities should endorse research in engineering education as a valued and rewarded activity for engineering faculty and should develop new standards for faculty qualifications.
- In addition to producing engineers who have been taught the advances in core knowledge and are capable of defining and solving problems in the short term, institutions must teach students how to become lifelong learners. Engineering educators should introduce interdisciplinary learning in the undergraduate curriculum and explore the use of case studies of engineering successes and failures as a learning tool.
- Four-year schools should accept the responsibility of working with local community colleges to achieve workable articulation with their two-year engineering programs.
- Institutions should encourage domestic students to obtain M.S. and/or Ph.D. degrees.

Copyright © 2010, American Society for Engineering Education

- The engineering education establishment should participate in efforts to improve public understanding of engineering and the technology literacy of the public and efforts to improve math, science, and engineering education at the K-12 level.
- The National Science Foundation should collect or assist collection of data and statistics on program approach and student outcomes for engineering departments/schools so that prospective freshman can better understand the "marketplace" of available engineering baccalaureate programs.

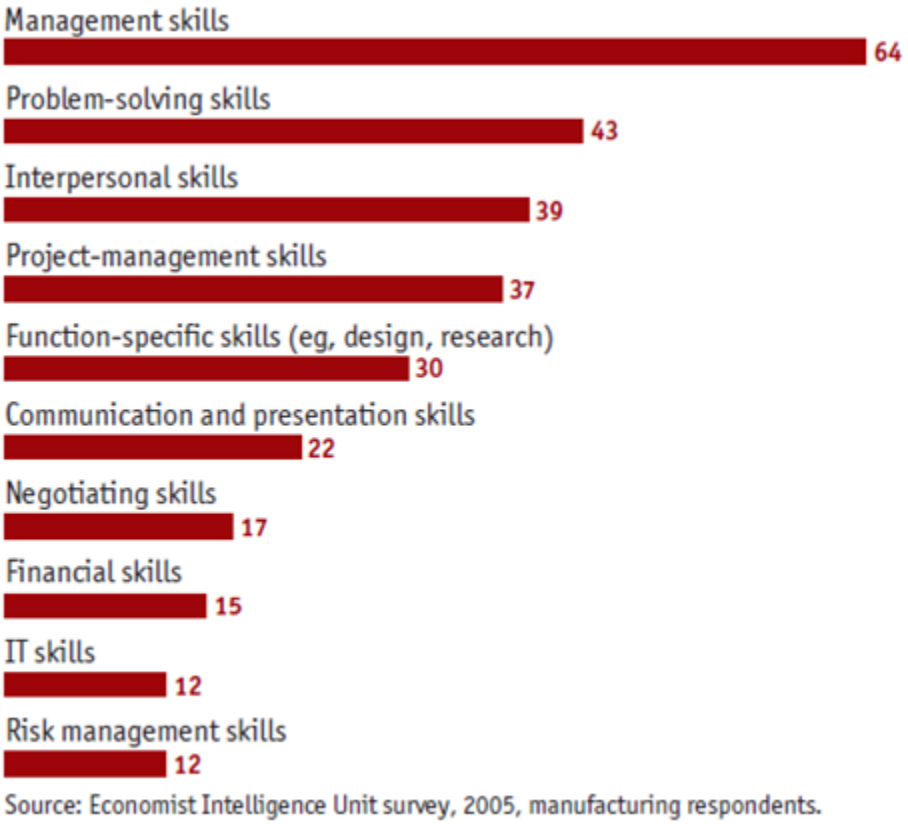
2.6 Global Economy in 2020

A report from the Economist Intelligence Unit sponsored by Cisco[3] Systems published in 2006 assessed likely changes in the global economy in 2020. As part of the research for this report, the Economist Intelligence Unit surveyed more than 1,650 executives around the world for their views on how their companies, and the environment in which they operate, would change over the next 15 years. According to this report, the world economy will be two-thirds bigger in 2020 than in 2005. Global GDP will grow at an average annual rate of 3.5% in 2006-20 (similar to the past 25 years).

This report also concludes that by 2020, ICT development will remain rapid, even if not as fast as in the previous decade. Although the EU and leading emerging markets will be catching up in this area, the previous research suggests that ICT begins to deliver GDP per head growth only after a certain threshold of development is reached; that ICT deployment and use begins to affect economic growth only after an adjustment period; and that the rewards of ICT depend on a complex interaction between technology and a range of other complementary factors relating to the business environment. As a result, the US will continue to reap disproportionate benefits from being the world leader in the development and application of ICT.

Copyright © 2010, American Society for Engineering Education

Another question that was asked from the industries was about the skills that will be most important to their organization's success over the next 15 years. The result is shown below:



3. Concluding Remarks

From what was discussed in this paper, it can be concluded that the flat, hot, and crowded world that we are living in, is changing at a rapid pace in different dimensions that requires several key skills to be integrated into the training and education of the future engineers, technologists, and scientists. The detailed study carried out by the Economic Intelligence Unit demonstrates that management skills, problem solving skills, function specific skills, and communication and presentation skills are crucial elements that the future engineers and technologists should possess to be able to survive successfully in the challenging world ahead of them. It is the responsibility of the policy makers to integrate these qualifications criterion into the educational curriculum so that the road is paved for the engineers and technologist to march on with a confidence. This confidence is needed to build a better world that although it might possess sophistication above our today's imagination, it can however become a world full of excitement and challenges that pulls together scientists and engineers from every corner of the world to further the achievements of mankind and uncover the world of mysteries yet unknown to man. These will not be possible if we do not begin to look at the multi-dimensional character of tomorrow's society. We need to be able to integrate whatever the instruments in hand we possess today that allows us to achieve

Copyright © 2010, American Society for Engineering Education

such a challenging task for tomorrow. Getting advice from the advisory commission, incorporating the ABET approach of closing the loop, taking advantage of Co-Op programs and more, should provide us with sufficient tools to build a very strong curricula for the future engineers and technologists.

References

[1] http://www.abet.org/mission.shtml

[2] Educating the Engineers of 2020, Adapting Engineering Education to the New Century. National Academy of Engineering of the National Academies. The national Academies Press. Washington, DC. www.nap.edu.

[3] Foresight 2020 Economic, industry and corporate trends. The Economist Intelligence Unit, 2006.

Copyright © 2010, American Society for Engineering Education