Engineers and Global Economy in the 21st century: A Conceptual Analysis.

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Abstract

Profile of an engineer of the 21st century is very different from that of a conventional engineer of earlier century. This is an era of "Knowledge Economy" where business environments have changed from catering to a one product requirement to complete solutions. New industries, new working environment and new technologies are emerging. Modern age engineers' job description is multidisciplinary and global, and it requires broad management skills. Beyond the hard core, basic technical skills, engineers need to develop talents associated with project management, systems engineering, global marketing, foreign languages interpersonal relations and even communications. The best engineers will be the ones who can organize, work in multidisciplinary and multicultural business environment and think globally. In Malaysia too, continued health of engineering profession will be a key driver of national economic growth. This paper is an attempt to conceptualize the future of engineering profession in general and of Malaysian engineers specifically, in a globalized world of 2020.

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According to Roger's Thesaurus, one of the synonyms of the word 'engineer' is 'inventor'. The same source mentions 'ingenious' as a synonym of inventor too. Historically, engineers have proven to be visionaries and creative leaders who have contributed to the welfare of the society by their 'ingenuity'. Their inventions such as the wheel, lever, steam engines, mechanical clock, paper and printing press, thousands of years back, to satellite and nuclear technology of modern era, are works of ingenuity that have revolutionized civilizations.

From Stone Age to Cyber Age, engineers facilitated most of the modern economic activities by inventing new technology though in the earlier times word 'engineer' was not in common usage nor was 'invention' confined to a particular profession. A little tinkering combined with imagination by some ingenuous individuals led to the creation of several new and marvelous products. Archimedes' screw, Egypt's pyramid, Great Wall of China and Hanging Garden's of Babylon are just a few examples of use of technology in the pre-scientific era. Even during the so called Dark Ages, engineers produced printing press and the mechanical clock. Today, engineering profession has evolved from being practical artists to scientific professionals who are constantly reinventing themselves.

The onset of the Industrial Revolution was a major turning point in human society. It was marked by technological innovations changing traditional artisans into modern professional engineers. It also saw the beginnings of formal engineering education. Practical thinking became scientific and technical training shifted from apprenticeship to university education. Engineering colleges appeared with well established curriculum. Workshops turned into to laboratories,

industrial research saw an upsurge, and individual inventions were organized into systematic innovations. It was also the period when advent of electricity took place and mass production was introduced. Chemical, electrical, and other science-based engineering branches developed mechanization of production systems, new energy sources, new methods of transportation and communications, including steam engines, steam driven ships, railways and telegraph. The industrial revolution triggered trends that continue even in the twenty-first century.

Twentieth century has seen more technological advances than the eleventh through nineteenth centuries combined throwing significant and formidable challenges to the engineering profession of the current century. The contributions of technology and engineers helped shape the world in which we live and the way we think, making it more productive and improving quality of life. Almost every part of our lives underwent complete transformation during the past 100 years due to the efforts of engineers, changes unimaginable a century ago. From lighting up our cities and villages to genetically modified mass food production , air conditioning and heating, laser and fiber optics, radio and television, entertainment, transportation, automobiles, airplane, space exploration, petroleum and gas technologies, imaging, computers, internet and communication to health care, engineering has impacted countless areas of our daily life completely. The recent spectacular Opening and Closing ceremonies of Olympic 2008 would have been beyond imagination without advancement in technology. There is nothing we touch that has not been engineered including the air we breathe and the water we drink. Engineers play a transformational role in the society. It would not be an exaggeration to claim engineering has challenged even the pivotal role of the governments because of all pervasiveness of information technology. Governments are no longer able keep their citizens or the world in the dark. Day after the Beijing Olympics ceremony, the entire world knew about the little girl’s lip synching.

As the population grows and its needs and wants increase, and the resources of the earth deplete, the problem of sustainable development without compromising on the quality of life is a daunting task. Modern engineers need to once again reinvent themselves to meet the challenges confronting them in the 21st century. Alvin Toffler, the futurist, said' "the illiterate of the 21st century will not be those who cannot read or write, but those who cannot learn, unlearn and relearn." Advancement in technology and emergence of new fields of sciences like nano, bio and info technology, terascale computing, genetic engineering, stem cell research, health informatics, to name a few makes Toffler's statement very apt for modern engineers. Modern engineers have to learn, unlearn and then relearn to be able to contribute to the society.

In this paper we attempt to visualize and conceptualize the basic traits and training that will be required by today's engineers in order to be a success in the current era.

The job description of 21st century's engineer has metamorphosed from single discipline into multidiscipline with global approach. Engineers now need to have holistic and continuous learning approach. Communication skills, thinking, problem solving and interpersonal skills are now as important as their technical knowledge. Global economy is very competitive and unforgiving that translates into constant upgrading of skills and learning new ones. Engineers can no longer bank on their understanding of technical concepts and problem solving capabilities only. Additionally they need to develop their "out of the box" and lateral thinking capability. Creative thinking is a critical component of the innovation process and modern engineers need it to remain in the competition. Einstein said, "Imagination is more important than knowledge".

Developing a new idea is only the first step. Ideas need to be translated into reality. This involves entrepreneurial skills, the ability to convert ideas into business opportunities. Thomas Edison once said, “Most of my ideas belonged to people who never bothered to develop them”.

The capacity to innovate and commercialize new goods and services remains vital to the future competitiveness of all participants in the global economy. Therefore it is imperative for engineers of 21st century to be technology savvy and action oriented, with an understanding of how to market their ideas, attract capital, create wealth and strategically operate their businesses keeping within the ethical boundaries.

New age engineers as their predecessors, are successfully facing these challenges. Moving forward in the 21st century’s global economy, engineers are contributing to unconventional disciplines, using traditional engineering skills, and facing diverse international cultures and broad systems problems. New technologies are emerging rapidly and are pervasively. Information has exploded in the 21st century as data flows rapidly around the world. A global market place has developed and countries are training scientists and engineers equipping them to meet the challenges of the 21st century. New engineers need to work as a member of multidisciplinary teams that could include ecologist, chemists, planners and economists coming from different cultural backgrounds. New challenges require new solutions and new attitudes and new approaches.

Engineers have driven the society in the past. In the future too they have formidable task of bringing change the success of which, according to NAE President Charles M. Vest “could dramatically improve the quality of life for everyone”. On February 15, 2008, The U.S. National Academy of Engineering (NAE) announced the grand challenges for engineering in the 21st

century. An international group of leading technological thinkers were asked to identify the Grand Challenges for Engineering in the 21st Century. Despite their western leaning, the challenges identified have no less relevance to Asian countries because the modern era technology requirement does not see the divide between West and East. In this paper we enumerate few of the identified challenges: they are solar energy, access to clean water, reverse engineer the brain, nuclear terror, secure cyberspace, enhance virtual reality, advanced personalized learning and Engineer the tools for scientific discovery. All these challenges have universal relevance.

Malaysia has taken the initiative of attracting, nurturing and supporting innovation and high technology industries. Realizing that science and technology are key to the success in the 21st century, the country has defined the goals in its National Science and Technology Policy II (NSTPII) that promotes the maximum utilization and advancement of Science and Technology as "a tool for sustaining economic development, improvement of quality of life and national security". This is of critical essence in developing the country's global competitiveness. The NSTP2 has defined the strategic framework that will enable the nation to participate and compete in the global economy driven by new innovation and technologies. Promoting a vibrant culture for science, innovation and techno-entrepreneurship is vital in building competence in key emerging technologies. These emerging technologies are the main challenges that Malaysian engineers have to prepare themselves to face in this century. Malaysia's target of having a competent work force of at least 60 RSEs (researchers, scientists and engineers) per 10,000 labor force by year 2010 is commendable and achievable.

Conclusion:

"Research has shown that the growth in the science and engineering work force is one key element contributing to growth in product and process innovation," says Cliff Waldman, in his report, "China's Educational Performance: Implications for Global Competitiveness, Social Stability, and Long-Term Development."

Ensuring a strong science and engineering workforce is already a priority for Malaysian government. Training scientists and engineers is only a part of the issue. Critical aspect of this issue is how they are trained. Cutting edge research and development has huge consequences. Boundaries between disciplines have blurred. Improvements in instrumentation and development of information technology have made it imperative that students are prepared for lifelong learning. Training successful innovators is essential for a future of Malaysia that is bright and vibrant. Investment in science and engineering has paid off well in other countries. India is a case in point, where its government supported its engineering education with the result that today the country's IITs (Indian Institute of Technology) have produced world class engineers that are in demand globally. They have been, to a great extent, partners in the technological revolution especially in Information Technology. The 11th Five Year Plan which is now under implementation is basically a knowledge investment plan. According to the Prime Minister of India, Dr, Manmohan Singh, "We have significantly increased allocation to the education sector with a five fold increase to an unprecedented Rs.275,000 crore," Approval had already been granted for eight new IITs, seven Indian Institutes of Management, 16 central universities, 14 world class universities, five Indian Institutes of Science, 10 new National Institutes of Technologies, 20 Information Technology Institutes, and 1,000 polytechnics, he added.

He further stressed, "India has the potential to create over 500 million trained people by the year 2020. That would be over a fourth of the global workforce. This big and unique opportunity for India will come from an education revolution that we must undertake as our most important national endeavor."

China’s growth in its research and development programs is ringing alarming bells in Western countries. China’s declaration of education, science and technology being strategic engines of sustainable economic development has resulted in annual R&D growth rate that is fastest than any other Asian nations. In January 2006, China initiated a 15-year medium to long-term plan for the development of science and technology. The nation aims to become an "innovation-oriented society" by 2020 and a world leader in science and technology by 2050. China already is an important player in high-technology markets, attracting investments from the world's major corporations. Nanotechnology-related patent applications alone have grown particularly fast, reflecting that China was one of the few countries to start focusing on nanomaterials in the 1990s. As per the latest available figures (2004), 2,400 such patents, 12 percent of the world total. In 2006, 36% of Chinese undergraduate degrees and 37% of graduate degrees were awarded in engineering. Chinese government sent its first man in space in 2003, third country after US and Soviet Union and had its first astronaut walk the space in September 2008.

Globalization is forcing educational institutes to shift their focus from conventional engineering education to new skills along with regular fundamental knowledge. This path of education would be stressful but without stress there is little incentive, without incentive there is no innovation and without innovation comes stagnation. Global challenges require perseverance and ingenuity for which the nation’s engineers must be qualified to manage. Innovation is the answer to surviving and prospering in today’s global market place. Innovation is required not

only in products and services, but in ideas too, ideas for creating new businesses, new ways of doing things, new ways of using technology, and innovative ways of doing business. In other words innovation is a new way of thinking. Today's challenge is aptly expressed by Edward de Bono "it is better to have enough ideas for some of them to be wrong, than to always be right by having no ideas at all".

The engineer of 2020 and beyond will face a bewildering array of new technologies, appearing at a neck breaking rate that will bring his or her professional qualifications constantly near obsolescence. The engineering community will face a world which is more connected than today, requiring both social and political acumen to navigate the changing world conditions. The modern labor market demands higher skills at all levels, in the laboratory, on the production line and at the administrative level. Engineers face challenges of ever-changing business models, shorter product life cycles, intense global competition and multicultural work environment. They will be able to face these challenges successfully if they acquire accumulated knowledge of technical disciplines as well as other fields such as social sciences and commerce. This accumulated knowledge will train them to be well rounded and well balanced with the ability to relate with multicultural work force both in engineering and business world.

More and more companies are orienting their operations globally. Malaysia should orient its education of science, technology and engineering along these lines. It is a necessity if Malaysia wants to retain and advance its presence in the global economy. Besides, the aspirations of the modern engineer are changing. Young, educated and dynamic, they see themselves as global citizens. They need the support of the government's education policy to nurture their creativity and ingenuity.

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