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Advice to Young Engineers

Engineering and engineering education have evolved dramatically in the past century—and the future is likely to bring even more rapid change.

In the early years of engineering, professionals possessed broad knowledge. It was common for engineers to recognize the need for a product and to see it from conception through to design and implementation. As societal needs changed, engineers were prized for their depth of knowledge in increasingly narrow areas within the broader discipline. They became experts in one defined field, for example, electrical or civil engineering. New areas of specialization changed the shape of the profession and broadened its impact.

Engineering breadth, ingenuity, and flexibility have needed to adapt to shifting technological, societal, political, economic, and environmental conditions. We have based our way of life on the availability of rapidly depleting energy and resources. Technology has spelled an end to some types of employment while creating others. Globalization and modern communications have radically altered the ways business and human affairs are transacted, creating new alliances, alignments, and markets.

Looking into the Future

One way we may begin to understand the directions in which 21st century engineering might evolve is to look to the past to assist our projections. The National Academy of Engineering Web page [1] lists the 20 most important engineering achievements of the 20th century, including electrification, automobiles, airplanes, water supply and distribution, electronics, radio, TV, agricultural mechanization, computers, telephones, air conditioning, refrigeration, highways, spacecraft, the Internet, and imaging. Clearly, the world our society takes for granted is a world envisioned and created by engineers.

Some of these key achievements will continue to shape our future. For example, the unabated demand for a sustainable means of transportation has spurred the search for alternative fuels. Finding renewable and environmentally friendly sources of inexpensive energy for manufacturing, transportation, and other human needs remains one of our most pressing problems. Engineers will continue to develop new products, systems, and methodologies to improve efficiency, safety, and sustainability. In addition, bioengineering, nanotechnology, and mega computing are likely to continue as preeminent research trends for the foreseeable future [2].

Beyond these emerging fields, the crystal ball is not as clear. Outcomes will depend on scientific breakthroughs and political decisions that we cannot predict. Will it be space exploration, Star Wars, attempts to undo environmental damage, feeding an ever-increasing world population, defending the human race against new diseases, or security issues that will capture our imagination and resources in the coming decades?

How then can I advise a young person aspiring to be an engineer? The question of what kind of engineering education would be most advantageous is analogous to asking athletes to train for future Olympic games. In that faraway future, the competition might be held in sporting events yet to be defined. When

The author of this article has long held leadership roles in our Society and is widely recognized for his research in multimedia. He has published extensively on digital signal and image processing as well as digital communications. Tas Venetsanopoulos writes that a versatile engineering education, based on a broad foundation, is likely to be the most appropriate training for a future that is difficult to predict. He advocates training engineering students to consider social, environmental, and human factors and not just to focus on developing technical excellence. Dean Venetsanopoulos encourages aspiring engineers to cultivate their communication skills, to think like entrepreneurs, and to see themselves as citizens of the world so they will be prepared to contribute to society's most pressing problems.

—Arye Nehorai
"Leadership Reflections" editor

faced with planning an engineering education now for a future determined by factors that are yet unknown, the natural response is to develop fundamental skills for a high degree of overall mental fitness.

A Broad Engineering Education

My experience suggests that a broad education will best prepare us for future challenges. This approach is not new. In 1878, the University of Toronto hired its first engineering professor, John Galbraith, who later became our first dean. In Galbraith's words, "It is plainly impossible within the short space of three or four years, and under academic conditions, to turn out an engineer, architect, or chemist fit for the full responsibilities of his profession" [3]. Galbraith believed that an engineering curriculum should be designed with this limitation in mind and should include only such subjects as the principles of science, the qualities of materials, the ability to read and assess technical literature, and the capacity to recognize skilled work. He also considered practical work experience essential.

As Galbraith suggested, the wisest course is to encourage students to obtain a broad education. I would add that students should pick an area of engineering they personally find appealing rather than trying to predict what sector will be "hot" when they complete their degrees. A low point in a particular industrial sector today does not necessarily mean that an industry will be wiped out four years later.

Our industry advisors suggest that well-rounded engineers are needed to develop solutions to some of society's most pressing problems. We need to teach students to consider social, environmental, and human factors as a starting point for design. Exposing students to a broad set of topics will stimulate ingenuity and innovation, without sacrificing technical excellence. I advocate using the engineering design process as a means of introducing students to problem solving, systems thinking, project management, team work, the social impact of technology, and the importance of verbal communications, interpersonal communications, and technical writing. Offering students greater flexibility in course selection, including allowing students to elect nontraditional options as minors, may help to develop engineers who are able to handle technical, as well as human, problems.

One of the great strengths of an engineering education is its versatility. Engineers are prized in the working world for their ability to define and solve problems, to think creatively, to work well in teams, for their comfort with numbers, for their knowledge of modern engineering tools, and for their ability to adapt to rapid technological change. It is this versatility, based on a broad foundation, that now makes engineering graduates sought after in divergent career paths, from the life sciences to the financial services. A broad education will also be the most valuable asset we can offer students to take into an uncharted future.

Six Suggestions for Young Engineers

The most important skill you should acquire from your years as an engineering student is to learn how to learn. Based on my own experience, I offer six additional suggestions for you to consider.

Make Short-Term Concessions to Achieve Long-Term Objectives

Engineering studies demand long hours, self-discipline, commitment, and a strong work ethic. Most students find they need to defer or curtail diversions from study to keep their heads above water, especially in subjects involving cumulative learning. The short-term restrictions will pay off later, through an achievement rich in long-term dividends.

Cultivate Your "Soft" Skills

Students might have chosen to study engineering because they excel in math, sciences, and technical subjects. But they will find that they are in far greater demand as engineers if they have also cultivated their oral and written communication skills, their people sense, and their leadership and negotiation skills.

Be Entrepreneurial

Thinking like an entrepreneur, regardless of whether you are working within a corporate environment or on your own, will allow you to make the most of opportunities as they develop. Rather than selecting the path of working for a large corporation as their parents' generation might have done, many enterprising students choose to start their own companies, some before graduation. Just one example is Alvin Ho Kwan Mok. While still an undergraduate, he founded IntelliGENE, a software company specializing in enterprise resource management and customer relationship management. Mok set up branches in Tokyo and New York to promote sales and attract capital. His firm grew from two to 40 employees in ten months before he sold it to external investors in April 2002. I know of other students that have founded companies that translate e-mail addresses and Web sites so they are accessible in numerous foreign languages; provide telecom services to the hospitality industry; and provide products for enterprise-level instant messaging (see www.ecf.utoronto.ca/~alumni and click on Skulematters for feature stories on some students' remarkable achievements).

Think Globally and Not Locally

Today we are experiencing the "global village" that University of Toronto professor and media guru Marshall McLuhan predicted [4]. Ideas may be conceived and designed in the West, while the product might be manufactured in China, using software produced in India. The resulting items are sold in global markets. Microsoft, Hewlett-Packard, Intel, and IBM all have labs around the world. Jobs in manufacturing and software development have begun to shift from the western world to the developing world.

Young engineers who will thrive in this kind of environment need to be prepared to deal with people of varied backgrounds, values, cultures, and religions. Engineers who see themselves as citizens of the world will be able to take advantage of a broader range of opportunities, wherever they may arise.

Do Extensive Planning

For those students who are planning to pursue a Ph.D. or a research project of substantial duration, my advice is to do the best planning possible. I have found that asking myself "Does this solve the key problem?" is a good way to keep on track. Another pitfall is designing technology for technology's sake; systems should be designed with human needs in mind [5]. Once you have made a decision, focus on solving the problem by using your own inner resources without relying on others' solutions. Only when you have satisfied yourself on the best way to proceed should you consider going to the literature to check what others, faced with similar difficulties, have done.

Life Is in the Journey, Not the Destination

Each passage of your life has something of value to offer you. In conclusion, I offer you an excerpt of the wisdom of the renowned Greek poet Constantine Cavafy who, in 1911, wrote the *Ithaka* poem:

Ithaka

When you set out on your journey to Ithaka,
Pray that the road is long
Full of adventure, full of knowledge,.....

Always keep Ithaka in your mind.
To arrive there is your ultimate goal.
But do not hurry the voyage at all.
It is better to let it last for many years;
And to anchor at the island when you are old,
Rich with all you have gained on the way,
Not expecting that Ithaka will offer you riches.

Ithaka has given you the beautiful voyage.
Without her, you would have never set out on the road.
She has nothing more to give you.... [6]

Tas Venetsanopoulos earned his B.Eng. from the National Technical University of Athens, Greece, and his M.S., M.Phil., and Ph.D. degrees from Yale University. He joined the Department of Electrical and Computer Engineering of the University of Toronto in 1968. In July 2001, he assumed his current position as the 12th dean of the Faculty of Applied Science and Engineering at the University of Toronto. He has received many honors and awards, including the IEEE's prestigious MacNaughton Award and the IEEE's Millennium Medal. He is a Fellow of the IEEE, the Engineering Institute of Canada, and the Canadian Academy on Engineering.

References

[1] http://www.greatachievements.org/

[2] http://www.spectrum.ieee.org/wfbonly/resource/jan04/

[3] R. White, *The Skule Story: The University of Toronto Faculty of Applied Science and Engineering 1873–2000*. Toronto: Univ. of Toronto Press, 2000.

[4] M. McLuhan and Q. Fiore, *The Medium Is the Message*. New York: Bantam, 1967, p. 63.

[5] K. Vicente, *The Human Factor*. New York: Knopf, 2003.

[6] C.P. Cavafy, *Selected Poems* (translated by D. O'Grady). Dedalus/Dufour Editions, 1998.