Patri K. Venuvinod, 2003, "Technovation and Mechatronics," Keynote Address, Mechatroics Coference, Mahatma Gandi Institute of Technology, Hyderabad.

TECHNOVATION AND MECHATRONICS

Patri K. Venuvinod
Executive Director
International Organization for Developing Universities (IODevUni)
Chicago, Illinois, U.S.A.

Over 25 years ago, I had left Andhra Pradesh in pursuit of greater professional satisfaction. I moved to Hong Kong.

When I entered Hong Kong, I thought it was like Mumbai (then, 'Bombay'). But, I was mistaken. Hong Kong had made rapid economic strides through *laissez faire* (non-interventionist policies). Decisions concerning industrial directions were totally left to the people. The role of Government was deliberately restricted to maintaining law and order and building the basic infrastructure. An independent commission against corruption (ICAC) had managed to contain public and private corruption significantly. Thus empowered, people developed small enterprises (not vertically integrated monoliths). An excellent communication infrastructure enabled horizontal integration. Hong Kong became a significant center for manufacturing. As a result, within my 25 years there, Hong Kong rose from being the 22nd to the 5th in the world in terms of gross domestic product (GDP). By 1986, the GDP of Hong Kong was nearly a third of that of India. Meanwhile, just a few kilometers away, the Chinese dragon was waiting to awaken.

When I moved to Hong Kong, India and China were on par in terms of most economic indicators. However, the infrastructure of China was in much worse shape owing to internal turmoil and a 'closed door' policy. Then came Deng Xiaoping who initiated an unprecedented 'open door' policy and a movement called the 'Four Modernizations'. I had the good fortune to participate in what was probably the first international delegation to visit China after it had opened its doors. I found industry in China in shambles. However, people in general were eager to progress materially by "doing whatever that works". Soon, Hong Kong entrepreneurs started investing heavily in China. Within a decade, over 70% of foreign direct investment (FDI) in China was from Hong Kong entrepreneurs. Thereafter I visited China many times. Each time, I noticed phenomenal progress owing to market-oriented policies, greater horizontal integration, and increased globalization. As a result, China has now become the world center for original equipment manufacturing (OEM). Recently, when I escorted some of my American friends on a 100 kilometer drive over the highway from Tianjin to Beijing, my friends had to keep reminding themselves that they were not in America but in China since a casual glance through the car window revealed few visible differences.

I have been periodically returning to Hyderabad to visit my extended family. Till recently, the only progress I could find was the size of the pothole at a crossroads near my mom's house. I was desperate to find the reasons.

According to classical economics (be it capitalistic or Marxist), there are four factors of production (read economic progress): capital, land, labor, and raw materials. India has all these in plenty. Why

had it fallen woefully short in economic performance? After much reading and introspection, I found a convincing answer in the theories of Joseph Schumpeter who had added a fifth factor of production: 'technovation'. Schumpeter considered this factor to be the most important.

Technovation means 'technological innovation'. Technology is nothing but a 'bag of hardware or software tools' capable of meeting humanity's diverse material and psychological needs. Maslow has identified five levels of human needs: physiological needs, safety needs, belonging and love needs, self-esteem needs, and self-actualization needs. Technology can be used to meet all these needs, directly or indirectly.

Many modern technologies depend upon science and the applications of scientific knowledge and principles. Each advance in pure science creates new opportunities for the development of new designs and ways of making things to be used in daily life. Hence, the availability of a good pool of trained scientists (as in China and India) can be an asset. On the other hand, technology provides science with new and more accurate tools for investigations and research. Although I was a trained engineer, it was difficult for me to come to terms with the benevolent power of technology because my childhood was spent in the peculiarly Indian era dominated by Gandhian notions of 'appropriate' technology. On the other hand, having been exposed to capitalistic as well as socialistic notions, I had developed a strong belief that without capital nothing could be achieved. I believed that 'planning by the Government' was the key in a capital-starved nation such as India. At the same time, the mammoth size and population kept stirring Malthusian fears in me. I wondered—would I see India progress to anything close to the so-called 'developed' world within my lifetime?

My earlier visits to China were conducted with a mindset (culture) dominated by such values, attitudes, and beliefs. No wonder, the rapid progress being made by China had surprised me. Like India, China had no capital at that time. It was also pursuing a planned approach based on socialistic thoughts albeit without a façade of democracy. However, it had grown out of the belief that, in a growing nation, it was imperative to protect domestic enterprises from foreign competition (Even today China has a large but highly unproductive state sector that no private firm wants to take over.). In fact, it had started welcoming competition in the belief that, in the process, technology would come in. It had and is still continuing.

But, is mere availability of technology enough? Again, Schumpeter provided me the answer. The answer (at least, to me) was in the second part of the term 'technological innovation'.

Innovation has been defined as "the introduction of a new or improved product, process, or service into the marketplace". A better definition is that "innovation is about new ways of delivering customer value." The focus on customers is in keeping with the fact that markets worldwide are no more producer-dominated but consumer-dominated.

Innovation need not relate only to the product or service itself—it can apply to any part of the business system or value chain associated with delivering the product or service to the customer. Toyota innovated in the manufacturing part of its value chain, with major beneficial effects for cost, product quality and model range. Federal Express innovated by replacing the point-to-point approach of its competitors with a hub-and-spoke system. Therefore, innovation can consist of changes to a particular link in the value chain, or to the creation of a fundamentally new value chain, bypassing the traditional approach.

Industrial innovation includes the technical design, manufacturing, management and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment. Innovation can be incremental. Contrary to popular opinion, Drucker says that innovation is capable of being presented as a discipline, being learned, and being practiced.

But, who could spearhead innovation from within a society? Again, I found the answer in the works of Schumpeter. Schumpeter recognized entrepreneurship as the engine of innovation.

However, unfortunately, the French verb *enterprendre* literally means 'between-taker.' Further, many English speaking people outside USA equate an entrepreneur with a "get-rich-quick fast-buck artist." In contrast, Webster dictionary defines an entrepreneur as someone who undertakes to "organize, manage and assume risk of business." The entrepreneur typically assumes responsibility for creating and developing new living businesses rather than burying old dead ones. In the context of technological evolution, this quality converts inventions into innovations.

Much of the 'Wild West' in U.S.A. was originally 'won' by entrepreneurs. Hong Kong reached its peak owing to the entrepreneurial spirit of its people. The same people pump-primed the economy of modern China. We see the beginnings of entrepreneurship (in the modern sense) in India—particularly in Andhra Pradesh.

Large organizations (e.g., governmental units) find it very difficult to innovate because of bureaucratic legacies and/or close public scrutiny that severely constrains their options. Quite often small can be beautiful by providing agility. Bureaucratic organizations impede innovation by giving precedence to procedures over goals.

While I was still learning about the power of technological innovation, the world of technology itself was experiencing dramatic changes owing to developments in computers and communications. Enterprises and units within enterprises started being integrated through extensive use of digital communication technologies. Engineering as well as consumer products started becoming 'intelligent' through the integration of mechanical, electronic and computer technologies. Even a new discipline called 'mechatronic engineering' focusing on such integration started emerging.

These developments transformed manufacturing technologies too. Machine tools became computer numerical control (CNC) machines that were smart enough to communicate with other machines. These developments resulted in a vision called flexible manufacturing systems (FMS) consisting of planned shop floors comprising hierarchically organized CNC production equipment communicating through local area networks (LAN). The hope was to meet the demand for increased product variety from consumers worldwide.

I did my bit to assimilate such computer-integrated facilities into my department—the Department of Manufacturing Engineering and Engineering Management at City University of Hong Kong. However, I was uneasy at the presumption that engineers such as me (mere mortals) were capable of anticipating the micro-behavior of highly complex shop floor systems in response to a constantly changing environment.

A bit of reading revealed to me that 'top-down planning' is doomed to failure owing to its own nature. Indeed, it appears that the development of a ground-breaking new technology has seldom been 'planned for'. In this context, I was impressed by the following views expressed by Devendra Sahal (a thinker of Indian origin): "Technology is a self-organizing system [like an ant colony] that evolves by trial-and error learning…Through interplay of the self-organizing system formed by a

technology and its sustained application and development there emerges a pattern of artifact design or technological guidepost which charts the course of further innovative activities…There is one difference between biological and technological evolutions. A biological species cannot interbreed whereas stepwise technological growth is quite frequently achieved by creative symbiosis of two or more previously unrelated technologies [e.g., Mechatronics]."

Meanwhile, the migration of its manufacturing shops into mainland China started to "hollow out" Hong Kong. Employment in manufacturing plunged from its peak of 48% to 6%. Our degree programs in manufacturing engineering were under threat. What could we do? I thought, Hong Kong could reassert its industrial superiority by moving to more value-adding activities. We couldn't move up all the way up to original brand manufacturing (OBM) which is the strength of highly developed economies such as those of U.S.A. and some European countries. We had to assume the intermediate ground by engaging in original design and manufacturing (ODM). Design thus became our operative word.

But, design what? We needed a definition that was generic enough to stand the test of time. In the event, we opted to launch the first 'mechatronic engineering' degree program in Asia. I am glad that similar programs are coming up in Andhra Pradesh.

Mechatronic Engineering may be defined as "*a synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes*." Thus, courses related to controls, electronics, sensors (not instrumentation or measurement), and automation are of particular importance. The discipline loses its purpose if all these subjects are not integrated through a design project inspired by some industrial practitioner. This means that issues concerning product design (including aesthetic design and certain customer related issues drawn from the field of marketing) are also important.

The discipline and profession of mechatronic engineering is of particular relevance in a society pursuing ODM as its competitive strategy. Having established its primacy in OEM, China has just started talking about ODM.

As for India, it has already lost to China with regard to OEM. In any case, success in OEM requires a stable society and extensive physical infrastructure. In contrast, ODM requires a horizontally networked pool of professionals straddling diverse disciplines. Through foresight or otherwise, India has built such a pool. It is now time to capitalize on the pool by moving beyond BPO (business process outsourcing) into ODM. Within the context of ODM, mechatronic engineering assumes particular importance.

Presently, there are some 217 engineering colleges in Andhra Pradesh with a total annual intake of over 60,000. However, the proportion of engineering graduates taking up domestic jobs is only about 30%. What would the rest do? When I put this question to many local principals, they tell me that there is a vast potential for employment in developed countries and that they are preparing students essentially for employment abroad. (One wouldn't dare to make such an assertion in public just a few years ago since going abroad was taken to be tantamount to abandoning once motherland.) This certainly is a credible answer. But, it is not complete. We need more. That could be the pursuit of entrepreneurship with all the connotations with regard to ODM and mechatronic engineering outlined above. I urge you to mull about this proposition.

Entrepreneurship thrives in an orderly but free society. Corruption, whether public or private, impedes entrepreneurship. Where there is more government, there is less entrepreneurship. I urge the Government to keep this in mind.

Research indicates, the first success of an entrepreneur occurs within the age-window of 25 to 35 years. Thus, entrepreneurship is a youth-oriented activity. Entrepreneurship thrives in a society that values youth, encourages individualism, frowns on power distance, tolerates failure, and stimulates moderate risk taking. I urge all educators to keep this in mind.