A Comparative Analysis of Manufacturing Engineering Education in the former USSR and Hong Kong

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Abstract

The former USSR and Hong Kong provide interesting contrasts in terms of manufacturing engineering education by virtue of the differences in their economic and industrial structures. This paper aims to provide a comparative overview of the practices of manufacturing engineering education in the two regions. In particular, industrial trends, national priorities, entry requirements, curricula, strengths and opportunities are compared.

Key Words: Manufacturing, Education

Introduction

The former USSR was a sovereign nation covering over 22 million square km and had a population of around 280 million. It commanded a substantial proportion of the world's natural reserves (e.g. 25% of oil, 55% of coal, and 43% of iron ore). In contrast, Hong Kong is a colony of UK (whose sovereignty will be to returned to China in 1997) covering only about 1000 square km and has a population of mere 6 million. It has no natural resources and , therefore, has had to depend mainly on the entrepreneurship and work ethic of its people. Thus, comparing Hong Kong with the former USSR, from any point of view, is like comparing David with Goliath

This paper provides a comparative analysis of manufacturing engineering education in the two regions. The analysis is based on the insights derived by the authors through their combined working experience (of nearly 50 years) with university level education in manufacturing engineering in the two regions.

Industrial History, Strengths, and Weaknesses

Manufacturing in the former USSR (henceforth, simply called the USSR) had a long history. Imperial Russia had been on the fringe of the industrial revolution sweeping Europe in the 19th century. However, after the USSR was formed following the October 1917 revolution, the country started facing many difficult problems owing to its feeling of "capitalistic encirclement" and the resulting political and economic isolation from the rest of the world. Consequently, to stimulate technological development from within, the central Government established several (30 to 50) ministries each of which focused on a specific industrial sector: e.g. machinery, power, mining, aviation, military production, machine tools and tooling. These efforts were coordinated centrally through national five year plans. Thus, by 1986, the USSR had achieved a per capita GNP of US$ 6490 which was only 30% lower than that in EEC. More importantly, it became the leader of the second world and was engaged in a neck-and-neck race with the USA in space research and nuclear arms. For instance, it was the USSR which launched the first satellite and first sent a man into the space. Nearly three-quarters of the working population was employed by the manufacturing sector to sustain these industrial efforts. These trends had two positive effects on engineering education. Firstly, engineers enjoyed high social prestige. (Many national leaders, e.g. Brezhnev, were engineers.) This meant that engineering schools were able to attract high caliber students. Secondly, there was close liaison between engineering schools and the industry with a substantial proportion of the R&D budget of the schools being financed by the industry.

In contrast, the industrial development of Hong Kong (henceforth, abbreviated as HK) is of more recent origin. At the beginning of the present century, HK was a sleepy village inhabited by fishing communities and, interestingly, pirates. Even by the 1950s, Hong Kong's manufacturing industry was largely confined to textiles and low-end products such as silk flowers. Starting from such a modest base, Hong Kong's manufacturing industry grew rapidly to encompass high quality textiles and garments, electrical appliances, electronic products, computer peripherals, watches, light engineering goods and a limited range of production machinery. Thus, by 1988, HK's manufacturing industry was employing around 900,000 workers who were contributing to nearly a quarter of Hong Kong's GDP. Today, with the recent spectacular growth in its service industry, HK ranks among the top 10 countries in the world

in terms of per capita income (over US$ 18,000 now in HK). Two factors contributed to this phenomenal growth. Firstly, the Government has been unwaveringly sticking to a *laissez faire* policy unmatched in any other part of the world and, therefore, confining itself to the maintenance of law and order, and the development of general infrastructure and education. Taxes have been low with a ceiling of around 15%. Defense needs are conspicuous by their absence. This has meant that a greater proportion of the Government's budget could be channeled into the development of infrastructure and education. Thus, presently, about 16% of HK Government's budget is devoted to education as compared to 10% in the USSR in the mid eighties. Secondly, the people of HK, who are largely made up of emigrants from mainland China, have been exhibiting a remarkably high degree of entrpreneurship. As a consequence, by 1988, there were over 80,000 manufacturing enterprises spread across the territory. The uniqueness of HK lies in its ability to horizontally integrate such a large number of small sized enterprises, each specializing in a narrow range of manufacturing activities (there are companies engaged just in mold polishing) into an agile, commercially driven, and export-oriented industrial system. Further, HK has always been closely connected with the world manufacturing community and able to attract substantial overseas investment.

A cursory review of the development of most industrialized societies (e.g. USA, and Japan) shows that industrial development typically occurs in three stages. The first stage is characterized by competition through increased productivity (P). In the second stage, the focus shifts to achieving higher quality (Q), i.e. achieving higher consumer satisfaction, while maintaining high productivity. The focus in the third stage is gaining further market share through superior innovation (I).

The P→Q→I transition seems never to have been properly consummated in the former USSR owing to the national policy of giving priority to the "production of means of production" rather than producing for public consumption or export. This policy resulted in each industrial ministry tending to be fully self sufficient with little interaction with other sectors. For instance, almost every major ministry tried to produce its own machine tools, molds, dies, stamps, etc. in spite of the fact that there existed a ministry specializing in machine tools. As a result, there was a concentration of industry in vertically integrated and bureucratically run industrial organizations of large size. However, due to a lack of consumer consciousness, the quality of goods produced remained poor. The term *quality* was in vogue but it was interpreted only at the product level and that too as mere conformance to specification. The roles of corporate organization, culture, and management in assuring quality were totally missed. Movements such as ISO 9000 and Malcolm Baldrige Awards were conspicuously absent. As for innovation, there indeed were some highly impressive pockets. But these existed mainly in the context of perceived defense needs. Consequently, these innovations only addressed technical issues with little regard to the $-sign, a consumer oriented definition of quality, and competition in the world market. For instance, Lazarenko of the USSR had invented EDM in 1948 and this technology is being extensively used across the world today. Yet, the USSR has hardly any share in the world EDM market. This phenomemenon, which has been repeated many times, because the USSR has been insulated from the world manufacturing community. Further, it seems to have missed out on the consumer electronics revolution and the transformation of manufacturing that has been occurring through extensive use of computers.

HK' industrial development, till the seventies, was mainly characterized by constant improvements in labor productivity through better training and use of progressively advanced forms of process technology, if not automation. However, by the eighties, HK realized that its competitive advantage of low cost labor was being rapidly eroded. Hence, in 1988, the Government launched (rather uncharacteristically) a major expansion of tertiary education (doubling in five years) and exhorted the industry to "move up-market" through the production of high-value added-goods. HK's manufacturing industry responded to these exhortations in three ways. Firstly, taking advantage of the opening up of China and the low labor costs prevailing there, it invested heavily in Southern China and moved a substantial part of its low-end manufacturing operations there. Secondly, it rapidly upgraded the manufacturing technologies employed within HK. Thirdly, it extensively adopted a variety of quality initiatives such as ISO 9000, TQM, etc. Thus, the P→Q transition seems to be nearly completed in HK now. However, it must be acknowledged that HK has not yet adopted innovation as a competitive weapon. This is partly because of the opportunities available for horizontal expansion into China, the fragmentation of HK's industry into a large number of small-sized units, and the general view of manufacturing as just another business to make money. This scenario has resulted in two major implications for manufacturing engineering education in HK. Firstly, engineers have not been enjoying a particularly high social status compared to other professionals. As a result, very few able students are seeking admission into engineering schools. Secondly, owing to the fragmentation of the manufacturing industry, few manufacturing enterprises have so far engaged in significant R&D. As a result, the onus of financing R&D efforts within the universities has had to remain with the Government.

Manufacturing Engineering Education

The formal organization of education for the manufacturing engineering profession, albeit as a

part of the mechanical engineering profession, started in Russia as early as in the last decade of the 19th century when the Russian Government established several *Polytechnic Institutes*: Kiev Polytechnic, Moscow Higher Technical School, etc. Only these institutes had the power to award *Diplomas* (Degrees) in engineering.

HK's initiatives towards educating manufacturing engineers are of more recent origin. The first Industrial Engineering department was set up only in the seventies. Today, there are four universities engaged in manufacturing engineering education.

The ethos of engineering education in the USSR was strongly influenced by many world renowned scientists such as Mendeleev, Gukovsky, Tsiolkovsky, Timoshenko, and Krilov. Under their supervision, Russian engineering schools established highly successful mechanical engineering departments. Much of the activity in these mechanical engineering departments was related to what we now call as manufacturing engineering. Thus, by the middle of the current century, the former USSR had produced many internationally known mechanical-manufacturing scientists: e.g. Lazarenko, Basov, Prohorov, Mitrafanov, Sokolovsky; Zorev and Loladze.

In contrast, as a result of the inclination of HK entrepreneurs towards short-term goals, till recently, there has been relatively little interest in engineering R&D in HK. However, HK Government has recently started injecting substantial funding to stimulate R&D activity in the tertiary education sector in realization of the importance of innovation as a competitive weapon in the 21st century.

With a view to obtaining some insight into the practice manufacturing engineering education in the USSR, we will now study the case of the Precision Engineering Faculty (PEF) at Kiev Polytechnic Institute (KPI). PEF is one of the four mechanical engineering faculties at KPI (we use the present tense the institution continues to function although the USSR does not exist anymore). It consists of six departments (Orientation and Navigation Systems, Instrument Manufacturing, Precision Mechanics, Optical Devices, Scientific and Analytical Instrument Making, and Non-destructive Test Instrumentations and Systems); and two research institutes (Advanced Technologies, and Special Purpose Instrument Making). Each of these departments was established under the direction of the Ministry of Education (of the USSR) to meet the perceived manpower needs of a specific industrial sector (ministry). Each department offers its program leading to an *Engineering Diploma* in mechanical engineering with a named specialization. The curriculum for each Diploma program was essentially identical across the nation as stipulated by the appropriate committee of the Ministry of Education. The duration of each program is 5½ years in the full-time mode. Part-time and correspondence courses are also available. The student strength is of the order of 1500 full-time, 200 part-time evening and 200 by correspondence. To serve these students, PEF employs about 130 teachers (Assistant Professors, Associate Professors, and Professors), and 60 technicians.

Turning now to HK, before joining a Degree program in HK, students are generally expected to have undergone 13 years of study (6 years at the primary level, 5 years at the secondary level, and 2 years pursuing "Advanced" level studies at the higher-secondary level) before being admitted for Degree level studies. Some students move to the vocational schools at the age of 15 and may return to degree studies after obtaining Diploma or a Higher Diploma award. In view of the "Advanced" level grounding already achieved in mathematics and physical sciences, engineering Degree programs are of 3 year duration in the full-time mode and 6 years in the part-time evening mode. Post graduate study options include M.Sc. programs through course work (2 years part-time), M.Phil. study by research (2 years full-time), and Ph.D. (3 to 4 years full time).

As a case study, we will now examine the programs offered by the Department of Manufacturing Engineering at the City University of HK (MfgE-CityU). MfgE-CityU was launched in 1987 and started its first degree program in Manufacturing Engineering program in 1989. The program duration is only three years because the entrants would already have had 13 years of schooling, including advanced level studies in mathematics and physical sciences. The program presently has about 250 students in the full-time mode and 150 students in the part-time evening mode. In addition, the Department offers a first degree in Mechatronic Engineering, two MSc programs (Automation Systems and Management, and Engineering Management) and research degrees (M.Phil and Ph.D.). In consonance with the *laissez faire* environment of HK, it was totally left to the Department itself to initiate the programs and develop the curricula. However, since CityU was originally a Polytechnic (following the British tradition), the department was required to objectively justify the curricula in the light of the emerging needs of HK industry. Initially, the Council of National Academic Awards (of the UK) had visited the Department to validate the programs. This tradition of external validation has recently been replaced by internal validation processes. MfgE-CityU has presently about 35 full-time teachers and 20 technicians to serve its 600 students.

The manufacturing engineering degree curriculum at MfgE-CityU (HK) reflects the broad-based and business-orientated manufacturing activity in HK industry. Therefore, the curriculum has been structured into three themes — the S, M, and E themes. The systems theme (S-theme) includes the study of relevant issues related to the design and management of the man-machines-materials-money system supporting manufacturing. Work design, production planning, materials

management, quality engineering, manufacturing simulation, etc. are important components of this theme. The Mechanical theme (M-theme) covers the study of engineering drawing, materials engineering, engineering analysis and design, manufacturing processes, tool design, and design for manufacture. The Electronics theme (E-theme) is concerned with the wide range of flexible automation techniques that have emerged since the mid-fifties. The subjects included in this theme are basic electronics, micro-processors, computer based data structures and networks, control principles, CAD/CAM, and flexible manufacturing techniques. These three themes are supported by 8 semester hours of mathematics, technical communications (in English), and 16 weeks of practical training. The student contact load is about 19 hours per week of which 45% is devoted to tutorial and laboratory sessions, student-centered activities, mini-projects, and final year projects. About 90% of the curriculum is mandatory whereas the rest is made up of electives to be chosen from. The program is largely application and integration oriented although a substantial proportion of the curriculum is science-based.

The degree curriculum at PEF (KPI, USSR) is substantially different from that at Mfg-CityU (HK). The USSR curriculum consists of the Humanities (Marxist economics, etc.) (10%), mathematics and physical sciences (25%), computers (15%), basic engineering (15%), engineering specialism (30%) , and management principles (5%). The engineering courses are largely similar in content to the M-theme in MfgE-CityU (HK). Thus, in comparison to manufacturing engineering programs in HK, USSR programs were over-specialized and uniform across the country. Clearly, this resulted from the general ethos of centralized bureaucratic planning, insulation of each industrial sector from others, and vertical integration within each industry. Such a curricular uniformity combined with over-specialization might explain why the otherwise brilliant engineers of USSR had such a little impact on the global market. Further, manufacturing engineering was interpreted in the classical and limited fashion of being just a subset of mechanical engineering. Hence, while the M- and E-themes were strong in the curricula, little attention was paid to the S-theme. In particular, important issues related to quality, management, and business remained unexplored.

Threats, Opportunities, and Conclusions

In December 1991, the former USSR broke up into a number of smaller republics. Many of these republics are now abandoning the socialistic ideal. There is growing enthusiasm for disbanding bureaucratic and centralized approaches to national organization. Consumer consciousness, although still dormant, is likely to develop soon. The need for national reconstruction might prompt the new leaders to seek entry into the global market and, hence, into the global manufacturing scene. Some republics might succumb under these threats. Others might see it as an opportunity for national reconstruction. For them, the reorganization of manufacturing industry and education should become a priority. A broader definition of manufacturing, well beyond the classical view of being just a subset of mechanical engineering, needs to be adopted. Manufacturing should not be defined merely as the art and science of making products, but as making them *competitively*. Diversity in manufacturing industry and education needs to be promoted. The concepts of quantity production needs to be replaced by product variety both in industry and education. The scope of manufacturing engineering curricula needs to be expanded to include a substantial treatment of the S-theme. In particular, issues concerning quality management, global manufacture, global supply chains, horizontal integration amongst small-sized enterprises, and manufacturing entrpreneurship need to be widely studied. In these endeavors, it is worth taking note of some of the industrial and educational policies followed by HK. In particular, industry-wide global awareness, akin to that in HK, needs to be developed. The inward looking policy of the USSR might have produced some good results till the early eighties (recall that the USSR's per capita income was only 30% smaller than that in EEC in 1983). But, this was beacuse the rest of the world itself was also generally divided into distinct economic entities. This picture has dramatically changed in recent times. The economies of most countries are globalizing rapidly. No country with an insular outlook can attain significant economic progress in the contemporary world.

HK will revert to China in 1997. There will inevitably be some readjustment in HK's economy while the *laissez faire* environment of HK tries to survive under the centralized planning system of China. But, given the industrial entrepreneurship of HK people (they presently provide employment for nearly 4 million workers in the industries they have set up in Southern China) and its well developed service sector (finance, shipping, etc.), it can provide valuable assistance (and, even, leadership) in the further growth of China. In particular, HK can become a regional control center in the global manufacturing climate of the 21st century. Thus, HK has sufficient reasons to feel rosy about its future. However, such a future will not be realized if HK's interest in manufacturing is not maintained. In particular, the challenge posed by the service sector (by virtue of the fact that it is able to provide greater return on investment) needs to be met squarely. At the same time, manufacturing in (and by) HK needs to further develop its global links through the extensive use of IT. It needs to move up-market through greater innovation. Manufacturing engineering education needs to keep pace with these imminent industrial transformation.