Technological Product Innovation:
An Educational Perspective from Hong Kong

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ABSTRACT

Having successfully passed through the eras of productivity and quality, Hong Kong now aspires to transform itself into a world-class center for technological innovation. In realizing this vision, Hong Kong's universities will have to inform public opinion through rational discussion and attune their courses and programs directed towards new product development (NPD) and technological innovation to the special needs of Hong Kong with regard to. This paper outlines the initiatives taken by an engineering department in Hong Kong to progressively meet these emerging needs. In particular, the programs/courses aimed at educating scientists and engineers in the areas of engineering management, mechatronic engineering, and management of technological innovation are highlighted. In the process, corporate cultures in Hong Kong and the innovation directions for Hong Kong are detailed.

INTRODUCTION

Many studies have indicated that, over the past 50 years, technological innovation has accounted for over one-third of the growth of the largest economy, the USA, in the world. The pace of innovation around the developed world has increased even more dramatically in recent years owing to technological developments in communications, computerization, the Internet, etc., and the resulting globalization of markets and the global distribution of the processes of new product realization (concept development, design, prototyping, manufacture, and servicing).

(Take in figure 1 around here)

Some are genuinely concerned (to the extent of being frightened) with the increasing pace of innovation. For instance, it is suggested in that "suppliers of new products replacing previous ones should bear in mind that they are also reducing, or even destroying, the assets of customers, either their own or some other supplier's [32]. This "creative destruction" is perhaps not exactly what Schumpeter had in mind when he was extolling the virtues of innovation at the beginning of this century." However, the majority consider opine that innovation, when taken in its broadest sense, can become the force that could liberate humanity in general from the preventable evil called poverty [13]. In any case, it is generally accepted that we cannot ignore the onward march of technological innovation.

A study of the industrial maturation of newly industrialized countries of the Far East (including Hong Kong) indicates that it has generally followed three successive but overlapping phases of competitive emphasis (see Figure 1) [31]. The first phase is characterized by competition through productivity (P), i.e., competing on the basis of smaller manufacturing cost and time. In the second phase, the competitive strategy shifts to achieving higher quality (Q), i.e., achieving higher consumer satisfaction, while maintaining productivity. The competitive focus in the third phase is on gaining further market share through innovation, i.e. "new ways of delivering customer value [20]". Innovation can take place with respect to a product, process, or service. Thus, innovation can be applied in any kind of industry.

Hong Kong's economic growth prior to 1980 was led mainly by the aggressive pursuit of global competition through productivity (P) within an environment of original equipment manufacturing (OEM). Around 1980, Hong Kong entered the era of quality (Q).

It is well known that as production processes standardize manufacturing industries, even high-tech manufacturing industries, become "footloose"—seeking out the lowest cost locations [3]. This process started in Hong Kong in 1982 when agreement was reached between China and Britain to return the territory of Hong Kong to China. As a result, by 2000, Hong Kong based enterprises were employing 4 to 5 million workers within the mainland. However, during the same period, the share of manufacturing in Hong Kong's GDP reduced to 6-7% (with the rest being taken up by the service sector).

By the late 1990s, the potential "hollowing out" of domestic manufacture had become a topic of intense concern and debate. People feared that exclusive reliance on the service sector (however prosperous) might make it vulnerable to flight of capital and economic stagnation in the event of a financial crisis. These fears actually materialized during the Asian financial crisis that had started in 1997. Hong Kong found itself amongst the regions hardest hit.

The negative developments described above led the Chief Executive of Hong Kong to form a special Commission on Innovation and Technology. The commission concluded in 1999 that Hong Kong should transform itself to become a world-class center for technology and innovation. The report also included new funding mechanisms (a science park, funding for university-industry collaboration, etc.). Will Hong Kong succeed in making the transition to the I-era? The verdict is still out.

Pessimists believing in classical economic theories think that Hong Kong is too small in terms of land, technically trained human resources, and capital to be able to challenge larger and better endowed nations in the arena of technological innovation. They also point to several perceived or real cultural handicaps of Hong Kong. On the other hand, a growing number of optimists believe that Hong Kong's cultural background and infrastructure already include several ingredients essential for success in the era of innovation. The most important of these is the proven entrepreneurial spirit—the driving engine behind economic growth according to Schumpeter [24] [25].

Irrespective of the degrees to which pessimists or optimists turn out to be correct, it is clear that the successful transition of Hong Kong into the era of innovation will mainly depend on two factors. Firstly, it needs to choose the innovation directions that best suit its correct it adopting the proper innovation strategies (directions). Secondly, it needs to develop the human resources equipped with the necessary technical and business-oriented competencies to sustain the chosen directions of innovation. Clearly, Hong Kong's tertiary education sector has a role to play in realizing both these objectives. This paper outlines the manner in which one engineering department from one of the universities in Hong Kong —the Department of Manufacturing Engineering and Engineering Management of City University of Hong Kong—has responded to this calling. The outline is derived from deep personal experience of the various initiatives undertaken (the first author was the founding head of the department during the period the initiatives to be described were undertaken). We will address some aspects that, apparently, have not yet been identified or discussed in sufficient detail in pedagogic literature related to new product development (NPD) and technological innovation (TI). It is also hoped that the discussion includes some issues of particular interest to countries in the Far East that are aspiring to embrace technological innovation as a competitive strategy.

INTERMEDIATE STAGES IN HONG KONG'S PROGRES TOWARDS TECHNOLOGICAL INNOVATION

"Innovation, perhaps more than any other economic activity, depends on knowledge … A new product introduction reflects the successful organization and synthesis of ... diverse types of knowledge [11]." Knowledge applied to tasks we already know how to do can boost productivity, while knowledge applied to tasks that are new and different is innovation [9]. The knowledge can be generated through scientific R&D conducted either in-house or by publicly funded organizations (e.g., universities). Multi-national corporations and large firms have the advantage of being able to afford high levels of in-house R&D so as to develop proprietary know-how that could lead to *radical* innovations. The manufacturing sector of Hong Kong however is dominated by small manufacturing enterprises (SME). An SME does not have the size to support substantial in-house R&D. Therefore it can only rely on public sources of knowledge—such as the local universities.

The progress of technological innovation (TI) in a region involves the coordination of several sub-systems (see Figure 2). Clearly, no single department or discipline can adequately cover issues related to all these sub-systems. As with many other universities around the world, in our university (City University of Hong Kong), this task is shared between the faculty of business and the faculty of engineering. Within our faculty of engineering, our department (the Department of Manufacturing Engineering) has emerged as the entity charged with the development and dissemination of knowledge related to TI.

Technological product innovation in Hong Kong seems to have progressed along the sequence: Technology (T)→Product ($\underline{P}$)→Innovation (I). Interestingly, in terms of timing, this T→$\underline{P}$→I sequence roughly corresponded to the P→Q→I sequence described previously with regard to regional economic growth.

(Take in figure 2 around here)

In Hong Kong, the T-phase had lasted till the early 1980s. The focus was on technology utilization rather than technology generation. The operating words were 'efficiency' and 'productivity'. The manufacturing sector was mainly in the OEM mode. Technology was basically imported (technology transfer). Local universities turned out a variety of specialist engineers (mechanical, electrical, electronic, manufacturing, etc.) basically to support industrial plant utilization and maintenance. There was some emphasis on design. But, much of this was to support the internal equipment and tooling needs of the plants, i.e., the designs were not for external customers.

The industrial scene in Hong Kong started to change (rather gradually) around the early 1980s. Changes happened in three directions: quality, automation, and a closer coupling between engineering and business (management).

As Hong Kong entered the era of quality (Q), it started to progressively embrace internationally inspired movements such as 'zero-defects', Taguchi experiments, ISO9000, and total quality management (TQM). The term 'customer' started to mean the 'end user' rather than merely the OEM client. At universities, we even started viewing our students as 'customers'. 'Customer satisfaction' was added to the list of operative words. These developments also forced a closer coupling between issues related to engineering and business management.

While the quality movement was progressing, there was increasing realization that Hong Kong's economic growth could not be sustained merely on the basis OEM. The Government started to encourage industrial and educational activities directed at 'moving up-market' and 'high value added' products. As a result, industries started to complement OEM with ODM (original design manufacturing), i.e., they started to engage in indigenous product design. Much of this ODM activity occurred with regard to electronic and electrical appliances, watches, and light industrial machinery. However, during the early stages, much of Hong Kong's industrial design activity was either related to the redesign of previously designed products for the purpose of ease of local manufacture, or detailed embodiment design of product concepts developed elsewhere. Thus, much of the indigenous design work was carried out by mechanical, electronic, or manufacturing engineers under the guidance of clients located elsewhere (mainly from the USA, EC, and Japan). In consequence, these engineers were mainly concerned with technical rather than business- or customer-related issues related to product development.

Meanwhile, major technological developments were taking place around the world. *Hard automation* (automation through mechanical means) started to be replaced by *soft automation* by taking advantage of rapid developments in electronics and computers. Most industrial equipment as well as consumer products started to become *mechatronic*, i.e., they started to simultaneously exploit mechanical, electronic, and computer (embedded) technologies. At the same time, computerization was rapidly encompassing almost every technical and business function carried out in every industry. This development led to the concept of *linking automation*. The essence of linking automation is in integrating all industrial functions through the utilization of computers. In the manufacturing sector, this led to the pursuit of computer integrated manufacture (CIM). Again, this led to a closer coupling between technical and business functions.

Different local universities responded differently (but, generally, in a complementary fashion) to the changing educational needs of Hong Kong industry. This paper outlines three initiatives taken by our department in this regard: Masters programs in Engineering Management, and Automation Systems & Management; an undergraduate program in Mechatronic Engineering; and a small suite of courses under the generic title of 'Management of Technological Innovation'. It may be noted that our engineering management and mechatronic engineering programs were the first ones to be launched in the respective fields in the entire Far East.

ENGINEERING MANAGEMENT

We have already highlighted how progress in technology has brought about a closer coupling between engineering and business (management) issues. This coupling should not be surprising if we recall that the acknowledged 'father' of 'Scientific Management' is the same as the father of ‘Industrial Engineering’. However, over the early part of the last century, the fields of management and engineering had drifted apart [27]. In particular, the award of MBA had become the dominant means by which engineering graduates could acquire an understanding of business issues.

However, most MBA programs aim at developing generalist managers by biasing their curricula towards issues related business, finance, and strategic management. This approach may suffice for engineering graduates wishing to ‘abandon’ their respective engineering fields to become corporate level general managers. However, the majority of engineering professionals progress to management positions within the general field of engineering. There is much literature (e.g., [1] supporting the opinion that MBA type programs do not meet the special needs of engineering managers. In the past, career-progression in industry was possible by climbing only one ladder: the management ladder. However, more and more enterprises around the world are now striving to become more competitive by focusing on their core technological competencies. Technology is making a strong come back owing to the ongoing movement towards technological innovation. As result, more and more enterprises are complementing the management ladder with a technical ladder (the so-called ‘dual ladder’ policy).

Badawy [1] also highlights several reasons for distinguishing between the educational needs of engineering managers and general business managers. He notes that, by virtue of their prior training as well the nature of subjects they study, scientists and engineers usually exhibit a bias toward objective measurement, ‘paralysis by analysis’, fear of loss of intimate contact with their fields, introversion, poor skills of delegation, and inadequate interpersonal skills. Therefore, it is helpful if programs are developed that are empathetic to the special needs of engineering graduates.

Our M.Sc. program in Engineering Management was developed in 1988 to meet the educational needs of working engineers (irrespective of their engineering specialization) transiting to the roles of engineering managers. The decision to launch the program and the initial curriculum were derived based on the data collected in response to a detailed questionnaire distributed to over 3000 registered engineers [30]. The curriculum included the following subjects: principles of management, organizational behavior, accountancy and finance, operations management, product management, and project management. Teaching the first three subjects has been the responsibility of staff from the business faculty. As the technological complexity of Hong Kong enterprises increased, there was a need to include elements of technology management within the curriculum. Initially, this was done by subsuming it within 'project management' by restructuring it as high-technology project management. More recently, separate courses titled Management of Technological Innovation (MTI) have been added. The nature of this set of courses will be described later in this paper.

Our interest in Technology Management as a subject area initially arose through our Master of Science (M.Sc.) in Industrial Automation program. Initially, this program was all technical in content. However, as Hong Kong's manufacturing sector started to move to the mainland, the concerns of engineers based in Hong Kong started to acquire business dimensions. As a result, this program has now been restructured into Automation Systems & Management. In the process, subjects such as 'Automation Strategy', 'Automation Systems Management', and MTI have occupied a greater part of the curriculum.

MECHATRONIC ENGINEERING: A NEW DISCIPLINE TO SUPPORT

Products with high-technology embedded in them may be said to be *technological products*. They are a part of "an emerging industrial value-adding structure that supplies functionality around a new basic technology system [2]." Currently, the computer represents the new basic technology sweeping the industrial world. Many modern products use embedded computers (computer-on-a-chip) to provide functionalities hitherto attained exclusively by mechanical means. One may also exploit the ability of a computer to be programmed at will to add new functionalities. For instance, we can create 'smart' products by programming the computer on the basis of fuzzy logic, or by making the computer behave like an artificial neural net. Thus, computer technology offers an opportunity for endless product innovation.

Mechatronic engineering is the emerging discipline that supports the development of this class of technological products. According to the Industrial Research and Development Advisory Committee of the European Community, mechatronics is "a synergistic combination of precision mechanical engineering, electronic [read computer] control and systems thinking in the design of products and manufacturing processes [8]."

Our undergraduate program in mechatronic engineering was launched in the early 1990s [29]. The graduates were expected to be different from the traditional specialist mechanical, electronic, or computer engineers. They would know the art and science of achieving the optimum synergy amongst the three basic technologies. This suggested that we had to recognize mechatronics as an integrative discipline. The science part was relatively easy to deal with. We could achieve it merely by including the basics of the three disciplines in the curriculum. The path to the integration of the three basic disciplines (which, hitherto, had remained distinct) was much more difficult. Literature concerning the conceptual structures underlying such synergy was sparse. We sought to resolve this problem by giving a product design orientation to the program. We designed our curriculum such that groups of students

(3 to 5 members) could work autonomously over a period of three semesters towards the development of the concept, embodiment design, prototype fabrication, and testing of a mechatronic product. Typical products attempted by our students include a smart household vacuum cleaner, a smart wheel chair for paraplegics, a 4-axis CNC (computer numerical control) turning-cum-milling center, and a 'smart cart' to reduce queues in super markets. In parallel, our students also study a course on "Design Management'.

MANAGEMENT OF TECHNOLOGICAL INNOVATION (MTI) AS A SUBJECT OF STUDY

In the previous sections, we have outlined how our educational ventures into the fields of Engineering Management, Automation Systems Management, and Mechatronic Engineering had brought us the realization that a deep understanding of how new product development (NPD) could be carried out as well as managed is of critical importance in sustaining Hong Kong's emergence as a world class center for technological innovation. Thus, in time, we developed a suite of courses under the generic title of 'Management of Technological Innovation (MTI) to serve undergraduate and postgraduate students of science and engineering. Initially, as novice teachers of MTI, we tended to pick a couple of contemporary books on MTI and taught *to* those books. The students' response was muted. They could not connect. Apparently, they, as students *from Hong Kong*, could not relate the topics beings discussed to their past educational experiences. This forced us to make a deeper study of the pedagogy of MTI. In the process, we realized that the teaching of MTI involved bringing together a large number of interrelated technical and business issues in a coherent manner. This section outlines the issues we have considered in this context.

Although Schumpeter had long back recognized innovation as the most important factor determining economic development [24], it is only since the 1980s that there has been an explosion of interest in innovation as a subject of study [12].

Schumpeter is also credited for having noted first that innovations are more than mere inventions. An invention is an idea, a sketch or model for a new or improved device, product, process or system. However, the majority of technical inventions do not lead to innovation. An innovation is accomplished only with the first commercial transaction involving the new product, process system or device, although the word is used also to describe the whole process. "Of course, further inventions often take place during the innovation process and still more inventions may be made during the diffusion process [13]".

Schumpeter made it clear that there could be no economic growth without pain. "Companies and industries, nations and peoples, rose and fell, and technology could be a decisive factor in this. Further, building on the teachings of the marginal utility school, he "elaborated a theory of economic development that was characterized by dynamic entrepreneurs' whose deliberate (rather than coincidental) innovations led to economic growth [32]."

An entrepreneur is one who creates and develops a new living business. (S)he identifies a business opportunity based on a realistic analysis of the prevailing competitive atmosphere, and then proceeds to organize, manage and assume the risk of business. A successful entrepreneur does not necessarily have a high I.Q., or superior analytical skills. Rather, (s)he should have a broad generalist thinking, strong drive, high self-confidence, a need to control and direct, moderate interpersonal skills, and sufficient emotional stability [19]. The first success of an entrepreneur usually occurs while (s)he is in the age bracket of 25 to 35 years .

The process of innovation usually occurs in four sequential phases. First, the basic idea is *created*. This is followed by invention where the idea is embodied, i.e., it is provided with a tangible form and structure. The crucial question at this stage is whether the particular embodiment is scientifically and technically feasible. The next phase is design for marketable production. At this stage, the commercial feasibility is examined. The final stage is reinnovation when one asks whether the product, process or service could be made better or cheaper or both.

It should be clear from the above observations that MTI is a *melting pot field* (see Figure 2) that brings together "the language of scientists, lawyers, advertisers, accountants, marketing planners, corporate strategists, organizational behaviorists, and many others. It is also an *expanding field*, taking on new tasks and performing them in new ways [6]". Can such a broad subject be taught at all within a university environment? The generally accepted answer seems to be 'Yes!' as evident from the large number of college courses and, even, programs assuming titles such as 'Entrepreneurship', 'Technology Management', etc., but essentially covering the same subject area as MTI. Experience with these courses seems to suggest that "every project set up to produce new products can benefit from proven methods of new products management [4]." However, a teacher of MTI needs to be careful in picking topics of relevance to the particular group of students (s)he is addressing. Further, during classroom delivery, (s)he should be sensitive to the particular culture and background of the students. Only then will the students be able to 'feel' that they are being treated as 'customers' and that 'value is being delivered to them in new ways'.

It is legitimate to view the subject area of MTI as belonging to the field of engineering/technology management. However, there is one caveat. The most critical part of any new product development exercise is the very first stage of coming up with the idea. Better the idea better are the prospects of the resulting innovation succeeding in the marketplace. The skill of creation (often from nothing) is called 'creativity'. Issues concerning creativity are not normally discussed within programs devoted to engineering/technology management. To that extent, innovation management needs special treatment.

The exercise of creativity can occur in three modes: serendipitous (e.g., accidental discovery of penicillin by Alexander Fleming), exploratory, or normative [18]. University faculty and scientists from some R&D organizations usually engage in exploratory creativity, i.e., they explore new opportunities on the basis of present knowledge and experience. In contrast, engineers serving in industrial organizations are usually required to start with a given ‘problem’ and apply their full creative abilities towards solving it (normative creativity).

Literature on creativity is replete with anecdotal accounts of people succeeding at creating brilliant new ideas. Interestingly, many of these ‘creative’ persons were scientists (e.g., Einstein is said to have imagined that he was riding a light beam before arriving at the theory of relativity) and engineers (e.g., Thomas Edison who said: “Genius is 1 per cent inspiration 99 per cent perspiration.”)

However, the experiences of extraordinary persons such as Einstein or Edison cannot be the models for the common (ordinary) scientists and engineers for whom creativity is merely a part (enjoyable or otherwise) of their job. These ‘ordinary’ persons have usually gone through university training that emphasizes logic, reasoning, language, numeracy, analysis, linearity, and abstract thinking. All these are aspects at which the left brains of humans excel. The tragedy is that, in the process, the right brain—the widely recognized seat of creativity—remains chronically underdeveloped.

A person who has not, at some time or another, personally experienced creativity cannot be expected to effectively manage others engaged in creative pursuits. Hence, a teacher of MTI needs to include within the coursework a fair number exercises directed towards *experiencing* creativity. In other words, the teacher herself/himself needs to be an innovative teacher rather than being just a teacher of innovation. The value of innovation needs to permeate every classroom activity, assignment, and assessment exercise. It would be nice if the teacher could lead by example—by making each class appear somehow different from the previous one. One way of achieving this is to relate the material to be taught in each class to one or more ‘hot’ news items. This requires the teacher to be broad in perspective in addition to being dynamic, humorous and entertaining in the classroom. (With creativity, as with humor, “we experience a ‘paradigm shift’, meaning that we suddenly see familiar material in a new way [21].) This is no easy task particularly while addressing scientists and engineers whose responses (as we have already noted) usually exhibit a bias toward objective measurement, ‘paralysis by analysis’, fear of loss of intimate contact with their fields, introversion, poor skills of delegation, and inadequate interpersonal skills [1]. It is therefore helpful if the teacher has an engineering background (as in the case of the present authors) so that (s)he can be empathetic towards science and engineering students. This also explains why many engineering/technology management courses offered around the world are delivered by faculties of engineering.

Another characteristic problem with technologists (at least with the better ones who are fascinated by technology) is that, when confronted with the challenge of a technological innovation, they focus right away on the technical part while giving only a cursory attention to consumer and business related issues. Often the result is a technological monster that does not make business sense—in other words, a white elephant. Sun has examined this problem in the light of empirical data collected from a set of manufacturing enterprises seeking to progressively acquire advanced manufacturing technologies (such as flexible manufacturing systems—FMS) [26]. He has tracked the technology adoption trajectory of each enterprise on a map of two quantifiable dimensions: Technology (T) and Organization (O). He has found that companies that had failed had typically followed the ‘concave’ path whereas those who had succeeded had followed the ‘convex’ path (see Figure 3). The lesson is that one should accord precedence to organizational (business and human) issues over technological issues.

Unfortunately, the trained instinct of a technologist is exactly the opposite. The teacher of MTI should be aware of this and try to correct it by demonstrating a deliberate bias towards business, organizational, cultural, and behavioral aspects of MTI.

(TAKE in figure 3 around here)

The following outlines the MTI curriculum we have arrived at on the basis of the above insights:

- Impact of IT and the Internet: thoughts by contemporary leaders of 'hi-tech' industries (e.g., [14]).
- Theories of technological growth: fluid, dominant design, transition, and mature stages of growth technology 'invasion of stable businesses by radical innovation', etc. [28]; "Technology is self-organizing system that evolves by trial-and error learning" [23].
- The relation between entrepreneurship and technological innovation. [25] [19].
- The relationship between corporate culture and technological innovation {15] [16]
- Strategic issues at the corporate level: competitive analysis, advantages of spatial localization of industry (Hong Kong wishes to spatially localize technological innovation); offensive, defensive, 'me too', branch plant, and other strategies; venture capital; risk analysis [22] [13].
- Theories and techniques of creativity: "No [creative] problem was ever solved in the conscious mind", bi-sociation [17]; brainstorming, morphological analysis, etc. [21] [7].
- Overview of techniques for achieving excellence in product development and manufacturing and their degree of maturation in Hong Kong: stages in product

development; design for manufacture, value engineering, concurrent engineering, quality function deployment, technology calender, bench marking, house of innovation [6] [10].

- Open-ended discussion on the directions of technological innovation best suited for Hong Kong.

Selected topics from the above are discussed in each semester with the aid of concise teaching notes placed on the Web. The teaching notes include several mini-case studies. Students are encouraged to privately read one or two relevant books in addition to the class notes. Postgraduate students are encouraged to contribute relevant anecdotal material derived from their work experience to the classroom. Occasionally, guest lectures are organized. Every student is required to submit an individual term paper at the end of the course. Typically, the theme for a term paper would be related to a particular technology or corporation (local or international) on which sufficient information is available on the Web or in magazines. However, postgraduate students would be encouraged to select the theme on the basis of their own work experiences. Assessment usually consisted of two class tests and a final examination.

Much of the MTI curriculum outlined above is common to many courses offered under a similar title around the world. However, in our curriculum, two items stand out as special: item D (about corporate cultures), and item H (about innovation directions for Hong Kong). This is because of (i) our belief that a deep understanding of these issues in a manner immediately pertinent to Hong Kong is essential if Hong Kong were to master technological innovation, and (ii) our observation that, so far, little informed public debate has taken place on these issues in Hong Kong. We therefore pick these two items for elaboration.

PREVALENT CRPORATE CULTURE IN HONG KONG

It is generally accepted that the behavior of the people in a region depends on their beliefs, values, and attitudes which, in turn, are determined by the region's history. These attributes are often aggregated under the notion of 'culture'. More formally, culture has been defined as 'the collective programming of the mind, which distinguishes the members of one category of people from another [16]."

A predominant proportion of Hong Kong dwellers are ethnic Chinese, who, according to popular opinion, have strong Confucian values albeit tempered by some British values. Hence, found it useful to recount the four key Confucian principles as outlined by [15]:

"The stability of a society is based on unequal relationships between people."

"The family is the prototype of all social organizations.

"Virtuous behavior towards others consists of not treating others as one would not like to be treated oneself."

"Virtue with regard to one's tasks in life consists of trying to acquire skills and education, working hard, not spending more than necessary, being patient, and persevering."

We would ask students to assess the extent to which the prevalent working behavior of Hong Kong natives continues to conform to the Confucian principles cited above. Usually, after a period of discussion, we would ask the students to anonymously record their assessments on a 5-point Likert scale (1: very weak conformance, 5: very strong conformance). The typical average responses to principles 1 to 4 were 3.7, 3.7, 3.3 and 3.5 respectively, thus pointing to a general belief in the continuing persistence of Confucian values.

Having sensitized students to the Confucian values, we often tried to stimulate classroom discussions involving questions such as the following: *Stability is clearly important when economic growth is driven by the pursuit of productivity and quality. In contrast, innovation* *means instability (many authors have referred to innovation as "creative destruction"). Will preference for stability (see Principle 1) impede innovation? There is evidence to suggest that a large proportion of Hong Kong's manufacturing enterprises are closely controlled by family members of the owners or, even, dominant shareholders. Will this affect how professionally the corporations are run? Isn't professionalism a prerequisite to innovation in the area of high technology? Doesn't Principle 3 actually enable one to compete more aggressively? Aren't the values stated in Principle 4 actually assets in the context of innovation?* Feedback received from our students often indicated that several students had found the discussions to be contributing to their self-awareness by forcing them to reflect in a more objective and focused manner regarding their own values, beliefs and attitudes as well of their peers from the viewpoint of innovation.

(TAKE IN TABLE 1 AROUND HERE)

We also found it useful to ask the students to examine Hong Kong's corporate cultural characteristics *vis a vis* those of potentially competing countries. However, we found scientifically obtained evidence facilitating such comparisons to be in short supply. An exception is the work of Hofstede where he had examined the cultural characteristics exhibited by workers in IBM (International Business Machines) units operating in several countries [15] [16]. A cluster analysis had led him to the discovery of the four corporate cultural characteristics defined below:

Power Distance Index (PDI) indicates the extent to which a society accepts the fact that power in corporations is distributed unequally and tells about the dependency relationships in the region. A large PDI points to considerable dependence (or counterdependence) of subordinates on bosses.

Individualism Index (II) implies a loosely knit social framework in which people are supposed to take care of themselves and of their immediate families. The opposite, collectivism, is characterized by a tight social framework in which people distinguish between in-groups and out-groups.

Uncertainty Avoidance Index (UAI) indicates the extent to which a society feels threatened by uncertain and ambiguous situations and tries to avoid these situations by providing greater career stability, establishing more formal rules, not tolerating deviant ideas and behavior, and believing in absolute truths and the attainment of expertise. A high UAI indicates increased anxiety and more expressiveness. Paradoxically, people with high UAI are often prepared to take risks to reduce ambiguity.

Masculinity Index (MI) indicates the degree to which tough values like assertiveness, performance, success and competition prevail over tender values like the quality of life, maintaining warm personal relationships, service, care for the weak, and solidarity.

Table 1 shows the average values recorded by Hofstede for the four cultural indices for a selection of countries—including Hong Kong.

However, in our classroom exercises, we would usually hide Hofstede's values for Hong Kong and ask the students to arrive at those values on the basis of whatever experience they might have had of corporate cultures in Hong Kong. This exercise usually stimulated quite animated discussions in our postgraduate classes since these students were working engineers in their daytime. In contrast, undergraduate students usually required quite a bit of prompting. The numbers in parentheses in the row for Hong Kong in Table 1 show the average values of the indices arrived at in one of our classes consisting of working engineers. Note that the students' perceptions are somewhat different from Hofstede's findings. This might have been because of differences in corporate settings or simply because our so-called 'survey' was not scientifically conducted. However, the point we wish to make is not about the validity or otherwise of these values but about the educational value derivable from the process of arriving at these values.

Our classroom discussions regarding culture would often end up in one question: What are the desirable values of Hofstede's indices? In one sense, this question is naïve since it suggests that culture is something so tangible that it can either be manipulated or imported lock-stock-and-barrel from abroad at will. But, unlike technology, culture (and, therefore, innovation) cannot be imported. In another sense, the question is profound since management literature suggests that an important part of a corporate manager's job is to nurture a 'proper' corporate culture. Further, there exist many successful case studies describing corporations that have managed to purposefully modify their corporate cultures. At the same time, the well-known notion of 'cultural relativism' suggests that one cannot make absolute judgments about the goodness or otherwise of a given culture in the absence of *a priori* specification of the desirable values to be adopted while making the evaluation. We have found the following open-ended classroom exercise to be effective in sensitizing our students to these issues.

Figure 4 illustrates a widely used map in management literature. It compares the pairs of values {PDI, II} recorded by Hofstede for a selection of regions. The four corners of the plot represent four reference models of corporate cultures and adopt the self-explanatory labels 'village market', 'family', 'pyramid of people', and 'well-oiled machine'. Clearly, each of these models is desirable in a different context. For instance, 'pyramid of people' is preferred by the military whereas 'well-oiled machine' is typical of a crew servicing a Formula 1 race car. Students note that Hong Kong is located closer to the top right hand corner labeled to 'Family'. They then recall that this is in broad agreement with their own stated belief in the continuing persistence of Confucian values in Hong Kong. We then divide the class into three groups: P, Q and I groups where the P group reflects on the concerns of corporations functioning in the era of productivity, and so on. (In a postgraduate class, this grouping could be based on student's own opinions about their own workplaces.) We then ask each group to locate its 'most desirable' culture on Figure 4. Next, we aggregate the class responses and plot the 'desirable' trajectory of culture as a corporation moves along the P→Q→I path. Figure 4 includes the trajectory usually identified in our classes. Finally, we ask the students to examine how this cultural trajectory could be 'engineered' and managed in their respective workplaces. This usually forces them to review many managerial concepts from diverse sources much more sensitively than they would otherwise have done. Often, this would result in a much deeper term papers being submitted by the students.

(TAKE IN FIGURE 4 AROUND HERE)

INNOVATION DIRECTIONS FOR HONG KONG

A theme that permeates our entire MTI course relates to how Hong Kong could find its own niche in the world of innovation given that (i) it seriously lacks natural resources, (ii) its trained human resources are limited, and (iii) it has limited experience with technological R&D. The following excerpts summarize some views regarding the appropriate innovation direction for Hong Kong (some were articulated by the teacher and some emerged through classroom discussions or term papers):

- Schumpeterian innovations are the result of 'entrepreneurial behavior'—the perception that it may be possible to exploit some latent demand or to attack existing firms with radically new product or process. Here lies the strength of Hong Kong. The entrepreneurial maturity of Hong Kong is well known. However, much of this entrepreneurial experience lies on the business side (service sector). Experience in technological entrepreneurship is weak.

The generally prevalent corporate culture in the manufacturing, engineering as well as service sectors of Hong Kong is not conducive for sustaining the spirit of innovation. A conscious shift in corporate culture towards greater individualism, lower power distance and masculinity is needed. This is not an easy task given the entrenched culture that is more tuned to the eras of productivity and quality.

- So far, the main repositories of technological knowledge in Hong Kong have been the engineering (utilities, transportation companies, construction companies, etc.) and manufacturing sectors. However, the engineering sector has generally preferred high-technology acquisition rather than technology generation. The manufacturing sector had occasionally shown flair for product innovation in some fairly advanced technological areas. But, the migration away from Hong Kong has been diverting the attention of Hong Kong manufacturers.

Companies with well-articulated R&D policies are very few. The implication is that Hong Kong's vision of becoming a world-class center for technological innovation would not be realized unless its manufacturing sector commits itself to establishing a strong R&D infrastructure through forward looking policies.

Radical innovation usually requires considerable R&D investment. In the developed countries, the major proportion of this investment comes from the private sector. In stark contrast, the share of current private investment in the total R&D budget of Hong Kong is uncomfortably close to zero. Unless this changes, Hong Kong may have to be content with the prevalent 'me too' syndrome with its innovative enterprise stuck at the level of *incremental* product/service improvement. However, there may be a way out in what Christensen [5] has suggested recently.

Christensen has made an extensive and deep analysis of innovation trends in several industry sectors (hard disk drives, cable excavation, integrated steel making, discount retailing, motor control and printers, logic circuitry, computers, personal digital assistants, software, motorcycles, electric vehicles, insulin, etc.), and arrived at several interesting and unconventional conclusions. He has classified technologies into two basic types: *sustaining* and *disruptive*. "Some sustaining technologies can be discontinuous or radical in character, while others are of an incremental nature…What all sustaining technologies have in common is that they improve the performance of established products, along the dimensions of performance that mainstream customers in major markets have historically valued [5]. However, Christensen goes on to note that, "occasionally, disruptive technologies emerge" that "bring to a market a very different value proposition than had been available previously." Generally, "disruptive technologies under-perform [at least in the near term] established products in mainstream markets. But they have other features that a few fringe (generally new) customers value. Products based on disruptive technologies are typically, cheaper, simpler [made from off-the-shelf components], smaller, and, frequently, more convenient to use." This last observation by Christensen could be of great value to Hong Kong entrepreneurs since it points to the fact that being small need not be a handicap. Hong Kong may be small in terms of R&D infrastructure. Yet, by carefully selecting a market-savvy innovation strategy involving disruptive innovation and nurturing a culture of innovation, it can certainly hope to seize leadership in selected industrial sectors.

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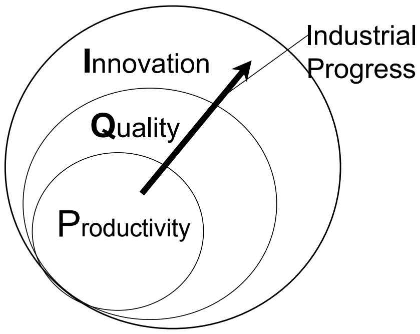

Figure 1 Stages in the industrial maturation of a region

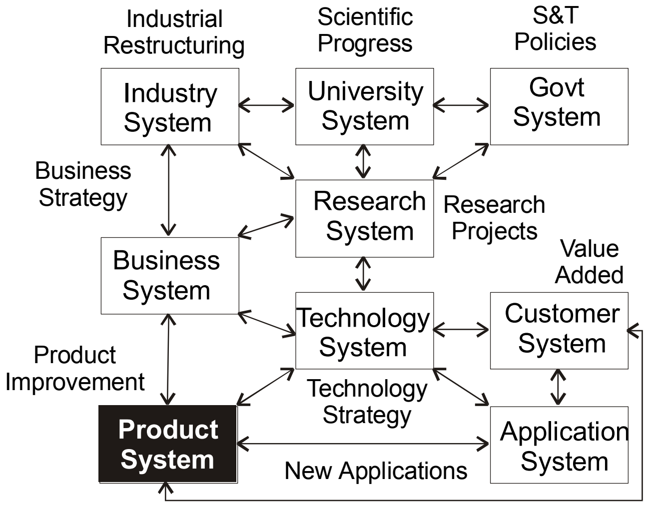

Figure 1 Systems involved in technological innovation (adapted from [2])

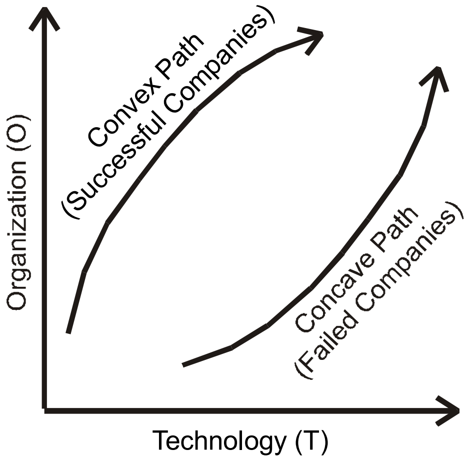

Figure 3 Two-dimensional technology adoption paths

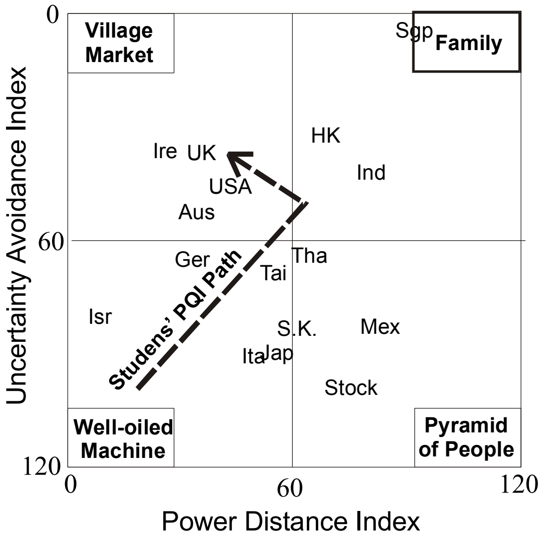

Figure 4 Can corporate culture be engineered?

Table 1 Comparison of Hofstede's cultural indices for different countries/regions

Country/Region	Indices of Corporate Culture (All values except those in parentheses are the mean values recorded by Hofstede for IBM plants in the respective country. The values in parentheses represent the average opinion of working engineers in one of our classes.			
	Power Distance Index	Individualism Index	Uncertainty Avoidance Index	Masculinity Index
Australia	36	90	51	61
Germany	35	67	65	66
Hong Kong	68 (72)	25 (53)	29 (65)	57 (67)
India	77	48	40	56
Ireland	28	70	35	68
Israel	13	54	81	47
Italy	50	76	75	70
Japan	54	46	92	95
Mexico	81	30	82	69
Taiwan	58	17	69	45
Thailand	64	20	64	34
Singapore	74	20	8	48
South Korea	60	18	85	39
U.K.	35	89	35	66
U.S.A.	40	91	46	62