Teaching Management of Technological Education to Engineers: A Regional Perspective from Hong Kong

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ABSTRACT

This paper outlines one approach to teaching the subject of Management of Technological Innovation (MTI) to potential scientists and engineers. The nature of MTI and its pedagogical implications are discussed from a Hong Kong perspective. The discussion focuses on the constraints associated with Hong Kong's vision of becoming a world-class center of technological innovation as well as the common frailties of people with exclusive training in scientific or engineering fields. It is noted that a broad and interdisciplinary syllabus supported by a dynamic classroom environment is the key to the effective teaching of MTI.

1 INTRODUCTION

Although Schumpeter had long back recognized innovation as the most important factor determining economic development [Scumpeter 12], it is only since the 1980s that there has been an explosion of interest in innovation as a subject of study [Freeman 94]. Many studies (e.g., [NSB 96] [Smith 95] [USCEA 95]) have indicated that technological innovation has accounted for over one-third of U.S. economic growth over the past 50 years [Bordogna 97]. The picture has changed even more dramatically since the 1980s. Technological developments in communications, computerization, the Internet, etc., have accelerated the pace of globalization of market competition and manufacturing. This, in turn, has accelerated the pace and diffusion of innovation.

Some are genuinely concerned (to the extent of being frightened) with the increasing pace of innovation. For instance, it is suggested in [von Braun 97] that "[s]uppliers 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. 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, others consider innovation, when taken in its broadest sense, to be a force that could liberate us from the preventable evil called poverty [Freeman 97]. But, everyone seems to agree that we cannot ignore the onward march of technological innovation.

Already industrialized regions such as U.S.A., EC, and Japan are well aware of the importance of technological innovation. In fact, their industrialization was a product mainly of their innovative efforts. People in these regions grew up with values and attitudes that are conducive to technological progress. However, this is not necessarily the case with most newly industrialized 'countries' (NIC) such as Hong Kong, Korea, Singapore and Taiwan or with countries such as China, and India which are still in the early phases of industrialization. These societies had missed the boat of industrial revolution. Whatever industrialization they have managed to achieve so far has been the product of technology transfer from already industrialized regions rather than of indigenous technological innovation. Till recently, they could be content with this scenario. However, the advent of globalization is now forcing them to compete on equal terms with the already industrialized countries. In particular, it has forced them to seriously examine how they could adapt to the growing pace of technological innovation worldwide.

The strategies adopted by the NICs to stimulate indigenous technological innovation have been quite varied. However, several common features can be identified: expansion of schools and universities, increased financial support to universities for conducting R&D, increased facilities for universities and local industries to engage in collaborative development, increased expectations from university staff to publish in reputed journals, increased pressure on universities to launch new courses aimed at stimulating and supporting industrial innovation, etc.

This paper focuses on the last feature from the point of view of one representative newly industrialized region—the Hong Kong Special Administrative Region (HKSAR)) of China. In particular, it summarizes the broad lessons learnt by the

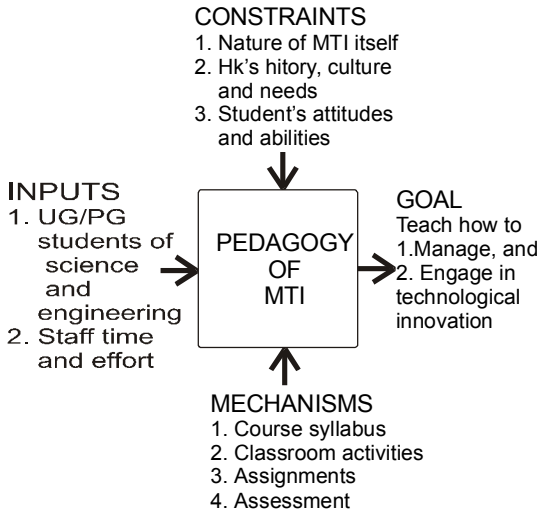

Figure 1 Issues reated to the teaching of MTI

authors of the present paper while teaching the essentials of 'Management of Technological Innovation (MTI)' to undergraduate and postgraduate students of engineering in a manner relevant to the perceived needs of Hong Kong students. The paper dwells on some aspects that, apparently, have not yet been identified or discussed in sufficient detail in pedagogic literature related to MTI. 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.

Figure 1 illustrates the broad framework within which this paper is presented. Our input and goal were clear. We ware charged with the responsibility for teaching undergraduate and postgraduate students of science and engineering how they could manage a team working on projects involving technological innovation and how they could themselves participate in the innovation process. 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.

An in-depth discussion of each of the issues we have so far identified is beyond the scope of this paper. We will merely outline a set of observations (often taken or quoted from published sources) related to a selection of the major issues followed by a statement of their pedagogic implications. We will discuss each constraint and, in the process, outline the 'mechanisms' we have found to be useful.

2 THE NATURE OF 'MANAGEMENT OF TECHNOLOGICAL INNOVATION' AS A SUBJECT OF STUDY

Innovation may be defined as the term referring to "new ways of delivering customer value [O'Hare 88]." Innovation can take place with respect to a product, process, or service. Thus, innovation can be applied in any kind of industry.

Schumpeter is generally credited for having noted first that innovations are more than mere inventions [Schumpeter 12]. 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 [Freeman 97]".

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, Schumpeter "elaborated a theory of economic development that was characterized by dynamic entrepreneurs' whose deliberate (rather than coincidental) innovations led to economic growth [von Braun 97]."

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 [Mclelland 76]. The first success of an entrepreneur usually occurs while (s)he is in the age bracket of 25 to 35 years .

"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 [Feldman 94]." 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 [Drucker 92]. 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. In contrast, small firms can only rely on public sources of knowledge. Therefore, often, small firms may have to be content with *incremental* innovations.

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 re-innovation 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* 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 [Crawford 00]". 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 [Buijs 87]." 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 innovation process-chain 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 [Majaro 88]. 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 [Petty 97].) This is no easy task particularly while addressing scientists and engineers whose responses (by virtue of their prior university training) 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 [Badawy 95]. 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 a significant number of 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) [Sun ?]. He has tracked the technology adoption trajectory of each enterprise on a map of two quantifiable dimensions: Technological (T) and Organizational (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 2). 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.

3 RECENT ECONOMIC HISTORY OF HONG KONG

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 3) [Venuvinod 97]. The first phase is characterized by competition through productivity (P). 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.

Prior to its cessation-cum-lease to Britain in 1898, Hong Kong was a rural and underdeveloped region. However, around the middle of the last century, the situation started to change dramatically owing to an influx of immigrants from the Chinese mainland. The entrepreneurship exhibited by these immigrants coupled with the *laissez faire* policy pursued by the Government of Hong Kong led to a highly effective and *horizontally integrated* economy in which both the

manufacturing and service sectors grew rapidly. Thus, by 1980, the share of manufacturing in Hong Kong's GDP reached 24%. Likewise, by about 1975, the share of manufacturing in employment reached about 48%.

Hong Kong's economic growth prior to 1980 was led mainly by the aggressive pursuit of global competition through productivity (P)—through significant reductions in production costs and production times within the general context of original equipment manufacturing (OEM). Around 1980, Hong Kong entered the era of quality, i.e. it started competing on the basis of quality (Q) in addition to productivity (P).

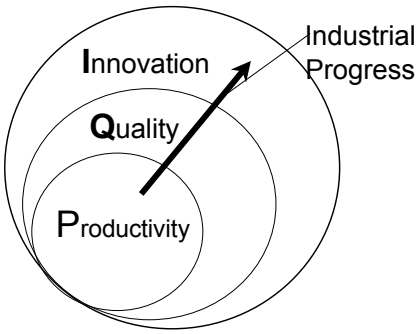

Figure 3 Stages in the industrial maturation of a region

It is well known that as production processes standardize manufacturing industries, even high-tech manufacturing industries, become "footloose"—seeking out the lowest cost locations [Bluestone 82]. This process started in Hong Kong in 1982 when an 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.

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 depend mainly on (i) the behavioral patterns of Hong Kong entrepreneurs, and (ii) the innovation strategies they choose.

4 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 [Hofstede 97]."

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, it is useful here to recount the four key Confucian principles as outlined by [Hofstede 80]:

1. "The stability of a society is based on unequal relationships between people."
2. "The family is the prototype of all social organizations.
3. "Virtuous behavior towards others consists of not treating others as one would not like to be treated oneself."
4. "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."

In our own MTI classes, we have found it useful to 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 proprietors 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.

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 [Hofstede 80] [Hofstede 97]. A cluster analysis had led him to the discovery of the four corporate cultural characteristics defined below:

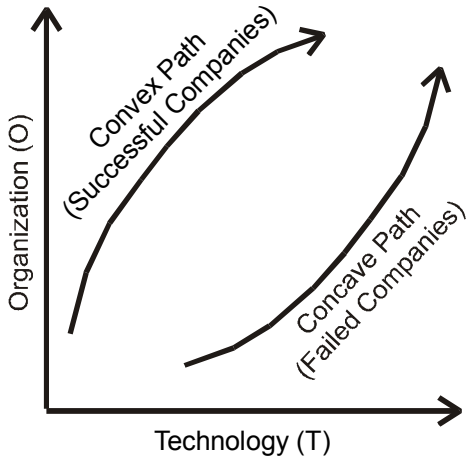

Figure 2 Two-dimensional technology adoption paths

1. *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.
2. *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.
3. *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.
4. *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 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

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.

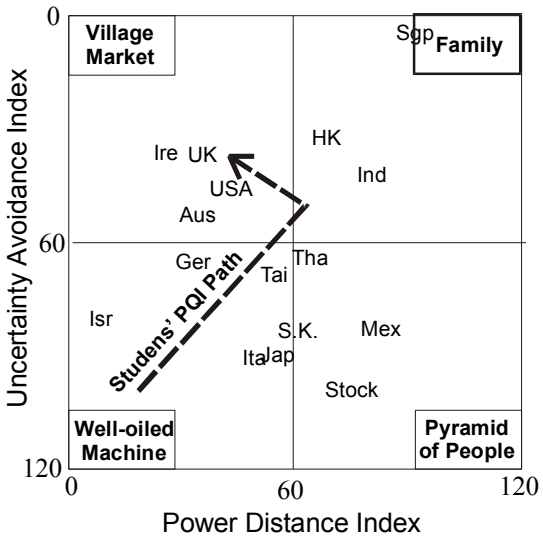

Figure 4 Can corporate culture be engineered?

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 map that is widely utilized 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.

5 INNOVATION DIRECTIONS FOR HONG KONG

A theme that permeates through 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, (i) its trained human resources are limited, and (iii) it has limited experience with technological R&D. We chose this integrative theme for two reasons. Firstly, so far, there has been only a limited informed debate on this topic despite the broadly stated wishes of the Government to turn Hong Kong into a world-class center for innovation and technology. Secondly, Hong Kong's progress in this regard would critically depend on how effectively current university students in Hong Kong would, upon graduation, perform as scientists, engineers, innovation managers, or entrepreneurs. Hence, they need to think deeply about the most appropriate near-time innovation directions for Hong Kong .

Our classroom discussions included some of the following concepts and issues:

- Theories of technological growth: fluid, dominant design, transition, and mature stages of growth technology 'invasion of stable businesses by radical innovation', etc. [Utterback 94]; "Technology is self-organizing system that evolves by trial-and error learning" [Sahal 81].
- The relation between entrepreneurship and technological innovation. [Schumpeter 12, 42] [Mclelland 76].

- The relationship between corporate culture and technological innovation {Hofstede 80] [Hofstede 97]
- 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 [Porter 90] [Freeman 97].
- Theories and techniques of creativity: "No [creative] problem was ever solved in the conscious mind", bi-sociation [Koestler 64]; brainstorming, morphological analysis, etc. [Petty 97] [de Bono 92].
- 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 [Crawford 00] [Eversheim 97].
- Impact of IT and the Internet: thoughts by contemporary leaders of 'hi-tec' industries [Gates 99].

Selected topics from the above list were discussed in each semester with the aid of concise teaching notes placed on the Web. The teaching notes included several mini-case studies. Students were encouraged to privately read one or two relevant books in addition to the class notes. Postgraduate students were encouraged to contribute relevant anecdotal material derived from their work experience to the classroom. Occasionally, guest lectures were organized. Every student was 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 consisted of two class tests and a final examination.

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 [Christensen 00] 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. [Christensen 00]. 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.

6 CONCLUDING REMARKS

In the above, we have highlighted Hong Kong's immediate concerns with regard to its vision of emerging as a world-class center of innovation and technology. We have outlined the importance of the subject of Management of Technological

Innovation (MTI) to the modern world in general and to Hong Kong in particular. We have pointed out that students of science and engineering need to get a broad grasp of this subject since the success of technological innovation in a region critically depends on their efforts. We have also outlined how we teach the subject to science and engineering students at our university. In describing our teaching approach, we have placed particular emphasis on the 'constraints' faced by us. While discussing the constraints, we have highlighted the major ingredients of our classroom material, classroom activities, course curriculum, and student assessment.

Our experience shows that science and engineering students find the study of MTI valuable but are uncomfortable with it. Their discomfort arises partly from the nature of the subject material and partly from the classroom dynamics required. In either case, it arises from what they have been used to while studying their respective science or engineering subjects.

For instance, in the authors' department, the syllabus and teaching plan for an engineering course is usually developed through a scrutiny of the proposed teaching plan from four points of view. First, we identify the 'science' content of the subject, i.e. we identify the general theories and principles underpinning the subject area and arrange them in as logical a fashion as we can. Next, we examine the range of 'tools' available for carrying out whatever class of engineering tasks the subject is directed at. We pick a manageable set of these tools, 'describe' them, and provide opportunities for students to obtain some hands-on practice. Next, we include student exercises directed at developing skills of 'application' (of the scientific principles and tools) in solving some engineering problems. Finally, we turn our attention to how the subject-specific knowledge that the student has acquired could be integrated with other subjects in the program. For the same subject area, the syllabus at the level of key words would usually be identical for undergraduate and postgraduate students. The difference in the teaching plan would be mainly that postgraduate students would be given a more 'in-depth' exposure to the 'science' and 'integration' features of the subject area.

Clearly, the MTI curriculum we have sketched in the previous sections does not conform to the above structured approach. This is because, when we deal with MTI, it is almost all 'integration' with very little of 'science' and 'tools' that are specific to MTI. The students find this absence of tangible 'science' and 'tools' very disturbing (at least initially). A teacher of MTI needs to be aware of this and compensate for it by adopting teaching material with a broad sweep. The teaching of MTI is all about breadth. Wider the material covered the more interesting and meaningful is the class. How would one differentiate between teaching MTI to undergraduate and postgraduate classes? The answer is in breadth and topicality.

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