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QFD-based Curriculum Development Model for Industrial Training

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Abstract

The business activities of the manufacturing industries in Hong Kong have markedly shifted from production to provision of trade and manufacturing services. To cope with the change, industrial training institutions requires new curriculum development methods for planning new syllabus and course contents for training new manpower. Moreover, the change from skill-based to knowledge-based jobs has increased the concern of incumbents on the kinds of industrial knowledge that is to be learnt by them. In regard to these changes, a Quality Function Deployment (QFD)-based industrial training curriculum development model was proposed for meeting the planning needs of the industrial training institutions and the learning needs of the job incumbents as well. Characterized by making a logical appropriation of roles and tasks among the parties involved in the curriculum development process, not only the expertise of the trainers and curriculum developers could be better utilized but the respective needs of the job incumbents and employers could also be effectively met. In the paper, besides the construction of the model and the ways the concerned parties to be involved in the curriculum development process, some useful QFD tools, such as affinity diagramming, Voice of Customer (VOC) table and Analytic Hierarchy Process (AHP), were suggested for operating the model.

Keywords: QFD, industrial training, curriculum development

1. Introduction

Industrial training was started in Hong Kong in the 1970s as a strategy of the government for supporting economic growth. Subsidies were granted for training skilled workers so as to assist manufacturers in improving productivity. As the

primary purpose was focused on meeting the workforce needs of the manufacturers and the major job was to teach workers the production skills, an employer-centred and teaching-oriented approach was therefore used to develop the industrial training curricula. Undoubtedly, this approach was useful to develop skill-based programs for training production workers. However, it may not be effective enough for the development of industrial training programs which best match the increasingly complex job duties, more educated job incumbents and fast changing job environment of today's service-oriented manufacturing industries. Rather, an approach that focuses on meeting the learning needs of job incumbents would be more appropriate and effective for developing knowledge-based industrial training programs to cope with the industrial change.

The proposed curriculum development model firmly adhered to the QFD principles and used the learning-oriented and job-incumbent-centred approach to develop curriculum. With the aim of achieving customer satisfaction, the model followed the basic process of QFD for operation. To assist the operation, VOC tables and affinity diagramming were used to process the performance requirements and to derive subject alternatives whilst AHP were used to identify the important customer requirements as well as the effective subject alternatives. Recognizing the importance of dually meeting the job performance requirements and the knowledge needs of the incumbents, the model emphasizes that both the employers' and job incumbents' voices have to be carefully listened to and provides a mechanism for appropriately incorporating the voices into the development process so as to yield a curriculum that would satisfy the respective needs of the two parties. In the process, trainers and program developers were mandated with new roles and tasks in the curriculum development process. The former make use of their subject-matter expertise to suggest the kinds of industrial knowledge for meeting the defined performance requirements and the latter make use of their professionalism to synthesis the derived subjects into an effective and coherent curriculum. Through logical task appropriation in the QFD process, the model creates an all-win situation for the all the parties concerned.

2. Learners As Primary Customers

Students are not the primary customers of industrial training though institutions rely on intuition fees for their income. For higher education in western countries, the switch of tuition fees from being subsidized by government to being paid by individuals has given rise to the problem of student consumerism. As their share of the tuition fees

rises, so the tendency among students to refer to themselves as customers grows. A study conducted with sociology undergraduates showed that the idea that "we're the customers – we pay the tuition" prevailed in the campus (Delucchi & Korgen, 2002). Many students believe that they have consumer rights exactly equivalent to those they experience in the marketplace, so they also assume they should be cheerfully served by the institutions because they are paying the bills. As a result, they increasingly expect to be amused (Edmundson, 1997), and, some even act like disgruntled consumers regarding their grades (Wiesenfeld, 1996).

Institutions should be aware of the fact that students are not their only customers and there are other stakeholders that they need to serve. Eager and Brennan (2007) contended that as students are neither the sole consumers nor the sole customers in the higher education system, institutions must not seek to serve only the interests of students to the exclusion of other stakeholder groups. Hewitt and Clayton (1999) pointed out that educational institutions have to recognize the divergent opinions of the stakeholders and they have to find ways to reconcile them for improving the quality of higher education. Ho and Wearn (1996) emphasized that higher educational institutions have to acknowledge the diversity of customers before they can successfully implement Total Quality Management (TQM). As raised by Sharrock (2000), students should not passively consume their education but actively "co-produce" it. Co-production is a concept that is based on the notion that the person providing the service and the next-in-line customer receiving the service share the responsibility for the quality and outcome of that service (Chappell, 1994).

Some might think the curriculum development of industrial training that should only need to listen to the employers will do. If curricula were developed with the aim of meeting the employers' performance needs, then it could bring positive benefits to both the industry and the employment of the society. Not only would the supply of appropriate manpower support industrial growth and development but students' employability would also be improved if they could be prepared for employers' workforce requirements. However, only addressing the performance needs of the employers is not sufficient for developing quality knowledge-based industrial training curricula for in-service job incumbents. An employer-centred approach is more suitable for developing pre-vocational curricula since the students generally do not have any knowledge of the industry; but it might not be appropriate for developing in-service industrial training curricula as the individuals, that is, the job incumbents and the students, to a certain degree, know what will needed for meeting the performance

requirements. Whilst employers are the users of the competency of the trained individuals, individuals are the direct recipients of the industrial knowledge to be taught by the course. Individuals, therefore, should also be involved in the curriculum development process.

In the new knowledge era, the emphasis of education and training has shifted from teaching to learning. This shift indicates that the central process of education is learning and the primary customers of education and training are learners. For industrial training, the primary purpose of the institutions is to provide the important kinds of industrial knowledge to job incumbents whilst that of the industrial training practitioners of the institutions is to facilitate the job incumbents to learn the knowledge. To genuinely improve quality, it is necessary to adopt both a learning-oriented and job-incumbent-centred approach for planning and delivering industrial training. Similar to the case of education, it is only the position of learners as primary customers which could give industrial training its unique character (Muller & Funnell, 1991, 1992); and, it is the way to serve the long-term interests of the students and the institutions (Bailey & Dangerfield, 2000).

3. Collaboration with Job Incumbents

It is unarguable that the student-as-customer analogy has caused many problems. However, the institutions would easily become bureaucratic ivory towers and unresponsive to the real needs of students if they totally rejected it (Laskey, 1998). Equally, it would be dangerous if students were identified as products because this would make them vulnerable to objectification and manipulation (Zollers & Fort, 1996). In recognizing these drawbacks, more and more educators have advocated considering students as collaborative partners for improving educational quality (Brower, 1994; Playle, 1996; Delucchi & Smith, 1997; Franz, 1998; Clayson & Haley, 2005).

The growing importance of learning and the changed nature of the manufacturing industries indicate that the job-incumbent-centred approach would be more appropriate for the development of in-service industrial training curricula. The job-incumbent-centred approach does not mean job incumbents are allowed to freely determine the knowledge areas or study subjects for the course. With this approach, employers are still responsible for informing what kind of performance is required whilst trainers are still responsible for advising what should be learnt. It is only to place the focus on the kinds of industrial knowledge which job incumbents found to be

important. Rather than the employers or the trainers, it is the incumbents who determine what to be included into the course contents from a given set of knowledge areas or study subjects, according to the importance found for meeting their job performance requirements.

4. Role Appropriation

Although multiple parties were commonly involved in using QFD to operate the curriculum development process, the purposes of involving multiple parties varied. In some cases, the purpose was to collect more ideas on the requisite qualities. For example, in the framework proposed for engineering curriculum design, employers and alumni were surveyed to obtain their ideas on the programme objectives and outcomes (Duffuaa & Al-Turki, 2003). In other cases, the purpose was to cater for a wide spectrum of interests of the stakeholders. Customers were asked about their expectations of the graduates, and they also took part in determining the curriculum features. In improving the educational quality of industrial engineering at the Middle East Technical University, students, employers and faculty members were invited to prioritize the competencies required of the graduates (Köksal & Eğitman, 1998). Likewise, the three stakeholder groups, these being students, faculty members and employers, were asked to prioritize seven given educational processes to identify the areas of improvement for an engineering department. Unlike the case of the Middle East Technical University, the ratings given by the three stakeholder groups were allocated with different weights so as to reconcile their respective degrees of importance in the final decision (Owlia & Aspinwall, 1998). In the design of an industrial engineering curriculum at Prince of Songkla University, besides employers, faculty and students, students' parents were also invited to express their expectations and identify the important qualities which the graduates were expected to possess (Boonyanuwat et al., 2008). A weighing method was once again used to reconcile the importance ratings of the stakeholder groups. Instead of balancing the stakeholders' needs by weights, the design of an introductory course in Engineering Graphics at Georgia Southern University used obtaining consensus as the method for resolving the difference in opinions between the employers, professional societies and accreditation boards on the quality requirements of the graduates (Desai & Thomassian, 2008). The problem with these cases was the needs of the involved parties were assumed to be of the same level and similar in nature. The only area of difference between the stakeholders was the magnitude of the importance of the needs. However, as the study conducted by Sahney et al. (2003, 2004a, 2004b) found, the needs and views of various

stakeholder groups may not always coincide, especially those of employers and students. Educators have to look for the issues which unite them to resolve their different interests and needs.

To improve higher educational quality, the importance of meeting the needs of the employers and students was highly emphasized (Bemowski, 1991; Foggins, 1992). In order to properly address the needs of employers and students, we have to realize that these two parties have different needs and their needs are of two different levels. The concept of internal-external customers displays the difference between the needs of employers and students (Siegel & Byrne, 1994, pp. 19-23). In this concept, employers were referred to as the external customers whilst students were considered to be the internal customers of educational quality. The former are the customers of educational institutions and the latter are the customers of the educational services provided by the institutions. When this concept is applied to industrial training curriculum development, employers are the customers of the students and students are the customers of the training contents. As employers and students are customers of two different levels, besides their needs, their roles and the activities in which they participate are also different. As contended by Akao et al. (1996), educational quality could only be properly designed when the evaluations done by students (internal evaluators) are based on the premise of satisfying the demands of companies (external evaluators). Following this logic, employers are responsible for defining the demanded qualities of the curriculum, for example, the graduates' competency; and, students are responsible for identifying the alternatives, such as the knowledge areas or study subjects, so that the developed curriculum can supply the qualities which the employers require.

The central purpose of involving multiple parties in QFD is to implement partnership in product and service development. Through partnership, the product or service which is developed can meet the respective needs of the parties. Quality curricula can hardly be the result if the purpose of involving multiple parties is simply to collect ideas or to cater for the needs of different parties. Rather, it should be the collaborative arrangement which could effectively facilitate the involved parties to contribute their expertise to building the curriculum. In view of this importance, the rationale of the model was to design a QFD operation process in which the members of the industrial training supply chain take up different but complimentary roles and responsibilities so that they could make use of their respective best knowledge to develop the curriculum collectively. In the following, the respective roles and responsibilities of the involved

parties in the development of learning-oriented industrial training curricula and the activities of each party participating in the process are discussed.

4.1 Employers

Employers are the external customers as they are the users of the job incumbents' competency. They have been playing an informative role in curriculum development. In former times, employers found it relatively easy to cite the kinds of skills required of workers on the shop floors. However, changes in job nature have meant that industry-specific knowledge is no longer the core knowledge required by the incumbents. Employers are finding it increasingly difficult to define industry-specific knowledge precisely and comprehensively for the job incumbents of the service-oriented manufacturing industries. Instead of directly asking the employers what should be taught, it would be more appropriate to invite them to define the performance requirements or to explore the technical capabilities which they expect the incumbents to perform for a particular job or task.

Within the QFD context, the parties who took part in prioritizing the customer requirements varied. In the development of a computer numerical control course, employer and graduate representatives were invited to attend a meeting to first suggest the objectives and then prioritize the suggested objectives for the course (Chao, 1997). At the Kocaeli University Köseköy Vocational School of Higher Education, besides the managers of the tyre companies, the faculty members were also invited to suggest and prioritize the skills and qualifications to be acquired by the graduates in the case of revising the curriculum of the Tyre Technology Department (Aytaç & Deniz, 2005). Although faculty members and alumni undoubtedly understand the requisite qualities of graduates, it may be more appropriate for the employers themselves to do the prioritization, simply because they are the customers of the graduates.

4.2 Trainers (Subject-matter-experts and/or Instructors)

Trainers will still play an advisory role in learning-oriented curriculum development. Instead of using their subject knowledge and field experience to determine what is be taught to the students, as in the case of the teaching-oriented curriculum development, trainers apply their expertise to suggest what could be useful for the incumbents to enhance their competency or improve their job performance. It would then be up to the job incumbents to make the final decision on what would be included in the course

contents. There are two major reasons for the change of the responsibility of the trainers in the curriculum development process. First, the incumbents know what they have to learn in order to match the job performance requirements. Second, the fast changing industrial environment makes it increasingly difficult for the trainers to identify the effective kinds of knowledge required for performing the job.

4.3 Job Incumbents

Job incumbents are the internal customers as they are the customers of the knowledge of the course. They also play an informative role in the curriculum development process. As previously discussed, the course contents are not freely determined by the job incumbents. However, the job incumbents will be the ones who prioritize the importance of the knowledge areas or study subjects which are suggested by the trainers in order to meet the performance requirements specified by the employers.

4.4 Curriculum Developers

Curriculum developers play the role of facilitator in the curriculum development process. They not only listen to the employers' views about the requirements for a given job but also work with the trainers on deriving the useful knowledge and innovating new subjects so as to assist the job incumbents in enhancing their competency for meeting the specified job performance. Their task is to design the course contents and arrange them in a logical and coherent manner. The contribution of the curriculum developers is to use their expertise in curriculum development and course design to match the expectations of the two major customers of industrial training, employers and job incumbents, and satisfy the needs of both of them.

5. The Model

Figure 1 shows the QFD-based curriculum development model for industrial training. It drew upon two core processes of curriculum development. The first core process of curriculum development that the model addressed, that is, the upper portion of the model, was needs analysis. Needs analysis is the starting as well as the key planning effort of almost every curriculum development project. Another core process of curriculum development that the model addressed, that is, the lower portion of the model, was content design. Upon understanding the kinds of knowledge required for meeting the specified job requirements, the development team members use their

expertise to compile and organize them into a coherent form so as to facilitate the learning of the knowledge. QFD played the role of providing the mechanism for integrating the two processes so as to prescribe a specification with which courses to be derived could achieve customer satisfaction.

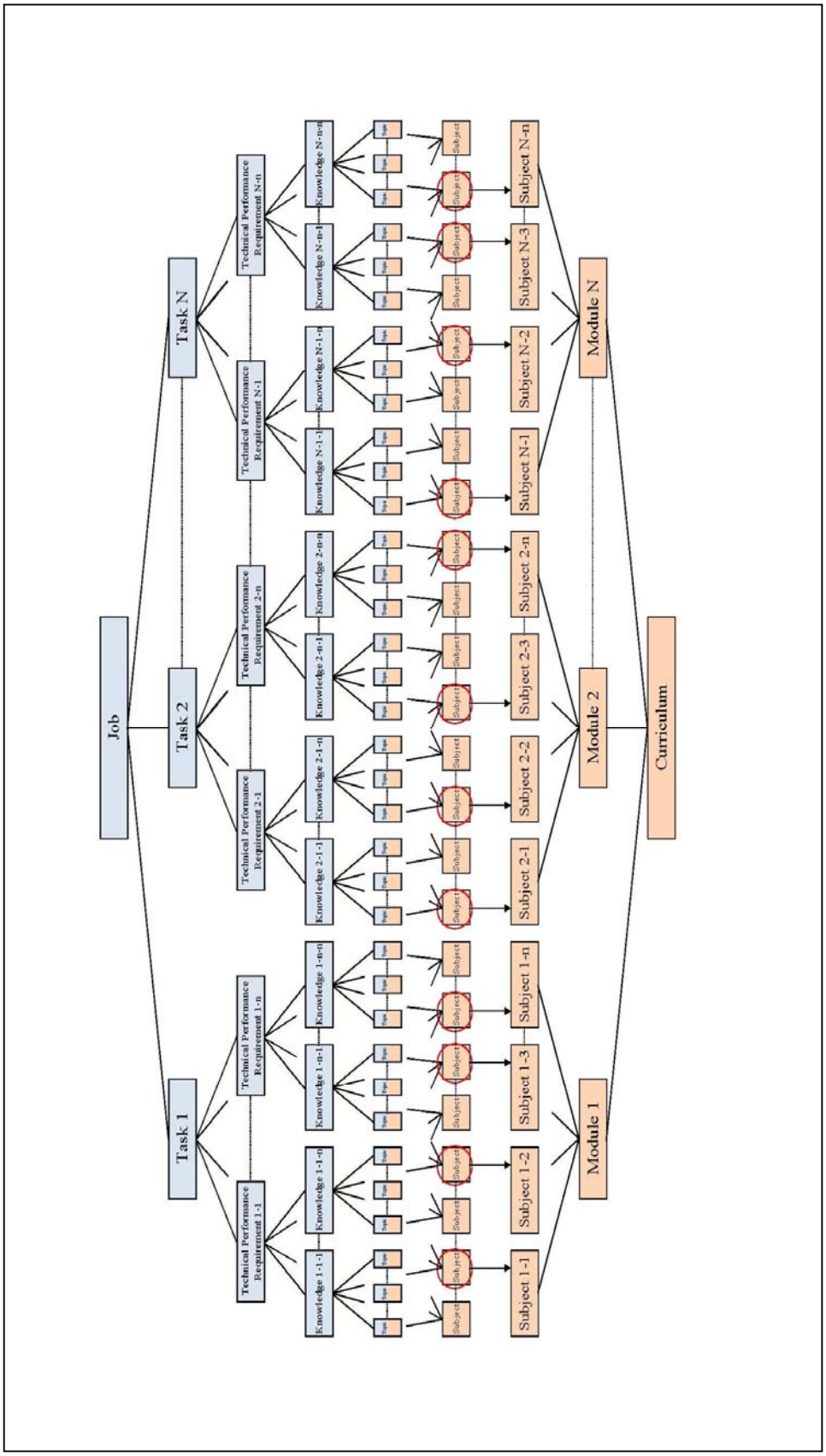

Figure 1: QFD-Based Curriculum Development Model for Industrial Training

5.1 Three Main Tasks

The model was developed to execute three basic tasks of QFD. The first task was to define the demanded qualities. This task requires the development team to collect and to analyze the VOC, extract the embedded meanings from the voices and put them into an organized structure that represents the customers' needs. Prioritizing the importance of the customer needs or identifying the important customers' needs is also required. The second task is to derive quality elements for meeting the demanded qualities. Team efforts, professional contributions and innovation are highly emphasized for executing this task. The third task is to review the degree of correlation between the demanded qualities and the quality elements so as to identify the few essential quality elements for further action or investigation. As Zultner (2005) explained, a small number of items have a very significant effect on the value which customers perceive. These few items, if done well, can deliver sufficient value to assure satisfaction on the part of the customers.

5.2 Operation of the Model

From the QFD point of view, VOC is the basis for partnership, both within the supplier as well as between the supplier and its customers (Akao, 1995). To be a responsible and professional supplier, it is necessary to capture, rank and deploy the VOC and translate that voice into staff actions (Mazur, 2003). The operation of the model is a procedure for the industrial training institutions to manipulate the VOC, with appropriate involvements of customers at different stages to develop industrial training curricula. By integrating the two core processes of curriculum development and the three basic procedures of QFD, the institutions could use the model to plan and to design industrial training curricula for any defined jobs. To achieve an efficient and effective operation, various data collection methods such as interview, questionnaire and *gemba* are suggested to use to capture the required qualitative and quantitative data. Whilst different data processing and analyzing tools including affinity diagramming, conversion table and AHP are highly recommended to employ wherever appropriate.

6. Extension of the Model

To provide greater benefit to industrial training, the model could be extended upstream to cover the overall curriculum planning of industrial training and downstream to address curriculum evaluation as well. By extending the model upstream, the planning

will not only be limited to the departmental level but it could also be made at the institutional or even the industrial levels. Equally, by extending the model downstream, the model will also address instruction quality in addition to that of curriculum. Table 1 shows an extended version of the model. In the extended version, the four basic steps of the PDCA cycle are used as the backbone of the model. The planning is started at the country/state level. The identification of key industries provides direction for the institution to do curriculum planning for the key jobs of its respective industry. Upon identifying the key jobs, a curriculum will be developed for each of them by the corresponding curriculum development team. After the curriculum is developed, the curriculum will be put into pilot run to assess the effectiveness of the curriculum. The curriculum development team reviews the curriculum by gathering students' comments from course evaluation and reviewing students' performance. Upon making the necessary improvements, the course is rolled out in full extent.

Operation							Data Required		Data Collection			Data Analysis	
PDCA	**Level**	**Process**	**Task**	**Step**	**Activity**	**Person/s In Charge**	**Information**	**Nature**	**From Whom**	**Method**	**Instrument**	**Techniques**	**Tools**
PLAN	Industry	Industry Analysis	Identify important industries/sectors	List emerging or technically advancing industries	Conduct analysis with government or economic/financial offices	Government officers	Economic and trechnolgy trend data	Quantitative	Government experts	Economic reports, interviews	Pre-set interview questions	Hoshin Kanri, New Lanchester Strategy, SWOT analysis, TRIZ	Excel
			Select key industries/sectors	Prioritize candidate industries	Meet with industry councils	Government officers	Industry potential	Qualitative	Industry experts	Trade reports	Pre-set interview questions	SWOT analysis	
	Company	Company Analysis	Select key companies	Identify leading companies to participate	Institution or industry council can select candidate companies or seek volunteers	Department chairs or faculty team	Company availability to participate	Qualitative	Faculty		Discussion	AHP	ExpertChoice®
			Identify jobs	Identify jobs to be addressed in new curriculum	Form high level job analysis/flow chart	Faculty and company managers	Current company approach and industry best practices	Qualitative	Company managers	Flow chart/value stream mapping	Discussion	Affinity diagram to build up to high level jobs	Post-It® notes
			Select key jobs	Prioritize key jobs to improve curriculum first	Focus curriculum improvement efforts	Faculty and company managers	Areas of changing technology, emerging jobs due to industry changes (geography, education, government policy, etc.)	Quantitative	Company managers	Discussion	Discussion	AHP	ExpertChoice®
	Job			Decompose each key job into its corresponding tasks	Conduct a structural analysis of the job	Program leader and curriculum developer	Tasks performed by the job incumbents to achieve their roles and functions	Qualitative	Field experts and/or job incumbents	Individual, semi-structured interviews	Pre-set interview questions, *Gemba* observation	Gemba Visits, affinity diagramming	
	Task	Needs Analysis	Define demanded qualities	Understand the technical performance requirements for each task	Collect and analyze technical performance requirements for each task		Technical performance requirements	Qualitative	Company managers	Discussion		Affinity diagramming	
					Establish a list of required technical performance requirements								
				Prioritize the technical performance requirements		Curriculum developer	Importance of the technical performance requirements for the task	Quantitative	Company managers	Survey	Questionnaire for pairwise comparison	AHP	ExpertChoice®
		Content Definition	Derive quality elements	Translate the technical performance requirements into subject alternatives	Generate ideas on the kinds of industrial knowledge areas for meeting the technical performance requirements	Subject-matter-experts/instructors and curriculum developer				Discussion		Conversion table	
					Synthesize the ideas into a list of subject alternatives	Subject matter experts/instructors and curriculum developer				Discussion		Affinity diagramming	
			Identify the quality elements for meeting the demanded qualities	Identify the subjects for meeting the technical performance requirements	Benchmark other institutions' courses and subject matter	Curriculum developer	What are emerging, changing subjects to be needed in the future	Qualitative	Field experts and/or job incumbents	Discussion		Affinity diagramming	
			Prioritize quality elements for meeting the demanded qualities	Prioritize subjects for meeting the technical performance requirements		Curriculum developer	Importance of the subject alternatives for meeting the technical performance requirements	Quantitative	Job Incumbents	Survey	Maximum Value table for highest priority technical performance requirements, and/or matrix for remaining technical performance requirements	MVT/QFD matrix (House) with Excel or using ExpertChoice® alternatives rating mode	ExpertChoice®/Excel
		Content Design		Design the training content according to the important subjects identified	Derive topics for each subject and compile them into a training content	Subject-matter-experts and curriculum developer							
	Job			Organize the designed training contents into a coherent curriculum	Organize the training contents into modules and supplement with necessary details	Curriculum developer							
DO	Department			Train/employ instructors in new curriculum and teaching methods, software, etc.		Program leader							
	Course			Pilot new curriculum	Conduct class according to the new curriculum	Subject-matter-experts/instructors	Student feedback	Qualitative	Students	Course evaluation	Questionnaire		
CHECK	Course			Test students		Subject-matter-experts/instructors	Student performance	Quantitative	Students	Assessments	Examination and test papers		
ACT	Course			Revise curriculum		Curriculum developer							
				Roll out new program		Subject-matter-experts/instructors							

Table 1: Extended Version of the Proposed QFD-based Industrial Training Curriculum Development Model

Implications and Conclusion

We have proposed a model that could be used by industrial training for curriculum development, including both planning for new curricula as well as improving the existing ones. At the departmental level of an industrial training institution, the model offers three major benefits. First, the function analysis of the model offered a mechanism for appropriately incorporated employers and job incumbents' voices into the curriculum development process. Second, the team approach of the development process stimulated interaction between members and fosters innovation. Last but not least, the process provided trainers and curriculum developers with the opportunity of applying subject-matter knowledge and field experience as well as expertise to develop quality curricula respectively.

The model could be simply used to develop curriculum for any defined job. However, it could also be used in a much greater extent for doing curriculum planning at the country/state and/or industry levels. Using the same principle and defining the responsibilities of the involved parties, the model could also be modified to design instructions as well.

The importance of this cannot be overstated. As technology transfer becomes more rapid and global, future competitiveness will lie even more critically with knowledge and the management thereof. Akao (2008) has in recent years promoted the integration of QFD and Knowledge Management which can be applied in the case of industrial training to move the implicit knowledge that subject matter experts have into explicit knowledge that can be taught to job incumbents. There are several implications to be further explored.

1. As economies evolve from emerging to emerged, the low cost producing countries will continuously advance from technical to knowledge based activities. That means that educational and training programs will be under constant pressure to rapidly adapt their curricula so that their young people will take and retain leadership positions in their respective countries rather than defaulting to emigration to the most advanced economies.
2. Due to rapidly advancing knowledge, education programs will be tasked to add greater skills, but not at the cost of ignoring the basics of quality. Thus, today's knowledge holders must find a way to pass on the "DNA" of their skills in such a way that the next generation will be able to rapidly absorb it and progress further. This means earlier education and capturing experiences through

simulation, gaming, and other technologies that will enable the more "plastic" brains of young people to internalize past knowledge upon which to build new knowledge. Past times appeared to offer the luxury of learning through the "school of hard knocks" or from one's failures, but the information revolution of today permits no such time to catch one's breath.

3. The ability to move beyond the obvious and known into future states of uncertainty due to changing markets, changing technologies, and changing economies will demand not just inventiveness, but true innovation where invention provides not just whiz-bang novelty but true value to society and customers. This means that students must learn to move beyond rote repetition of what they are taught into truly thinking outside their comfort zone of "self" and exploring the world of "others." Thus, even QFD thinking itself should become a treasured tool to teach students a structured way how to identify and prioritize their "next-step in the process" as well as "next-to-next" customers and beyond so that they can create newness that will provide true quality not only to users, but to employers, and ultimately society.

Glossary

Student – One who studies a course
Learner – One who learns the knowledge and/or skills provided by a course
Job Incumbent – One who does the job of a given job category
Subject Matter Expert – One who is an expert of a given subject
Curriculum Developer – One who is responsible for the development of a curriculum
Trainer – One who provides and/or delivers the knowledge and/or skills for a subject or course
Educator – An education practitioner
Employer – One who provides employment

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