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Six sigma and Total Quality Management

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1. The practices and implementation of Six Sigma

In the past two decades, Six Sigma methodology has been widely adopted by industries and non-profit organizations throughout the world. In this section, we demonstrate the development of Six Sigma program, and discuss the features and the five steps of the improvements

1.1 The introduction of Six Sigma

Six Sigma methodology was first espoused by Motorola in the mid 1980s. (Antony & Banuelas, 2002; Wiklund & Wiklund, 2002). At that time, Motorola was facing Japanese competition in the electronics industry and needed to make drastic improvements in its levels of quality (Harry and Schroeder, 2000; Linderman et al., 2003). A Six Sigma initiative ,which is originally focused on manufacturing process and product quality (Harry & Schroeder, 2000), is also designed to change the culture in an organization through breakthrough improvement in all aspects of the business (Breyfogle III et al., 2001, p.32). The Six Sigma architects at Motorola focused on making improvements in all operations within a process—thus producing results far more rapidly and effectively (Harry & Schroeder, 2000). The successful implementation of the Six Sigma program in Motorola led to huge benefits. Motorola recorded a reduction in defects and manufacturing time, and also began to reap financial rewards. Within four years, the Six Sigma program had saved the company $2.2 billion (Harry & Schroeder, 2000). The crowning achievement was being recognized with the Malcolm Baldrige National Quality Award (Breyfegle III et al., 2001; Wiklund & Wiklund, 2002).

IBM, SONY, and Allied Signal successfully followed Motorola in implementing Six Sigma. Allied Signal began its Six Sigma activities in the early 1990s, It successfully attained savings of US$2 billion during a five-year period (Klefsjö et al., 2001). Sooner, the impressive results obtained by Allied Sigma induced General Electric (GE) to undertake a thorough implementation of the Six Sigma program in 1995 (Pande et al., 2000) as a corporate initiative to improve net profits and operating margin (Hendricks and Kelbaugh, 1998). The 1999 annual report of GE showed that the implementation produced more than US$2 billion in benefit (Slater, 2001; Coronado & Antony, 2002, Raisinghani et al., 2005).

As a result, the impressive benefits of implementing Six Sigma programs in Motorola, Allied Signal, and GE led the Six Sigma methodology being widely adopted by industries throughout the world. American Express, Ford, Honda, and Samsung have all applied the methodology (Klefsjö et al., 2001; Sandholm & Sorqvist, 2002; Yun and Chua, 2002). The Six Sigma has become the most prominent trend in quality management (Sandholm & Sorqvist, 2002; Yang, 2004) not only for manufacturing and service industries, but also for non-profit organizations and government institutes.
The GE-6σ program and the Motorola Six Sigma program did have some differences. Whereas Six Sigma activities in Motorola had focused on product quality and the manufacturing process, the GE-6σ program extended the improvement activities to cover all key processes related to customer satisfaction.

1.2 Some key views on Six Sigma

Several prominent researchers have expressed views on Six Sigma.

* Hahn et al. (1999) emphasized that Six Sigma improvement is a highly disciplined and statistically based approach for removing defects from products, processes, and transactions, involving everyone in the corporation.
* Harry & Schroeder (2000) emphasized that Six Sigma provides maximum value to companies—in the form of increased profits and maximum value to the consumer through high-quality products or service at the lowest possible cost.
* Harry & Schroeder (2000) also concluded that Six-Sigma is a business strategy and philosophy built around the concept that companies can gain a competitive edge by reducing defects in their industrial and commercial processes.
* Pande et al. (2000) commented that Six Sigma is a comprehensive and flexible system for achieving, sustaining, and maximizing business success. It is driven by close understanding of customers' needs and disciplined use of facts, data, and statistical analysis.
* Pearson (2001) described Six Sigma as a program that combines the most effective statistical and non-statistical methods to make overall business improvements.
* Slater (2001) stated that the Six Sigma approach provides a very specific control program with control techniques that ensure continuation of improved processes.
* Lucas (2002) described Six Sigma as a statistical business system and a functional methodology for disciplined quality improvement that achieves successful outcomes.
* Treichler et al. (2002) concluded that Six Sigma is a highly disciplined process that helps organizations to focus on developing and delivering near-perfect products and services. It is also, in Treichlers' (2002) view, a change-acceleration process that focuses on pursuing success and the rapid adoption of change.
* Yang (2004) asserted that the GE-6σ program and the Motorola Six Sigma program did have some differences. Whereas Six Sigma activities in Motorola had focused on product quality and the manufacturing process, the GE-6σ program extended the improvement activities to cover all key processes related to customer satisfaction.

In addition to the major features noted above, other features of the GE-6σ program include (Breyfegle III et al., 2001; Pande et al., 2000; Treichler et al. 2002).

* GE-6σ projects are integrated with the company's visions and strategies;
* all GE-6σ projects are rigorously evaluated for financial impact;
* everyone who contributes to the success of the program receives significant rewards, especially in terms of staff promotion;
* significant financial incentives (representing 40% of all bonuses received by employees) are tied to GE-6σ projects;
* a sound statistical approach to improvement is adopted;
* projects are completed rapidly (usually within 3–6 months); and
* bottom-line results are expected and delivered.

1.3 Implementation of GE Six Sigma

The main features of GE-6σ are discussed above, in this subsection we introduce the implementation of GE Six-Sigma:

* improvement steps;
* staff roles; and
* investment in training.

1.3.1 Improvement steps

There have been many improvement models for process improvement or re-engineering. Most of these have been based on the steps introduced by W. Edwards Deming, which can be characterized as 'Plan', 'Do', 'Study', and 'Act' (PDSA)(Deming, 1993). GE-6σ has a five-phase improvement cycle that has become increasingly popular in Six Sigma organizations: 'Define', 'Measure', 'Analyze', 'Improve', and 'Control' (DMAIC). There is another cycle characterized as 'Define', 'Measure', 'Analyze', 'Design', and 'Verify' (DMADV) (Pande et al., 2000). Like other improvement models, the DMAIC (or DMADV) model is grounded in the original Deming PDCA cycle. Usually, Six Sigma organizations use DMAIC for process improvement and DMADV for process design (and redesign). Table 1.1 describes the specific tasks in each step, and the tools and techniques used in the steps.

Step	Specific tasks	Tools and techniques employed
Define	● Identify improvement issues ● Organize project team ● Set-up improvement goal ● Estimate financial benefit	● Customer complaint analysis ● Cost of poor quality (COPQ) ● Brainstorming ● Run charts, control charts ● Benchmarking
Measure	● Map process and identify inputs and outputs ● Establish measurement system for inputs and outputs ● Understand the existing capability of process	● Process map (SIPOC) ● Cause and effect matrix ● Gauge R&R ● Control charts ● Process capability analysis ● Failure models and effects analysis (FMEA)

Analyze	• Identify sources of variation in process • Identify potential critical inputs • Determine tools used in the improvement step	• Cause-and-effect diagram • Pareto diagram • Scatter diagram • Brainstorming • Analysis of variance (ANOVA)
Improve	• Conduct improvement actions • Use experiments • Optimize critical inputs	• Design of experiment (DOE) • Quality function deployment (QFD) • Process capability analysis • Control charts
Control	• Standardize the process • Maintain critical inputs in the optimal area • Verify long-term capability • Evaluate the results of improvement projects	• Standard operation procedure • Process capability analysis • Fool-proofing (Poka Yoke) • Run charts

Table 1.1 DMAIC steps and tools usage

1.3.2 Staff roles

Along with the systematic improvement steps described above, the design of specific roles and their effective operations are important factors of the GE-6σ program. Senior management is ultimately responsible for the success of the project through the provision of sufficient support, resources, and strong leadership. The implementation of GE-6σ is thus top–down. The chief executive officer (CEO) is usually the driving force who sets up the vision, develops the strategies, and drives the changes. Apart from the critical role of the CEO, other players also have their specific roles (Henderson and Evans, 2000):

(i) '**Champions**' are usually the senior managers, who are the sponsors of the project and responsible for success of Six Sigma efforts, they are fully trained business leaders who promote and lead the deployment of Six-Sigma projects;

(ii) '**Master Black Belts (MBBs)**' are the full-time teachers and consultants, they are responsible for Six-Sigma strategy, deployment, training, mentoring, and results. A master Black Belt in Motorola has leaded as a Black Belt for about ten successful projects at least five years, and needs the recommendation of high managements;

(iii) '**Black Belts (BBs)**' have the key operational role in the program as full-time Six Sigma players, they are fully-trained Six-Sigma experts and lead the improvement teams. They are qualified as they successfully leaded at least two Six-Sigma projects;

(iv) '**Green Belts (GBs)**' are the process owners who, led by the BBs, work on Six Sigma projects while holding down their original job functions in the company.

1.3.3 Investment in training

Because training is a key ingredient in achieving success through Six Sigma (Pande et al, 2000), Motorola and GE have invested heavily in employee training for their Six-Sigma programs. Motorola invested $150 million per year in Six-Sigma courses, GE also spent $ 500 million per year in the implementation of Six-Sigma program (Sandholm and Sorqvist, 2002), GE has invested more than a billion dollars in this effort (Hahn et al., 1999). GE has designed

a complete training plan for the various roles described above—from the CEO, to the 'Champions', 'MBBs', 'BBs', and 'GBs'. In addition, the training program extends to all other employees in the organization. The training courses are comprehensive and cover team leadership skills, measurement and analytical tools, especially statistical methods, improvement tools, planning and implementation skills, and so on. For examples,

(i). C**hampions** have one week champion training related to Six-Sigma development, leadership, and the implementation plan.

(ii). **BBs** spend about four to five weeks to receive the intensive, highly quantitative training, roughly corresponding to the five steps of the implementation of Six-Sigma improvement project. Thus, the length of training is approximately 16-20 weeks.

(iii) **GBs** receive the training of six to ten days. The courses include the statistical tools and the use of statistical software, the detailed modules of five steps, the innovative and improvement tools, and the skill of project management.

(iv) **MBBs** then take over the responsibility of the training for all the BBs and GBs.

2. The critical success factors of the implementation of Six-Sigma

In this section we want to discuss the critical success factors for the successful implementation of Six-Sigma projects. We investigate the importance degree of the critical success factors in implementing Six Sigma, and their implementation level by using the questionnaire survey.

2.1 The consideration of critical success factors

Table 2.1 lists the key factors, as asserted in five previous studies. The factors identified by Coronado & Antony (2002) and Antony & Banuelas (2002) are almost identical, with the exception that Coronado & Antony (2002) added one extra factor ("communication"). Most of the success factors in the other three studies are included in the work of Coronado & Antony (2002). The total twelve critical success factors in Coronado & Antony (2002) are considered in the present study

In addition, two additional key factors, "complete evaluation system of project performance" and "promotion and incentive for employees tied to the results of Six Sigma projects", are also considered in this chapter according to Yun & Chua (2002) and Sandholm & Sorqvist (2002). The former introduces the factor of "accurate and fair evaluation of all successful Six Sigma projects with meaningful recognition and rewards for employees". The later suggests "focus on results" to assert that the employee promotion and incentive compensation are tied to the results of Six Sigma projects.

Finally, apart from the above, another key success factor somewhat neglected by previous studies is the application of techniques and innovations. Although Coronado & Antony (2002) and Klefsjö et al. (2001) mention it as a required technique in the progress of Six Sigma projects, and Yun & Chua (2002) asserts that "linkage with all innovation and infrastructure activities" is also a key factor. We therefore add another key factor: "usage of innovative techniques and IT systems". In total, a study is conducted to adopt fifteen critical success factors in the questionnaire to investigate the extent to which they are implemented and their degree of importance from the firms' perspective.

The author conducted the empirical study for those enterprises have implemented Six Sigma program in Taiwan, The aim of this empirical study is to investigate the importance degree and the implementation level of the critical success factors. Thus, the research design is conducted according to the aim of the research. The Likert-type scale is used in the questionnaire. In the investigation of the importance degree of the critical success factors, a five-point scale from 1 (not important) to 5 (very important) is used. In the analysis of implementation level, a five-point scale from 1 (not implemented) to 5 (full implemented) is adopted

2.2 The analysis of critical success factors

The main focus of this study is to analyze the degree of importance of critical success factors for Six Sigma effectiveness as perceived by the respondents, and to assess the implementation level of these critical success factors by the organizations (see Table 2.2). As Henderson & Evans (2000) notes that "top management leadership and support" should be the critical success factor, our first priority of success factors is "top management involvement and commitment". The other critical success factors are prioritized as follows: "cultural change", "communication with all employees to achieve congruence", and "training in Six Sigma", and so on. It should be noted that "employees' promotion and incentive tied to the results of Six Sigma projects" is considered as an important factor for the success of Six Sigma in GE (Hendericks & Kelbaugh, 1998; Henderson & Evans, 2000). However, in Taiwan, this practice is not followed in the industries investigated.

Hahn et al., 1999	Key factors for Six Sigma effectiveness	● Quantified functional impact ● Continued top management support and enthusiasm ● The emphasis on a quantitative and disciplined approach ● The value placed on understanding and satisfying customer needs ● Combining the right projects, the right people, and the right tools
Yun & Chua, 2002	Success factors for Six Sigma effectiveness	● Strong proactive support with required resources provided by top management ● Acceptance and implementation of Six Sigma's basic disciplines by employees ● Linkage with all innovative and infrastructure activities ● Accurate and fair evaluation of all successful Six Sigma projects with meaningful recognition and rewards for employees

Sandholm & Sorqvist, 2002	Requirements for Six Sigma success	● Management commitment and visible support ● Treatment of Six Sigma as a holistic concept ● Investment of adequate resources ● Focus on results ● Customer orientation ● Focus on training and its content ● Adaptation to an organization's situation and needs ● Prioritization and selection of projects ● Development of uniform language & terminology ● Development of strategy to introduce Six Sigma ● Follow-up and communication of success stories ● Responsiveness to external influences.
Coronado & Antony, 2002	Critical success factors for Six Sigma projects	● Management involvement and commitment ● Cultural change ● Communication ● Organization infrastructure ● Training ● Linking Six Sigma to business strategy ● Linking Six Sigma to customers ● Linking Six Sigma to human resources ● Linking Six Sigma to suppliers ● Understanding tools and techniques within Six Sigma ● Project management skills ● Project prioritization and selection
Antony & Banuelas, 2002	Key ingredient for Six Sigma effectiveness	● Management involvement and commitment ● Cultural change ● Organization infrastructure ● Training ● Project management skills ● Project prioritization and selection, reviews and tracking ● Understanding the Six Sigma methodology, tools, and techniques ● Linking Six Sigma to business strategy ● Linking Six Sigma to customers ● Linking Six Sigma to human resources ● Linking Six Sigma to suppliers

Table 2.1 Critical success factors for Six Sigma effectiveness

Critical success factor	Importance degree		Implementation level		To be improved factor
	mean	order	mean	order	
1. Top management involvement and commitment	4.808	1	3.885	2	*
2. Cultural change	4.365	2	3.192	11	*
3. Organization infrastructure	4.019	10	3.596	4	
4. Training in Six Sigma	4.192	4	3.981	1	
5. Project management skills	3.865	12	3.577	5	
6. Project prioritization and selection	4.077	9	3.558	6	
7. Understanding methods, tools and techniques within Six Sigma	4.137	7	3.667	3	
8. Linking Six Sigma to business strategy	4.192	5	3.423	9	*
9. Linking Six Sigma to customers	4.192	6	3.269	10	*
10. Linking Six Sigma to human resources	3.725	13	2.882	14	
11. Linking Six Sigma to suppliers	3.635	14	2.692	15	
12. Communication with all employees to achieve congruence	4.231	3	3.519	7	*
13. Complete evaluation system of project performance	4.135	8	3.481	8	
14. Employees' promotion and incentive compensation tied to the result of Six Sigma projects	3.885	11	2.981	12	
15. The usage of innovative techniques and IT systems	3.596	15	2.942	13	

Table 2.2 Importance degree and implementation level of critical success factors

Most of the organizations paid significant attention to training in Six Sigma. The factor of "training in Six Sigma" is thus the first priority of implementation level, followed by such factors as "top management involvement and commitment", "understanding methods, tools and techniques within Six Sigma", "organization infrastructure", and so on (see Table 2.2). In Table 2.2, if a critical success factor has a higher importance degree with a lower implementation level, then the firm should pay more attention on its implementation. In this case, we denote five CSFs as the "to be improved" factors for the industries in Taiwan:

- Top management involvement and commitment
- Cultural change
- Communication with all employees to achieve congruence
- Linking Six Sigma to business strategy
- Linking Six Sigma to customers.

3. The Integrated Model of TQM and Six Sigma

By the end of the 1970s, the competitiveness of Japanese industries had equaled or exceeded that of American industries. In large part, this was due to the successful Japanese implementation of company-wide quality control (CWQC) (Powell, 1995). By the 1980s, Japanese CWQC had been replicated in the United States, and total quality management (TQM) soon became the prevailing business strategy adopted by industries around the world. This evolution of TQM has resulted from the development, on a global scale, of a consistent philosophy concerning the relationship between business and customers. At various stages in this development, different ideologies and practices for implementing quality management have been prominent, but the consistent goal has been to pursue the quality of products and services, to reduce costs, and to raise business performance. The success of Japanese industries in the total and effective implementation of TQM meant that Japanese firms led the way in the production of good-quality products at lower cost.

3.1 The decreasing adoption of TQM and the increasing trend of Six-Sigma

The successful implementation of TQM does indeed result in better business performance, as firms expect (Hendricks & Singhal, 1996; Gunasekaran, 1999; Hansson & Eriksson, 2002). The benefits come in the areas of cost reduction, increased market share, increased profit, and enhanced business competitiveness (Youssef et al., 1996; Gunasekaran, 1999). TQM has therefore been widely adopted by industries, even in non-profit and governmental organizations (Powell, 1995; Zabaha et al., 1998).

Several critical factors are essential if TQM is to be successfully implemented. These include the support of top management, visionary leadership, effective management of human resources, employee involvement, and a corporate culture of commitment to quality and customer satisfaction (Joseph et al., 1999; Sureshchandar et al., 2001). However, in practice, these corporate factors are not easy to achieve. As a result, the literature contains reports of several cases in which the implementation of TQM has failed. Hubiak & O'Donnell (1996), for example, have asserted that approximately two-thirds of companies in the United States have either failed or stalled in their attempts to implement TQM. Many of these TQM programs have been cancelled, or are in the process of being cancelled, as a result of the negative impact on profits (Anonymous, 1996). The failure implementation of TQM is due to several factors. Besides the difficult achievement of TQM practices, one of them is that TQM has been a rather diffuse concept, with many vague descriptions but few more graspable definitions, and the management does not have a complete picture of what TQM really means (Hellsten & Klefsjö, 2000). Another one is that too management teams over the world do not realize that implementation of TQM means a cultural change (Hansson & Klefsjö, 2003). In fact, TQM was one of two workplace trends that recorded a significant decline in 1996 (Anonymous, 1996). Academic discussion of TQM and its implementation has suffered a similar decline in recent years.

Is this trend really due to poor corporate business performance as a result of the implementation of TQM, with a consequent decline in the implementation of TQM, as has been asserted (Anonymous, 1996)? It is a contention that this is not an accurate reflection of the current status of TQM. Reports of instances of failed TQM implementation are only part of the explanation for the apparent declining trend in TQM. In reality, TQM has been so prominent for about twenty years that many firms and institutions have incorporated TQM

into daily management activities. The result is that a well-established model of TQM has been so much a part of the routine business activities, that the 'decline' in discussion and implementation of the TQM is apparent, rather than real.
As interest in TQM has apparently waned, interest in the Six Sigma program has increased. Since General Electric (GE) initiated its Six Sigma program (GE-6σ) in October 1995, the results have been far beyond the company's original hopes and expectations. Based on the remarkable business successes achieved in GE and other large corporations, an increasing number of companies have initiated the GE-6σ program as a business improvement and re-engineering strategy (Pearson, 2001; Lucas, 2002). As a result, the Six Sigma program has gained great popularly in recent years (Slater, 2001; Lucas, 2002). It has even been suggested that TQM will be replaced by Six Sigma as the main strategy for successful business management. However, such assertions reveal a fundamental misunderstanding of the nature of TQM and its relationship with GE-6σ.
For example, Pande et al. (2000) have asserted that TQM is less visible in many businesses than it was in the early 1990s, pointing to several major TQM gaffes as reasons for this apparent decline. According to Pande et al. (2000), these problems include a lack of integration, leadership apathy, a fuzzy concept, an unclear quality goal, failure to break down internal barriers, inadequate improvements in performance, and so on. They conclude that Six Sigma can overcome many of the pitfalls encountered in the implementation of TQM and, hence, that Six Sigma's expansion heralds a 'rebirth' of the quality movement (Pande et al., 2000). However, Klefsjö et al. (2001) and Lucas (2002) have a different perspective. Klefsjö et al. assert that Six Sigma is a methodology within- not alternative to - TQM. Lucas asserts that Six Sigma is essentially a methodology for disciplined quality improvement. Because this quality improvement is a prime ingredient of TQM, many firms have found that adding a Six Sigma program to their current business system gives them all, or almost all, of the elements of a TQM program. Lucas has thus concluded that:
Current Business System + Six Sigma = Total Quality Management
The TQM pitfalls noted by Pande et al. (2000) are not essential features of TQM. Rather, they are caused by incorrect practices adopted by firms, especially the lack of proper endeavour shown by management in the implementation of TQM.

3.2. Total quality management

Since TQM began in the mid 1980s, several gurus, like Deming, Juran and Ishikawa have much contribution on the development of TQM (Boaden, 1997). Besides, many researchers and experts on quality management have been eager to study the essentials of TQM. In the beginning, there was a lack of consensus on the contents and practices of TQM. Now, with TQM having been implemented for more than twenty years, academics and practitioners alike have achieved a degree of consensus on TQM.
Tobin (1990) has stated that TQM is a totally integrated program for gaining competitive advantages by continuously improving every facet of organizational culture. TQM programs are usually based on the 'quality philosophies'-- customer focus, employee participation, teamwork, and management by facts and continuous improvement (Brown, 1992). TQM is therefore an integrated management philosophy and set of practices that emphasize increased employee involvement and teamwork, continuous improvement, meeting customers' requirements, team-based problem-solving, constant measurement of results, closer relationship with suppliers, and so on (Ross, 1993). Short and Rahim (1995)

have agreed that TQM can be viewed as a set of philosophies and methods used by an organization to guide it in continuous improvement in all aspects of its business. McAdam and McKeown (1999) have concluded that customer focus, employee involvement, empowerment, teamwork, measurement tools, training, quality systems, and top management commitment are all key factors in the successful implementation of TQM. Boaden (1997) also examine the critical elements of TQM based on some early studies. It is worthwhile to refer to the research of Sila & Ebrahimpour (2002), they conduct a huge investigation of elements of TQM survey based on 347 researches published between 1989 and 2000.

These views indicate that, although various researchers approach the issues of TQM from different perspectives, there is a general consensus regarding the essential principles, practices, and values of TQM (Hellsten & Klefsjö, 2000). On the basis of these various approaches, especially the research of Sila & Ebrahimpour (2002) and Yang (2003a), the present subsection asserts the following to be essential agreed elements of TQM:

* customer focus and satisfaction;
* training and education;
* top management commitment, support, and leadership;
* teamwork;
* employee involvement;
* quality assurance;
* quality information system and application;
* continuous improvement;
* flexibility
* benchmarking and strategy planning;
* process management;
* product and service design and quality control;
* employee management and empowerment;
* corporate quality culture;

3.3 Comparison between TQM and GE-6σ

As previously noted, the passion for TQM has apparently declined, whereas GE-6σ has been receiving increased attention (Anonymous, 1996; Pande et al., 2000). As a result, there are several assertions related to the relationship between TQM and GE-6σ appeared, especially the treatise that TQM will be replaced by GE-6σ. However, there are very few studies in the literature that directly compare TQM with GE-6σ completely, and in the limited studies that do exist, conclusions on the relationship between TQM and GE-6σ have differed significantly.

Harry (2000b) has claimed that Six Sigma represents a new, holistic, multidimensional systems approach to quality that replaces the "form, fit and function specification" of the past. However, it is not readily apparent from Harry (2000a) which aspects of this multidimensional systems approach are presumed to be absent from TQM.

Breyfegle III et al. (2001) have stated that Six Sigma is more than a simple repacking of the best from other TQM programs. Pande et al. (2000) had already taken a similar approach when they provided a review of some of the major TQM gaffes, and then compared TQM and GE-6σ in the light of these problems with a view to showing how successful implementation of Six Sigma can overcome these failures. However, it should be noted that

these gaffes are principally a result of inappropriate implementation processes, rather than being caused by inherent TQM concepts and practices.

In view of a lack of consensus on the relationship between TQM and GE-6σ, the present section wants to compare TQM and GE-6σ by using complete perspectives. The author reviewed several studies (Boaden, 1997; Hermel, 1997; Goh, 2002), and selected the appropriate criteria used in these researches, and then integrated into 12 dimensions. They are: (i) development; (ii) principles; (iii) features; (iv) operation; (v) focus; (vi) practices; (vii) techniques; (viii) leadership; (ix) rewards; (x) training; (xi) change; and (xii) culture (Yang, 2004). These are presented in Table 3.1, which represents a comprehensive review of the similarities and differences between the two approaches.

3.4 Integration of TQM and GE-6σ

It has been suggested that the implementation of TQM results in an over-emphasis on customer satisfaction, with a relative neglect of the pursuit of profits (Anonymous, 1996). Indeed, several empirical studies have asserted that implementing TQM might not achieve any significant positive effect on profitability (Bergquist & Ramsing, 1999; Harry, 2000b; Breyfegle III et al., 2001). Furthermore, Harry (2000a) has noted that "What's good for the customer is not always good for the company". In contrast, it is argued that GE-6σ achieves both customer satisfaction and excellent financial performance.

The major problem with TQM is that there is a disconnection between management systems designed to measure customer satisfaction and those designed to measure business profitability, and this has often led to unwise investments in quality (Breyfegle III et al., 2001). It should be recognized that the objective of TQM is to achieve customer satisfaction, in order to increase customer loyalty. To sustain competitiveness and long-term profitability, companies not only devote themselves to attracting new customers, but also to retaining old customers in a continuous business relationship with incremental additional purchasing. For these reasons, increasing customer loyalty should be one of the main concerns of all companies (Gorst et al., 1998). Any assessment of the effectiveness of TQM thus requires a system to measure customer loyalty.

If a management system cannot raise business performance and profitability, it will obviously be abandoned by firms. It is therefore apparent that indicators of customer loyalty and business performance should be added to TQM measurement systems. It is well known that GE-6σ pursues both customer satisfaction and high profits. If an integrated model of TQM and GE-6σ were developed, synergistic effects could be anticipated. In the integrated model proposed here, two major indicators are included—customer loyalty and high profit performance.

Dimension	TQM	GE-6σ	Comments
1. Development	Started in the mid 1980s, influenced by Japanese CWQC developed in the 1970s	First espoused by Motorola in 1987. GE adopted Six Sigma program in 1995, resulting in many benefits.	TQM and Six Sigma began at about the same time. TQM was widely and quickly adopted, but interest has now declined. The situation with GE-6σ is the reverse.
2. Principles	• Customer satisfaction (satisfaction of customers' needs) • Pursues zero-defect, • Responsibility for quality • Continuous improvements	• Pursues financial performance • Focuses on voice of customer • Pursues zero-defect • Emphasis moved from problem-solving to problem prevention • Rapid change	TQM over-emphasizes customer satisfaction, and this can sometimes negatively affect profits. GE-6σ focuses on both customer satisfaction and financial performance.
3. Feature	A systematic approach to quality management by integrating concepts, methods, processes, and systems.	Uses project management to perform thorough change and process re-engineering, which are integrated with the company's vision and strategy.	TQM is essentially a system of continuously improving the quality of every aspect of business life. GE-6σ focuses on radical change (which is also integrated with vision and strategy).
4. Operation	Continuous improvement through employee involvement and teamwork in total quality activities.	Specially designed roles and a highly disciplined training program using statistical methods to perform reengineering of key processes through project management.	TQM emphasizes that every person is involved in quality improvement at all levels. GE-6σ uses specially designed roles and disciplined training to progress the radical changes.
5. Focus	TQM focuses on all quality activities, all processes, and all systems.	Key processes and systems are all driven by the voice of customers.	TQM considers every aspect of quality. GE-6σ initially emphasizes the key processes related to customer needs, but gradually extends its improvement scope.

6. Practices	● QCC, QIT ● Suggestion system ● Project management ● Daily control ● Hoshin management ● SPC, TPM	● Project management ● BPR ● DMAIC or DMADV ● Benchmarking ● Design of structural roles	TQM methods are more traditional, and are learnt from Japan. GE-6σ uses methods that can produce more aggressive results.
7. Techniques	● Seven QC tools ● Control Chart ● DOE ● Taguchi methods ● Cp, Cpk, ppm ● New seven QC tools ● Kano's model	● Analysis of variance ● Multiple linear regression ● DOE ● Taguchi methods ● Cp, Cpk, ppm ● FMEA, QFD ● Reliability ● Kano's model	The statistical tools used in TQM and GE-6σ are very similar. However, the statistical tools used in TQM are quite basic, whereas GE-6σ uses more advanced SQC tools.
8. Leadership	● Managers demonstrate best behavior, and influence subordinates by example ● Autonomic management ● Decentralization and delegation ● Motivation ● Empowerment	● Top management stresses leadership ● Senior managers are responsible ● Senior managers are mentors ● Top management emphasize the execution of 6σ-program	Both TQM and GE-6σ emphasize leadership, especially the commitment and support of top management. However, TQM has a bottom-up management style whereas GE-6σ gives emphasis to top-own leadership.
9. Rewards	● Manager's praise and encouragement ● Promotion ● Bonus rewards	● 40% of bonuses are tied to the results of 6σ projects ● Promotion dependent on project results ● High status accorded to MBBs and BBs	GE-6σ programs have more motivations and rewards than TQM.

10. Training	• Education and training for every person • Focus on instilling quality consciousness • Leaders' instruction on daily basis • Improvement tools	• Vast investment in training • MBBs are the teachers and mentors • BBs have training, combined with the DMAIC process • GBs have training with the application of improvement tools	Both TQM and GE-6σ emphasize employee education and training, but GE-6σ has more investment in training than TQM. In GE-6σ, training and its application are combined
11. Change	• Gradual and slow • Improvement results are small, and do not bring big changes	• Vast change • Re-engineering • Change is fast, and its scope is large.	GE-6σ emphasizes fast change and significant re-engineering. Change coming from TQM is progressive.
12. Culture	• Setting up of a quality culture with customer focus • Employees are autonomous • Employees have a team-awareness	• Cultivation of a culture incorporating the concept of pursuing business performance • The culture change is caused by the re-engineering • Innovation-awareness	TQM brings about a culture change with a quality focus and customer orientation. The culture change in GE-6σ is fast, with an emphasis on pursuing customer satisfaction and business performance.

Table 3.1. Comparison between TQM and GE-6σ

3.4.1 Integration of management principles

Although the management principles of TQM and GE-6σ are somewhat different, there is congruence among their quality principles, techniques, and culture (as was demonstrated in Table 3.1). As a result, the integration of TQM and GE-6σ is not as difficult as it might seem. The critical task is to combine the best aspects of TQM continuous improvement with those of GE-6σ re-engineering. Although the activities of a quality Control circle (QCC) and quality improvement team (QIT) cannot achieve significant effects in themselves, they can cultivate quality concepts and team awareness among employees. Therefore, QCC and QIT can be performed by the operators and junior staff members to progress continuous improvements while focusing on daily operations and processes. GE-6σ projects can be applied by engineers and senior staff members to the key processes and systems that are related to customer requirements and the provision of performance in products and services. For GE-6σ projects, some aggressive goals can be set, in conjunction with rapid project completion times. The target performances can be set according to the criteria of the critical-to-quality (CTQ) of key process—which are, in turn, determined according to the voice of customers (VOC). In TQM, the improvements are based on a customer satisfaction

survey and an understanding of customers' requirements (Yang, 2003b). In this fashion, these two ways of understanding customers' needs and expectations can be combined. See Figure 3.1 for a depiction of the model.

3.4.2 Integration of implementation practices

Having discussed integration of management principles, the discussion now turns to the integration of implementation practices between the two systems.

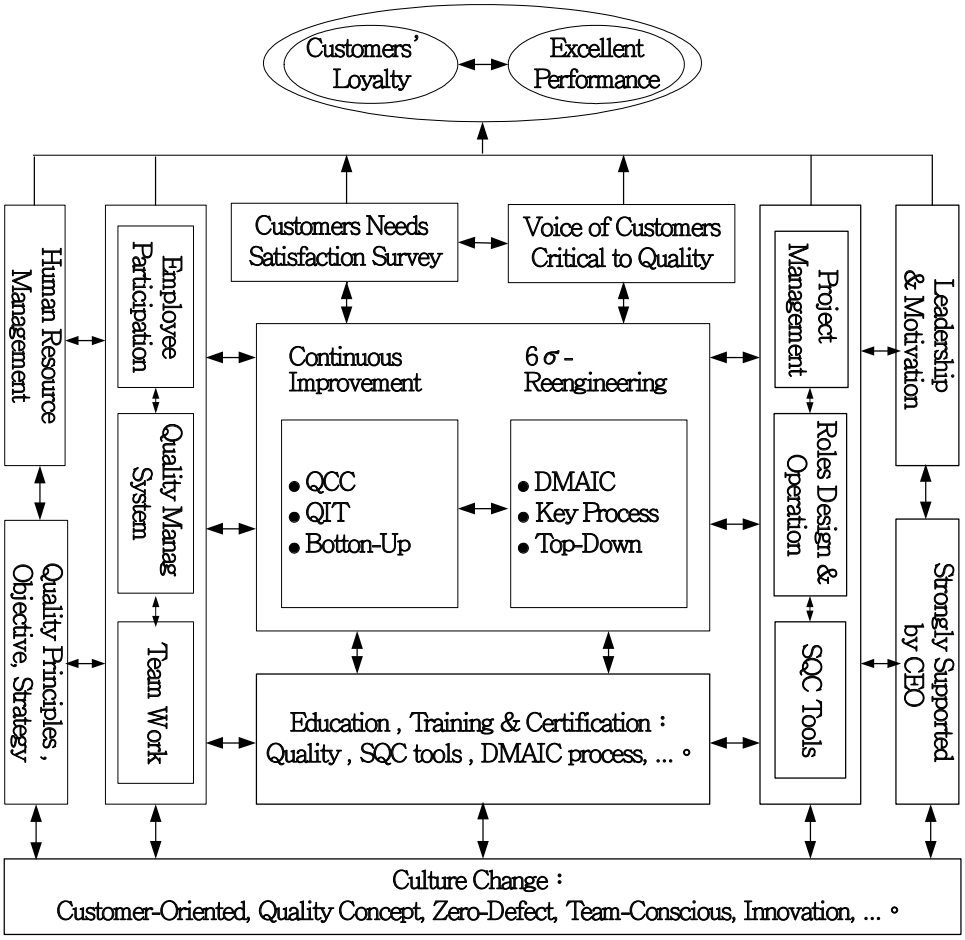

Fig. 3.1 Integrated framework of TQM and GE-6σ

Employee participation, teamwork, quality management system, human-resources management (HRM), quality principles, objectives, and strategies are the key enablers of TQM implementation. They are also the critical factors in upgrading business performance,

and are therefore also required for the implementation of GE-6σ. The practices of GE-6σ are project management, role design and operation, statistical quality control (SQC) tools, leadership and motivation, full support from the CEO, and so on. Most of these practices are also integral to TQM implementation. The framework of the integration of these practices and related systems of TQM and GE-6σ is shown in Figure 3.1 (Yang, 2004).

Both TQM and GE-6σ emphasize employee education and training, and there is only slight difference in the details of such training. Statistical tools and improvement methods are the main ingredients of the training contents for both TQM and GE-6σ. Apart from these statistical tools, TQM and GE-6σ have other shared training imperatives—including basic concepts, leadership and communication skills, and project management. Apart from these shared elements, in planning training for an integrated model of the two programs, it is necessary to cover the elements that are not shared in common. This is incorporated into the model. Moreover, a certification system for fulfilling the needs of the GE-6σ scale can be developed.

3.4.3 Integration of cultural changes

Both the implementations of TQM and GE-6σ will bring the culture changes of the organization (Boaden, 1997; Pande et al., 2000; Klefsjö et al., 2001). However, GE-6σ also emphasizes an awareness of speed and innovation, and is heavily performance oriented. These cultural features are the critical factors in pursuing excellent performance, and in raising competitiveness. In contrast, these have been somewhat neglected previously by TQM. In the integrated model presented here, these cultural features will enhance the performance effects of TQM implementation.

Summarily, in this integrated model, continuous improvement and 6σ-reengineering are the key activities, located in the center of Figure 3.1, and the customers' needs and the voice of the customers are the derivers of the improvement and reengineering. The initiatives of TQM and those of GE-6σ, located in the two sides separately, can be integrated as the enablers of the integrated system. Comprehensive education and training with certification to the employees are the powerful force in the realization of these practices. Finally, the culture changes with the features described in the base of Figure 3.1 are the fundaments of the successful implementation of this system. The overall objective of this integrated model is to reach both the customers' loyalty and excellent performance.

3.4.4 Practical examples and conclusion

TQM and GE-6σ can certainly be integrated very well, as the following two examples illustrate. INVENTEC is a hi-tech company in Taiwan that has implemented TQM for many years. Indeed, the company won the National Quality Award in Taiwan in 1995. In addition to its long-standing practice of TQM, INVENTEC also introduced the GE-6σ program in 2000. It then integrated this with its existing TQM system. The Ford Motor Company in Taiwan is another successful example of the integration of GE-6σ with TQM.

These two examples confirm that an integrated model of TQM and GE-6σ is feasible and practical. The successful application cased show that this integrated model will be a powerful and practical approach with great potential for all industries. This integrated model is also could be a suitable quality management system for the non-profit