XIV INTERNATIONAL CONFERENCE ON INDUSTRIAL
ENGINEERING AND OPERATIONS MANAGEMENT
The integration of productive chain wit an approach to sustainable manufacturing.
Rio de Janeiro, Brazil, 13 to 16 October - 2008

COMPARING THE USE OF METHODS, TECHNIQUES, AND TOOLS PROMOTED BY QUALITY MANAGEMENT SYSTEMS AND PROGRAMS

Augusto Virgilio Mascarenhas da Fonseca (PPG/POLI/US)
fonsecaavm@gmail.com
Dario Ikuo Miyake (PRO/POLI/US)
dariomiy@usp.br

This work defines methods, techniques, and tools and gives examples of their use of in quality management. Different quality systems and programs such as ISO 9000, Total Quality Management (TQM), Six Sigma, and the National Quality Award off Brazil (NQAB) are presented. Integrated quality management system is approached and an alternative for the selection and use of quality management methods, techniques and tools is proposed.

Palavras-chaves: Quality tools, Quality management, Quality system

1. Introduction

The field of quality management has evolved and expanded its horizons in terms of applications and gained more and more relevance with the improved systematization of its body of knowledge.

Thus, quality management has been applied to several sectors of the economy, geared both to the production of goods such as chemicals, steel and services such as education and health care.

Regarding its body of knowledge, there is a growing concern about the conceptual and taxonomic aspects, as the approaches to quality are more studied, which is illustrated by the Total Quality Management (TQM), and ISO 9000 series, and Six Sigma for instance.

Quality cannot be duly understood and attained without the use of certain management techniques and tools (KWOK & TUMMALA, 1998; BASU, 2004; TARI & SABATER, 2004; BAMFORD & GREATBANKS, 2005; HAGEMEYER et al., 2006).

The goal of this work is to present several aspects of quality management methods, techniques, and tools. The importance of the systems and programs studied will be discussed and some knowledge limitations will be outlined. It is presented the use of core values in the selection of quality techniques and tools. This study was carried out by literature review and analysis, particularly from international and Brazilian journals.

In this work, quality-oriented techniques and tools will be referred to as quality techniques and tools (QT&T) for the sake of simplicity. It will be indicated if it is used with a particular connotation. For example, in TQM we have TQM QT&T.

2. Definition of quality methods, techniques, and tools

Quality was first approached as a form of management function in the first half of the 20th century. Quality management gained a scientific status with the work of Walter A. Shewhart on process control and the creation of control graphs (GARVIN, 1992). From then on, it evolved and several other techniques and tools have been developed in the area or incorporated to it, such as the design of experiments (DOE), which derives from agricultural studies.

Some authors and professionals in the field of quality management do not distinguish the terms “technique” and “tool” with regards to quality. However, such distinction can be drawn for greater clarity.

According to McQuater et al. (1995), it is appropriate to say that a tool can be seen as a scheme that has a strict role (clear, objective) in the solution of a given problem. It is commonly used by itself. Histogram, scatter diagram, affinity diagram, matrix diagram, and control chart are examples of quality tools.

In contrast to tools, a technique has a broader application (McQuater et al., op. cit.). Simply put, a technique consists in a set of tools associated with a solution of a given problem. For example, the application of statistical process control (SPC) can require the use of tools like control chart (Xbar, R, CUSUM, and so forth), histogram, box plot, stratification and

acceptance sampling table, among several other possibilities. Thus, a technique has a broader application than an associated tool does. Design of experiments (DOE), benchmarking, and quality function deployment (QFD) are examples of techniques.

It is also worth pointing out the propriety of the distinction between techniques and tools. A manager in the field of quality can identify the need of using a certain technique without needing to know all the tools associated with the technique, particularly its possible and more complex variations. The manager may also resort to the literature and consultants for guidance on how to select tools. For an example, see Tague (2005).

Besides the terms “technique” and “tool”, there are other associated terms, such as method and methodology. Straightforward, it is possible to say that the method indicates what to do, that is, the steps to follow to attain the goals. Examples of quality methods are the PDCA (plan, do, check and act) cycle, approved by ISO 9000:2000, and the TQM, and the DMAIC (define, measure, analyze, improve and control) cycle, the method of organization of project improvement used in the Six Sigma approach. From a pragmatic viewpoint, methodology is the study of methods and the process of generation of such methods (FONSECA & MIYAKE, 2006).

3. Use of QT&T in different systems and quality programs

Quality methods, techniques, and tools are essential for understanding and practicing quality management. Thus, they must be used in different quality systems and programs, such as in ISO 9000, TQM, Six Sigma, and the national quality awards.

It is useful to distinguish the different quality systems and programs that will be approached next: a) some standardized systems, b) Total Quality Management (TQM), c) Six Sigma, and d) the Brazilian National Quality Award. Some examples of use of QT&T in these quality systems and programs are also given.

3.1. Use of QT&T in standardized systems

There are several quality standards. Standards ISO 9000:2000 and ISO/TS 16949:2002 will be highlighted.

According to ISO 9000:2000, a quality management system is a management system to direct and control the quality in an organization (ISO, 2000).

ISO 9001:2000 is known worldwide and may serve as a model to elaborate quality management systems. More specifically, the ISO 9000:2000 standard family was developed to support organizations in the implementation and operation of effective quality systems. According to Souris (2005), ISO 9000:2000 has several strong points relative to leadership, measurement process, focus on the customers, continuous improvement approach, among others. However, it has some gaps. For instance, this standard does not specify ways of improving process, that is, it presents "what must be done", but not "how to do it."

ISO/TS 16949:2002 is an internationally widely accepted standard proposed by ISO and by the automotive industry. It covers requirements of ISO 9001:2000 and is much more prescriptive. An advantage is that it allows a more objective implementation; the recommendation of the use of QT&T contributes to the system design (FERREIRA, 2005). Thus, this standard defines “what to do” and “how to do”. A means of using QT&T in ISO/TS

16949:2002 can be found in the work of Oliveira (2003), who discusses its use in her study of the optimization of the quality management system in two steel mills.

3.2. Use of QT&T in TQM

A quality system can be defined in different ways at different times and in different quality approaches. This is the case of TQM, which has several versions and denominations, such as Total Quality Control (TQC), Company-Wide Quality Control (CWQC), and Strategic Quality Management (SQM).

According to Hellsten & Klefsjö (2000), the difference between the terms related to TQM is often unclear and creates confusion. The concept of TQM can be understood by taking it as a management system that employs core values, such as customer-based approach, focus on process, management commitment, fact-based decisions, continuous improvement, and others.

According to Shiba et al. (1997), the methods and QT&T evolved along with the concept of quality. Other QT&T have been incorporated to TQM from the statistical process control and inspection, including the seven basic tools and the seven management tools. After that, other QT&T, such as benchmarking, fault tree analysis (FTA), value analysis, regression analysis, and others have also been incorporated.

3.3. Use of QT&T in the Six Sigma

A quality program consists in an implementation approach for use in the quality management system. Six Sigma is an example of a quality program model. According to Werkema (2002, p.15), "it is possible to define Six Sigma as a **highly quantitative** disciplined management strategy that aims at **increasing the profitabilily of companies sharply** by improving product and process quality and increasing customer and consumer satisfaction."

The QT&T used in Six Sigma had already been proposed in modern TQM. However, in Six Sigma, they are applied with a more strategic focus involving financial aspects and used in a highly structured and systematic form (KLEFSJÖ et al., 2006).

Snee (2004) presents the QT&T most common in the Six Sigma program, namely: process map, cause and effect matrix, measurement system analysis (MSA), capability study, failure mode and effects analysis (FMEA), multivariate study, design of experiments (DOE), and control plan.

Andrietta et al. (2005) conducted a field exploratory survey with a non-randomized sample of 78 companies in Brazil that apply the Six Sigma program. Part of the results informs on the use of 58 specific QT&T in each step of the DMAIC method of Six Sigma. They concluded that ten of the following QT&T were used the most in decreasing order: sampling, histogram, Pareto diagram, brainstorming, control chart, capability index, flowcharting, process map, measurement system analysis (MSA), and statistical process control (SPC).

3.4. Use of QT&T in the National Quality Award of Brazil

In general, the different national quality awards share several points. Some examples are the criteria related to leadership, strategic planning, customers, processes, and results. However, other aspects may differ from award to award. Such is the case of the Deming Prize, which

focuses on the application of specific QT&T. Additionally; the Canada Awards for Excellence, the Malcolm Baldrige National Quality Award (USA), and the Deming Prize do not deal with social aspects (MARTINS et al., 2007)

The National Quality Award of Brazil (NQAB) core values are leadership and constancy of purposes, vision of the future, focus on the customers and the market, social responsibility, people valorization, process and information orientation, development of partnerships, generation of value, systemic thought, organizational learning and innovation culture (FNQ, 2007). The NQAB mode of excellence was conceived based on the core values mentioned and it emphasizes the PDCL cycle concept (plan, do, check, learn). The NAQB does not prescribe practices, work methods, or tools.

3.5. Comparison of the use of QT&T from the perspective of different quality management systems and programs

Klefsjö et al. (2006) state that studies comparing TQM and Six Sigma directly have drawn varied conclusions. They consider Six Sigma an approach in the broad field of TQM. Yang (2004) had already said that Six Sigma can not replace TQM and that both practitioners and academics see their integration as an important trend.

Comparatively to ISO 9000:2000, Souris (2005) considers Six Sigma complementary, and goes on to say that among other aspects, the quality culture resulting from the use of the standard affords a basis for the understanding and the use of Six Sigma.

Some examples of the use of QT&T in different quality systems and programs are given next.

Pinto et al. (2006) carried out a quantitative survey of 1,000 of the largest Brazilian companies most experienced in the adoption of quality management systems and programs, such as ISO 9000, TQM, and Six Sigma. The sample comprised 198 companies that responded the questionnaire appropriately. Among other aspects, the use of methods and QT&T in each quality system and program was analyzed. In all, cause-and-effect diagram, Pareto diagram, histogram, statistical process control (SPC), and the scatter diagram were the methods and QT&T most used, along with PDCA in the case of ISO 9000:2000 and TQM. In the case of Six Sigma, DMAIC, hypothesis test, analysis of variance (ANOVA), and FMEA were also largely used. 5S was largely used only in TQM.

Ricondo & Viles (2005) compared the approaches of Six Sigma, TQM, reengineering, lean, and the learning organization (LO). Concerning the QT&T used, they concluded that some of them are shared by all approaches, such as the seven basic tools (7QC), the seven management tools (7QM), statistical process control (SPC), benchmarking, team-working, brainstorming, to name a few. Other QT&T are specific or particularly important for other management systems such as in the case of system-thinking tools for LO, kanban for lean, information technology (IT) tools for reengineering, statistical tools for TQM and Six Sigma, among others.

4. The integrated quality management system

Many quality management and improvement programs employ QT&T. However, managers may have difficulty in understanding, implementing, and maintaining them. To solve this problem, it is necessary to align and integrate the quality management systems. A possible

alternative would be adopting a national quality award model.

4.1. The integrated quality management system based on a national quality award

It is possible to propose a quality award that comprises all the criteria of the current awards. Nevertheless, it is worth pointing out that the awards have particular characteristics, such as those of the NQAB, which is updated yearly based on the management practices of world-class organizations (FNQ, 2007). Therefore, a company that has not attained an excellence level may fail to qualify for the award due to the extension and complexity of the award.

An alternative approach is creating an integrated quality management system. Instead of adopting an external reference model as those in literature, the company must develop its own quality management system.

An integrated management system (IMS) can be used to integrate different management systems. This can be achieved with the use of standards, such as ISO 9001 (quality management systems), ISO 14001 (environmental management systems), and BS 8800 (Occupational Health and Safety Management Systems). Nevertheless, it is not enough to use each standard separately. It is necessary to integrate training and auditing procedures, policies, goals, planning and purchase, among others. The study of the common and complementary elements of these three standards allows the formulation of a model, such as done by Idrogo (2005).

In the case on an integrated quality management system (IQMS), only the systems and the quality programs are integrated. However, it is controversial which quality systems and programs would be taken into consideration. Some managers such as Kubiak (2003) commented that the several approaches can work in a mutually supporting and integrated manner. ISO 9000 provides the structure for a basic quality management system. In contrast, the Malcolm Baldrige National Quality Award provides integration and represents excellence in management. The balanced scorecard gauges progress. In turn, Six Sigma and lean manufacturing drive improvement.

4.2. The integrated quality management system based on the use of core values

As previously proposed, the concept of a quality improvement system or program may be understood through the use of core values. We propose using core values to integrate the different quality management systems and programs.

An example of the use of core values in different quality management systems and programs is given in Table 1. It presents four approaches. In the **first approach**, the core values refer to the eight quality management principles indicated in ISO 9000:2000. The **second one** includes some TQM core values obtained in the study by Karuppusam & Gandhinathan (2006). These core values were established through the analysis of 37 empirical studies found in papers in 13 journals from 1989 to 2003. The recommended core values were submitted to Pareto analysis for the effective implementation of TQM. It was obtained 56 values. Table 1 shows the first 11 core values, which jointly correspond to about 70% of the frequency of occurrence. The **third approach** was based on the study by Santos (2006), who presented a review on Six Sigma and highlighted the main points of the works, called here core values. The **fourth approach** refers to the fundaments of the NQAB, which may also be understood as core values in the present work.

The evaluation of the four approaches presented in Table 1 shows that several of their core values are similar. For example, the aspect "customer" is considered in all approaches, despite variations. However, some aspects apparently disagree. For example, "system" and "improvement" are not comprised in the second approach. It deserves further discussion. Although the TQM theoreticians see these two aspects as fundamental, their percent occurrence was very low. Other aspect seems to exist only in one of the approaches, such as "quality department".

Another important observation is that each core value in the study by Karuppusam & Gandhinathan (op. cit.) has underlying sets of categories. For example, quality data comprises quality information, quality information system, and quality information usage measurement, and others.

Finally, it is necessary to point out that the core values presented in Table 1 were obtained only to illustrate possible relationships between the four quality approaches. Thus, it is not appropriate to say that the table presents all the core values of TQM and Six Sigma, particularly because different authors and practitioners have different views of these management approaches.

5. Models for the selection and use of QT&T

QT&T can be selected in several ways to solve practical problems. Here are some of them.

Tague (2005) presents a matrix for the selection of QT&T with 148 QT&T and their variations. They are categorized in three different ways to help the reader to choose the appropriate tool. To select a tool, it is necessary to answer three questions: a) what do we want to do with this tool? b) where are we in our quality improvement process?, and c) do we need to extend or to focus our thinking?

Aspect	1. Approach based on ISO 9000:2000	2. Approach based on Karuppusam; Gandhinathan (2006) on TQM	3. Approach based on Santos (2006) on Six Sigma	4. Approach based on NQAB
Customer	Customer focus	Customer focus	Impact on the customer and to the market	Focus on the customer and in the market
Leadership	Leadership	The role of management leadership and quality policy	Commitment of the leaders	Leadership and constancy of purposes Vision of the future
People	Involvement of people	Employee relations Human resource management and development		People valorization
Education & training		Training	Qualification and learning	Organizational learning
Process	Process approach	Process management		Process- and information-oriented Value generation
System	System approach to management		Strategic and managerial approach	Systemic thought
Improvement	Continuous improvement		Statistical thought, Six Sigma methodology (DMAIC/DFSS); Six Sigma projects	Culture of innovation
Information	Factual Approach to management	Quality data	Measurement of performance	Process and information oriented
Supplier	Mutually beneficial supplier relationships	Supplier management		Development of partnerships
Quality department		Role of quality department		
Society				Social responsibility

Table 1 – Examples of use of core values in different quality systems and programs

According to Hagemeyer et al. (2006), concerning the Six Sigma training, in general, users focus much on the "how" to use QT&T and do not go deep into the way each technique and too must be selected and related to each other to solve problems efficiently and effectively. There are several options for the selection of QT&T. One of them is to use an x-y type matrix with the tools on the y-axis and the DMAIC phases on the x-axis. Each tool is indicated as to its suitability for each DMAIC phase. The bibliography of each tool is indicated for further information. This type of matrix shows that the tools can be used in multiple steps of the DMAIC process.

This work presents another way that may help in the selection and use of QT&T. As previously said, it is possible to show the structure of a management system based on core values, techniques and tools. However, it is necessary to assess the core values that may change over time, as well as their meanings. The techniques can also be perfected, and new

techniques may come up or be assimilated by other management theories. Therefore, instead of treating each system particularly, we give examples of how an organization can select the methods and QT&T based on the core values. For such, it is necessary to resort to an intermediate step, the detailing of the core values. The critical factors are included in this step. Table 2 shows the relationships between some core values, the critical factors, and the quality techniques and tools.

Core Values	Critical factors	Quality techniques and tools
Focus on the customer	Market investigation After-sales service Attending customer's complaints Reports from vendors	Survey Check sheet Questionnaire Conjoint analysis (CA) Multidimensional scaling (MDS)
Culture innovation	Support from top management Team work Proper training Commitment	Quality function deployment (QFD) Focus Group Delphi method FMEA Design of experiments (DOE)
Management based on information	Quality audit Quality costs Employee performance and satisfaction evaluation Problem solving approach Communication strategies	Suggestion plan Poster Use of indicators Graphics Seven QC tools

Table 2 – Relationships between some core values and some of their critical factors and some of the respective quality techniques and tools.

It is necessary to resort to the methods to select QT&T based on Table 2. In the case of ISO 9000 and TQM, the method indicated is the PDCA cycle. The PDCA cycle may be applied to the following forms of management: a) quality maintenance, which aims at allowing anticipating the results at the company, b) quality improvement, for the continuous improvement of the company results with the existing processes, and c) quality planning or innovation, need to promote radical changes of existing products and processes or to generate new products and processes. The PDCA cycle for the maintenance of quality is commonly referred to as SDCA, where the "S" for standard takes the place of the "P" for planning." For the quality improvement and planning management, there are the respective PDCA cycles for improvement and planning (AGUIAR, 2002).

In the case of Six Sigma, the structured method of organization of improvement projects is the DMAIC. There is a correspondence between the DMAIC method and the PDCA cycle. DMAIC places great emphasis on planning. The "P" for planning of PDCA encompasses the DMA phases (define, measure, analyze), and part of phase I (improve) of DMAIC. The Design for Six Sigma (DFSS) appeared as an extension of the quality planning of Six Sigma for the design of new products or services. The DMADV (define, measure, analyze, design and verify) method is used to implement DFSS (WERKEMA, 2002).

As said, there are several options to select QT&T. Another means of selecting and using

QT&T is presented next.

Based on Table 2, it is possible to make another table that shows all the core values and the critical factors of a specific quality system or program and the associated QT&T. The core values and the critical factors selected are the ones that cause major strategic impact in the company. Next, with the help of a method, it is possible to set the priorities for QT&T. For example, let's suppose that the core value "focus on customers" was chosen as a priority. "Attending the customers' complaints" can be a critical factor selected to represent this core value. A strategic objective can be "reducing the number of complaints." The corresponding goal can be "Reducing the number of complaints by 40% until the end of a given month of the year." In the case of the PDCA cycle of improvement, step P (plan) starts at the "problem identification) phase. In this phase, one must start by defining the problem related to the goal already defined appropriately (AGUIAR, op. cit.). In this case, the QT&T to be used can be check sheet, mind map, sampling, sequential graph, sampling, and others. That is to say, departing from the core values and with the help of the critical factors and methods, one can determine the QT&T.

6. Conclusions and suggestions for future research

The scientific character of the discipline of quality was established by the work of Walter A. Shewhart on variability problems that resulted in quality problems. According to Bisgaard & Mast (2006), quality management will not disappear in the future. Taking Shewhart as a reference, they anticipated that a scientific approach to the solution of problems will continue to provide the basis for the work of quality professionals. However, quality management will always need improvement and adapting to new circumstances. The quality systems and programs employ and will continue to employ several excellent QT&T in the solution of problems, as well as several innovations useful for management.

One can say that QT&T must not be regarded as a solution for all quality problems, but rather as a set of potential means to solve such problems after careful selection according to the circumstances.

We discussed the relationships of QT&T with different quality management systems and programs. Taking the concept of core values into account was important to show the similarities and the differences between the options of approaching quality. At last, we suggest a relationship between core values, methods, techniques, and quality tools.

For future research, we propose determining the core values of a given organization and stipulating the critical factors, defining the method(s) to be used in the organization, and directing the development of improvement projects, and selecting the quality tools for the solution of certain problems.

References

AGUIAR, S. *Integração das ferramentas da qualidade ao PDCA e ao programa Seis Sigma*. Belo Horizonte: Editora de Desenvolvimento Gerencial, 2002.

ANDRIETTA, J. M.; MIGUEL, P. A. C. & MAESTRELLI, N. C. Técnicas e ferramentas utilizadas em empresas que aplicam o programa seis sigma no Brasil: resultados de uma survey. In: ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, XXV, 2005, Porto Alegre. Anais ... Porto Alegre: ABEPRO, 2005. pp. 1420-1427. CD-ROM.

BAMFORD, D. R. & GREATBANKS, R. W. The use of quality management tools and techniques: a study of application in everyday situations. *International Journal of Quality & Reliability Management*. v. 22, n. 4, pp. 376-392, 2005.

BASU, R. Six-Sigma to operational excellence: role of tools and techniques. *Int. J. Six Sigma and Competitive Advantage*. v. 1, n. 1, pp. 44-64, 2004.

BISGAARD, S. & MAST, J. De. After Six Sigma what´s next? *Quality Progress*, pp. 30-36, Jan. 2006.

FERREIRA, J. J. A. Modelos normalizados de sistemas de gestão. *In*: CARVALHO, M. M.; PALADINI, E. P. (orgs.). *Gestão da Qualidade*: teoria e casos. Rio de Janeiro: Elsevier, 2005.

FNQ – FUNDAÇÃO NACIONAL DA QUALIDADE. Critérios de excelência. São Paulo: Fundação Nacional da Qualidade, 2007.

FONSECA, A. V. M. & MIYAKE, D. I. Uma análise sobre o Ciclo PDCA como um método para solução de problemas da qualidade. In: ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, XXVI, 2006, Fortaleza. *Anais*... Fortaleza: ABEPRO, 2006. CD-ROM

GARVIN, D. A. *Gerenciando a qualidade*: a visão estratégica e competitiva. Rio de janeiro: Qualitymark Ed., 1992.

HAGEMEYER, C.; GERSHENSON, J. K. & JOHNSON, D. M. Classification and application of problem solving quality tools: a manufacturing case study. *The TQM Magazine*, vol. 18, no. 5, pp. 455-483. 2006.

HELLSTEN, U. & KLEFSJÖ, B. TQM as a management system consisting of values, techniques and tools. *The TQM Magazine*. v. 12, n. 4, pp. 238-244, 2000.

IDROGO, A. A. A. As interfaces entre os sistemas de gestão. *Banas Qualidade*. pp. 85-92, set. 2005.

ISO – INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. *NBR ISO 9000:* sistemas de gestão da qualidade – fundamentos e vocabulário. ABNT 2000.

KARUPPUSAMI, G. & GANDHINATHAN, G. Pareto analysis of critical success factors of total quality management: a literature review and analysis. *The TQM Magazine*. v. 18, n. 4, pp. 372-385, 2006.

KLEFSJÖ, B.; BERGQUIST, B. & EDGEMAN, R. L. Six Sigma and Total Quality Management: different day, same soup? *Int. J. Six Sigma and Competitive Advantage*. v. 2, n. 2, pp. 162-178, 2006.

KUBIAK, K. An integrated approach system. *Quality Progress*. v. 36, n. 7, pp. 41-45, July 2003.

KWOK, Ka Yin & TUMMALA, V. M. R. A quality control and improvement system based on the total control methodology (TCM). *International Journal of Quality & Reliability Management.* v. 15, n. 1, pp. 13-48, 1998.

MARTINS, K. R. P.; WALTER, S. A. & MARTINS, M. E. A. Aplicação dos critérios de excelência dos principais prêmios da qualidade do mundo como instrumento de avaliação da gestão. In: ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO, XXVII, 2007, Foz do Iguaçu. *Anais* ... Foz do Iguaçu: ABEPRO, 2007. CD-ROM.

McQUATER, R. E.; SCURR, C. H.; DALE, B. G. & HILLMAN, P. G. Using quality tools and techniques successfully. *The TQM Magazine*, v. 7, n. 6. pp.37-42, 1995.

OLIVEIRA, V. P. *Análise de utilização de ferramentas para otimização do sistema de gestão da qualidade em empresas siderúrgicas.* São Paulo, 2003. 134 p. Dissertação (Mestrado). Escola Politécnica da Universidade de São Paulo. Departamento de Engenharia de Produção.

PINTO, S. H.; CARVALHO, M. M. & HO, L. L. Implementação de programas de qualidade: um survey em empresas de grande porte no Brasil. *Gestão & Produção,* v. 13, n. 2, pp. 191-203, mai .ago. 2006.

RICONDO, I. & VILES, E. Six Sigma and its link to TQM, BPR, lean and the learning organization. *Int. J. Six Sigma and Competitive Advantage*. v. 1, n. 3, pp. 323-354, 2005.

SANTOS, A. B. *Modelo de referência para estruturar o programa de qualidade Seis Sigma*: proposta e

avaliação. São Carlos, 2006. 312 p. Tese (Doutorado). Universidade Federal de São Carlos.

SHIBA, S.; GRAHAM, A. & WALDEN, D. *TQM*: quatro revoluções na gestão da qualidade. Porto Alegre: Artes Médicas (Bookman), 1997.

SNEE, R. D. Six-Sigma: the evolution of 100 years of business improvement methodology. *Int. J. Six Sigma and Competitive Advantage*. v. 1, n. 1, pp. 04-20, 2004.

SOURIS, Jean-Paul. O Seis Sigma e a ISO 9001: rivais ou parceiros? *Banas Qualidade*, pp. 84-88, julho 2005.

TAGUE, N. R. The quality toolbox. 2nd. ed. Milwaukee: ASQ Quality Press, 2005.

TARÍ, J. J. & SABATER, V. Quality tools and techniques: Are they necessary for quality management? *Int. J. Production Economics*. v. 92, pp. 267-280, 2004.

WERKEMA, M.C.C. *Criando a Cultura Seis Sigma*. Rio de Janeiro: Qualitymark Ed., 2002. (Série Seis Sigma; V. 1).

YANG, Ching-Chow. An integrated model of TQM and GE-Six-Sigma. *Int. J. Six Sigma and Competitive Advantage*. v. 1, n. 1, pp. 97-111, 2004.