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Japanese total quality control, TQM, Deming's system of profound knowledge, BPR, Lean and Six Sigma

Comparison and discussion

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Abstract

Purpose – The purpose of this paper is to compare and discuss the evolution of six important management systems: Japanese Total Quality Control (JTQC), Total Quality Management (TQM), Deming's system of profound knowledge, Business Process Reengineering (BPR), Lean Thinking and Six Sigma. Indeed, the contribution of this paper lies in the concurrent analysis and classification, by the means of a literature review, of the results and critical implementation factors of the six systems. Deming's Plan-Do-Check-Act (PDCA) has been used to classify the findings from the literature review.

Design/methodology/approach – The research methodology is based on a literature review. The literature review has been carried out for each single system, trying subsequently to compare and discuss the results.

Findings – Inside the six systems, nine common factors have been found and proposed. They are: results and benefits; management style; deployment of the system; employee management, deployment and participation; voice of the customer; tools, techniques and IT; optimisation of the system; day-by-day check and control of the results and review of the system.

Research limitations/implications – This paper presents some limits due to the fact that it is based on a literature review. This implies that more research about the findings should be carried out: TQM in Western companies, Six Sigma that could have substituted TQM, Six Sigma and TQM in Japan, Deming's system developments and the influence of the Japanese style on Lean Six Sigma.

Originality/value – For the first time a paper tries to compare and discuss the six most important systems dedicated to quality and operations improvement.

Keywords Total quality management, Business process re-engineering, Japanese total quality control, Deming's system, Lean thinking, Six Sigma

Paper type Literature review

Introduction

Japanese total quality control (JTQC), total quality management (TQM), Deming's system of profound knowledge, business process reengineering (BPR), lean thinking and Six Sigma are quality and operations improvement systems all oriented towards process improvement. They have implementation factors and results in common such as: continuous improvement, customer satisfaction, people and management involvement to mention a few. Nonetheless, the systems also present different and important characteristics due to their different origins and the historic path of implementation inside companies.

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The literature itself has considered the systems at different times and in different ways. Six Sigma comes from the USA, it is the most recent system, and along with the Japanese Toyota production system (TPS) revisited by Womack and Jones (1998) with the new name lean thinking, it is still extensively researched and discussed by practitioners and academics (Wedgwood, 2006). The literature on TQM and JTQC reached a peak in the middle of the 1990s, although less so with TQM but it is still being researched (Osayawe Ehigie and McAndrew, 2005). BPR became very popular in the USA in the early 1990s, since then interest in it has decreased and nowadays only the term reengineering has been inherited (Stoica *et al.*, 2004). Deming's system has been analysed and discussed less than the other systems.

In the light of this there is a need to better compare and discuss the evolution of the systems, the ways of implementing them, their distinctions and what they share in common. Indeed, the main purpose and contribution of this paper lies in the concurrent analysis and classification, by the means of a literature review, of the results and critical implementation factors of the six systems. Deming's Plan-Do-Check-Act (PDCA) model (Deming, 1950) has been used to classify the results from the literature review.

The findings will open an interesting debate for future research about the future of the systems and the lessons learnt from their evolutions.

The findings could also be a useful comparison programme for practitioners that want to apply the systems or integrate them.

Literature review

A few authors have investigated two, three or four of the mentioned systems but no authors have compared all the six systems at the same time.

Very few articles analysed Deming's system trying to compare it with other systems; the only interesting articles have been written by Gitlow (1994, 1995). Gitlow compared JTQC and Deming's system in detail, finding several points of agreement and disagreement between the two systems. Unfortunately the author limited his research to the two systems.

Martinez-Lorente *et al.* (1998) compared American and Japanese TQC with TQM. The paper is an interesting analysis of differences between American and Japanese ways of implementing the systems. For the authors the differences are linked to culture, politics and company philosophy. The professionalism and specialisation, high turnover rates, easy layoffs and short-term profits of the Taylor's system are the external factors that have created a different approach in the USA.

Ricondo and Viles (2005) wrote the most extensive paper in terms of comparisons. Lean, Six Sigma, TQM, reengineering (BPR) and learning organisation are compared at the same time. In an interesting way they found that many quality tools and techniques are shared by all the approaches, such as the seven basic tools, the seven management tools, statistical process control, benchmarking, teamwork and brainstorming, to mention the most important. The authors also found that each system has its own specific tools and techniques such as *kanban* for lean organisation, information technology (IT) tools for BPR and statistical tools for TQM and Six Sigma.

Dahlgaard and Dahlgaard-Park (2006) tried to compare the principles and results of lean production, Six Sigma quality and TQM. Some foregone conclusions emerged such as Lean and TQM had developed from Japanese practices. In a more original way

the authors claim that lean production and Six Sigma are new alternative TQM roadmaps, even if there is not any specific validation of this issue in the paper.

More recently Johannsen (2011) wrote a paper dedicated to state-of-the-art integration in quality management and pointed out that there is a lack of guidelines for integrating lean management, Six Sigma and TQM. The results are more a research agenda for the future than a point of view concerning what are the common characteristics and the differences.

To sum up, the authors have analysed some, but not all, of the systems, identifying differences in terms of origin, culture, tools and techniques and other factors. However, there is a lack of an accurate comparison among all the six systems in order to understand the common results and critical implementation factors, their differences and whether some of them can be an alternative to the others.

Research methodology

The research methodology is based on a literature review. In the literature there is neither an academic discussion nor case studies carried out by practitioners concerning the six systems at the same time. Therefore, the research is first based on a literature review of each single system trying subsequently to compare the findings. This specific comparison is structured following the PDCA cycle as a way of implementing the systems top-down and bottom-up. As several papers suggested, PDCA can be successfully used as a framework for implementing different management systems.

Deming's system naturally has the PDCA cycle in its DNA. Ishikawa (1985) slightly redefined the PDCA cycle in order to include goals, targets, methods for reaching them as well as training and education (Moen and Norman, 2006). Deming's PDCA can surely be considered the most common pattern inside TQM (Cheng, 2008). Linderman *et al.* (2003) for instance suggested that in case of process improvement Six Sigma is patterned after the PDCA cycle. Lucas (2002) found that Six Sigma uses a modified PDCA management cycle. Cheng (2008) and Graves *et al.* (2000) discussed that Six Sigma and TQM are based on a PDCA management cycle. Dennis and Shook (2007) analysed PDCA as a methodology and cornerstone for Lean. BPR is not directly linked to PDCA, however, its way of implementing can be associated with it. For instance, Muthu *et al.* (1999) introduced five steps to implement BPR, similar to PDCA, as discussed in the BPR section.

The Plan stage is usually dedicated to the strategies, the definition of the objectives (Kondo, 1998; Tani, 1995; Ramsey *et al.*, 2001) and the design of the organisation, including in part human resources management (Conti, 1997).

The Do stage is considered the implementation phase from the voice of the customer capture until the delivery of the product/service (Conti, 1997). Ishikawa (1985) used to include training and education in the Do stage. In the Check and Act stages the organisation checks to evaluate how it conforms to the Plan stage and Acts on what has been learned (Johnson, 2002).

In the discussion section, the findings of the literature review will be summarised and compared with each other within the PDCA cycle in order to obtain for the six systems the results and their critical implementation factors.

These latter, as shown in Figure 1, are considered to be the way of implementing the systems to achieve the same fundamental target: process improvement. Although the objective of this paper is not to go into philosophical discussions, process improvement can be ontologically considered the nature of being (Hirschheim *et al.*, 1995) of the six systems.

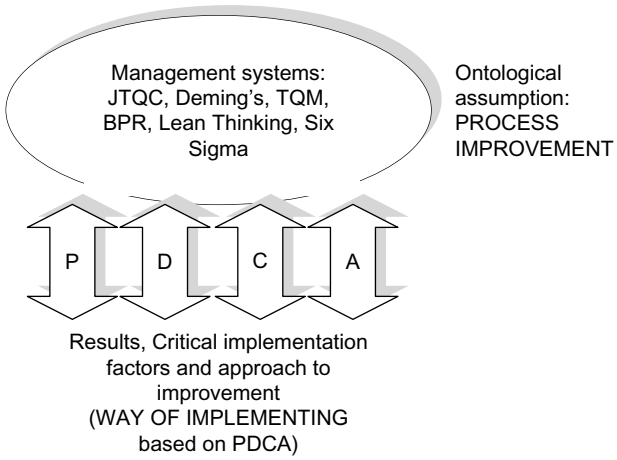

Figure 1.
Ontological assumption and way of implementing for the systems

Japanese total quality control

TQC is surely the oldest system and its roots sink into the earliest statistical research carried out by Shewart (1939). These principles were further developed in Japan after the end of the Second World War. Feigenbaum (1961, p. 6) developed TQC, defining it as:

> A network of the management/control and procedure that is required to produce and deliver a product with a specific quality standard.

It can be noted that Feigenbaum's definition of TQC was focused on the so-called quality assurance that implies respect of standards, procedures, work instructions to reach above all effectiveness for the customer (Ishikawa, 1985).

TQC in Japan evolved into company wide quality control mainly due to Ishikawa (1985), leading TQC towards the so-called Japanese TQC (JTQC).

According to Ishikawa (1985), TQC tries to optimise cost-effectiveness and usefulness, while satisfying customers at the same time. The same results can be found in Kano (1993, p. 13): he clearly stated that the purpose is to increase "customer satisfaction and quality assurance".

Ishikawa (1985), King (1989) and Mizuno (1988) analysed the Plan stage which in its strategic dimension is based on policy management and is known as *hoshin kanri*. Kano (1993) strongly believed that top management should create the right energy and motivation to promote and sustain quality.

Iizuka and Osada (1988) and Ishikawa (1985) discussed participatory management and the humanistic view of the worker in JTQC. Promotional activities or administrative systems (Gitlow, 1995) are the "vehicles" of JTQC for managing the organisation and all the employees. JTQC has principles such as daily management, cross-functional management, voluntary quality control circle and training. Daily management is based on the improvement of best-practice methods and the quality control circle operates day by day involving all the levels and employees. Kano (1988) pointed out how a quality circle should be underpinned by respect of humanity, building a bright and enjoyable workshop environment that improves without limits human potential. Furthermore, Ishikawa (1985) considered that TQC was not exclusively a task for quality specialists, even though people have to receive training and education for the best practices.

By contrast, Feigenbaum (1961), more representative of the American approach, discussed how quality control needed a particular specialisation of some figures and departments.

In the Do stage, Ishikawa (1985), Iizuka and Osada (1988) and Kano (1988) agreed that having a customer orientation, where the customer can also be considered the next process, is a fundamental pillar of JTQC. The quality circles, along with the management, are supposed to manage processes by fact, achieving targets that can include quality, cost, scheduling, quantity, sales and profit and safety. Ishikawa (1985), in particular, stressed the use of the seven basic tools such as check sheets, Pareto, histograms, stratification, control charts, cause-and-effect diagrams and interrelationship diagraphs. However, depending on the problem, management tools and advanced ones such as design of experiments, quality function deployment, Taguchi and many others can be applied. Some tools that typically are classified within lean thinking are also used inside quality circles. For instance, mistake proofing or poka-yoke systems along with 5S and cleanliness, arrangement, neatness, discipline and orderliness can be traced to JTQC (Shingo, 1986, 1989).

In the literature concerning JTQC there is no evidence of any particular way of reporting and controlling the results achieved by quality circles. Ishikawa (1985) pointed out how the results in general are measured by indicators, linked in particular to product conformity. Reactions to nonconformities are managed by corrective actions and problem solving. Audits can be led to control and check the quality assurance system (Gitlow, 1995). Lessons acquired from corrective actions can be carried out in other similar processes by the means of preventive actions. Mizuno (1988) explained how the results from the corrective and preventive actions can become inputs in the *hoshin kanri* system for the Act stage.

Total quality management

As previously discussed, Japanese companies have developed TQC mainly using the teachings of Ishikawa, Deming and Juran. Feigenbuam was the first to use the term TQC but he started introducing differences between American and Japanese TQC (Martinez-Lorente *et al.*, 1998); these differences have been extended by TQM.

Ishikawa shifted the attention from the term "control" to "management". According to Martinez-Lorente *et al.* (1998), in the literature the idea began that quality does not just have to be controlled but managed. Probably this was the actual beginning of the TQM movement and principles. According to several authors (Grant *et al.*, 1994; Milakovich, 1991; Ehigie and Akpan, 2004), Deming (1986) was one of the founders of TQM, launching it in the world through the book *Out of the Crisis*.

Nowadays there is a huge quantity of literature about TQM but, according to Knights and Willmott (2000), sometimes authors contradict each other and it is not clear what TQM contains. The literature shows confusion beginning from the management styles and their strategies. An interesting paper by Chatterjee and Yilmaz (1993, p. 16) points out how TQM gurus such as Deming, Juran and Crosby did not agree on quality strategies:

> [...] Deming is strongly opposed to management by objectives [...] Crosby recommended zero defects as a quality objective [...] Juran and Deming are against this because the inherent variability in all processes [...]

However, senior managers should be very involved and the most important critical characteristic for TQM implementation in the West seems to be management behaviour and participation, management by fact and long-term vision (Porter and Parker, 1993). A steering committee of senior managers normally leads the implementation programme. TQM focuses on quality performances, such as costs of poor quality (COPQ), although in the literature cases of integration between TQM and corporate social responsibility (CSR) (McAdam and Leonard, 2003; Zink, 2007; Meehan *et al.*, 2006) and TQM and environmental aspects (Kitazawa and Sarkis, 2000; Daily and Huang, 2001; Miles and Russel, 1997) are frequent. *Hoshin kanri* in TQM is still one of the most used strategic systems (Akao, 2004) in Japan, even though TQM is also associated with the American balanced scorecard and other deployment systems (Hoque, 2003).

In terms of human resources, TQM stresses the use of team building and team efforts (Ross, 1993; Spector and Beer, 1994; Bubshait and Farooq, 1999) and employee involvement is mandatory. During the 1980s, in TQM and JTQC, implementation at the bottom level was carried out through quality circles. Unfortunately, quality circles failed in many Western companies as described by Hayward *et al.* (1985) and Drago (1988) and companies had to think about different improvement teams. The reasons lie, first, in weak senior managers' leadership, and second in nonparticipation and once more in an unclear connection with company strategies.

In the Do stage, voice of the customer capture as well as basic and advanced statistical tools are fundamental to improvement projects and no author criticised them. Sila and Ebrahimpor (2002) investigated critical factors of TQM concluding that, in the literature written in English until 2000, TQM had been studied in dozen of ways grouped into 25 categories. The authors outlined how TQM has also been influenced by national awards such as the Malcolm Baldridge and the European Foundation for Quality Management Award. For instance, benchmarking and self-assessment are largely used and derived from this field.

Finally, it seems that Western TQM in the course of time is losing its identity. In reviewing papers (Saylor, 1992; Pike and Barns, 1993; Ross, 1993; Zairi *et al.*, 1994; Omachonu and Ross, 1994; George and Weimerskirch, 1998) it can be found that many improvement projects have been carried out under the TQM "umbrella" but without a similar pattern. Paton (1994) even defined TQM as a philosophy not a science and as such it cannot be developed through a precise roadmap or pattern. Hellsten and Klefsjö (2000) found that the "fathers" of TQM sometimes do not like the concept. Furthermore, the same authors found that the same TQM concept could have different names and that there are vague descriptions and few definitions of TQM. However, it seems that in Japan TQM still has its own identity, strictly linked to JTQC (Yamaji and Amasaka, 2008); other Eastern countries also recognise that there is a successful Japanese TQM style that can be followed (Nassir Shaari, 2010).

Deming's system of profound knowledge

Deming's system is based on Deming's last book *The New Economics: For Industry, Government, Education* edited in 1993 and following the masterpiece *Out of the Crisis* published in 1986. As previously stated, Deming is unanimously considered one of the fathers of TQM and his works are widely known and quoted. However, there are few articles and case studies about Deming's system of profound knowledge and its implementation.

The system is divided in four interdependent parts: appreciation of a system, theory of variation, theory of knowledge and psychology. A system is broken down into several components and the management has the responsibility of heading the components in the same way. Within the system there are two causes of variation, special and system causes. Employees and technicians have to find and resolve the causes. Knowledge should be based on a theory and managers, by the means of theory, have to predict the future events starting from the past. There is no truth, theory can be reviewed and changed. Psychology helps to understand employees, their interactions and the interactions with the system. Management must understand intrinsic and extrinsic motivation as well as over justification (Gitlow, 1994).

Deming (1993), in the Plan stage, criticised the practice of management by objectives: it does not lead towards results for the entire system and all the stakeholders. Management should not privilege one or few stakeholders. Employees, customers, suppliers, stockholders, the community and even the competitors should receive welfare from the company in the long-term. Deming (1993, p. 2) stated: "A product or service possesses quality if it helps somebody and enjoys a good and sustainable market".

In Deming's system there is no trace of particular processes in order to deploy objectives and goals. In any case, Deming claimed that methods are more important than goals and targets. Many negative cases of defined targets that are reached but reached in wrong ways are analysed in the second chapter "The heavy losses" of his book. The long-term process is named by Deming "analytic management" and it is in contrast to the short-term results-only orientation, named "enumerative management".

Management must promote and create a balance of intrinsic and extrinsic motivation (Gitlow, 1994). This can be considered one of the most interesting and characteristic elements of the system. The energy released by intrinsic motivations is, by far, more positive for improving processes and employees, and in this way their potential and joy of working shines. A win-win environment is fundamental to stakeholders, including employees. A cooperative environment has to be preferred by management instead of a competitive environment. Competition can lead people and departments to reach their own goals and not the goals of the entire system. According to Gitlow (1994), the pursuit of customer satisfaction is internally motivated as well and in any case cannot be achieved without regard to the stakeholders' needs.

In the Do stage Deming's system does not emphasise any particular tool or group such as advanced statistical tools. Each organisation can choose its tools for reducing variation. Anyway, Deming believes in the tools and techniques of quality management and Shewart (1939) and his tools are often quoted.

Managers must not introduce a fear climate inside the organisation, and performance check processes that introduce ranking of employees or departments are not the best for Deming (Gitlow, 1994). Instead, it is vital for a manager to learn the psychology of individuals, to spend time listening to them and understand why they failed. Variation has to be measured and continually reduced, and the theory which underpins the system periodically revised on the basis of its capacity to predict the future.

As Deming (1993, p. 66) himself said: "the book is for people who are living under the tyranny of the prevailing style of management" and in this way it can be considered a behavioural guideline for managers, especially in the USA.

Business process reengineering

BPR leads to deep redesign of business processes. It was popular during the 1990s basically as a reaction to recession; in those years companies needed to downsize and to better apply information technology (IT) (Davenport and Short, 1990; Cole, 1994; Mumford, 1994). In reviewing the literature it can be observed how the number of dedicated papers has decreased during the past five years. Hammer and Champy (1993) can be considered "the parents" of BPR developing the first complete pattern to implement BPR.

According to Knights and Willmott (2000), BPR in the Plan stage improves cost, quality, service, speed and organisational transformation around processes. The approach to change is very fast and can be considered "revolutionary". Senior management should act an aggressive and autocratic style of leadership and employees become important only at a later stage. Consequently, BPR is more top-down or imposed than the other systems.

According to Hammer and Champy (1993), human resources involvement is important as well as teamwork, empowerment and responsibility. Limerick and Cunnington (1995) also argued that the strength of BPR lies in the empowerment of the individual. However, redistribution of responsibilities is an inevitable outcome of process reengineering (Davenport, 1993) and this could lead to a "hypermodern neo-authoritarianism" as Willmott (1995) suggested. Knights and Willmott (2000), as already seen, claimed that BPR is mainly a top-down implementation and employees become important in the later stages. According to Hammer and Champy (1993) and Bradley (1994), similar to Six Sigma, there are precise players such as a steering committee; the "czar", who ensures resources and knowledge for the projects; project leaders; process owners and reengineering teams.

In the Do stage, BPR is focused on the voice of the customer (Hammer and Champy, 1993) and its capture. In addition, BPR is "IT-minded", the reengineering cannot be carried out without using computers, software and databases. According to Kettinger *et al.* (1997), BPR techniques and tools are strongly based on mapping, benchmarking and IT; they include project management, brainstorming, cause-effect diagrams and problem solving (Klein, 1994; Kettinger *et al.*, 1997; Chou and Chou, 2007).

The way of implementing BPR into the processes is underpinned by a well-structured pattern. Muthu *et al.* (1999) tried to summarise this approach for BPR. It is the sum of BPR methodologies described in the literature and it introduces five interesting steps similar to the PDCA cycle:

(1) preparing for BPR;

(2) map and analyse As-Is process;

(3) design to-Be process;

(4) implementing reengineered processes; and

(5) improving continuously.

Thyagarajan and Khatibi (2004, p. 58), tried to summarise the critical implementation factors discussed depicting reengineering in seven important areas:

(1) Emphasise customer satisfaction.

(2) Use performance improvement programmes and problem-solving techniques.

(3) Focus on business processes.
(4) Use teams and teamwork.
(5) Bring about changes in values and beliefs.
(6) Work to drive decision making down to lower levels in the organisation.
(7) Require senior level commitment and change management for success.

Lean thinking

Since the 1970s, competition has been increasing on factors such as zero defects, on-time delivery, price and relevant customisation (Piercy and Morgan, 1997). This scenario is the opposite of the so-called "Mass production" (Shingo, 1989), in which there is a huge demand for products and services that are manufactured with low-cost resources and with poor personalisation and quality. In order to reduce the wastes that increase process lead time and reduce value added for the customers, Taiichi Ohno, past Toyota Production Manager, invented TPS in the 1960s (Ohno, 1988). Lean production is a name derived from the book *The Machine That Changed the World: The Story of Lean Production* (Womack *et al.*, 1991). Although Lean production is focused on effectiveness in the production process, lean thinking is more focused on the efficiency in the company as a whole, including offices (Chiarini, 2011).

In general, the shorter the process, the Leaner the organisation and consequently the fewer the wastes (Sugimori *et al.*, 1977), thus lean thinking is focused on the extreme simplification of the "mainstream" with the intent of avoiding any kind of waste and accelerating the flow.

In the Plan stage the typical system for deploying strategies is *hoshin kanri*, introduced at the same time for JTQC (King, 1989). The typical goals to follow are linked to waste reduction, as well as COPQ and customer satisfaction (George, 2002). Over time Lean has proposed interesting new metrics along with its typical tools, such as lead time and overall equipment effectiveness (OEE) (Nakajima, 1988) to mention a few.

Lean thinking is for long-term oriented managers with a very clear vision (Womack and Jones, 1998). Managers are bound to create a culture of getting quality right the first time similar to TQC and TQM, going and seeing for themselves problems and improvements in the processes (Liker, 2004).

According to Womack *et al.* (1991), quick and voluntary teams continually try to remove wastes and there is not a pattern as rigorous and hierarchical as the Define, Measure, Analyse, Improve and Control (DMAIC) of Six Sigma for improvement projects. Only through reviewing practitioner literature or by directly analysing case studies, can it be found that teams usually manage "*Kaizen* events" or "*Kaizen* weeks" (Robertson *et al.*, 1992; Manos and Alukal, 2006; Manos, 2007; Dickson *et al.*, 2009), where *Kaizen* is the Japanese translation of continuous improvement. The peculiarity of these improvement projects is the short duration (on average a week) and the maximum involvement of people (Wickens, 1993; Liker and Meier, 2006). Similarly to JTQC, all the employees at all levels should be involved, creating an atmosphere of continuous learning and respect for people (Liker, 2004). Ohno (1988), who is considered one of the fathers of Lean, proposed in his book the same JTQC concept of respect for humanity presented by Ishikawa (1985).

The Do stage is particularly characterised by specific tools such as 5S, *Kanban*, *Heijunka*, total productive maintenance and many others (Nakajima, 1988; Ohno, 1988;

Shingo, 1989) invented by Toyota and other Japanese companies. Lean does not need advanced statistical training, nor certified Black and Green Belts. Self-empowerment and responsibility are as important as team building and team efforts. There is no trace in the academic literature of the application of Lean tools in engineering departments. Companies prefer tools derived from TQC-TQM and Six Sigma that are specialised for engineering and design. There is not, for instance, an approach similar to the so-called Design for Six Sigma (DFSS) (Mader, 2002; Coronado and Antony, 2002; Yang and El-Haik, 2009).

The *hoshin kanri* drives a strategic process of review (Witcher and Butterworth, 2001) in the Check and Act stages, and day-by-day results are managed by visual control (Shingo, 1989). This peculiar tool has led to the principles that no problems have to be hidden, that production can be stopped to fix them and last, but not least, people can learn from mistakes (Liker, 2004). Similarly to Deming, some authors linked to the Lean Accounting topic (Maskell and Baggaley, 2004; Kennedy and Widener, 2008) discussed how to fix standards and targets for cost, but indicators can be dangerous to the continuous improvement principle.

Six Sigma

The term Six Sigma was coined by a Motorola Engineer named Bill Smith (Harry and Schroeder, 2000). In fact, Six Sigma is today an American federally registered trademark of Motorola. In the early and mid-1980s with Chairman Bob Galvin, Motorola engineers decided that the traditional quality levels that measured defects in thousands of opportunities did not provide enough quality results; instead, they wanted to measure the defects per million opportunities (DPMO). Motorola developed the new Six Sigma standard, created the methodology and the required cultural change associated with it. Six Sigma helped Motorola realise powerful bottom-line results in the entire organisation; in fact, Motorola documented more than $16 billion in savings because of Six Sigma efforts. Since then, hundreds of companies especially quoted in the US stock exchange have adopted Six Sigma as a way of doing business (Pande *et al.*, 2000).

Six Sigma is a long-term journey. According to Harry and Schroeder (2000), Six Sigma has a specific deployment starting from the business plan. Harry (1998) and Harry and Schroeder (2000) claim that Six Sigma leads mainly to reduction of poor quality cost; this point can also be found in the work of several other authors (Coronado and Antony, 2002; Wiper and Harrison, 2000; Antony and Banuelas, 2002; Antony, 2004).

The DPMO concept is not just a slogan but a very grounded way to measure how successfully Six Sigma objectives are implemented. It has been demonstrated "on the field" that Six Sigma improves business performance in many ways and, in the final analysis, company margins (Harry, 1998; Slater, 1999). Some authors (Davison and Al-Shaghana, 2007) have pointed out how Six Sigma organisations have a higher quality culture than non-Six Sigma organisations and managers have a clear quality vision.

Six Sigma is not focused on social responsibility results (Goh, 2002), even though some authors (Kuei and Madu, 2003) believe that with some limits Six Sigma needs to extend to include environmental management and safety dimensions.

Six Sigma projects take on average from a few months (Goh, 2002) to one year and thus their yield is short- to medium-term based.

Reviewing the literature concerning the management of the organisation, many authors deal with two important figures: top and senior managers and their commitment to an effective and long-lasting Six Sigma application (Harry and Schroeder, 2000; Henderson and Evans, 2000; Coronado and Antony, 2002; Antony and Banuelas, 2002; Linderman *et al.*, 2003).

A "sponsor" and a "champion" are supposed to manage the company as a whole towards Six Sigma. Hence, without a clear and well-noticed top management commitment Six Sigma can fail after a few months of implementation. In addition, leadership and strategic management for Six Sigma should be "visionary" because culture and charisma can easily move strategies to processes.

Starting from the paper of Harry (1998), it is taken for granted that Six Sigma organisation needs important figures such as Master Black Belt, Black Belt and Green Belt.

Black and Green Belts should be certified through precise and well-coded training (Harry and Schroeder, 2000). A Master Black Belt usually is a Black Belt who has successfully carried out several projects and can act as a trainer for Black and Green Belts.

Six Sigma teams led by a Black or Green Belt need worker participation as well. Linderman *et al.* (2003) dealt with the aspect that Six Sigma organisations should, by extensive programmes, train all the employees. Therefore, at this level, Six Sigma requires team building and team efforts and each Six Sigma team leader is supposed to be trained on these subjects not only on statistics. However, Hahn *et al.* (2000), in their discussion about statistics training, referred to a "democratisation of statistics" within Six Sigma. Every employee should be trained, at the requested level for his/her role, on statistics and quality tools. Six Sigma programmes have to balance the cultural and technical skills (Eckes, 2001) of every worker. In this way Six Sigma introduces a hierarchical participation of staff in decision making and a precise development of the skills which employees are bound to acquire. Managers should select the best employees for projects (Brue, 2000) based on their abilities to bring assigned tasks to a close. Each participant within Six Sigma projects is controlled by a Black or Green Belt but participants are supposed to take on responsibility about rules and scheduling. It is not so difficult to notice how employees are led and managed mainly by extrinsic motivations, rather than intrinsic ones.

The role of employees within the improvement team has received some criticism in terms of commitment and motivation. Goh (2002), for instance, analysed Six Sigma limits, pointed out that it hardly sustains creativity, breakthrough or entrepreneurship among staff. The author in his findings stated that Six Sigma is not suitable for enhancing creativity and ability of interpretation as well as priorities of the organisation, especially economical, and it can sacrifice growth of people and talent development. Therefore, extrinsic motivations in terms of customer satisfaction and savings are more important than intrinsic motivations such as growth of staff.

In the Do stage it is fundamental to capture the voice of the customer. Six Sigma tends to cut down external COPQ (Harrington, 1986) such as warranty costs, returned goods and penalties. According to El-Haik and Al-Aomar (2006) and Pyzdek (2009), this is what Six Sigma does better, especially through quality function deployment, a tool used in the first stages of the project.

According to Byrne and Norris (2003), the DMAIC pattern is perhaps the most important part of Six Sigma DNA. DMAIC is something unique and it helps in the deployment of projects without failures; every stage, from Define to Control, is validated through a "tollgate" check, which can stop the project if the result stage is not what is expected. Design processes are instead well managed using the DFSS pattern (Mader, 2002; Coronado and Antony, 2002; Yang and El-Haik, 2009).

Within the DMAIC pattern, Six Sigma teams can use numerous tools dependent on the scope and the kind of stage. Among these, Six Sigma inherits well-known quality management tools (Klefsjo *et al.*, 2001; Dahlgaard and Dahlgaard-Park, 2006), including advanced statistical tools. Six Sigma has also borrowed tools derived from TPS (George, 2002, 2003; Bendell, 2006). The DMAIC toolset is very open and can be surely enlarged in the future.

Six Sigma has a strong approach based on facts and data. All the project results are validated using "sigma level" around the target. In several companies, the finance department is assigned to calculate and report these savings to senior management. The results of the project can be submitted to an actual external certification (Pyzdek, 2009) led by auditors. Hahn *et al.* (2000) are convinced that the disciplined data-driven approach is the foundation of Six Sigma.

The results of each Six Sigma project should be collected in order to learn from them. In this way, companies like GE are using a database for the projects and their features (Slater, 1999) as well as statistics software. Snee and Hoerl (2003) pointed out that many companies celebrate the Six Sigma teams and spread Six Sigma results to all the staff; Harry and Schoereder (2000) suggested a specific communication plan to reach this goal.

In the first years of 2000 Six Sigma encountered lean thinking (George, 2002; Smith, 2003) creating "Lean Six Sigma". Nowadays it is considered a well-established system for process improvement as confirmed by several authors (Arnheiter and Maleyeff, 2005; Kumar *et al.*, 2006; Wedgwood, 2006). The marriage seems to be happy. Indeed, Six Sigma is problem focused and it assumes that process variation is waste because it generates defects and COPQ. In addition to design processes, Six Sigma proposes the interesting DFSS system. Lean thinking, by contrast, is focused on process flow and lead time and views any activity that does not add value as waste. Therefore, it combines the "speed" introduced by Lean, and Six Sigma capability of reducing variation. Nevertheless, in reviewing the authors above mentioned along with George (2002, 2003), Lean Six Sigma looks more like a DMAIC pattern enhanced with Lean tools than the real fusion of two systems.

Discussion and comparison about the common characteristics of the systems

After reviewing the literature and analysing the findings, these latter can be compared and grouped in order to define the results and the critical implementation factors of the six systems. Along with the results and benefits, eight common factors have been found and proposed as shown in the second column from the left in Table I. They are: results and benefits; management style; deployment of the system; employee management, deployment and participation; voice of the customer; tools, techniques and IT; optimisation of the system; day-by-day check and control of the results; review of the system.

All the six systems share customer satisfaction as a common tract. COPQ is pursued in the systems linked to quality such as JTQC, TQM, Deming's, Six Sigma as well as Lean but in different ways. JTQC is focused on quality assurance, TQM and Six Sigma manage COPQ according to Harrington's (1986) classification who divided them into external and internal, these latter further divided into prevention, appraisal and defective costs. Lean considers defectiveness inside the so-called wastes and not-value added activities, and Deming's system linked COPQ to process variation, whereas BPR considers COPQ just one of the costs that can affect profitability. According to Goh (2002), Six Sigma, like BPR, is a very cost-oriented system and it can sometimes sacrifice other results to achieve short-term savings.

BPR needs an "autocratic" and aggressive management sometimes more oriented to short-term results. TQM and Deming's are the only systems that take care of CSR and the stakeholders as a whole. Management should be involved and participate in all the systems. Deming's is the only system that points out that managers should act like psychologists, trying to improve internal people's potential.

JTQC and Lean share the same typical Japanese way of deploying the system based on *hoshin kanri*. TQM, Deming's system and BPR do not suggest a precise way of deploying, whereas Six Sigma invented the DMAIC pattern. According to Harry and Schroeder (2000), DMAIC ties up the business level to the operations one and can be followed for long-term goals as well as short-term projects; for the design processes Six Sigma suggests the DFSS system.

JTQC, Lean and Deming's system point out the importance of the respect for humanity, although Deming's system is particularly focused on win-win situations and cooperation instead of competition. Deming's system in this way emphasises how intrinsic motivations should be more pursued than extrinsic external motivations.

The quality circles suggested by JTQC, TQM and Deming's system as voluntary teams for improvement were sometimes experienced as failures in Western culture. The reasons lie in weak senior managers' leadership and in an unclear connection with company strategies (Hayward *et al.*, 1985; Drago, 1988). However, cultural and even religious influences seem to lie in the participatory manner of managing employees. For instance, Picken (1987) analysed the influence of the Shinto belief in the innate goodness of human nature and consequently the intrinsic capacity of people to grow; by contrast, in Western societies the worker is expected to perform according to external factors.

According to Table I, voice of customers is surely a common critical implementation factor, even though in Deming's system it should be followed in accordance to all the stakeholders' needs. Lean is particularly demand driven; the orders pull and synchronise all the processes.

Tools and techniques are more or less the same in JTQC, TQM, Deming's system and Six Sigma. They are typical of the quality management world, from the seven basic tools to the advanced statistical ones. Six Sigma projects are often carried out with specific statistical software. Deming's system and Six Sigma promote tools that reduce variation inside processes and Six Sigma contextualises the tools and techniques strictly within the DMAIC pattern. Lean offers personalised tools for reducing wastes and to stream the flow. BPR is based on a massive use of software in order to map, reengineer and standardise the processes.

The entire system should be performed for all the systems, even though BPR, because of its nature, can be used for short-term results inside a few processes or departments.

Table I. Results, critical implementation factors and approach to improvements of the six systems

	JTQC	TQM	Deming's	Lean	BPR	Six Sigma
1. Results achieved and benefits	Customer satisfaction and quality assurance	Customer satisfaction, COPQ and CSR performance	Customer satisfaction, staff satisfaction and all the stakeholders	Reduces waste, cost reduction system, particularly increases value added for the customer	Cost reduction system, customer satisfaction, streamline and downsize oriented	Customer satisfaction, cost reduction system, particularly concerning COPQ
2. Management style	Long-term oriented, management by fact, respect for humanity, participatory management and capacity to involve all the staff	Long-term oriented, management by fact, capacity to involve all the staff, participatory management	Clear view of the system of profound knowledge, long-period oriented, not particularly focused on numerical targets, promoting cooperation and not competition, being a "psychologist"	Long-term oriented, management by fact, respect for humanity, participatory management and capacity to involve all the staff	"Aggressive" and autocratic top management. Long- and short-term oriented	Long-term oriented, management by fact, capacity to involve all the staff, participatory management
3. Deployment of the system	*Hoshin kanri*	*Hoshin kanri* and other particular systems for deployment	No particular systems for deployment	*Hoshin kanri*	No particular systems for deployment	Use of a specific DMAIC pattern DFSS within design processes
4. Employee management, development and participation	Use of quality control circles Maximum involvement, respect for humanity, improvement of human potential Education and training for the best practices Extrinsic and intrinsic motivation trade-off	Use of quality control circles and other improvement teams Maximum involvement Education and training for the best practices Extrinsic and intrinsic motivation trade-off Training on quality tools and problem solving	Use of quality control circles Maximum involvement Cooperative employees rather than competitive Intrinsic motivation has to be developed Quality training for reducing variation	Use of *Kaizen* events Maximum involvement Respect for humanity, improvement of human potential Training on specific tools Extrinsic and intrinsic motivation trade-off	Use of reengineering teams with a "Czar" as team leader People involvement, structured hierarchy Extrinsic motivation leads people Training for specialists of mapping and reengineering	Improvement teams, certified yellow and black belts as team leaders Maximum involvement, structured hierarchy Extrinsic motivation leads people Training on quality tools and statistics

(continued)

	JTQC	TQM	Deming's	Lean	BPR	Six Sigma
5. Voice of the customer	Voice of the customer defined in relation to competition	Voice of the customer defined in relation to competition	Voice of the customer is defined in observance to stakeholders' needs	Voice of the customer is defined for the value added, processes are "demand driven"	Voice of the customer defined in relation to competition	Voice of the customer defined in relation to competition
6. Tools and techniques, IT	Typical quality tools (basic, managerial and advanced). Problem Solving, quality audits	Typical quality tools (basic, managerial and advanced). Problem Solving tools	Quality tools are important, even if each organisation choose its own tools based on the theory	Uses specific and well-coded tools invented in the so-called TPS	Tools for analysing and mapping processes, tools for problem solving. IT for mapping and reengineering the processes	Typical quality tools (basic, managerial and advanced). Problem solving and project management tools. IT for managing statistical data
7. Optimisation of the system	The entire system should be performed for all the systems	The entire system should be performed for all the systems	The entire system should be performed for all the systems	The entire system should be performed for all the systems	The entire system should be performed for all the systems. Few processes or departments can be affected by reengineering	The entire system should be performed for all the systems
8. Day-by-day check and control of the results	Non-conformities indicators. Quality audits, status of the corrective and preventive actions	Performance indicators	Performance indicators. No use of targets. Methods are more important than goals	Visual control and management. Performance indicators including lean metrics	Performance indicators	Performance indicators. Certification of the improvement projects using sigma level and savings
9. Review of the system	Quality indicators *Hoshin kanri*	Performance indicators Self-assessment Benchmarking	Review of the theory	*Hoshin kanri*. Performance indicators including lean metrics	Performance indicators	Performance indicators in particular COPQ

Table I.

Six Sigma can also be used for short-term results; however its powerful results in terms of reducing COPQ are normally reached in the long term.

Indicators are the measures to control the day-by-day results in all the systems. JTQC takes into account indicators linked to non-conformities as well as quality audits and corrective-preventive actions. TQM and Six Sigma use COPQ indicators as long as Six Sigma validates the results of the projects measuring the sigma level or variation around the target to be achieved. Lean is more focused on the concept of visual control and promotes its typical indicators such as lead time and OEE. Deming's system cautions about the use of targets as indicators, focusing more on the methods to reach improvements.

The periodical review of the systems in JTQC and lean thinking is mainly based on *hoshin kanri*. TQM introduces the self-assessment and benchmarking process whereas Deming's system tries to understand if the "theory" which underpins the system is right in terms of stakeholders' satisfaction. BPR stresses the cost reduction results as well as the downsizing of the organisation. Six Sigma wants finance managers to review and certify the COPQ results and the savings in general. Managers sometimes can even have recourse to external certification such as financial auditors and comptrollers.

Lessons learned from the comparison and discussion

Many lessons can be learned from the previous comparison and discussion of the literature review findings.

First, it seems that TQC in Western cultures has evolved into the TQM system losing over time its Japanese style. Some authors have claimed that TQM gurus have sometimes brought confusion to the discussions (Chatterjee and Yilmaz, 1993), other authors that several projects have been carried out under the TQM umbrella but with a different approach and results. Patton (1994) even claimed that TQM is more a philosophy than a precise science. In any case, looking at Table I it can be noted how TQM, even if it has lost its identity, maintains the typical quality tools and techniques as does JTQC.

Furthermore, management style, as well as cultural factors, seems to have carried TQM away from Western companies. Deming (1993) listed the mistakes that Western management should avoid in order to implement what is called a system of profound knowledge. From Table I it can be noted how Deming's system has several points in common with JTQC and even with lean thinking. However, looking at the very few papers about Deming's system, a lack of interest in this system and probably in its application can be asserted. Deming was one of the fathers of TQM and surely influenced TQM in Japan; despite that, it is not so clear what TQM in Japan has inherited from Deming's system of profound knowledge.

From the late 1990s the number of papers dedicated to TQM began to decrease, in the meanwhile some authors claimed that the new "fad" Six Sigma was borne (Näslund, 2008). However, the findings of this paper do not lead in this direction. Six Sigma is not a fad; rather it could be an evolution of systems that have not succeeded in adapting themselves to Western culture, in particular TQM. Indeed, like TQM, Six Sigma tries to reduce COPQ, it inherits all the TQM tools but it offers a very structured and measurable pattern, the DMAIC, for improving processes. This is particularly aligned to the Western thought that expects a worker to perform according to external motivations

(Picken, 1987). By contrast, companies in Japan believe in the influence of the Shinto belief in the innate goodness of human nature and consequently the intrinsic capacity of people to grow.

From the literature it seems that Six Sigma, especially in the USA, has almost substituted TQM. Nonetheless, how many companies have embraced Six Sigma leaving TQM and in what circumstances this has happened is still uncertain.

BPR was popular during the 1990s basically because companies needed to downsize and better apply IT. Nowadays, the use of IT to support business operations is no longer considered a breakthrough but just a tool and downsizing is just linked to economic crisis, especially in the USA. Looking again the critical implementation factors in Table I, Six Sigma is a hierarchical system, that orients employee management towards external motivations rather than intrinsic, and it can also be used instead of BPR in the short-period for getting aggressive savings.

In the literature written in English there is no trace of Six Sigma application in Japanese companies. TQM in the Japanese style is still implemented even though is not so clear what are the differences, if any, from the original JTQC and how it has been evolving since.

JTQC and Deming's system seem to share some critical implementation factors with Lean as well. This is in part taken for granted considering the same Japanese origin. In fact from the Table I it can be noted how JTQC shares critical factors such as the use of *hoshin kanri* deployment, and the same way of managing employees in terms of respect for humanity, improvement of human potential as well as quick voluntary teams similar to quality circles. This is particularly claimed in the original Japanese works of Ohno (1988) and Shingo (1989).

Combining the "speed" introduced by Lean and the Six Sigma capability of reducing variation, Lean Six Sigma seems to be a well-established system as confirmed by several authors (George, 2002; Arnheiter and Maleyeff, 2005; Kumar *et al.*, 2006; Wedgwood, 2006). However, from a review of the literature concerning Lean Six Sigma, it seems that the critical implementation factors of Lean shared with JTQC are not taken into account or minimised, only the generic involvement of people is underlined in Lean Six Sigma. Dozens of providers that propose a Lean Six Sigma based certification for Black and Green Belts can be found on the internet. However, these courses look like a Six Sigma – DMAIC course enriched with Lean tools and techniques. Unfortunately neither in the academic literature nor in professional training are there specific references to how to balance and emphasise the intrinsic factors that can grow people's potential.

Conclusions

In this paper, literature concerning six important management systems has been reviewed in order to understand what the results achieved by the systems and the critical implementation factors of each of them are. The results and the critical implementation factors have been grouped in Table I using the PDCA cycle, showing thus a possible way of implementing the systems. Furthermore, the comparison and discussion of the findings shown in Table I has led to important conclusions and remarks.

First it seems that in Western cultures TQC has evolved into the TQM system gradually losing its Japanese style. Nowadays TQM has lost its identity but it maintains the typical quality tools and techniques of JTQC.

Deming's system of profound knowledge is an interesting guideline for Western managers, however, it has had less success than JTQC, TQM and the other systems in the literature. Even the influence of Deming's system on the current Japanese TQM is unclear.

From the end of 1990s Six Sigma seems to have gradually substituted TQM especially in US companies, even if there is no trace of Six Sigma applications in Japan. Six Sigma has a more hierarchical approach and for managing people extrinsic motivations are followed more than intrinsic ones. Six Sigma could also substitute BPR. In fact a short-term aggressive reengineering project could be managed with Six Sigma – DMAIC.

Last but not least the "marriage" between the Japanese Lean and the American Six Sigma systems has brought a new acclaimed management system. However, from the review of the literature Lean Six Sigma seems more like a DMAIC enriched with Lean tools rather than a Six Sigma in which the Japanese style of managing people is strongly taken into account.

Agenda for future research

This paper presents some limits mainly due to the fact that is based on a literature review. Thence, first of all, practitioners and academics could carry out case studies inside companies that have applied all the six systems or the majority of them. Critical implementation factors presented in Table I need to be validated and eventually put under discussion.

In addition this paper enters in the open debate of TQM in Western companies. Surely TQM has lost its popularity, but for what reasons? Has Six Sigma gradually substituted TQM in the West because is more suitable for that culture? There is too much theoretical research, the scientific community needs more case studies concerning companies that have embraced Six Sigma and left TQM. Using a survey within a sample of companies and by the means of quantitative inquiries the hypotheses of a changeover from TQM to Six Sigma could be validated. Furthermore, BPR practitioners could analyse whether the DMAIC pattern can perform in alternative aggressive and short-term oriented reengineering projects. Another interesting question arises from this paper. Is there an interest concerning Six Sigma in Japan? Or do Japanese companies continue implementing, as emerged from some literature, TQM in their own style? How far is this latter system from the original JTQC? It could be useful if Japanese practitioners and academics participated more in this debate proposing Japanese case studies as well as general research.

And what about Deming's system of profound knowledge? Academics could analyse whether or not it has left something to be inherited, for instance by Six Sigma. Practitioners could analyse successful case studies of Deming's system implementation along with some of the other systems.

Finally, Lean Six Sigma needs more investigation from academics and practitioners because the degree of influence of the Japanese style on Six Sigma is unclear. Is it just a matter of integrating tools and techniques or could it finally be the way to introduce to Western culture what JTQC, TQM and Deming's system seems not to have achieved?

References

Akao, Y. (2004), *Hoshin Kanri. Policy Deployment for Successful TQM*, Productivity Press, New York, NY.

Antony, J. (2004), "Some pros and cons of Six Sigma: an academic perspective", *The TQM Magazine*, Vol. 16 No. 4, pp. 303-6.

Antony, J. and Banuelas, R. (2002), "Key ingredients for the effective implementation of Six Sigma program", *Measuring Business Excellence*, Vol. 6 No. 4, pp. 20-7.

Arnheiter, E.D. and Maleyeff, J. (2005), "The integration of lean management and Six Sigma", *The TQM Magazine*, Vol. 17 No. 1, pp. 5-18.

Bendell, T. (2006), "A review and comparison of six sigma and the lean organizations", *The TQM Magazine*, Vol. 18 No. 3, pp. 255-62.

Bradley, S. (1994), "Creating and adhering to a BPR methodology", Gartner Group Report, pp. 1-30.

Brue, G. (2000), *Six Sigma for Team Members*, Morningstar Communications Group, Pagosa Springs, CO.

Bubshait, A. and Farooq, G. (1999), "Team building and project success", *Cost engineering*, Vol. 41 No. 7, pp. 34-8.

Byrne, G. and Norris, B. (2003), "Drive Baldrige level performance", *Six Sigma Forum Magazine*, Vol. 2 No. 3, pp. 13-21.

Chatterjee, S. and Yilmaz, M. (1993), "Quality confusion: too many gurus, not enough disciples", *Business Horizons*, Vol. 36 No. 3, pp. 15-18.

Cheng, J.L. (2008), "Implementing Six Sigma via TQM improvement: an empirical study in Taiwan", *The TQM Journal*, Vol. 20 No. 3, pp. 182-95.

Chiarini, A. (2011), "Integrating lean thinking into ISO 9001: a first guideline", *International Journal of Lean Six Sigma*, Vol. 2 No. 2, pp. 96-117.

Chou, A.Y. and Chou, D.C. (2007), "The complementary role of business process reengineering and information technology to total quality management practices", *International Journal of Information Systems and Change Management*, Vol. 2 No. 1, pp. 21-9.

Cole, R. (1994), "Reengineering the corporation: a review essay", *Quality Management Journal*, Vol. 1 No. 4, pp. 77-85.

Conti, T. (1997), "Total quality management", *Total Quality Management & Business Excellence*, Vol. 8 Nos 2/3, pp. 5-15.

Coronado, R.B. and Antony, J. (2002), "Critical success factors for the successful implementation of six sigma projects in organizations", *The TQM Magazine*, Vol. 14 No. 2, pp. 92-9.

Dahlgaard, J.J. and Dahlgaard-Park, S.M. (2006), "Lean production, six sigma quality, TQM and company culture", *The TQM Magazine*, Vol. 18 No. 3, pp. 263-81.

Daily, B.F. and Huang, S. (2001), "Achieving sustainability through attention to human resource factors in environmental management", *International Journal of Operations and Productions Management*, Vol. 21 No. 12, pp. 1539-52.

Davenport, T.H. (1993), *Process Innovation: Re-engineering Work Through Information Technology*, Harvard Business School Press, Boston, MA.

Davenport, T.H. and Short, J.E. (1990), "The new industrial engineering: information technology and business process redesign", *Sloan Management Review*, Vol. 31 No. 4, pp. 11-27.

Davison, L. and Al-Shaghana, K. (2007), "The link between six sigma and quality culture – an empirical study", *Total Quality Management & Business Excellence*, Vol. 18 Nos 3/4, pp. 249-65.

Deming, W.E. (1950), *Elementary Principles of the Statistical Control of Quality*, JUSE, New York, NY.

Deming, W.E. (1986), *Out of the Crisis*, MIT, Center for Advanced Engineering Study, Cambridge, MA.

Deming, W.E. (1993), *The New Economics: for Industry, Government, Education*, MIT, Center for Advanced Engineering Study, Cambridge, MA.

Dennis, P. and Shook, J. (2007), *Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production Systems*, Productivity Press, New York, NY.

Dickson, E.W., Singh, S., Cheung, S.C., Wyatt, C.C. and Nugent, A.S. (2009), "Application of lean manufacturing techniques in the emergency department", *The Journal of Emergency Medicine*, Vol. 37 No. 2, pp. 177-82.

Drago, R. (1988), "Quality circle survival: an exploratory analysis", *Industrial Relations: A Journal of Economy and Society*, Vol. 27 No. 3, pp. 336-51.

Eckes, G. (2001), *Making Six Sigma Last: Managing the Balance between Cultural and Technical Change*, Wiley, New York, NY.

Ehigie, B.O. and Akpan, R.C. (2004), "Roles of perceived leadership styles and rewards in the practice of total quality management", *Leadership & Organization Development Journal*, Vol. 25 No. 1, pp. 24-40.

El-Haik, B. and Al-Aomar, R. (2006), *Simulation-based Lean Six-Sigma and Design for Six-Sigma*, Wiley, Hoboken, NJ.

Feigenbaum, A.V. (1961), *Total Quality Control*, McGraw-Hill, New York, NY.

George, M. (2002), *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed*, McGraw-Hill, New York, NY.

George, M. (2003), *Lean Six Sigma for Service*, McGraw-Hill, New York, NY.

George, S. and Weimerskirch, A. (1998), *Total Quality Management: Strategies and Techniques Proven at Today's Most Successful Companies*, Wiley, New York, NY.

Gitlow, H. (1994), "A comparison of Japanese total quality control and Dr Deming's theory of management", *The American Statistician*, Vol. 48 No. 3, pp. 197-203.

Gitlow, H. (1995), "Understanding total quality creation (TQC): the Japanese school of thought", *Quality Engineering*, Vol. 7 No. 3, pp. 523-42.

Goh, T.N. (2002), "A strategic assessment of Six Sigma", *Quality & Reliability Engineering International*, Vol. 18 No. 5, pp. 403-10.

Grant, R., Shani, R. and Krishnan, R. (1994), "TQM's challenge to management theory and practice", *Sloan Management Review*, Vol. 35 No. 2, pp. 25-36.

Graves, S.C., Gershwin, S. and Popoola, O.A. (2000), "Development of a methodology for the rapid implementation of a sustainable lean manufacturing system", available at: http://dspace.mit.edu/handle/1721.1/9000 (accessed 3 August 2011).

Hahn, G.J., Doganaksoy, N. and Hoerl, R. (2000), "The evolution of Six Sigma", *Quality Engineering*, Vol. 12 No. 3, pp. 317-26.

Hammer, M. and Champy, J. (1993), *Re-engineering the Corporation: A Manifesto for Business Revolution*, Harper Business, New York, NY.

Harrington, H.J. (1986), *Poor-quality Cost*, ASQ Quality Press, Milwaukee, WI.

Harry, M.J. (1998), "Six Sigma: a breakthrough strategy for profitability", *Quality Progress*, Vol. 31 No. 5, pp. 60-4.

Harry, M.J. and Schroeder, R. (2000), *The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, Doubleday, New York, NY.

Hayward, S.G., Dale, B.G. and Fraser, V.C.M. (1985), "Quality circle failure and how to avoid it", *European Management Journal*, Vol. 3 No. 2, pp. 103-11.

Hellsten, U. and Klefsjö, B. (2000), "TQM as a management system consisting of values, techniques and tools", *The TQM Magazine*, Vol. 12 No. 4, pp. 238-44.

Henderson, K.M. and Evans, J.R. (2000), "Successful implementation of Six Sigma: benchmarking GE Company", *Benchmarking: An International Journal*, Vol. 7 No. 4, pp. 260-81.

Hirschheim, R., Klein, H. and Lyytinen, K. (1995), *International Systems Development and Data Modeling. Conceptual Foundations and Philosophical Foundations*, Cambridge University Press, Cambridge.

Hoque, Z. (2003), "Total quality management and the balanced scorecard approach: a critical analysis of their potential relationships and directions for research", *Critical Perspectives on Accounting*, Vol. 14 No. 5, pp. 553-66.

Iizuka, Y. and Osada, H. (1988), *JTQC in Japan Today*, Process Management Institute, St Paul, MN.

Ishikawa, K. (1985), *What is Total Quality Control? The Japanese Way*, Prentice-Hall, Englewood Cliffs, NJ.

Johannsen, F. (2011), "State of the art concerning the integration of methods and techniques in quality management – literature review and an agenda for research", *European Conference on Information Systems* (*ECIS*) *2011 Proceedings. Paper 41*, University of Regensburg, Regensburg.

Johnson, C.N. (2002), "The benefits of PDCA", *Quality Progress*, Vol. 35, pp. 120-1.

Kano, N. (1993), "A perspective on quality activities in American firms", *California Management Review*, Vol. 35 No. 3, pp. 12-31.

Kano, N. (1998), "What is JTQC?", University of Miami Quality Program Faculty Lecture Series, Miami, FL.

Kennedy, F.A. and Widener, S.K. (2008), "A control framework: insight from evidence on lean accounting", *Management Accounting Research*, Vol. 19 No. 4, pp. 301-23.

Kettinger, W.J., Teng, J.T.C. and Guha, S. (1997), "Business process change: a study of methodologies, techniques, and tools", *MIS Quarterly*, Vol. 21 No. 1, pp. 55-80.

King, R. (1989), *Hoshin Planning: The Development Approach*, GOAL/QPC, Methuen, MA.

Kitazawa, S. and Sarkis, J. (2000), "The relationship between ISO 14001 and continuous source reduction programs", *International Journal of Operations & Production Management*, Vol. 20 No. 2, pp. 225-48.

Klefsjo, B., Wiklund, H. and Edgeman, R.L. (2001), "Six Sigma seen as a methodology for total quality management", *Measuring Business Excellence*, Vol. 5 No. 1, pp. 31-5.

Klein, M.M. (1994), "Reengineering methodologies and tools. A prescription for enhancing success", *Information Systems Management*, Vol. 11 No. 2, pp. 30-5.

Knights, D. and Wilmott, H. (2000), *The Reengineering Revolution? Critical Studies of Corporate Change*, Sage, London.

Kondo, Y. (1998), "Hoshin Kanri – a participative way of quality management in Japan", *The TQM Magazine*, Vol. 10 No. 6, pp. 425-31.

Kuei, C.H. and Madu, C.N. (2003), "Customer-centric Six Sigma quality and reliability management", *International Journal of Quality & Reliability Management*, Vol. 20 No. 8, pp. 954-64.

Kumar, M., Antony, J., Singhc, R.K., Tiwarid, M.K. and Perry, D. (2006), "Implementing the Lean Sigma framework in an Indian SME: a case study", *Production Planning & Control*, Vol. 17 No. 4, pp. 407-23.

Liker, J.K. (2004), *The Toyota way – 14 Management Principles from the World's Greatest Manufacturer*, McGraw-Hill, New York, NY.

Liker, J.K. and Meier, D. (2006), "Automation, motivation and lean production reconsidered", *Assembly Automation*, Vol. 26 No. 2, pp. 98-103.

Limerick, D. and Cunnington, B. (1995), *Managing the New Organization: A Blueprint for Networks and Strategic Alliances*, Business and Professional Publishing, Sydney.

Linderman, K., Schroeder, R.G., Zaheer, S. and Choo, A.S. (2003), "Six Sigma: a goal-theoretic perspective", *Journal of Operations Management*, Vol. 3 No. 21, pp. 193-203.

Lucas, M.L. (2002), "The essential of Six Sigma: how successful Six Sigma implementation can improve the bottom line", *Quality Progress*, Vol. 35 No. 1, pp. 27-31.

McAdam, R. and Leonard, D. (2003), "Corporate social responsibility in a total quality management context: opportunities for sustainable growth", *Corporate Governance*, Vol. 3 No. 4, pp. 36-45.

Mader, D.M. (2002), "Design for Six Sigma", *Quality Progress*, July, pp. 82-6.

Manos, A. (2007), "The benefits of Kaizen and Kaizen events", *Quality Progress*, available at: www.proferoinc.com/pdf/qp0207lean.pdf (accessed 20 March 2010).

Manos, A. and Alukal, G. (2006), *Lean Kaizen*, Quality Press, Milwaukee, WI.

Martinez-Lorente, A.R., Dewhurst, F. and Dale, B.G. (1998), "Total quality management: origins and evolution of the term", *The TQM Magazine*, Vol. 10 No. 5, pp. 378-86.

Maskell, B.H. and Baggaley, B. (2004), *Practical Lean Accounting: A Proven System for Measuring and Managing the Lean Enterprise*, Productivity Press, New York, NY.

Meehan, J., Meehan, K. and Richards, A. (2006), "Corporate social responsibility: the 3C-SR model", *International Journal of Social Economics*, Vol. 33 Nos 5/6, pp. 386-98.

Milakovich, M.E. (1991), "Total quality management in the public sector", *National Productivity Review*, Vol. 10 No. 2, pp. 195-213.

Miles, M.P. and Russell, G.R. (1997), "ISO 14000 total environmental management: the integration of environmental marketing, total quality management, and corporate environmental policy", *Journal of Quality Management*, Vol. 2 No. 1, pp. 151-68.

Mizuno, S. (1988), *Management for Quality Improvement: The 7 New QC Tools*, Productivity Press, Cambridge, MA.

Moen, R. and Norman, C. (2006), *Evolution of the PDCA Cycle*, available at: http://pkpinc.com/files/NA01MoenNormanFullpaper.pdf (accessed 3 August 2011).

Mumford, E. (1994), "New treatments or old remedies: is business process reengineering really socio-technical design?", *Journal of Strategic Information Systems*, Vol. 3 No. 4, pp. 313-26.

Muthu, S., Whitman, L. and Hossein, S.C. (1999), "Business process reengineering: a consolidated methodology", *Proceedings of the 4th Annual International Conference on Industrial Engineering Theory, Applications, and Practice*, US Department of the Interior – Enterprise Architecture, US Department of the Interior, Washington, DC.

Nakajima, S. (1988), *Introduction to TPM: Total Productive Maintenance*, Productivity Press, Cambridge, MA.

Näslund, D. (2008), "Lean, Six Sigma and Lean Sigma: fads or real process improvement methods?", *Business Process Management Journal*, Vol. 14 No. 3, pp. 269-87.

Nassir Shaari, J.A. (2010), "Barriers to implement TQM in Japanese way: a study on companies in Malaysia", *International Review of Business Research Papers*, Vol. 6 No. 5, pp. 400-10.

Ohno, T. (1988), *Toyota Production System: Beyond Large Scale Production*, Productivity Press, Cambridge, MA.

Omachonu, V.K. and Ross, J.E. (1994), *Principles of Total Quality*, St Lucie Press, Delray Beach, FL.

Osayawe Ehigie, B. and McAndrew, E.B. (2005), "Innovation, diffusion and adoption of total quality management (TQM)", *Management Decision*, Vol. 43 No. 6, pp. 925-40.

Pande, P.S., Neuman, R.P. and Cavanagh, R.R. (2000), *The Six Sigma Way: How GE, Motorola and Other Top Companies are Honing their Performance*, McGraw-Hill, New York, NY.

Patton, S. (1994), "Is TQM dead?", *Quality Digest Magazine*, April, pp. 1-5.

Picken, S.D.B. (1987), "Values and value related strategies in Japanese corporate culture", *Journal of Business Ethics*, Vol. 6 No. 2, pp. 137-43.

Piercy, N.F. and Morgan, N.A. (1997), "The impact of lean thinking and the lean enterprise on marketing: threat or synergy?", *Journal of Marketing Management*, Vol. 13 No. 7, pp. 679-93.

Pike, J. and Barns, R. (1993), *TQM in Action*, Chapman & Hall, London.

Porter, M. and Parker, A. (1993), "Total quality management, the critical success factors", *Total Quality Management & Business Excellence*, Vol. 4 No. 1, pp. 13-22.

Pyzdek, T. (2009), *The Six Sigma Handbook: A Complete Guide for Greenbelts, Blackbelts, and Managers at All Levels*, McGraw-Hill, New York, NY.

Ramsey, C., Ormsby, S. and Marsch, T. (2001), "Performance-improvement strategies can reduce costs", *Healthcare Financial Management*, pp. 2-6 (supplement).

Ricondo, I. and Viles, E. (2005), "Six Sigma and its link to TQM, BPR, lean and the learning organisation", *International Journal of Six Sigma and Competitive Advantage*, Vol. 1 No. 3, pp. 323-54.

Robertson, D., Rinehart, J. and Huxley, C. (1992), "Team concept and Kaizen: Japanese production management in a unionized Canadian auto plant", *Studies in Political Economy*, Vol. 39 No. 4, pp. 77-107.

Ross, J.E. (1993), *Total Quality Management: Text, Cases, and Readings*, St Lucie Press, Delray Beach, FL.

Saylor, J.H. (1992), *TQM Field Manual*, McGraw-Hill, New York, NY.

Shewart, W.A. (1939), *Statistical Method from the Viewpoint of Quality Control*, The Graduate School The Department of Agriculture, Washington, DC.

Shingo, S. (1986), *Zero Quality Control: Source Inspection and the Poka-yoke System Study*, Productivity Press, Cambridge, MA.

Shingo, S. (1989), *A Study of the Toyota Production System from an Industrial Engineering Viewpoint*, Productivity Press, Cambridge, MA.

Sila, I. and Ebrahimpor, M. (2002), "An investigation of the total quality management survey based research between 1989 and 2000: a literature review", *The International Journal of Quality & Reliability Management*, Vol. 19 Nos 6/7, pp. 902-71.

Slater, R. (1999), *Jack Welch and the GE Way: Management Insights and Leadership Secrets of the Legendary CEO*, McGraw-Hill, New York, NY.

Smith, B. (2003), *Lean and Six Sigma – a One-two Punch, Quality Progress*, available at: www.tbmcg.com/acrobat/press_public/QP_-_Lean_and_Six_Sigma_-_One_Two_Punch.pdf (accessed 15 June 2010).

Snee, R.D. and Hoerl, R.W. (2003), *Leading Six Sigma*, Prentice-Hall, Upper Saddle River, NJ.

Spector, B. and Beer, M. (1994), "Beyond TQM programmes", *Journal of Organizational Change Management*, Vol. 7 No. 2, pp. 63-70.

Stoica, M., Chawat, N. and Shin, N. (2004), "An investigation of the methodologies of business process reengineering", *International Systems Education Journal*, Vol. 2 No. 11, pp. 3-10.

Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S. (1977), "Toyota production system and Kanban system: materialization of just-in-time and respect-for-human system", *International Journal of Production Research*, Vol. 15 No. 6, pp. 553-64.

Tani, T. (1995), "Interactive control in target cost management", *Management Accounting Research*, Vol. 6 No. 4, pp. 399-414.

Thyagarajan, V. and Khatibi, A. (2004), "BPR – a tool for managing the change", *J. Hum. Ecol*, Vol. 15 No. 1, pp. 57-61.

Wedgwood, I. (2006), *Lean Sigma, A Practitioner's Guide*, Prentice-Hall, Upper Saddle River, NJ.

Wickens, P.D. (1993), "Lean production and beyond: the system, its critics and the future", *Human Resource Management Journal*, Vol. 3 No. 4, pp. 75-90.

Willmott, H. (1995), "The odd couple?: re-engineering business processes; managing human relations", *New Technology, Work and Employment*, Vol. 10 No. 2, pp. 89-98.

Wiper, B. and Harrison, A. (2000), "Deployment of Six Sigma methodologies in human resource function: a case study", *Total Quality Management*, Vol. 11 No. 4, pp. 270-728.

Witcher, B.J. and Butterworth, R. (2001), "Hoshin Kanri: policy management in Japanese-owned UK subsidiaries", *Journal of Management Studies*, Vol. 38 No. 5, pp. 651-74.

Womack, J.P. and Jones, D.T. (1998), *Thinking: Banish Waste and Create Wealth in your Corporation*, Simon & Schuster, New York, NY.

Womack, J.P., Jones, D.T. and Ross, D. (1991), *The Machine that Changed the World: The Story of Lean Production*, Harper Collins, New York, NY.

Yamaji, M. and Amasaka, K. (2008), "New Japan quality management model: implementation of new JIT for strategic management technology", *International Business & Economics Research Journal*, Vol. 7 No. 3, pp. 107-14.

Yang, K. and El-Haik, B. (2009), *Design for Six Sigma: A Roadmap for Product*, McGraw-Hill, New York, NY.

Zairi, M., Letza, S.R. and Oakland, J.S. (1994), "Does TQM impact on bottom-line results?", *The TQM Magazine*, Vol. 6 No. 1, pp. 38-43.

Zink, K.J. (2007), "From total quality management to corporate sustainability based on a stakeholder management", *Journal of Management History*, Vol. 13 No. 4, pp. 394-401.

Further reading

Luebbe, R.L. and Snavely, B.K. (1997), "Making effective teams decisions with concensus building tools", *Industrial Management*, Vol. 9 No. 1, pp. 6-17.

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