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Enhancing the Future Impact of Six Sigma Management

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Abstract: Though Six Sigma has proven to be an effective framework for performance improvement in a wide variety of industries for many years, the future development of Six Sigma needs to be explored. In this paper, we briefly review the background and development of Six Sigma and suggest ways to enhance and extend the effectiveness of Six Sigma in the coming years. We propose the future development of Six Sigma from three perspectives: strategy, integration and innovation. Some challenges are addressed for Six Sigma's spreading to service systems. Research shows that when Six Sigma becomes more pervasive and inclusive, it will offer opportunities for excellence in performance in the production of goods and services in a wide variety of businesses.

Keywords: Continuous improvement, DMAIC, organizational excellence, quality management, Six Sigma.

1. Introduction

More than a quarter of a century after its inception, Six Sigma can be considered a mature framework for performance improvement – as for maturity assessment at the organizational level, see He [20]. Traditionally, the Six Sigma framework is understood to be motivated by the need to improve manufacturing processes and has gained its popularity after successes at large corporations; however, after years of propagation and practice, Six Sigma has been subject to a wide variety of interpretations in industry. A transnational comparative study among Netherland, UK and USA conducted by Iwaarden *et al*. [25] shows that although a body of knowledge has been developed which centers around standardized methodologies, the approach to Six Sigma varies among organizations. Some use it as a general quality philosophy, while others use it as a statistical tool only. The variation in understanding and implementation results in differences of Six Sigma benefits as well as the sustainability of Six Sigma programs. It would be useful at this juncture to take stock of the overall journey that has been taken in the name of Six Sigma, with an examination of what it might take to make Six Sigma continue to be effective and relevant in the coming years.

2. Evolution of Six Sigma for Quality

There are many published papers on how Six Sigma has been developed (Schroeder *et al*. [36]; Goh [16]; Montgomery and Woodall [32]). Some also present thoughts on the future directions of Six Sigma (Antony [1]; Kwak and Anbari [28]; Bisgaard and De Mast [4]). It is always a challenge to forecast the future of any management methodology,

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especially one that has been understood in many ways and has been subject to various interpretations. Six Sigma was first motivated by the need to improve quality to meet customer demands, so when it comes to speculating the direction of development of Six Sigma, one tends to consider the future direction for Quality. Almost twenty years ago, in 1996, the American Society for Quality (ASQ) gathered a number of quality experts worldwide for a "Future of Quality" study, selecting major factors that would affect the future and speculating the impact such factors might bring to the world and hence the direction for future quality practitioners. Thereafter the exercise was conducted on a triennial basis, each time pointing to key factors that might affect Quality, such as globalization, social responsibility, rapid social reform, ageing population, innovation, and so on. Such exercises do have their place for the quality professionals, but the factors identified tend to be "macro" in nature, and their significance in societal development far exceed their direct impact on the quality profession *per se.*

Six Sigma originated from Motorola in 1986 arising from the need to improve product quality and face competitions, with customer satisfaction and business competitiveness as the objective. With Six Sigma implementation, the company won the Malcolm Baldrige National Quality Award in 1988. Thereafter the company's sales volume, profits and share prices increased. With the success of Six Sigma at companies such as Allied Signal, Wall Street started to hear about Six Sigma. In the mid 1990s, Jack Welch at General Electric (GE) provided the best example of leadership and corporate-wide initiatives for Six Sigma. Gradually Six Sigma is not just about statistical tools, though statistical thinking is its backbone; it is not just about quality improvement, but implemented with a view to core competitiveness of a corporation. Further details are described by Harry and Schroeder [19] and Hahn *et al*. [17].

Following the remarkable success of implementation of Six Sigma at General Electric, Six Sigma was noticed, accepted and implemented by many other corporations. Today, the applications of Six Sigma have gone beyond Motorola and GE to the world, from the West to the East, from Fortune 500 multinationals to common organizations, from manufacturing to service industries such as banking and healthcare. Six Sigma has been recognized not just a way to improve quality but as a management concept and systematic approach to continuous improvement, strengthening leadership, enhancing customer satisfaction, increasing profits and business competitiveness. Six Sigma's DMAIC has gained popularity though it may not be very effective for ill-structured problems (De Mast and Lokkerbol [11]).

3. Ingredients of Six Sigma Successes

From the historical development of Six Sigma, it can be seen that while Six Sigma concepts originated from Statistics, and as a management framework for continuous improvement it has gone far beyond its statistical contents. Many previous authors have discussed the key elements of Six Sigma (Hahn *et al*. [17]; Kwak and Anbari [28]; Shroeder *et al.* [36]), but obvious similarities can be seen between what Six Sigma entails and the quality gurus of the past have advocated. For example, Shewhart and Deming's Plan-Do-Check/Study-Action (P-D-C/S-A) cycle as well as Juran's ten steps for quality improvement are mirrored in Six Sigma DMAIC implementation – especially the latter, which is worth being recalled here (Juran and Godfrey [26]; Brady and Allen [6]): 1, Build awareness of the need and opportunity for improvement; 2, Set goals for improvement; 3, Organize to reach the goals; 4, Provide training; 5, Carry out projects to solve problems; 6, Report progress; 7, Give recognition; 8, Communicate results; 9, Keep score of

improvements achieved; 10, Maintain momentum by making annual improvement part of the regular systems and processes of the company.

Six Sigma, though built upon what is largely known to the quality profession, ensures its remarkable effectiveness essentially on three counts: first, a relentless top-down approach (which is diametrically different from the philosophy of believers of Quality Control Circles or QCC); secondly, emphasis on project selection and attention to a project's strategic value to organizational goals and thirdly, the prevalence of statistical thinking in all improvement projects, in conjunction with a more structured and systematic approach. It must be understood that while the Six Sigma framework might initially appear novel, there is nothing in its implementation that could be construed to be against the teaching and admonition of quality gurus such as Deming (Deming [12]), Juran (Juran and Godfrey [26]), Feigenbaum (Feigenbaum [14]) and so on. Detractors of Six Sigma might focus on analytical aspects such as the "1.5 sigma shift", but never on the concept of variation reduction and decision making based on analysis of factual data.

4. Academic Research on Six Sigma

Literatures on Six Sigma have two categories: practitioner literature and academic literature. Most early time literatures were from practitioners and focused on application. In many areas of engineering and management, academic research is often the harbinger of new or improved products or applications. Compared with the widespread practice of Six Sigma in the corporate world, there was a relative lack of attention paid to Six Sigma in academia before the year 2000. Early literature on Six Sigma before comprised mostly elaboration of what it is, and more research-oriented works tended to focus on questions such as its nature in contrast to past frameworks such as Total Quality Management (TQM). After 2000, there was considerable increase in research on Six Sigma in tandem with its rapid spread and acceptance in industry, such as what is reported in the *Journal of Operations Management* (JOM) - as in Linderman *et al*. [29], Zu *et al*. [41], and the *International Journal of Production Economics* (IJPE) – as in Chakravorty [9] and De Mast and Lokkerbol [11]. A detailed account of the literature was given by Brady and Allen [6]. Generally, published Six Sigma papers may broadly be categorized as follows:

4.1. Case Studies

Six Sigma case studies, scattered in various journals, are made up of two types, one relates to transformative outcomes at the corporate level (Goel and Chen [15]; Kumar *et al*. [27]), the other concerns specific problems in technical or management areas (Hsu *et al*. [23]; Sohoo *et al*. [37]; Su *et al*. [38]). Many accounts appeared in engineering journals are aimed at technical personnel for an understanding of Six Sigma from a problem-solving perspective. Most literatures in this aspect are mostly practical.

4.2. Study of Theoretical Advances

This concerns mainly the basic framework and its development in the context of Six Sigma, and often touches upon the relationship between Six Sigma and other management models, in both theory and practice – see, for example, Schroeder *et al.* [36], Linderman *et al.* [29] and Zu *et al.* [41].

4.3. Research into Success Factors and Models of Six Sigma Implementation

Many such studies are conducted from the systems perspective, and quite commonly made use of survey results. The interpretations could also range from the strategic to the tactical level, see Chakravorty [9], Pande *et al.* [33], Sanders and Hild [35] and Breyfogle III *et al*. [7].

4.4. Research into Six Sigma and Innovation

There are continuing controversies and different opinions concerning whether Six Sigma adds and takes away the spirit of innovation, though there have been a number of companies using Six Sigma as the motivator for management innovation (Antony [2]; Montgomery [30]; Montgomery [31]; Hindo [21]; Hargadon [18]; Hoerl and Gardner [22]; Yang *et al*. [39]; Bisgaard and De Mast [4]). Just as Box and Woodall [5] pointed out, Six Sigma and quality tools can be used to manage risks in innovation and Six Sigma tools, especially designed experiments and Design for Six Sigma methodology are widely used in product and process design and innovation. The reason for the controversies is the different people still have different understandings about Six Sigma. Six Sigma has gone well beyond its early stage of defect reduction. Montgomery and Woodall [32] divided Six Sigma into Generation I, II, and III respectively and made a very good comment on Six Sigma and innovation.

4.5. Research on Six Sigma Project Selection

As Six Sigma project selection is by itself related to multi-criteria decisions, some have made use of formal procedures such as multi-criteria decision methods in the project selection processes and started a direction for research: e.g. Yang and Hsieh [40], Büyüközkan and Öztürkcan [8].

4.6. Study of Integration of Six Sigma and Other Management Models

This is exemplified by Six Sigma and lean production; there is room for enriched Six Sigma through the combination of DMAIC/DMADV (Define, Measure, Analyze, Design, Verify; a typical Design for Six Sigma (DFSS) process. Some companies may use other DFSS processes) and other frameworks such as quality management systems, supply chain management, balanced score card and so on: see Hwang [24], De Mast [10], Ehie and Sheu [13], Arnheiter and Maleyef [3] etc. As De Mast and Lokkerbol [11] pointed out, Six Sigma is a generic, but there is no a single authoritative account of the DMAIC method. With extended application of Six Sigma, the DMAIC method is, as all problem solving method, subject to power/generality trade-off, which has first resulted in an evolution towards more generality (beyond manufacturing and variation reduction), and later into a large number of domain-specific adaptations. For some Six Sigma project, it can be powerful to integrate Six Sigma with other management models or methods.

Thus, in no small way, Six Sigma owes its continuing popularity by continually integrating its systematic and structured framework with whatever methodology a particular industry finds useful; the result is a fortified approach to achieving excellence that none of the lone component is able to match. As is also discussed in the next section, this will be an important mode in which Six Sigma will sustain itself.

5. Future Evolution of Six Sigma

Perhaps the term Six Sigma will be replaced by some other names one day, but the concept of continuous improvement in management initiatives will never become out of date. The future of Six Sigma depends mainly on two fronts: one, whether Six Sigma can bring about continuous benefits for an organization; two, whether Six Sigma itself is capable of absorbing and integrating other management thinking and tools to further its prowess.

From a high-level perspective, the key words determining the evolution of Six Sigma are: strategy, integration and innovation.

5.1. Strategy

While Six Sigma is a methodology for systematic and rigorous solution of problems, experience in its implementation points to the fact that its results often proved to be short-term and non-sustainable. As literature study shown by Brady and Allen [6], top management commitment is the first and most important factor for Six Sigma success. High profile, high-level leadership recognition is needed of the fundamental objective of Six Sigma, namely establishing a long-term sustainable management model that in turn becomes a core source of competitiveness ingrained in the organizational culture. The organization in turn would realize, through Six Sigma, management innovation, technical innovation, human resource development, corporate culture formation and so on. Only by implementing Six Sigma at the strategic level could organizational buildup and continuous improvement be assured.

Implementing Six Sigma at business strategic level requires top management have their strategic goals and develop a plan to achieve these goals through Six Sigma. A good example is Tiayuan Iron and Steel Corporation (TISCO), the largest stainless steel manufacturer in China as well as in the world. Its strategic goal is to build the world's most competitive stainless steel producer. Before implementing Six Sigma at TISCO, the top management realized that TISCO had two major obstacles through benchmarking: low product quality and low management capability. TISCO decided to overcome these obstacles through Six Sigma and deployed it at strategic level in 2005. It developed a 5-year plan every five years and annual plan for Six Sigma implementation. Through Six Sigma TISCO achieved great successes in terms of quality improvement, management team development and sustainable development and won China Quality Award. Now Six Sigma becomes corporate culture of TISCO.

5.2. Integration

As commented above, the integration of Six Sigma with other management models and methods has been the focus of research on Six Sigma and practical implementation, which will continue to be the trend. There are three essential dimensions in the integration of Six Sigma management, as shown in Figure 1 below.

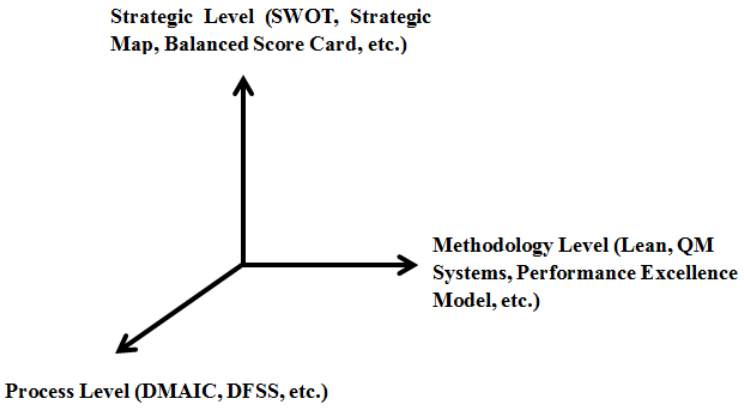

Figure 1. Three dimensions in the integration of Six Sigma.

At the strategic level, to help an organization realize its strategic goals, project selection in Six Sigma must take the organization's objectives fully into account and secure opportunities for improvement through such strategy and analysis of key process indicators (KPI); such opportunities will then constitute the direction of the Six Sigma project. SWOT analysis, business strategy map, balanced scorecard etc. can be useful tools for identifying opportunities for improvement from strategic point of view.

Though there exists body of knowledge (BOK) of Six Sigma (e.g. ASQ's BOK of Black Belts), it's rather difficult to limit the scope of Six Sigma tools. In fact, at the methodology level, Six Sigma toolkits should be open in nature, so that Six Sigma can be integrated with many management theory and methods such as lean production, quality management systems, performance excellence model, supply chain management, theory of constraints and so on. An increasing number of corporations are now implementing what is labeled as Lean Six Sigma; however, the concept and practice of "lean" should already have been taken into account in a serious Six Sigma organization.

As for the process level, even though the DMAIC approach is rigorous and effective, the deployment of it improves only existing processes, whereas impacts are found in terms of quality, costs and cycle times in the design of a product or a service. More companies now start with DFSS which is likely to be the focus of Six Sigma research from now on.

5.3. Innovation

As a system for enterprise innovation and continuous improvement in an enterprise, Six Sigma has two distinct characteristics: first is in the management model, where Six Sigma makes good use of the integration of planning and execution, via the leadership and participation of top management to promote areas such as process optimization, continuous improvement, knowledge management, supply chain management; second is the operating methodology itself, which gathers management thinking, methods and tools together in an effective manner to offer an operable technical roadmap, resulting in integration and innovation as progress is made. Now Six Sigma methods are widely used for developing new products and services that reach new and broad market; that is, for innovation (Box and Woodall [5]). The future of Six Sigma depends on that if our understanding of Six Sigma can go beyond its old metric meanings. As Montgomery and Woodall [32] pointed out, this metric is nonessential aspect of the Six Sigma process improvement and product design frameworks and is now doing more harm than good.

6. Spreading to Service Systems

An important direction for the impact of Six Sigma to be further felt is the application of improvement initiatives to service systems. Many researchers start with the seminal work of Parasuraman *et al*. [34], but a host of challenges associated with the application of Six Sigma to service systems remain, some of which are as follows:

(1) The definition of "Critical to Quality" or CTQ index is usually not straightforward: customer expectations as a rule are personal and subjective, hence difficult to prescribe and measure.

(2) Consequent to the above is that what constitutes a defect or defective might not be easily defined, and seldom does a service transaction belong to two well defined states.

(3) The recognition of defects or defectives could be delayed, and there is a lack of symmetry, i.e. a non-defect or non-defective is often less noticed.

(4) Service processes as a rule require more customization and their outcomes are locality dependent, thus do not lend themselves readily to standardization.

(5) Common factors in manufacturing such as the role of raw materials or inventory management might be irrelevant or inapplicable.

(6) Rather than material flow, transformation and utilization of information tend to be important considerations.

(7) For problem solving, system boundaries and constraints could be difficult to identify.

(8) Effects of noise, i.e. disturbances from unknown and/or unwanted sources, could be unexpected and/or significant.

(9) Customers themselves could be voluntarily or involuntarily involved (for example, in the planning of vacation via information on the net, or a DIY purchase of a commodity with on-line payment as the only option).

(10) Lifestyle, values and cultural factors could be involved in "customer satisfaction" assessments.

(11) With the above considerations, attempts to calibrate and benchmark a process could be inaccurate, impossible, or simply meaningless.

(12) Original Six Sigma concepts such as "short-term" and "long-term" levels of performance could be even harder to evaluate in an objective way.

Thus Six Sigma Black Belts trained in handling of problems in manufacturing process might have too rigid a mind set when confronting service oriented projects. The data commonly available for service systems also tend to have statistical properties unlike those found in manufacturing. If results of Six Sigma problem-solving in service systems are found to be wanting, quite possibly the reason is not the failure of Six Sigma but the inadequacy of the tools used for their analysis.

7. Pervasive Six Sigma Implementation

A significant opportunity for the spread and prevalence of Six Sigma that has been largely overlooked is its propagation through small and medium enterprises. To-date almost all Six Sigma success stories are based on applications in large corporations, sometimes giving the impression that Six Sigma is only for large organizations (e.g. Harry and Schroeder [19]; Pande *et al.* [33]). One can understand how larger organizations tend to be trend setters and models of success, but Six Sigma has reached a stage where its efficacy is no longer in doubt, and there is no element in this methodology that suggests that it should be the monopoly of large companies and multinationals.

One important consideration in the realization of the top-down approach is the much flatter organizational structure found in smaller organizations, which actually facilitate changes in thoughts and practices. Thus, for example, Six Sigma can be swiftly put in place without the formality of arranging for initiatives from the Human Resource or Quality Department. In fact once the direction is set, needed specific resources such as manpower, raw materials, machine time for Six Sigma projects can be marshalled without the sluggishness of any in-company bureaucracy; indeed if the outcomes are good, formal change, adoption or standardization would not encounter as much "not made here" resistance as that tends to be seen in large, multi-location organizations. Thus it is time that smaller companies capitalized on their organizational nimbleness to leverage on what Six Sigma could offer.

From another point of view, owing to short production runs and short-term logistic needs, many small and medium enterprises tend to be operating with sub-optimal practices and processes. This actually presents interesting opportunities for effective Six Sigma applications. What is important is the stress on statistical thinking in problem solving; intractable situations frequently encountered by small and medium enterprises are precisely where the traditional deterministic approach should give way to statistical thinking. Again, the change in mind set is certainly less challenging in a smaller organization than what could be encountered in a multi-division, multi-cultural or multi-continental organization with its myriad of business leaders and power centers.

8. Concluding Remarks

The thrust of the discussion in this paper is how Six Sigma could continue to be recognized and used in the future, both from a high-level view and from the practice level. To-date Six Sigma has a good track record, is still embraced by many organizations, and tends to be thought of by those seeking improvements. Though no longer considered a management fad, Six Sigma could fade away like some previous management approaches it if its existence continues to be confined to its "classic" form, to large corporations and to manufacturing. In short, the deliberations here have been inspired by the vitality of Six Sigma so far, against the backdrop of its impressive success in the past.

It bears repetition that even as a mature methodology, Six Sigma still has an untapped potential for which the beneficiaries include smaller organizations, traditionally not known to be fertile grounds for Six Sigma. Further inroads into service industries are an inevitable phenomenon. Aspects of development of the Six Sigma management methodology itself have also been elaborated in this paper. Thus there is much to be expected in terms of what Six Sigma could do for business excellence in the years to come, achieved through pervasiveness and inclusiveness, not merely the mechanics of DMAIC, as the prominent feature.

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