

Analysis on Application of Six Sigma Approach in Business Organizations

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Abstract — The six sigma method is one of the popular practices that can be used to improve quality. It can be applied to business or organization to improve critical quality of services, products and operation processes. Being initiated in manufacturing industry, six sigma method has being spread and applied to various industries. To enterprises or organizations in various industry fields, it has been taking considerable time for them to contact, recognize or experience the six sigma approach. Also there are so many relevant applications and studies in real world and theorem researches. However, we're curious on all the cases which have already applied six sigma programs of quality improvement. Whether the majority of them have achieved sweet results just as those classic cases like Motorola had ever gotten, or most of them merely experienced another wave of ordinary quality activities? The purpose of this study is aimed to know the real situations faced by business organizations of various fields during applying and implementing the six sigma method. Comparing to all past various quality improvement activities the enterprises and organizations had ever attended, do their current attitude for performing six sigma method can really help coming out an expected significant quality improvement? For possible applications of six sigma concepts to refer in the future, this study also concludes major deficiencies appeared during past application of six sigma techniques in various industry areas.

Keywords—Business organization, Quality improvement, Six sigma, Statistical process control, Structured procedure.

I. INTRODUCTION

Six sigma is a process improvement tool, a kind of program and a set of concepts arising from the quality improvement actions developed by Motorola [1] [2], and followed by some well-known enterprises such as Allied Signal and General Electric (GE) in mid of 1990s. After vigorously promoting this management thinking and improvement program, the quality of their products and operations was greatly enhanced. Also the quality cost was reduced as well in these companies and thus created considerable income. Six sigma method of quality improvement thus attracts much awareness from many industry sectors and forms a new wave. It's become very popular and draws more and more enterprises joining the ranks of six sigma programs for quality improvement.

There has been decades of experience of promoting six sigma concepts in many countries of the world. Through the promotion from many official departments of industry management, non-governmental organizations and management consultants companies, large numbers of business organizations have joined this continuous boom to promote implementation of six sigma program of quality improvement. These enterprises and organizations allocate resources on staff education and training projects, and ask their employees learn the concepts of six sigma and its improvement techniques. They all naively expect being satisfied with excellent outcome on the day of project closure.

With respect to all the past programs of quality improvement that most enterprises have ever performed, the six sigma method particularly emphasis its verification on the performance goal achieving of six sigma level in statistical meaning beside the dedicated procedure for improvement. In accordance with inherent concept of six sigma, the improvement actions for achieving quality goal must be continuously facilitated and tracked until target of six sigma level is fully achieved. Also, the final outcome must be strictly verified before program closure can be declared. Most of all, the threshold of defect rate for project closure is 3.4 DPMO (Defects per Million Opportunities) according to six sigma level of statistical requirement. DPMO means the number of defects detected per million samples, which conception is equivalent to commonly used term PPM. For most industries of common operation level, to achieve this world-class quality goal of 3.4 defects in one-million samplings is really not so easy. Not to mention all the uneven enterprise participants from various industries under this six sigma boom.

This study aims to explore the practice status of implementing six sigma projects in enterprises and organizations of various fields. What we concern is whether these companies can fully achieve highly expected accomplishment per six sigma thinking after contact of six sigma concepts and techniques for so many years. The following content in this paper will explore first the literature of six sigma development. Then, a study will be proceeded and focus on the important connotation of six sigma method for quality improvement.

A broadly survey and comment on the practice of six sigma method applied by various industry fields for solving quality issues is performed in the next. Finally, a summary aims to conclude this research.

II. DEVELOPMENT OF SIX SIGMA

Six sigma is a powerful approach to improve critical quality of services, products and processes. It uses advanced statistical method and techniques to detect and remove process variants and thus to elevate key performance to a high class level [3]. The concepts of six sigma help us to realize an important fact. It is revealed that there exists an indivisible direct link between nonconformity of key performance and quality cost waste and customer satisfaction as well. The six sigma method, a powerful tool with statistics sense for quality improvement, provides a solution and helps companies to strongly intervene and find out a breakthrough point between enterprise profitability and quality. Rigorously applying six sigma can help enterprises to pursue a world-class level quality [4] [5]. After the rapid booming of six sigma method in manufacturing industry, many enterprises of various industry sectors have been consequently following this big trend and practically promoting this quality improvement method. In addition, it also attracts academic community and leads to a considerable number of researches on this topic. Most of these studies focus on the inherent meaning of six sigma, the possible scale of impact made by six sigma on operation performance, etc. [6] [7].

Six sigma method of quality improvement includes a DMAIC procedure (Define, Measure, Analyze, Improve, Control) of 5 steps as its management model [8]. Kwak and Anbari [9] extensively investigate the benefits that organizations can receive after successfully applying six sigma. And, they also find out the obstacles that enterprises might encounter in the stage of phasing in six sigma programs. They conclude that if an enterprise want to successfully use six sigma method to further enhance company's operations, the most important keys should include involvement of senior managers, organizational support, capability of project leaders or promoters, change of corporate culture, and continuous implementation of staff training and education. Zu, et al. [10] insist that the organizations shall earnestly do all-round implementation of the six sigma procedure of steps. Correctly positioning and implementing six sigma's structured improvement procedure will make it very different from all of the past traditional quality improvement methods. Otherwise, it will just wrap the traditional quality management programs to another appearance.

In addition to being applied to improve existing processes or products quality, six sigma concepts have also been further extended to helping new product development. For the management of new product development process, six sigma management practice has been developed and named Design for Six Sigma (DFSS). DFSS is a six sigma approach developed for the management of new product development process [8]. It proposes a procedure of 5 steps architecture named DMADV (Define, Measure, Analyze, Design, Verify) for new product development to follow. Applying DFSS on product or process development will enable enterprises to provide brand new products and processes which characteristics are more powerful, more reliable and more efficient [11].

Six sigma techniques are also further combined with the concepts of lean production, and then develops lean six sigma. Lean production is a systematic method for waste minimization. Lean production itself has originally built a lot of tools for quality improvement. Combining lean with structured improvement procedure of six sigma, lean six sigma provides an excellent result of continuous improvement and conceptual integration [12]. Näslund [13] argues that the development of both concepts of lean and six sigma are gradually replacing the trend of JIT and TQM. His research also reflects what most deficient enterprise organizations really need during their reformation or improvement are systematized information exchange and full communication. These critical needs are just claimed by lean and six sigma. Snee [14] claims that lean six sigma is capable of promoting improvement of business processes, and sustainable development through its goal and method setting. He declares that the six sigma, with its development of data-based process management system, is a powerful tool to develop leadership ability of improvement, and help organizations to create cash in times of economic hardship.

Six sigma is an approach of quality improvement. It shall be collaborated to other quality standards for implementation, since it's not an independent management system. Appropriate use of six sigma method can reduce defect rate of processes and products, cost of deficient quality, and enhance customer satisfaction. Nevertheless, it's very important to properly select the performance items to facilitate six sigma program. Improper applications and projects selection may lead to counterproductive and waste organization's resources [15].

III. THE CONNOTATION OF SIX SIGMA METHOD

As the name of six sigma method emphasizes, the verification criteria of six standard deviations level in Statistics viewpoint is the most important requirement of the method. It's also needed to make continuous effort to improve and achieve the ultimate goal. This strict thinking is the main reason for so much admiration attracted by this approach. The full implementation of six sigma method of quality improvement should be able to take into account two key elements. One is to comply with the structured improvement procedure of 5 steps, and another is to verify final outcome (Refer FIGURE 1). After implementing all improvement actions, the final result of nonconforming rate shall be officially verified. The threshold setting for performance verification must adhere to meet the request of six standards deviations control level in statistical sense. Otherwise, this new approach will be reduced to just re-pack the traditional quality improvement methods, and will be no big difference to so many common activities of quality improvement in the past.

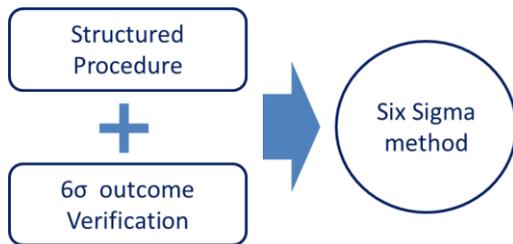


FIGURE 1. CRITICAL ELEMENTS OF SIX SIGMA METHOD

In six sigma approach, the main requirement for the process of improvement is named DMAIC procedure. Here we first illustrate this DMAIC procedure of improvement. Generally speaking, DMAIC refers to five steps: Define, Measure, Analyze, Improve and Control (Refer FIGURE 2) [8]:

Step 1. D – Define: Understanding the issues to be addressed, and defining the scope and objective for quality improvement.

Step 2. M – Measure: Identifying real key performance indicators of the quality problem. Setting objective for the performance to pursuit and planning measurement instruction, then collecting data to reflect the status quo.

Step 3. A – Analyze: Analyzing the data with statistical and quality control techniques to determine the variation. Then, paying attention to find out the real main causes of the quality deficiency.

Step 4. I – Improve: Planning improvement plan after considering all possible impacts from the causes of quality problem. Then, proceeding to implement the plan and verify its outcome.

Step 5. C – Control: Phasing in control activities for the effective practices that have been justified with validation. Proceeding standardization for these corrected operations to ensure its continuing implemented.

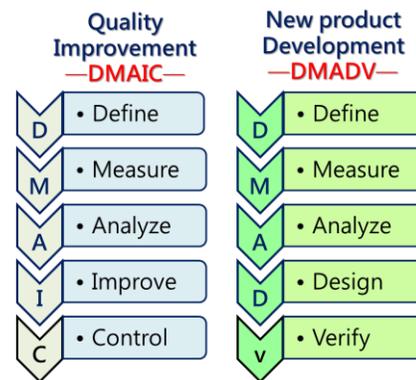


FIGURE 2. THE DMAIC PROCEDURE OF SIX SIGMA METHOD

In addition, with the spread of six sigma concepts, a new product development process management method DFSS (Design for Six Sigma) is proposed soon after. It is proposed specifically for the design processes of new service or new product development. According to its planning, the whole development processes of new product contains a DMADV procedure of 5 steps including Define, Measure, Analyze, Design and Verify [8]. Here we describe it as follow:

Step 1. D – Define: Understanding the strategy objectives of product development and defining customer needs.

Step 2. M – Measure: Determining measurement methods for quality performance items, production process control parameters and risk assessment items.

Step 3. A – Analyze: Analyzing the whole design content, and evaluating design techniques. Then selecting the best design alternative.

Step 4. D – Design: Implementing full design. Proceeding a rigorous review and check for all stages in the whole design procedure.

Step 5. V – Verify: Verifying all of the final functions, characteristics and quality of this new design. Justifying the production process planning and then transferring it to production line.

As to the requirement on final quality outcome, the aimed performance shall fulfil both precision and accuracy requests in the statistical sense. That implies the standard deviation of the quality characteristic measurement shall be substantially reduced, no matter it's for process or product improvement. For final result that has been fully improved, measurements of the key quality characteristics of interest shall be highly concentrated. So that the space between the nominal average line and the nearest specification line shall be able to accommodate at least six standard deviations (Refer FIGURE 3). Therefore, under the assumption of possibly maxima deviation of 1.5 standard deviations, the substantial nonconforming rate can be reduced to below 3.4 PPM (or DPMO) (Refer TABLE 1).

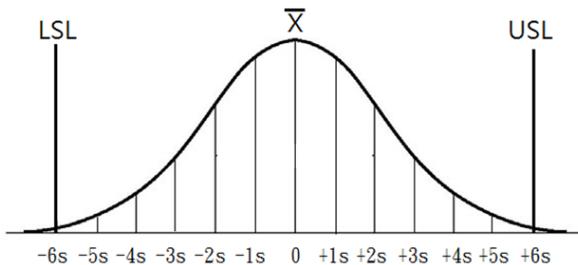


FIGURE 3. THE SIX STANDARD DEVIATIONS SYSTEM

**TABLE 1.
THE INFLUENCE OF SIGMA SYSTEM ON QUALITY PERFORMANCE**

Sigma	Defect (PPM)	Yield (%)	Cpk
$\pm 1\sigma$	691462	30.85380	0.33
$\pm 2\sigma$	308537	69.14630	0.67
$\pm 3\sigma$	66807	93.31930	1.00
$\pm 4\sigma$	6210	99.37900	1.33
$\pm 5\sigma$	233	99.97670	1.67
$\pm 6\sigma$	3.4	99.99966	2.00

IV. THE PRACTICAL APPLICATION OF SIX SIGMA METHOD

The six sigma method is well known in the field of manufacturing quality management. There are numerous management consultants have planned plenty of courses and strongly recommend to enterprises and organizations. In addition to expanding their business scale, but also leading to broadly applications of six sigma method to various industries. Many college schools also create six sigma courses for students to select. All these trends make six sigma methodology a famous doctrine in quality management.

According to a survey conducted by Antony, et al. [16], there are a large number of small- and medium-sized enterprises participate in this six sigma boom.

But, there are really few cases can get real praise for their success after their implementation on these programs. The study also found that many companies involved in the six sigma programs did not really care about or expect its possible outcome of quality improvement. Neither did they put enough resource to support the operation of these projects. Other related concepts such as the lean six sigma did not get much attention from these small and medium enterprises, too. The study concludes and claims that the close participation of managers from higher level, as well as effective connecting six sigma concepts with the customer needs and business strategy, are the critical factors for success of six sigma method deploying in small- and medium-sized enterprises.

Six sigma has been recognized as a good quality improvement method in manufacturing industry since it initially appeared in mid of 1980s. But its application in the service industry is still in the initial stage of development. According to the broadly survey by Chakrabarty, et al. [17], the structured improvement procedure of six sigma can indeed benefit significant improvement in service industry, though it's really slow in applying to various service industry fields. Beside its rapid development in manufacturing industry, six sigma approach has also been applied to many fields of service. Since focuses of concerning are different between manufacturing and service industries, the development of six sigma is different [7]. For instance, six sigma concepts have been applied to health care [18] [19]. In medical care field, there exist many operations which allow no mistake. That means an irreparable regret will be induced once any mistake occurs. In circumstance of strict operating characteristics like that, six sigma method is expected to have a broader development space to perform its capability on high quality improvement. In addition, six sigma concepts has also been applied to software industry. Through gradually developing and defining important quality attributes in software industry, six sigma techniques can be applied to the special environment of software industry area as a powerful tool and technology in quality improving [20].

Six sigma method has been booming in business community for decades. There are a few large enterprises can successfully drive their performance improvement with implementing six sigma programs. However, although there have been a considerable number of business organizations joining the immense wave of six sigma improvement programs, the real improvement on their business is still doubtful. Do the substantial benefit created from practical application of six sigma in these companies can really fully achieved as it should be?

The answer of this question may be not so optimistic. Looking at all the practices in general business organizations and application researches, the common significant deficiency in application of six sigma can be classified into the following. Any one of the following major flows on implementation will make a six sigma project eventually fails on quality improvement.

(1) *Merely emphasizing on following the steps of improvement procedure, whereas ignoring the strict confirmation on performance goal achieving:* An interesting common phenomena is found. A lot of literature on case study of applying six sigma shows that they merely focus on one thing, the following of DMAIC steps. They may have a paranoid thinking that following the DMAIC steps is equal to fully practice six sigma techniques of quality improvement, and thus do not pay more attention to verify the necessary yield rate after improvement implementing. It reveals that, to some extent, these project teams are just only anxious to finish all steps of program implementation as soon as possible. Such attitude will not substantially benefit the quality improvement, but only waste the opportunity cost of time of team participants. This situation also reflects that the cohesion within this kind of organization may have a serious problem.

(2) *Performance goal setting do not follow the required level of six sigma control in Statistics viewpoint:* Part of enterprise organizations which implement six sigma programs of quality improvement really can find out the critical performance items to be improved, in addition to accordingly following the required procedure of six sigma improvement. But, unfortunately, they do not insist on setting a justified performance goal for project team to pursuit with continuously improvement. That means a threshold of six sigma level of statistically control for nonconforming rate to achieve. So that, the whole six sigma programs for these companies had been improperly closed before further proposing a series of improvement actions to achieve ideal performance goal. Accordingly, they failed to achieve the ideal performance goal of six sigma level. It is regrettable that the quality improvement projects failed to achieve the ideal goal and were not able to continue to seek better improvement actions, so that the ideal goal of the six sigma approach should not be fully exploited.

(3) *Improperly choosing a noncritical performance item to improve:* Another common situation is about the object selection for performing quality improvement.

In fact, not all of the quality problems are suitable for six sigma approach to improve. Since the six sigma method usually needs a great collaboration effort from project team and takes much more opportunity cost as well, it is more suitable to facilitate only on the real critical performance items of process or product. The quality issues of noncritical performance items in general do not necessarily require such a high level of improvement. This partiality concerns about organization cost and resource efficiency. In general, for a business organization which performs six sigma improvement project, the involved team sometimes makes a myth of misunderstanding. They might only nominally keen on performing a six sigma program. They might reluctantly come up with a not so important theme to drive, and thus lose the pragmatic meaning of six sigma method of critical quality improvement.

According to Antony's survey on UK service organizations which have already introduced six sigma activities, their defect rate of the improved performance is about 98 DPMO [21]. This performance level is far worse from the expected 3.4 DPMO that shall be achieved under six sigma control per statistical viewpoint. Indeed, it is not easy to enhance quality to a high class threshold required by six sigma. In addition to a good quality management capability and practice, the technical level restrictions also created harsh obstacles. Anyway, basing on the pragmatic and implementation level of six sigma, the genuine recognition and actual participation of the senior managers are the keys to the success of these activities. The project manager must be able to well implement the project's control and allocate plenty of necessary resources such as infrastructure and finance. Also the program leader or project manager shall be able to induce enthusiasm and confidence of the participating members as well. Then, they can have the opportunity to make this quality improvement activities to be truly successful.

V. CONCLUSION

Six sigma approach of quality improvement have been well-known and admirable. One of the main reason is due to its rigorously structured procedure planned for quality improvement. The even more important one is the focus of requiring continuous taking actions for improvement and the final verification on the performance outcome. The key performance shall be verified per a world class standards of six sigma level in statistical sense before the project can be closed. That is the very reason of it's named as six sigma.

However, observing all application cases and researches of six sigma method in general practice of enterprises or organizations, most of which focuses only emphasis on following the DMAIC disposal steps during quality improvement process. The trouble is that most of project cases did not focus or insist on the strict verification of improved quality with highly six sigma level per statistical viewpoint. It is clear that the world class six sigma level of performance verification did not been assured with these imperfect project closures.

Yang and El-Haik, experts of design for six sigma, claim that people's power and process power are the most important factors for successfully implementing six sigma activities [22]. In the whole process of project management of six sigma, systematically strong support and participation are needed for enterprises or organizations from top to bottom. Also, full education and training for team members of project shall be continuously provided. Besides, in the process of project promotion, an extremely harsh, flexible project management and a rigorous statistics tool usage are also needed. Indeed, it's not easy to promote quality's key performance items up to six sigma level for processes or products either in manufacturing or service industry. In addition to the positive mentality of employees, somehow the restrictions and upgrades of industrial technology shall be involved. However, it will take considerable effort and cost for business organizations to promote six sigma activities of quality improvement. Therefore, the real key performance items to be improved shall be carefully selected to prevent cost waste from misplacing organization resources. Moreover, for the performance items which six sigma aims to improve, they shall be verified very carefully to conforming to the final acceptance criteria before formally closing the cases. It is necessary to have practical statistical tools on verifying the six sigma level of high quality control. Otherwise, it will just waste a bunch of manpower to complete a nonsense activity. This conclusion is worthy of paying attention for all participants of six sigma in the future. Only regarding to these concludes, enterprises may have chance to success when performing six sigma program in the future.

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