
# June 22, 2011 (Wednesday) 55th EOQ Congress

**CONCURRENT SESSIONS** **Wednesday 8:30 – 12:30**
**KEMPINSKI HOTEL CORVINUS** **Erzsébet tér 7-8, Budapest V.**

**REGINA BALLROOM I.** **Wednesday 11:00 – 12:30**

## 18.1. SIX SIGMA AND LEAN MANAGEMENT

**Session Chair:** ***Charles Aubrey****, Anderson Pharmaceutical Packaging an AmeriSource Bergen Company, USA*

**11.00 Six Sigma as a Change Agent in Quality Management**
*Thong Ngee Goh, National University of Singapore, Singapore*

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Professor T. N. Goh from Singapore earned BE (Bachelor of Economics) with Great Distinction, University of Saskatchewan, Canada, 1969; PhD, University of Wisconsin, Madison, USA, 1973. He has been Professor at the National University of Singapore where he was earlier Head of the Dept of Industrial and Systems Engineering; Dean, Faculty of Engineering and Director, Office of Quality Management. He is now Academician, International Academy for Quality (IAQ); Fellow, American Society for Quality (ASQ); Honorary Member, Singapore Quality Institute; he was also Founding President of the Institute of Industrial Engineers, Singapore. His professional and research areas include: Quality Management & Quality Engineering methodologies, Six Sigma and its derivatives such as Design for Six Sigma and Lean Six Sigma: applications to manufacturing and service as well as Manpower Development.
He was awarded a lot of honors, e.g. in 2010 theHarrington-Ishikawa Medal from the Asia-Pacific Quality Organization. He has more than 300 referred papers in quality and technical journals and conference proceedings; he authored or co-authored four advanced books on quality and has served on editorial boards of ten international technical journals.

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# Six Sigma as a Change Agent in Quality Management

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***Summary:***

Six Sigma as an organizational quality improvement framework has taken industry by storm for almost a quarter of a century. Together with its derivatives and extensions, notably Design for Six Sigma (DFSS) and Lean Six Sigma (LSS), Six Sigma has a unique and important background, namely it is not the crystallization of academic research but an outcome arising from industrial imperatives. Six Sigma has therefore been promoted and propagated mainly by non-academics, unlike many other quality initiatives in the past. In more recent years, it has also been advocated for application to service systems, in contrast to various quality improvement techniques that were developed primarily with reference to manufacturing processes. While the merits of Six Sigma and its associated schemes have often been explained and cited, credit has seldom been explicitly given to one important contribution of Six Sigma, namely the change it has brought about to the approach to attaining excellence in performance. This presentation relates the important differences in quality management mindsets prior to and after the advent of Six Sigma. It is explained how, instead of the essentially motivational and behavioral approach in the past, Six Sigma stresses tangible concepts and arrangements, and has more practical procedures and methodologies than mere inspirational slogans. The paradigm shift from behaviorism to analytics, perceptible in organisations serious about Six Sigma applications, should be recognized as a remarkable phase in the history of quality management and efforts for organizational excellence: it should be so recognized because an organization stands or falls, ultimately, on the quality of the products or services it generates.

**Key words**: Six Sigma; quality management; statistical thinking; analytics; performance improvement; organizational excellence

## 1. Introduction

Six Sigma as a quality improvement framework has been known in industry for more than a quarter of a century – see, for example, Brady and Allen (2006). Today more organizations have begun to adopt Six Sigma and its extensions and derivatives such as Design for Six Sigma or DFSS (Tennant, 2002; Gremyr, 2005) and Lean Six Sigma or LSS (George, 2002). It would be meaningful to examine what makes Six Sigma or Lean Six Sigma an undoubtedly successful approach for practitioners and even more importantly, to point out the paradigm shift that Six Sigma tools have brought about in the way in which quality improvement and organizational excellence is to be achieved. In particular, the shift from the traditional behavioral angle to the down-to-earth and tangible ways for making progress is highlighted.

In this paper, the term "Six Sigma" covers the "classic" Six Sigma methodologies and all its variants including Lean Six Sigma. By now there is an abundance of literature explaining the details of Six Sigma and its general success factors, e.g. Pyzdek and Keller, 2009; Goh, 2002, 2010 and Hahn, 2005, so they will not be elaborated here. What is brought up in the subsequent sections is however seldom explicitly pointed out by these summaries and reviews.

## 2. Pre-Six Sigma quality paradigm

The impact of Six Sigma is best appreciated via a comparison of quality paradigms "before" and "after". Before Six Sigma became popular in the late 1980s, it was common – and is still not uncommon today – to see "policies" and slogans in company newsletters, banners in lobbies, posters in staff cafeterias and so on, that exhort for behavior that supposedly will lead to quality, such as:

1. *We Aim for Zero Defect!*
2. *We Work for Continuous Improvement!*
3. *Do Things Right the First Time!*
4. *Customers are Our Biggest Asset!*
5. *Quality is Everybody's Business!*
6. *Company-Wide Improvement!*
7. *Quality is free!*
8. *"In Data We Trust"!*

and so on.

These exhortations and proclamations are basically good and correct in motivation; indeed one would be hard put to find fault with any of these where the journey to organizational excellence is concerned.

For the serious minded in quality management, there might be deeper meanings in some of these slogans, but in professional courses and public relations exercises, concise tag lines and sound bites are the order of the day, and the lay man would usually go beyond

the literal meanings of such statements. However, with the advent of Six Sigma, all of these could be seen in a different light.

## 3.**Six Sigma versus Traditional Perspectives**

### *2.1 Honest view of the reality*

Six Sigma is the very framework that pronounces loudly from the outset that "The Emperor has no clothes on", i.e. that there is no such thing as a Zero Defect process. If there is any process that is said to have zero defect, then the data supporting such as statement must be either limited in applicability, i.e. the results is from a very specific physical environment, or is short term in nature. In fact statistically, it is theoretically not possible to establish, via any sample, that the mean number of defects of a population is zero.

Even if Zero Defect is merely held up as a vision or just as a guiding principle, once it is perceived as such, the motivation for achieving it could be totally lost. Indeed even before the motivation is lost, there is no commonly accepted metric for showing progress toward that impossible target. It may be said that in the real world, all efforts in performance improvement, when honestly stated, must have an aim inferior to the Zero Defect target, and any proclaimed plans to achieve a performance of non-zero defect would be viewed with suspicion if not ridicule.

Six Sigma changed all that. All Six Sigma practitioners know the 3.4 *dpmo* or "defects per million opportunities" benchmark, as well as the procedures for judging the "sigma levels" of imperfect processes. Most Six Sigma projects are about improving the sigma level of a process, i.e. from one non-Zero Defect performance to another, yet could claim success and recognition in the end by virtue of an improved sigma level.

The spirit of Six Sigma is indeed an unrelenting effort to eliminate defects, with the knowledge that there is no such thing as a Zero Defect outcome. - By the way, if there is, under the condition that "money is no object", then there would not have been an *Apollo 13* incident, just to cite one example
.

### *2.2 Concrete improvement efforts*

When a succession of Six Sigma projects strive to improve the sigma level, the spirit of continuous improvement is truly put into action. Unless there are tangible or demonstrable results, "continuous improvement" would remain a slogan: it has no beginning, no ending, possibly no identifiable owners. It is there all the time, and if nothing specific is implemented, one might simply argue that only the spirit is around: in any case, if "continuous" is the only official mode for improvement, it is unlikely that anything long-term and self-sustaining will result, not to mention any possibility of significant changes in organizational culture.

Again, this is not the case with Six Sigma. A "Six Sigma organization" – more and more companies are calling themselves Six Sigma companies in their communications with stakeholders and customers – actually ceases to be one, once it stops launching Six Sigma projects. Six Sigma advocates "project by project" improvement, which by necessity requires specifications of objectives (e.g. what kind of improvements in sigma levels), starting and finishing dates, resources required, progress reviews, and assessment of actual achievements at the end of each project.

Six Sigma is in fact this is even more pro-active than certification to standards such as ISO9000, as the certification basically is an indications that certain *prescribed* requirements have been found satisfied by the auditors in question, and that state of the organization can be expected to last for the period of validity of certification, say three years. As it has been very aptly put, "I have never seen any solid evidence that ISO/QS certification alone has resulted in reduced variability, higher yields, safer and more reliable products, or better "quality" (Montgomery, 2001).

### *2.3 Not dependent on will power alone*

As for "Do things right the first time", this is a concept which, if not supported by appropriate techniques and tools, smacks of blind belief of will power and brute-force efforts such as multiple inspection. No account is taken of the impact of ensuring, at all costs, "right the first time" on system productivity. In fact after being right the first time, one would like to know if there is anything to sustain the performance – otherwise the follow-up statement could well be "wrong the second time".

With Six Sigma, "right the first time" is never the emphasis; rather, demonstrable and sustainable improvements of the process sigma level are the key requirement; process owners will be encouraged and recognized when there is a hard-won improvement, rather than being obsessed with being "right" in every step of the way. In fact more importantly, Six Sigma entails the roadmap DMAIC or Define-Measure-Analyze-Improve-Control for process improvement, equipping anyone to do things "right more and more often" with hard techniques that usually are acquired through specialized training.

### *2.4 Explicit customer-centricity*

In Six Sigma, attention to customer needs starts from the word "go" – as it is a requirement that in any project, the sigma level must be in terms of some performance index that is "critical to quality" or CTQ. Thus the attention paid to the selection and definition of CTQ would be more than what a slogan, correct as it is, might achieve where customers are concerned. For an elaboration of CTQ determination, see Goh, 2009 for example

2.5 Recognition that Quality is not a democracy

Another attention-catching slogan that appears often in pep talks is that "Quality is everybody's business". While this is intrinsically correct, in practice there would invariably be people within an organization that have been trained more intensively, are more perceptive in problem formulation, are better communicators with people of different job background, and so on. In other words, not everyone has the same capability in using hard techniques for quality improvement.

Take, for example, the Quality Control Circle (QCC) movement. Its implantation is based on the assumption that people such as operators and supervisors on the production floor will know the problems best and are the best people to tackle them; such bottom-up approach does have its role to play, but it is hardly the case that production floor people are aware of technology changes, market requirements (e.g. as related to legal matters, environmental concerns), and business directions. The likely result is that some local optimization (or sub-optimization) gets over-rated as valuable achievements and contributions to "company-wide improvements".

In Six Sigma, it is explicitly required that professional, intensive training be given to outstanding employees of an organization so that upon successful completion of the training, they could lead improvement teams to address concerns at various parts of the organization. Depending on the positions, responsibilities and contents of training, trained personnel are given designations in a hierarchy: *Champions – Master Black Belts – Black Belts – Green Belts – Yellow Belts,* and so on. This is not unlike an army where there are Generals, Colonels, Lieutenants, Sergeants, and foot soldiers and so forth, though the chain of command and control would not be as rigorous.

With the structure for trained personnel, there can be a better match of problems and projects with the capabilities of persons assigned to them; for example, it would not be sensible to have a senior, highly trained Master Black Belt to handle QCC-type project, or a rank-and-file QCC facilitator to lead a team for complex process modeling and optimization.

### *2.6 Upfront about company-wide application*

As for the notion of company-wide improvement, this is feasible only if there is a critical mass of personnel and a reasonably complete set of understood methodologies. An isolated workshop of Quality Function Deployment (QFD) here, an occasional course on Statistical Quality Control (SQC) there, with employees "selected" to attend, for example, is unlikely to lead to company-wide appreciation or application of QFD and SQC. To implement Six Sigma, there are recommended numbers of each category of specially trained personnel with respect to the size of an organization (Harry and Schroeder, 1999); again this is akin to firepower in an army: below a certain threshold there is no point initiating a war because the chances of winning it are known to be extremely low!

Other useful ideas, such as those encompassed in the Pareto Principle ("Vital Many" and "Trivial Few") or Failure Mode and Effects Analysis (leading to "Risk Priority

Numbers"), point to the fact that there are always priority or urgent areas for attention and action in an organization. If "company-wide" campaigns are endlessly carried out, it is natural that gradually there will be a loss of focus and inevitable stretching of the limited manpower in problem-solving and trouble shooting. A "company-wide' campaign is subject for stirring speeches and in-house newsletter headlines, but the reality is that it seldom survives beyond the campaign period.

### *2.7 Six Sigma quality improvement cannot be free*

It is well known that the training of Six Sigma professionals is not cheap. Investments in people, time and money are essential for any serious Six Sigma effort. Training a critical mass of personnel is a major decision as well; in fact other than quick "demonstration" projects, "to achieve Six Sigma, an organization must endure extensive psychological changes… it takes between three and five years for Six Sigma to become entrenched in even the most progressive organizations."(Harry and Schroeder, 1999).

The needed expenditure and effort would be a major reason why publicized Six Sigma success has come mostly from large organizations, but then there can be no "free" quality without such initial investments. That is also a reason why "success stories" are less often heard from smaller organizations.

### *2.8 Application of statistical thinking at the core*

It is not uncommon to hear of statements such as "Facts based on Data", "No Data, No Talk", or even "In God we trust; the rest must bring data". While on surface such statements do render an awareness of the importance of data, they are not meant to be blindly followed where problem solving is concerned. Data refers to numbers that carry information. Data could vary in reliability (e.g. as affected by sampling techniques and methods of measurement and collection), hence it is not always true that "some data is better than no data".

Over-emphasis on data themselves tends to draw attention away from what really is needed for quality improvement, or what is generally referred to as *statistical thinking*. According to the American Society for Quality, statistical thinking is a philosophy of learning and action based on the following fundamental principles:

- All work occurs in a system of interconnected *processes*;
- *Variation* exists in all processes; and
- Understanding and *reducing variation* are keys to success.

Thus Six Sigma addresses quality problems by way of statistical thinking, with its ensuing statistical analysis, using data as the major, common medium of information. The conscious use of statistical thinking and integration of statistical tools are important features of Six Sigma that would correct the common idea that data (or statistical tools) are emphasized and used for their own sake.

## 3. Six sigma as change agent

Apart from the above changes in the thinking framework, the role of Six Sigma as a change agent may be summarized in the Table I. At least ten major items in paradigm shifts can be discerned, and most of them can be identified behind every success story of Six Sigma (or DFSS, LSS) in practice.

TABLE I. Items of paradigm shift with Six Sigma as the change agent.

| Paradigm shift | Pre-SS | With SS | Specific tools or indicators |
|---|---|---|---|
| 1 | Inward looking – focused on internal performance; seek customers to buy what is made/ what is offered as service | Outward looking – generate products /services according to what customers desire | CTQ |
| 2 | Improvement efforts are mostly technically oriented | Improvement efforts are mostly directed by business needs | Bottom line |
| 3 | Technical viewpoint and performance needs; mostly product orientation | Statistical thinking as overarching framework and process orientation | Statistical procedures |
| 4 | Disjointed application of statistical tools | Alignment of statistical tools | DMAIC |
| 5 | Individual and incompatible measures of performance | Common metric across different processes and industries | *dpmo* |
| 6 | No specific recognition of time effect | Required recognition of time effect | Short-term and long-term characteristics |
| 7 | No specific grading of improvement professionals | Clear definition and recognition of different grades of personnel | C, MBB, BB, GB… |
| 8 | Little opportunity, intention or ability to make use of computing power | Leveraging on prevalence of IT hardware and software | e.g. MINITAB |

| | | | |
|---|---|---|---|
| 9 | Static, prescriptive methodologies | Organic, growing methodologies | Six Sigma derivatives |
| 10 | Variation and waste considered in separate efforts | Variation and waste reduction simultaneously | LSS training and projects |

## 4. Ingredients for effectiveness

Six Sigma aligns and integrates statistical tools for quality excellence in a manner that has not been done before. It also emerged at the right phase of the development of information technology, with data processing hardware and software becoming prevalent at the personal level. Such theoretical and practical advantages render Six Sigma a formidable approach to quality improvement.

All the above factors lead to realization of what makes a methodology effective, as suggested by this equation:

$$E = K \text{ x } P \text{ x } I,$$

where $E$ is effectiveness of the methodology in practice, $K$ is the knowledge that the methodology entails, $P$ is the power of that knowledge, and $I$, an item too often neglected by academic researchers, is implementation.

With this simple equation, one could easily imagine the consequence of a lack of any of the three ingredients for effectiveness, and the mutual reinforcement that can be seen when all three are present and strong. Implicit in this equation is the truism that unless there is implementation, nothing effective will result.

To repeat, the intensive training of Six Sigma professionals (Black Belts in particular) brings knowledge to them and their organizations; the power of statistical thinking associated with the knowledge sweeps away the ineffective exhortations of the past, and the timely information technology makes implementation by non-statisticians possible and in fact inevitable. This has led to the "Six Sigma phenomenon" that has persisted for more than a quarter of a century.

## 6. Concluding Remarks

Six Sigma as a framework 'of industry, by industry, and for industry' has been viewed by academics as 'nothing new'. This is perhaps true if one is looking for original statistical tools, but the merit of Six Sigma lies in its effectiveness in aligning known improvement tools in a logical order, as explained in the previous section.

It is emphasized in this paper that advocating and realizing the change from "Quality by Slogan and by Motivation" to "Quality by Statistical Thinking and Aligned Methodologies" is the greatest contribution that Six Sigma has brought about to the field

of quality management, in both manufacturing and service. No comparable pervasive paradigm shifts have resulted from any other previous quality frameworks or standards. Once could well conclude that the traditional and simple-minded exhortations for better performance have outlived their usefulness. Fresh perspectives and procedures, typified by those of Six Sigma based systems, are essential for quality excellence the next phase of advancements in organizational development. Once the paradigm shift from behaviorism to analytics is achieved, a quantum jump in performance can be expected, and realization of its significance will continue to keep Six Sigma and its derivatives and extensions popular on a global scale.

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