Six Sigma and the Cost of(Poor) Quality

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Abstract

Any organization's Six Sigma program may be at high risk without heeding the lessons learned from the past and that tries to operate without a robust business foundation. A foundation that preferably should consist of stepping-stones such as a 5-S house-keeping program, an effective Integrated Management System (IMS), which includes a strong focus on planning for quality to fully capture the Voice of the Customer (VOC), and an organization-wide training scheme, as well as a reliable Cost of Poor Quality (COPQ) system. That's the best advise I can give to any organization that wishes to embark on a Six Sigma improvement program and hope to be successful. The paper will elaborate on the above issues and provide suggested solutions based on the review of published historical information and the experiences encountered over the last four decades by the author, as a quality practitioner and consultant, in industries that produced safety-critical product. This author maintains that few fundamentally new or useful things have been created in the field of Quality during the last couple of decades. Nevertheless, this paper deliberates on a number of relatively "newer" issues including the concept of "three types of customers", the CTC, "Critical To Customer" term, the eight Quality Management Principles of the new ISO 9000 family, the growth of industry-specific standards, the adoption of Integrated Management Systems, the rebirth of AS2561 COQ standard, the spread of Six Sigma as well as related ASQ certification and the need for a robust business foundation to ensure Six Sigma survival.

Key words: Six Sigma, Cost of Quality

1. Introduction

This paper is a shortened and up-dated version of that originally presented at the SAQ-Shanghai Juran Institute's Six Sigma Forum during SIF-4 (the fourth International Shanghai Industry Fair) in November 2002 and contains a historical review and some free practical advise by a lifelong quality practitioner.

As Foundation President of the AOQ-College of Juran Medallists, and on behalf of all my fellow Juran medallists, I wrote this paper with Dr. Joseph M. Juran (also a fellow Austrian by birth) on my mind. As a contribution to his 100^{th} birthday, which is fast approaching, I found it highly appropriate to draw extensively on the time-honored works of this amazing man, quality pioneer and role model. I consider much of his work as foundation material for any successful continual improvement programs such as, for example, an organization-wide IMS and / or Six Sigma program or project/s.

In relation to the necessary foundation for a successful Six Sigma program and the Cost of Poor Quality, I wish to emphasise up-front the following two points

Firstly, Jack Welch, former CEO of General Electric (GE), quite rightly insisted that all estimated, and later the actual costs, and the resulting claimed savings of all Six Sigma projects had to be validated by GE's financial management.

Secondly, Dr. Joe Juran, the Austrian-born-American, Founder of the Juran Institute and one of the earliest authorities on quality cost-collection, cost-reporting and cost-reduction methods also insists, that all defects reported by the quality function, need to be converted into the language of management. This means into Dollar values (or into your local currency) for ensuring maximum management attention and action.

Juran also highlighted the use of the Pareto principle to separate the "vital few" from the "trivial many". This helps to maximize the benefits obtained from concentrating on the few major loss-creating areas. Thus the involvement and co-operation of the two control departments existing in most organizations, that is finance and quality, will basically ensure two things:

(1) That the amount of waste, in terms of number of defects, which in most cases is compiled by the quality function, is brought to the notice of top management and

(2) That the converted and reported money value is backed-up with the credibility "normally" associated with the financial accounting function.

Note: The recent scandals caused by some of the USA, Australian and other country's financial and auditing organisations, makes the word "normally" of major importance. Six Sigma and its benefits are described by many, in a variety of ways, and here is

what Motorola University had to say on the internet. Quote: Motorola invented the Six Sigma(r) Methodology to enable business improvement in the late 1980's.The impact this methodology has on improving business performance is dramatic and well documented. Companies around the world have implemented Six Sigma and Black Belt programs to:

- Improve customer satisfaction
- Maximize process efficiencies
- Increase competitive advantage and market share
- Save millions of money in operating expenses. Un-quote.

This author wishes to add his opinion to the above statement: All the above benefits may be achieved somewhat easier and perhaps more reliably with the aid of a robust business foundation, such as an organization-wide Integrated Management System, that is supported by an effective "Cost Of Poor Quality" or "Cost of Quality" scheme.

2. Planning of programs/processes and training of personnel

In regards to planning, Asians, namely the Chinese in earlier times (and some 1500 years later the Japanese) appear to have led the rest of the world. That was at least the case in China's construction industry, which once again appears to be in an un-paralleled position, in the world, especially, when one considers the current construction boom in Beijing, due to being the host of the 2008 Olympic games and Shanghai, that was chosen just days ago, to be the host of World Expo 2010.

As a Juran Medallist and recipient of the inaugural Shanghai Magnolia Award, I feel it is my pleasure, as well as my duty, to support my preceding statement with a short extract from J. M. Juran's book "A history of managing for Quality", edition 1995, pp 18-20. Quote: "Application to architecture -

The construction of Chang-an city (now Xi'an) during the Sui Dynasty (581-618 A.D.) was an architectural miracle. Figure 1.10 (in the book) is a picture of the city plan. It was a great metropolis built in a vast piece of wilderness under careful planning and design. The area of the whole city reached 84 square kilometers in neat formation and orderly distribution and was divided in three parts to include the palace city, the imperial city and the extensive city.

Each city required high protective walls. In the palace city were palaces, imperial halls, and buildings where the emperor lived and exercised his rule. The imperial city contained the central government's office buildings. There were 11 big streets leading from south to north and 14 big streets leading from east to west. These were further divided into 108 lanes and alleys to include the official residences, people's living

quarters, and the commercial markets. There were also rivers and channels providing the city with water and drainage as well as a means of transporting goods and materials necessary for living. There were recreation sites as well.

In the course of the city's construction, 1 million to 2 million civilian workers were mobilized. Construction of this large-scale metropolis was started in June 582 and finished NINE (9) MONTH later (in March 583 A.D.). This was possible only through superb planning, design, construction, and high-level management. The architects in the Sui Dynasty had already used 1:100 ratio in designing the drawings and making the wood models. The key measurements like the area and width of the houses, the height of the pillars and platforms, and the length of the outstretching of the eaves were all marked in ratios that were clear at a glance. This shows that the technology of designing had advanced to a quantitative stage.

No doubt we all can and should learn a lot from past practices and experiences of earlier generations. To have built a city of that magnitude, in just 270 days, (using between 270 and 540 million man-days) and all this, without an electronic computer and without ISO 9000 is just incredible. Of course, they did have the abacus and they used 1:100 scales.

Now-a-days, despite the high technology and proven management techniques, productivity achievements and cycle times of that order are mere pipe dreams. Today's constraints are somewhat different and often caused by high cost and long distances. Take the world-car-concept and the global aircraft design and manufacturing partnerships. They are just two examples, where industries are virtually "forced" to plan and design on an international front, and to train the necessary human resources to a common standard well before production commences. This means that the globally enforced and ISO 9001-based industry-specific standards, QS 9000 / ISO 16949 and SAE-AS 9100 respectively, all help to ensure the full requirements are taking care of, and actual outcomes meet planned arrangements.

All projects should start with appropriate planning. Good planning is vital to achieve planned program or project outcomes. Dr. Juran stated that "All improvement occurs project-by-project, and in no other way". This philosophy, as well as some relatively modern process flow models / methods, such as the P-D-C-A cycle (Plan-Do-Check-Act) by Deming or the D-M-A-I-C (Define -Measure-Analyse-Improve-Control) phases, as used in Six Sigma, are fortunately all available for use by today's planners/ designers, Quality, Six Sigma and other professionals.

Juran's Trilogy, which encompasses the three main phases of product realization, on the other hand, has been available for many decades. The trilogy comprises, Quality

Planning (QP), followed by Quality Control (QC) and Quality Improvement (QI).

Further, for the benefit of newcomers, as well as old-timers in the field of quality and Six Sigma, this author has compiled a partial list of time-honored quality and project management tools, that may be used in the respective Six Sigma D-M-A-I-C phase/s. This has been done with the help of the excellent training material, sourced from this author's associates Rath & Strong (R&S). Note that the collection and / or control of COPQ may be applied in any of the five DMAIC phases. As for the training and competency development of personnel, ISO, ASQ, EOQ, SAQ, CQA, AOQ, R&S and AQAC are time-honored sources of training and/or certification sources. For example the ISO 10005 Guideline standard is considered a useful document to enhance the training regime associated with any organisation's management system and improvement programs.

The American Society for Quality (ASQ), has conducted since the mid 1960s, world-wide certification programs for Quality and Reliability professionals. AOQ and AQAC are still supporting the ASQ re-certification efforts for the third decade. Recently ASQ has established certification schemes and examinations for Quality Improvement Associates (QIA), Calibration Technicians (CT) and for Black Belts (BB). A scheme for Green Belts (GB) is in progress.

These certification schemes were apparently necessary to give potential employees and / or customers added confidence, that a trained BB or GB has the competence as prescribed in the ASQ- Body of Knowledge (BOK). This was reportedly triggered, by the tens of thousands of Belts in the USA, who were trained (by hundreds of Six Sigma Training organizations / Consultants / Educational Institutions), using training schemes that were not based on a nationally / internationally recognized BOK.

3. Some historical and useful aspects related to the Cost of Poor Quality and Six Sigma

This author maintains that Jack Welch and Joe Juran should be heard when it comes to Six Sigma and the Cost of Poor Quality (COPQ), respectively. The interest shown by the private and public sector, in the 15 year old topic of Six Sigma, is now very high in the West as well as in China, Korea, Japan etc, especially since the year 2000.

However, the Cost Of Quality, although having existed for over 50 years, is only now becoming more widely used, as it is becoming recognized as a vital part of the Six Sigma improvement process.

Its history can be traced with Juran's Quality Control Handbook.

Edition 1 of the "Handbook" published in 1951 already covered the Cost Of Quality.

Of course it does not cover Six Sigma, as this term was only registered 36 years later, in 1987 (around the same time when the first issue of ISO 9000 was published).

Edition 4 of the Handbook was published in 1998 and consists of 1808 pages. It refers, in more than 70 areas throughout the book, to the more appropriate term, the Cost Of Poor Quality, rather than the earlier term, the Cost of Quality. Interestingly enough, Six Sigma does still not appear in the Edition 4 index, which I believe to be the most authoritative handbook of quality ever published anywhere in the world. (For that matter, the term "Six Sigma", is not found in Volume 1 and 2 of the ISO Standards Handbook on "Statistical Methods for Quality Control", fourth edition, published in 1995, that is, some 8 years after registration of the term "Six Sigma" by Motorola.).

Edition 5 of Juran's Handbook is now available and highly recommended as the most complete single reference book on quality management covering manufacturing as well as service quality. Many others including Phil Crosby, Thomas Pyzdek and James Harrington have also written extensively about Quality Costs and/or Six Sigma.

Standards Australia published in 1982, the world's first National Standard, AS2561 Cost of Quality. This author submitted then to the standards committee an Operating Cost and Quality Cost Structure chart, that he previously created and used in the aircraft industry. This chart was appended to the Standard without change and serves as a guide to standard users over the last two decades. This can be verified by fellow Acn. Merv Burt, a colleague of mine, who also was involved in the creation of this standard. Now 20 years later, once again, this author was involved in the Standards Australia ISO 9000 / QR8 committee, when AS2561: 1982 was recommended for update and submitted as a possible basis for an ISO standard.

4. Integrated Management Systems

The recommendations in the above section on their own may not guarantee that Six Sigma survives for any time longer than Total Quality Management (TQM was one of 40 or so "flavor of the year" solutions that came on the scene and eventually faded away, at least in Australia).

In this author's opinion another pre-condition needs to be met, namely a customer focused business foundation must exist on which a Six Sigma program can thrive. This foundation may consist of a number of stepping-stones that can include the Japanese 5S-good house-keeping program, that takes care of the "low hanging fruit" (as it is often referred to in the Six Sigma language) and an ISO-based Quality

Management System (QMS) as a minimum. However, for maximum effectiveness and efficiency the organization that takes Six Sigma goals seriously and wishes to aim for best-in-class status, should preferably have a fully Integrated Management System (IMS), based on ISO Standards and guidelines, including the appropriate industry-specific standards in place. Only then can an organization really hope to maintain an all-embracing COPQ system and an Audit regime, that ensures company-wide continual improvement as well as a sustainable Six Sigma program. This could improve an organisation's chance of winning a National Quality or Excellence Award and then perhaps go on to win the International APQO Award.

5. A tip for the International Organisation for Standardisation (ISO) and Chinese Authorities

An international Financial Accounting Management System (FA MS) has been called for by some corporate world leaders, some time before the Australian and US corporate "creative financial accounting" and conflict of interest with some auditing / consulting providers became public. One of these leaders is American-born Paul Anderson, (until recently the Chief Executive Officer (CEO) of Australia's and now the world's largest mining company, BHP Billiton). This CEO obviously knows the value of such an international standard, as he has had to deal with budgets and financial reports from many countries, which were most likely based on many different local accounting standards. Such an international standard could even be more popular than ISO 9000 and would be of great assistance to the half a million or so Joint Ventures (JV) between Chinese and Foreign enterprises.

6. Industry-specific standards

Further system robustness and confidence in Six Sigma can be achieved with industry-specific standards. Some of the major global industry sectors have already been operating for years in an environment where the business foundations are one or two stepping- stones above the generic ISO 9001 QMS level. Some of these industries and their industry-specific management standards are shown in

7. The three universal types of customers

This author maintains that all elements of a cost-effective IMS must be customer-focused and must strive to satisfy the three types of customers, which in reality each organization has. It does not really matter whether the organisation is private or public, manufacturing or service, produces hardware,

software or educational qualifications, is large or small, and/or is located in the West or East. They are:

CUSTOMER TYPE 1-THE REGULATORY CUSTOMER-Who provides your license or approval/authority to operate CUSTOMER TYPE 2: EXTERNAL CUSTOMER-Who pays you for the product or service CUSTOMER TYPE 3: INTERNAL CUSTOMER-Who does the work and passes it to the next internal customer or the external customer, as appropriate.

The greatest threat to any quality initiative is the relatively low average working life of a CEO in Australian organisations (and probably in other countries also). Only the CEO (when fully supported by the board members) can really provide the necessary leadership and resources defined by the eight management principles in ISO9000 in order to achieve continual QMS improvement and / or real Six Sigma break-through performances.

8. Some time-honored controls which are essential for quality improvement programs and Six Sigma

Now I will quote from an address I gave to the Australian Federation of Automotive Part Manufacturers (FAPM) in Canberra, ACT, Australia. It is really all about some important types of controls that contribute significantly to any improvement program including Six Sigma project/s. They are:

Control of Supplies, Control of Processes and Control of Quality Costs.

8.1. Quote: "Control of supplies"-

Prevention is the name of the game in quality assurance, and this is most important in the area of purchased parts and material. Let me give you an idea how much it can cost a firm to find and replace defective supplies. Company HP (Hewlett Packard) apparently received 1000 million parts each year and assuming 1 % are not to requirement, that amounts to 10 million defective parts per year. The cost of finding and replacing one faulty item is a mere 60 Cents at receipt-inspection stage. Further down the line at assembly stage, it cost $10 per defective part, and in service the replacement costs escalate to a staggering $100 per faulty part, or 1000 million dollars per year. By spending a mere 6 million dollars a year for goods-inwards inspection, HP save a potential $994 million dollars a year. The secret is to find and replace all defective parts before they reach the production line". Un-quote.

8.2. Quote: "Population (Process) control"-

Another important area in any cost-effective quality system is manufacturing and process control. Once more, P & W (Pratt & Whitney) have an enlightened approach to this. They embarked on a very successful "population control" program. I

thought the Pill was doing the intended job. What is it, how does it work, and what benefits are derived from this program? It comprises statistical process control performed on the spot by trained operators. P & W spread the gospel that processes produce populations rather than individual pieces, and if you control the populations, all individual pieces are controlled. The principle is quite simple. In a distribution curve for a good population, all measurement results are well centered and the spread of the population lies well within the specification limits. There should be a little safety margin either side of the population and its upper and lower tolerance limits for real comfort. As an example lets take the results from two production runs, one without population control and the other with. In each case 50,000 pieces were produced. Prior to population control, more than 16 % had to be reworked or allowed concessions. This was reduced to 1 % with the population control method. Also scrap was reduced from 3,331 parts to 4 parts in 50,000." Un-quote.

8.3. Quote: "Quality Costs"-

I would like to draw your attention to an Australian Standard on Quality Costs, AS 2561. I hope your accountant (better known in the service industry as the bean counter) will make good use of it, so he can provide management with regular quality cost reports. Of course, the quality controller must provide him in the first place with the actual defect data". Un-Quote.

Special note: I would now like to draw the reader's attention to the foregoing Canberra address written by this author. THIS FAPM ADDRESS WAS GIVEN WORD-FOR-WORD, not yesterday, not last month, not last year, BUT EXACTLY 20 YEARS AGO. The above quoted extracts come from AOQ-NSW monthly publication, "Target ", page 5 and 6, dated March -April 1983 and reprinted in this paper. Only a few words (in brackets) were added this time, for the purpose of clarification.

Most approaches outlined above, were actually witnessed on site by this author, during a twelve week long self-funded study tour in 1980, with visits covering then the largest USA aircraft and European automotive manufacturers. The above product and process control approaches by HP and P & W indicate that they were aiming for performance levels indicative of a Six Sigma program, nearly a decade before Motorola registered the term Six Sigma.

9. Quality Cost Categories

There are four universally accepted categories of quality costs namely, Prevention, Appraisal, Internal Failure and External Failure. The first two are necessary or un-avoidable, while the latter two are of the avoidable type. Anything that is done

more than once (or handled twice or more often than planned) can be considered wasted effort and a generator of Poor Quality Costs.The idea is to optimize prevention and appraisal costs in an effort to minimize or remove failure costs, and thus increase your firm's ability to survive in this highly competitive world.

10. Reported waste

One has heard a lot over the last 30 or 40 years regarding excessive waste in business and in industries in general. Most recently reported figures, relating to avoidable quality costs in the USA are still really unacceptably high by any measure. This applies regardless of whether the costs relate to sales/revenue or operating costs. They range from an average of 25 % to 50 % of operating costs. To be specific the average price of nonconformities as a % of operating costs in USA manufacturing businesses is about 25%, in the service industry about 35% and in software development as high as 50%. What a waste of energy and resources. Sadly, there would only be a handful of industrial organisations in the West and Asia, whose performance may be better than that.

11. Where do the huge Six Sigma savings come from?

There are relatively few cost-benefit related case studies in the Six Sigma literature available to-date, which demonstrate the relevant details. This is certainly the case in the 200 or so presentations / papers, covered in the proceedings of the 12 international Six Sigma conferences this author has participated in, since the beginning of the new millennium. By that I mean case studies that demonstrate how those frequently reported billions of Dollars (USD) of cost savings and benefits from Six Sigma are actually derived.

Therefore, I feel the contents of above Australian Quality cost standard can be of real value to all grades of Six Sigma belts and all others involved in the Cost of Poor Quality measurements and preventive / corrective processes. Stop press: To soften the above statement I must add that at a very recent Six Sigma conference in Australia, a Six Sigma Champion, from the giant US aerospace corporation Raytheon stated, that they have on their database fully documented and verified financial accounts/reports for some 4,500 completed Six Sigma Projects. These are reportedly accessible to all concerned within the corporation for ongoing improvement purposes.

12. What has really changed in the world of quality?

As you probably be well aware from the

foregoing quotes, nothing much of substance has really changed in the field of quality, since that time. I am certain most of my 70 fellow members of the IAQ, the International Academy for Quality, would agree with me on my above stated opinion. All the vital ingredients referred to above (especially the above extracts on quality control) were being applied 20 years ago. Some, such as the most important and useful variation reduction tool, the Shewhart control chart, for example, even dates back some 80 years. Granted, with Six Sigma there is now more focus on bottom-line benefits on each project, training of trouble-shooting specialists, top management commitment and certainly more media attention than on any of the previous forty or so quality initiatives during the last half a century. Much of it is due to "recent" converts to Quality, such as industry leaders Jack Welch from GE and Robert Galvin from Motorola. They had to increase their organisation's management performance and quality levels of product and services rapidly and drastically, or face a slow but sure death from the Japanese, German and other foreign competition. Mere name changes? Yes, plenty.

The characteristics of a "Critical and /or Major" category would most likely be a safety-critical requirement in any industry and / or what is in the Six Sigma language now known as a "Critical to Quality" (CTQ) characteristic. This author prefers to also use the term CTC, meaning "Critical to Customer". A term that he coined for non safety-critical items and for characteristics, that do not really affect the product's form, fit or function. However, these features may still be considered important by the customer, such as appearance or aesthetics etc. AQLs (Acceptable Quality Levels) remain still the prime measuring unit in Batch/Lot sampling inspection, whereas ppm (parts per million) and DPMO (Defects Per Million Opportunities) now relate strongly to the Six Sigma discipline.

To reinforce the above findings, it is well to note, that parts per million (ppm) quality (that relates to Six Sigma quality levels) were actively pursued in Japan and later in other places, during the period late 1970s and early 1980s. A long time before the term Six Sigma was registered by Motorola.

This author finds that the move of quality metrics, measurements/defect rates, from "one part per hundred" (1/100 or 1 %) straight to "one part per million" (1/1000,000 or 1 ppm) ignores an intermediate level of performance, such as "one part per thousand" (1/1000 or 1 promill). The "one part per thousand level" would have perhaps attracted the majority of organizations that feel intimidated by the "part per million" metric.This intermediate level would have suited about 90 % of organizations in Australia, especially the small to medium enterprises (SMEs). This was realized during the 1999/2000 onsite

Quality and Six Sigma survey of nearly 20 Australian manufacturing and service organizations, that were visited by this author and Prof. XU Jichao, VP- ZIA, Zhengzhou Institute of Aeronautics, Henan. None of the Quality representatives then interviewed had previously heard about Six Sigma. Soon after that, the AOQ-QUALCON held in February 2000 in Sydney had a few papers on Six Sigma, as well as a panel discussion during a Quality and Six Sigma forum that included half of the members of the newly formed College of Juran Medallists (CJM). The above survey by two members of the international quality movement, from Australia and China, together with the above quality conference and forum may very well be considered the official birth of Six Sigma in Australia. However, in the last three years commendable progress has been made as far as Six Sigma awareness in Australia and China. This author can personally attest to that, since he presented at Six Sigma conferences by IQPC in Sydney, Melbourne, Kuala Lumpur, Beijing, Hong Kong, Singapore and at conferences and seminars by APQO in Beijing and Kuching, by ZIA in Zhengzhou by SQCA/SAQ in Shanghai. As well as many seminars in about a dozen Universities and quality organizations all over China during five lecture tours in the last two years alone, stretching from Shanghai, Nancheng, Wuhan, Zhengzhou, Anyang, Xi'an, Xiamen, Beijing, Chengdu to many other places. AOQ, Standards Australia, some Australian Academic institutions and others are now taking up training for Six Sigma in earnest. Six Sigma is now a world-wide phenomenon.

13. Conclusion

In conclusion, this paper has emphasized the risks associated with Six Sigma and at the same time provided some solutions, to ensure its momentum can be sustained, while delivering expected results. One of these solutions is to put a solid business foundation in place.

Such a foundation can be built over time with AQAC's stepping - stone approach, that embraces the Japanese 5S good house-keeping program, followed by an integrated management system, that really needs to be supported by an organization-wide Cost of Poor Quality scheme. Otherwise, the likely end-result is that Six Sigma may end up a disappointment to many, as TQM did.

The author maintains also, that we must take note from the lessons learned throughout history. Hence, the inclusion in this paper of many case studies from industry and the many references to management authority Dr. Joe Juran. They demonstrate the value of good standards, the systems approach, proven tools and methods, the need for proper planning, personnel

training and professional certification, where relevant, as well as effective process control and above all an effective cost-control scheme should exist.

The above journey back into history demonstrates that not really much of substance has been created in the field of Quality over the last quarter century. The exception would be the Cost of Quality Standard AS 2561 and perhaps the ISO quality management standards, and even these can be considered a progression from Mil - Standards and other prior norms from Europe and other places.

Certainly plenty of re-packaged programs or new names having virtually similar meanings have appeared during this period eg COPQ v. COQ, CTQ v. C of C, ppm v. Six Sigma quality, Black Belts v. CQEs, Green Belts v. CQTs. DMAIC is an extension of PDCA, while 6 Sigma and 1.5 Sigma shifts are included in variation control. Quality Systems have progressed over more than five decades from Quality Inspection to Quality Control to Quality Assurance to Quality Management and currently to Integrated Management Systems etc. One wonders where we will be tomorrow?

Finally, it is the author's opinion, that Six Sigma, or whatever its future name might be, will probably survive in those organizations, that heed the above advice.

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