THE IMPLEMENTATION OF SIX SIGMA IN MANUFACTURING ORGANIZATIONS: MOTIVATIONS AND RESULTS ACHIEVED

A IMPLEMENTAÇÃO DE SEIS SIGMA EM ORGANIZAÇÕES DE MANUFATURA: MOTIVAÇÕES E RESULTADOS

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RESUMO

O contexto competitivo força as organizações a escolher ferramentas de melhoria que assegurem o máximo de eficiência para as suas operações. Existem muitos artigos sobre Seis-Sigma na literatura técnica, mas as pesquisas científicas são escassas. Esta pesquisa visa avaliar como as implementações Seis-Sigma são realizadas, e identificar fatores críticos de sucesso, analisando seis indústrias que já adotaram Seis-Sigma. Os resultados mostram convergência entre as empresas e aspectos que maximizam ganhos além daqueles publicados sobre metodologia Seis-Sigma. A pesquisa conclui que aderência na metodologia, apoio dos Gestores de nível mais elevado e alinhamento com outras iniciativas são fatores críticos de sucesso.

ABSTRACT

The competitive context forces organizations to choose improvement tools that yield maximum efficiency from their operations. There are many articles about Six Sigma in the technical literature but academic research is not so abundant. This research aims at evaluating how Six Sigma implementation takes place and identifies critical success factors, by analyzing six industrial organizations which have already adopted Six Sigma. The results show convergence between organizations and aspects that maximize gains beyond those publicized on Six Sigma methodology. The research concludes that adherence to the methodology, support from Upper Management and alignment with other initiatives are critical success factors.

PALAVRAS-CHAVE

Seis Sigma, Competitividade, Programa de Qualidade.

KEYWORDS

Six Sigma, Competitiveness, Quality Program.

INTRODUCTION

The competitive environment where organizations thrive to succeed witnesses changes taking place at an ever-faster pace, and so management strategies must be constantly improved to face the challenges imposed by competition, which in turn forces organizations to make choices that will lead them to differentiate themselves, innovate, increase efficiency and identify, create and maintain competitive advantages.

To overcome these challenges, organizations must pay careful attention to identify, develop and implement manufacturing strategies, aligned with corporate strategies (Wheelwright, 1985). Also, according to Slack (1992), manufacturing strategies contribute to increase the competitiveness of the organization through waste reduction, improvement on quality, delivery speed and reliability and in flexibility.

For years, organizations have been looking for the right tool that will improve all these factors. Some did succeed adopting TQM, as detailed on the articles by Reed (2000) and Kaynak (2003). Other organizations have found other ways to help their improvement efforts, being Six Sigma one of these tools. More recent than TQM, Six Sigma is a re-packaging of tools already known and employed by a large number of organizations.

Six Sigma is a project management tool based on measurable goals and objectives, and divides the problem or improvement opportunity into distinct phases of definition, measurement, analysis, improvement and control (DMAIC), employing statistical tools at each one of these phases to validate each and every decision taken at each phase of the project.

The robustness of the statistical tools employed simplifies the understanding of the process by the members of the project, thus generating simultaneously individual and team learning, and also creating commitment to the project performance and results.

Contrary to TQM, the primary drivers leading to Six Sigma adoption are the financial results published by organizations that have already adopted, as opposed to the original intent of TQM, that aimed at creating a Quality Management System, team involvement, cost reduction, customer satisfaction, safety and moral benefits, which, put together would eventually result in financial improvements.

RESEARCH PROBLEM AND OBJECTIVES

The technical literature related to the Six Sigma topic is dedicated to explore the implementation methods used by organizations, the origin and evolution of Six Sigma, and the critical implementation factors. Very often it denies that Six Sigma is an evolution or is complementary to TQM.

Meanwhile, the academic literature evaluates Six Sigma aspects separately, either under a goal definition and achievement perspective, such as Linderman (2003), under learning aspects, as Wiggenhorn (1990), Baldwin (1997) and Wiklund (2003), or explaining the factors motivating Six Sigma adoption, as described by Belohlav (1993).

This article has as its main objective the purpose of determining the common aspects found in organizations that have already adopted Six Sigma, in regard to:

- driving forces leading to the choice of Six Sigma;
- adherence to Six Sigma methodology;
- team and individual behavior;
- goal definition and achievement;
- training and learning, both individual and organizational.

The existing technical and academic literature was revised on the light of the aspects identified, and these theoretical aspects were compared to the actual 'real life' condition.

LITERATURE REVIEW

Despite the importance of quality be known for centuries, when manufacturing techniques were passed from master and artisans to apprentices, the administrative, technical and scientific aspects were

only studied and developed in the beginning of the 20th Century, along with the specialization of work.

According to Yong and Wilkinson (2002), Quality, on its multiple dimensions – excellence, value, conformity to specifications, meeting and exceeding customers' expectations – was known and practiced over 4,000 years ago, with evidences found on the ancient Egyptian and Chinese civilizations.

In the beginning, Quality was based on self-inspection performed by masters and artisans on their own production, mainly in small quantities. The Industrial Revolution changed the way products were manufactured, with the birth of division and specialization of work, together with mass production. The responsibility of product quality on a production line is assumed by the foreman.

In the 1920's the quality control concept is introduced, by the analysis of statistical variation of critical product variables, based on the pioneer studies performed by the Bell Laboratories. Shewhart publishes in 1931 his book *Economic Control of Quality of Manufactured Product*, which introduces a scientific footing on the quality discipline for the first time. Shewhart recognized that variability was a key concern in any production process.

The first inspection teams are created, mostly linked to World War II efforts, when the value of statistical quality control (SQC) is recognized. SQC aimed at increasing work efficiency and waste reduction, while inspection tasks were limited to the shop floor.

After the War, Quality starts evolving to Quality Assurance, when the focus shifts from detection to prevention of defects. Quality concepts need to be broadened to cover not only production and product conformance, but also to improve other aspects, such as understanding of customers' expectations, design and material procurement.

The concept of Total Quality Control (TQC) is introduced by Feigenbaum (1983) in the late 1950's:

> an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of the various groups in an organization so as to enable production and service at the most economical levels which allow for full customer satisfaction.

With the birth of TQC, in the early 1960's, concepts such as Cost of Quality (or rather Cost of Poor Quality), institution of aggressive goals (Zero Defects) and reliability engineering are created.

Figure 1 describes the creation and evolution of quality concepts and tools, and its relationship with Six Sigma. As observed, most of the tools used by Six Sigma have been available for more than 50 years.

SIX SIGMA

Dating back to the late 1970's, and created as a way to train and disseminate statistical techniques to identify, solve and control problems on all levels of the organization, Six Sigma has become over the last years, alone or together with Lean Manufacturing techniques, probably the most adopted improvement tool by organizations interested in reducing waste, improving quality and therefore increasing profits, not only on the manufacturing arena, but expanding to all businesses, private and government.

According to Wiggenhorn (1990), the origins of Six Sigma date back to 1979, on an effort initiated by Motorola to develop a training program that would be understood and absorbed by its entire workforce, after other two trials that had previously failed. Before Six Sigma, training was based on expositive classes, and there was no systematic approach to compare results of training.

On the process of reinventing the training method, Motorola found that a good part of its work force was illiterate and unable to perform simple arithmetic operations. Everyone, from top management to shop floor needed to be able to understand and use quality tools.

In order for that to happen, everyone needed to effectively understand their own work and the equipment used. That understanding needed to happen on a participative way, not individually and on a trial-and-error basis. Communication between

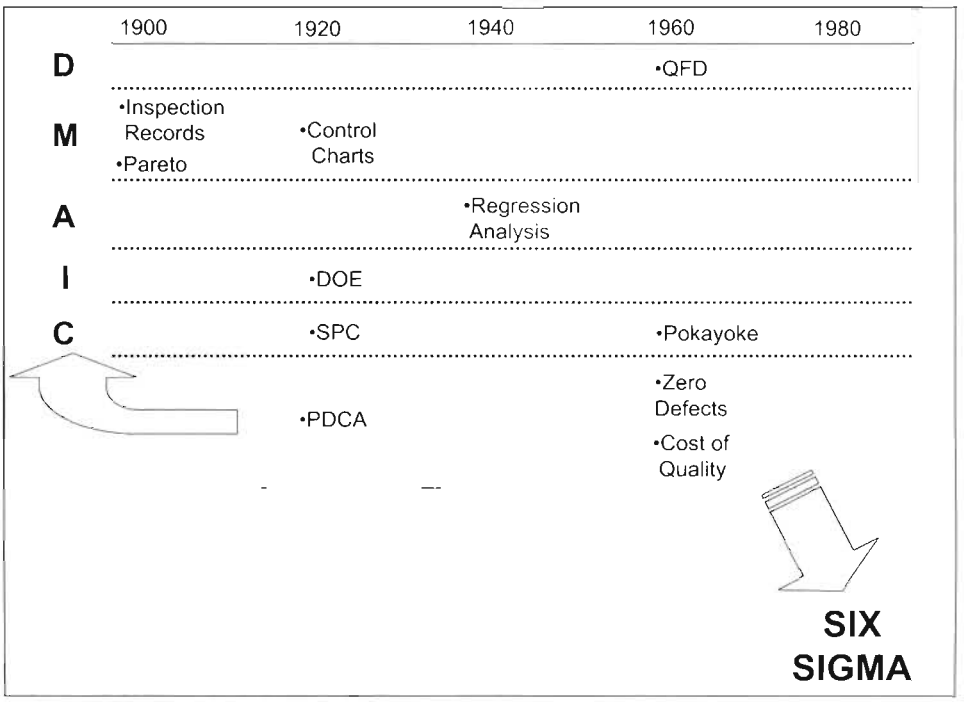

Figure 1 – quality concepts and tools
Source: Research Data

hierarchical levels and departments was needed. The diagnosis results showed that a shift from training to education was needed.

The goal then was to design a systematic approach that would educate and commit all personnel to understand its own work place, process, identify and solve small problems, and if needed, communicate effectively with support areas to solve complex problems and initiate improvements. All support organization should be available to meet new demands generated by the work force.

The initial program was composed of five parts: Statistical process control; Basic industrial problem solving; presentation of conceptual material; effective meetings and finally on how to define objective, describe them and measure progress.

REFERENCE ON LITERATURE FOR THE FIVE SELECTED ASPECTS

To support the research, the five common factors evaluated on the organizations analyzed were identified on the literature review:

- driving forces leading to the choice of Six Sigma;

The adoption of Six Sigma gained publicity encouraged by Motorola's win of the 1988 Malcolm Baldrige National Quality Award, devoted to the positive results of Six Sigma achievements. More recently, General Electric publicized Six Sigma as "it is now the way we work – in everything we do and in every product we design." Six Sigma is now commonplace in all industries.

All literature available leads to the fact that Six Sigma is adopted to promote improvement on the financial bottom-line results.

Besides the profusion of 'success cases', Six Sigma addresses one concern raised by Skinner (1986), when the 'Productivity Paradox' was published. Instead of taking actions and measuring results separately, Six Sigma estimates results and sets goals before actions are taken, thus increasing the likelihood of positive results.

- adherence to the methodology;

Six Sigma methodology is described on existing literature, which guides the user through steps

or phases to identify and solve a problem. These steps are usually defined as DMAIC (Define, Measure, Analyze, Implement and Control). Literature listed includes, but is not limited to Harry (2000), Pande (2000), Eckes (2000) and Breyfogle (2001). Although each author may propose changes to the methodology, there is little deviation from the original DMAIC structure.

- *team and individual behavior*;

Literature describes the understanding of this aspect so much as to integrate Six Sigma to the organization's culture and thus increased the likelihood that it will be absorbed into the culture of the company, as well as to better understand and overcome resistance to the changes proposed by the Six Sigma projects.

Eckes (2001) describes types of resistances, the competencies required of the leader and ways to measure acceptance. Linderman (2003) examines the effect of goal-setting to motivation and commitment, while Blakeslee (1999) describes important aspects related to individual and team behavior, specifically Upper Management commitment, the need for full-time team leaders and the benefits of integration with existing initiatives.

- *goal definition and achievement*;

Goal setting is an integral part of the Six Sigma methodology, specifically in financial terms, driving attention and support from Upper Management to the Six Sigma initiative and projects. The goal is also a reference and signals rewards to team members if the projects succeeds.

Linderman et al. (2003) details the relationship between Six Sigma and goal theory. Six Sigma aims at producing measurable financial results by setting clear, aggressive and achievable goals. This creates commitment at individual and team levels.

- Training and learning, both individual and organizational.

The training and learning aspects are covered by much of the literature available on Six Sigma, being of special interest the questions of the structured hands-on training method and the simplification on the use of complex statistical tools when training is the subject; and on how the team is involved, the use of practice fields and real life objectives.

Wiklund (2002) discusses Six Sigma as a company-wide approach for organizational improvement incorporating organizational learning, and its ability to instill cultural change.

Baldwin (1997) and Wiggenhorn (1990) detail the origins of Six Sigma within Motorola University and how it was set up as a training program with the intent of changing the culture of the organization, by promoting learning of problem solving tools and need for change on its members.

Snee (2000) focuses on the fact that Six Sigma is a robust and simple training method, even though it trains teams on the use of complex tools, and yet, the main objective are financial results, with learning coming as additional gain.

RESEARCH DESIGN

After the identification of key aspects of Six Sigma, the research was designed to verify how organizations were adhering to the assumptions described on the literature.

Six manufacturing organizations which had adopted Six Sigma for the previous two to five years were selected. All of them operated ISO 9000 based quality systems. Four companies are second or third tiers of the automotive industry, one is on the agricultural segment and the last one is on the metalworking segment. Annual sales of the manufacturing units range from U$ 40 million to U$ 500 million. Number of employees ranges from 300 to 2,000 for each manufacturing unit. The interviews were conducted with area managers or Six Sigma program coordinators, all of them directly involved with the Six Sigma program on its organization. One person was interviewed on each organization, following a questionnaire containing aspects related to:

- driving forces leading to the choice of Six Sigma;
- adherence to the methodology;
- team and individual behavior;
- goal definition and achievement;
- training and learning, both individual and organizational.

RESULTS

The research was exploratory, aiming to compare how the different Six Sigma aspects take place in the organizations. Results were grouped from total convergence, partial convergence, no convergence and finally no reference to a given aspect.

- driving forces leading to the choice of Six Sigma

Surprisingly, all interviews revealed that 'bottom line results' were not the primary driver that led to the choice of Six Sigma adoption. Three out of six companies reported the need to 'step up' their existing quality systems to a higher level, and Six Sigma was chosen as proved to be a robust method using statistical tools, based on a project management structure. One company reported the desire to improve product and process quality, regardless of financial results, that would be considered as 'positive side effect', another stated Six Sigma as a Quality Department initiative to find ways to involve other areas on improvement projects, while the last one said Six Sigma implementation was mandated from Corporate Headquarters.

All organizations did agree that existing publicity regarding positive results, including financial gains made both Six Sigma choice and implementation easier, and probably overcame resistance. It was also mentioned that Six Sigma explains that 'better quality does not cost more'.

- adherence to Six Sigma methodology

In regard to the methodology, all organizations approved the steps defined for each of the project phases. All the organizations adopted periodic checks to verify discipline to the prescribed methodology, as the desire to jump to the next step was detected often. All organizations have also implemented financial validation of the results at the last phase of each project.

Identified as critical by the organizations was the need for Upper Management to follow-up and support initiatives and maintain focus and priority on the projects.

The organizations did not converge to define selection criteria for project leaders. While half of the organizations defined selection of project leaders based on personal and analytical skills, and choice of the elected by a multidisciplinary committee, the other half relied on management indication, not following objective criteria.

- team and individual behavior

All the organizations agreed that resistance to change was observed as the projects were initiated. Resistance was identified at all levels, from managers not willing to support projects that would promote changes to their areas, team members not willing to cooperate and also team leaders refusing to follow the methodology. The performance of the projects was very dependent on the commitment and ability of the project leader to follow the methodology and to involve team members. Constant incentives and follow up contributed also to project and program performance. Six Sigma motivated people at various levels of the organization, when they started to feel as part of the improvements.

Not all of the organizations agreed to items that are common sense on the literature, specifically: need for change was not communicated throughout all the organizations, some organizations communicated only for those directly involved with Six Sigma projects; even if individual resistance was identified, not all organizations had a plan to overcome this resistance; some organizations set aggressive goals, while other were afraid that goals considered too aggressive would result in low commitment levels.

- goal definition and achievement

Goals must be set on the first phase of the projects, to act as guidelines to the other project phases. All organizations reported that very often the deadlines had to be renegotiated, bur very few projects were cancelled or had smaller goals.

Goals acted, together with learning, as the biggest motivation factor.

- training and learning, both individual and organizational

All the organizations agreed that Six Sigma is a training program very successful on promoting learning. Teams on the training program need practice fields, proportioned by the Six Sigma projects.

Six Sigma, despite using complex statistical tools, explains why the result happens and the solution works, and is easily transmitted to others and used as reference for other projects.

Even being recognized as a training program, all organizations affirmed that learning at individual and team levels was the most important change for the culture of the organization, and more likely to remain over time. The learning gains exceeded the expectations of all of the organizations.

ANALYSIS COMPLEMENTARY TO RESEARCH

After conducting the interviews, and analyzing convergence between organizations, it is also possible to establish findings based on the literature review:

- Six Sigma and Lean Manufacturing

One of the organizations described the mutual reinforcement between the two initiatives – Henderson (2002) and Nave (2002) report that, regardless of the initial choice, structured improvement actions result on gains, whenever there is less process variation, inventory reduction, higher flexibility to customer demands, meaning that both Six Sigma and Lean Manufacturing will lead to the same results, and are mutually reinforcing when adopted simultaneously.

- Six Sigma and Quality in Japan

Six Sigma may be understood as a re-edition, or rearrangement of tools already known. This statement is based on the similarity between the quality efforts driven by Deming and Juran in Japan between 1950 and 1970, when technicians were trained on the use of statistical tools, supported by Upper Management, and driven by the need Japan had for an aggressive improvement on quality and productivity levels, in order to compete with the West. The constant use of the quality tools and the philosophy of continuous improvement led to cultural change. This may explain why the use of Six Sigma is more widespread between westerner companies, as Japan has already adopted similar forms of Six Sigma.

- Six Sigma and Strategic Alignment

Two organizations described that subordination of Six Sigma to Strategic Planning brings as benefits more visibility to the improvement projects, better follow-up from Upper Management and, as a consequence, higher priority and resource availability. Priority projects concur to team involvement and search for common objectives, which results in better learning and reinforces the culture of fact based decision making. The organizations that aligned Six Sigma to Strategic Planning also state that it increases the chance of making Six Sigma perennial, as it becomes accepted and absorbed into the culture of the organization. One of the organizations even reported that the Six Sigma Program coordination role progressed from leading projects to consulting, as different areas started driving improvement initiatives and taking responsibility for the results.

The importance of subordination of Six Sigma to Strategic Planning or the interaction between Six Sigma and Strategic Planning may be described in three different aspects:

- Learning – as Six Sigma provides practice fields, is based on a disciplined approach and decisions must be based on facts, the variables to promote learning are present. The learning process should be oriented; the responsibility for

project review should be taken by the Program Coordinator, capable of evaluating both technical and behavioral aspects of the projects. This methodology is described by Wiklund (2002), describing the extension of gains by better evaluating learning aspects on Six Sigma.

- Coordination of efforts between areas and improvement strategies – as expected, the application of improvement efforts not coordinated between different areas of the organization will result in worst results when compared to coordinated efforts, mostly due to the need for rework, training and overcoming resistances on areas that have not led the effort. The same is also true when improvement tools, including Six Sigma are not coordinated with other improvement efforts. Eckes (2001) mentions that randomized, localized, and departmental improvements can result in benefits when viewed in isolation, however, they frequently result in under-optimization, because dependent activities are treated as though they are independent activities.

- Business Strategy Execution – although Six Sigma was originally created focusing on learning and process variation reduction, according to Barney (2002), Motorola is evolving Six Sigma into a 4-step, high performance system aimed at business strategy execution. The new improvement cycle will be divided into:

- 1. Align executives to the right objectives and targets.

- 2. Mobilize improvement teams.

- 3. Accelerate results.

- 4. Govern sustained improvement.

As described by Bossidy (2002), strategy definition must be followed by a robust implementation plan. Six Sigma has proven to be a good result attainment method.

Figure 2 illustrates the relationship between strategic alignment and Six Sigma and adherence to the Six Sigma methodology and the results achieved by the organizations that were focus of this research, on the opinion of the organization's members. The figure shows that a higher degree of adherence to the methodology, combined with a high degree of alignment between Six Sigma and the organization's Strategic Planning will

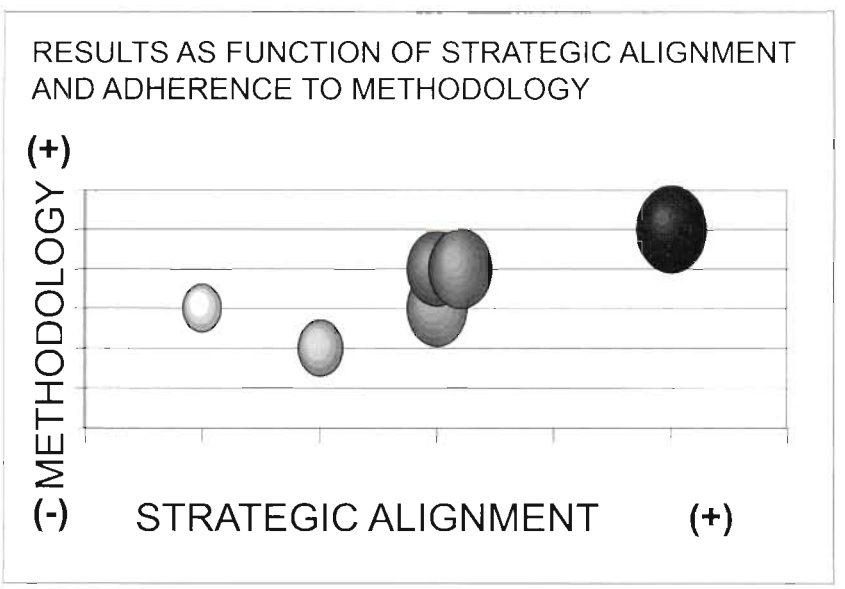

Figure 2 – relationship between adherence to Six Sigma methodology and strategic alignment and effect on results

generate better results, represented by the darker circle. Opposite to that, on the occurrence of either low adherence to the methodology or little alignment between Six Sigma objectives and organization's overall objectives, results will have a tendency to be less substantial.

CONCLUSION AND FUTURE RESEARCH

Six Sigma is a set of statistical tools of simple application that produces results for the organizations using it. Due to its proven results, as publicized by other organizations with previous success cases, and of the positive results of the first projects completed within the organization, Six Sigma receives support and commitment from both project members as well as from the top management organization, both critical success factors related to the dissemination into the organization's culture.

From the five aspects identified on the research design, it is possible to affirm from the analysis performed on the six organizations evaluated, and on the further literature analysis, that:

- results achieved exceeded the expectations, which was identified as the key driver towards the choice of implementing Six Sigma;

- results and implementation are reinforced if the discipline to the methodology is maintained. All organizations reported the participant's desire to 'jump to the next step'. At this point, it is critical that Top Management must take part on the progress reviews to assure discipline is maintained.

- as expected, Six Sigma contributes to team involvement, but care must be taken on the selection of project leaders and to adapt Six Sigma to the organization, both on the program implementation and as the program progresses over time.

- goal definition must follow the methodology, and also respect the organization's culture.

- learning, being the original Six Sigma intent was the aspect all organizations did not hesitate to affirm that results exceeded by large the expectations.

Not focus of the original research design, the analysis of alignment between Six Sigma and other existing initiatives, in particular Strategic Planning has proved to be a key factor both for improving results and guarantee integration of Six Sigma into the organization's culture.

The adoption of Six Sigma may also be a reinforcing factor for organizations identifying a need to increase the effectiveness of existing Quality Systems, as Six Sigma promotes improvements on specific items, but also by the organizational learning in general, and specifically on the use of quality and project management tools.

The research supporting this article was designed to evaluate the process improvements resulting from the implementation of Six Sigma on industrial organizations. As Six Sigma seems to be evolving into a higher stage, focusing on the overall business improvement, further research could be performed to evaluate Six Sigma results beyond Manufacturing Strategy, into Business Strategy.

Recebido em: mar. 2005 · Aprovado em: jun. 2005

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