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A REVIEW OF SIX SIGMA APPROACH: METHODOLOGY, OBSTACLES AND BENEFITS

Kumar Dhiraj[1]& Kaushish Deepak[2]
Department of Mechanical Engineering, Geeta Institute of Management and Technology, Haryana, India

Abstract
Six Sigma is an approach that improves quality by analyzing data with statistics. In recent years there has been a significant increase in the use and development of the Six Sigma methodology in manufacturing industry and others. The Six Sigma approach has been increasingly adopted worldwide in the manufacturing sector in order to enhance productivity and quality performance and to make the process robust to quality variations. Understanding Methodology, key features, obstacles of the six sigma method allows organizations to better support their strategic directions, and increasing needs for coaching, mentoring, and training. It also provides opportunities to better implement six sigma projects. This paper reviews Methodology, obstacles and Benefits of six sigma practices and identifies the key factors influencing successful six sigma project implementations. Effective six sigma principles and practices will succeed by refining the organizational culture continuously. Cultural changes require time and commitment before they are strongly implanted into the organization.
Key words: Six sigma, DMAIC, Methodology, Benefits, Obstacles.

1. Introduction
Six sigma method is a project-driven management approach to improve the organization's products, services, and processes by continually reducing defects in the organization. It is a business strategy that focuses on improving customer requirement understanding, business systems, productivity, and financial performance. Dating back to the mid-1980s, applications of the six sigma methods allowed many organizations to sustain their competitive advantage by integrating their knowledge of the process with statistics, engineering, and project management (Anbari, 2002). Numerous books and articles provide the basic concepts and benefits of the six sigma method (Harry and Schroeder, 2000) (Hoerl, 1998, 2001). The challenges and realities in implementing the six sigma method successfully are immense. However, the benefits of applying the six sigma method to technology-driven, project-driven organisation are equally great. The objective of this paper is to review and examine the evolution, benefits, and challenges of six sigma practices and identify the key factors influencing successful six sigma project implementation. The paper also integrates the lessons learned from successful six sigma projects and their potential applications in managing traditional projects, and considers further improvements to the methodologies used for managing six sigma projects. Wider applications of six sigma principles to the organization will succeed through senior management involvement, organizational commitment, cultural change, and effective project management.

What is Six Sigma?
Six Sigma can be defined as a business improvement strategy used to improve business profitability, drive out waste, reduce costs of poor quality and to improve the effectiveness and efficiency of all operations so as to meet or even exceed customers' needs and expectations (Antony J. and Banuelas R., 2004).
'Six Sigma' is a management innovation methodology to produce virtually all products or services that are defect free based on the process data by improving business processes and thereby satisfying customer and employee and reducing costs. In short 'Six Sigma' is several things
A statistical basis of measurement: 3.4 DPMO
A philosophy and a goal: as perfect as practically possible, (Greg Brue, 2002).

2. Methodology of Six Sigma
Six Sigma has been defined as the statistical unit of measurement, a Sigma that measures the capability of the process to achieve a defect free performance. Six Sigma has the ability to produce products with only 3.4 defects per million, which is a world-class performance. Six Sigma has also been described as a high performance data driven approach in analyzing the root causes of business problems and solving them.

2.1 Basic Concept
Six Sigma is considered to be a new initiative introduced by Motorola in the late 1980s, hence several papers from the early 1990's concentrate on explaining the development of Six Sigma using the Motorola case (Tennant G., 2001). These authors discuss the new Motorola quality improvement program, namely Six Sigma, which has led to improvements in their quality performance and consequently propose Six Sigma as a new opportunity for any organization that wants to improve quality. Other authors attempt to investigate and explain the Six Sigma methodology in a descriptive manner without empirical evidence or any related business. These papers are valuable to researchers new to Six Sigma in providing background information, and giving evidence of the emerging importance of the methodology. Two key conceptual papers also consider the overall concept, attempting to analyse the development of Six Sigma and explain its statistical foundation. Bothe presents a statistically based reason for adding a 1.5 Sigma shift before estimating process capability, proposing a new capability index, called dynamic Cpk (Bothe D., 2001). He also suggests future

study on the impact and behavior of the shift in various circumstances. Antony studies the strengths and the weaknesses of Six Sigma in detail and links Six Sigma to statistical thinking (Antony J. and Banuelas R., 2004). He suggests that Six Sigma has a strong statistical foundation and consequently is likely to continue to be of importance in the future.

2.2 Two perspectives of six sigma processes

A.) Business viewpoint

In the business world, six sigma is defined as a 'business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations (Antony and Banuelas, 2001). The six sigma approach was first applied in manufacturing operations and rapidly expanded to different functional areas such as marketing, engineering, purchasing, servicing, and administrative support, once organizations realized the benefits. Particularly, the widespread applications of six sigma were possible due to the fact that organizations were able to articulate the benefits of six sigma presented in financial returns by linking process improvement with cost savings. Table 1 summarizes Six Sigma business strategies, tools, techniques, and principles.

B.) Statistical viewpoint

Six sigma method has two major perspectives. The origin of six sigma comes from statistics and statisticians. Hahn et al. (1999), Hoerl and Snee (2002), and Montgomery (2001) discuss the six sigma method from a statistical, probabilistic, and quantitative point of view. From the statistical point of view, the term six sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% where sigma is a term used to represent the variation about the process average (Antony and Banuelas, 2002). If an organization is operating at three sigma level for quality control, this is interpreted as achieving a success rate of 93% or 66,800 defects per million opportunities. Therefore, the six sigma method is a very rigorous quality control concept where many organizations still performs at three sigma level (McClusky, 2000).

Table 1. Strategies, Tools, Techniques and Principles (Young Hoon Kwak, et.al, 2006)

Strategies & Principles	Tools & Techniques
Project management	tatistical process control
Data-based decision making	rocess capability analysis
Knowledge discovery	asurement system analysis
Process control planning	Design of experiments
Data collection tools & Techniques	Robust design
Variability reduction	ıality function deployment
Belt system	Failure mode & effects analysis
DMAIC process	Regression analysis
Change management tools	Analysis of means & variances Hypothesis testing Root cause analysis Process mapping

2.3 DMAIC Process

DMAIC is a closed-loop process that eliminates unproductive steps, often focuses on new measurements, and applies technology for continuous improvement. Some papers focus on explaining the DMAIC contents, with some authors discussing each phase of DMAIC in detail (Snee R. D., 2004). For example, Rasis et al. present self-learning training material for DMAIC, using a fictitious application (Rasis D., 2003). This paper helps the readers to learn how to carry out a small-scale Six Sigma project, including guidance on the application of tools. It indicates a perceived need for training material and suggests that an avenue for further research is to develop training material to cover wider range of applications and larger scale projects. Other papers concentrate on specific aspects of DMAIC, such as the project selection process in the Define phase or process control in the Control phase, explaining some key measures in Six Sigma, such as project metrics and Roll Throughput Yield (RTY).

For example, Snee emphasizes the importance of the project selection process in the Define phase for the successful implementation while Mason suggests using multivariate statistical process control in the Control phase. These papers tend to explain the features of DMAIC rather than critically appraising or enhancing it. Future research should investigate whether aspects of DMAIC need to be modified to increase its scope, for example for the service sector or non-profit organizations. If so, research to enhance the methodology may then be needed. Table 2 presents the key steps of Six Sigma using DMAIC process.

Table 2. Key Steps of DMAIC Process (Young Hoon Kwak, et.al, 2006)

Step	Key processes
Define	Define the requirements & expectations of the customer. Define the project boundaries. Define the process by mapping the business flow.
Measure	Measure the process to satisfy customer's needs Develop a data collection plan Collect and compare data to determine issues and shortfalls
Analyze	Analyze the causes of defects and sources of variation Determine the variations in the process Prioritize opportunities for future improvement
Improve	Improve the process to eliminate variations Develop creative alternatives and implement enhanced plan
Control	Control process variations to meet customer requirements Develop a strategy to monitor and control the improved process Implement the improvements of systems and structures

2.4 DFSS Process

Design for Six Sigma (DFSS) is a systematic methodology utilizing tools, training and measurements to enable the organization to design products and processes that meet customer expectations and can be

produced at Six Sigma quality levels (Mader D.M., 2002). DFSS is potentially far more effective than DMAIC as its application is in the early stage of new product/process development, thus the papers under this category aim to provide an explanation of DFSS and why it is different from DMAIC. For example, Mader explains the DFSS methodology, its key aspects and how it enhances the design process, improving New Product Development (NPD).Antony presents DFSS using the Identify, Design, Optimise and Validate (IDOV) approach. Treichler et al. discusses the use of DFSS in the design function of major US corporations and Koch et al. explain DFSS in detail, using as an example the application of DFSS in automotive crashworthiness under an engineering design context. All of these studies of DFSS have been undertaken in a manufacturing context. Hence, there is a need for more extensive study to consider new areas of DFSS application, such as how DFSS can be applied to nonmanufacturing processes.

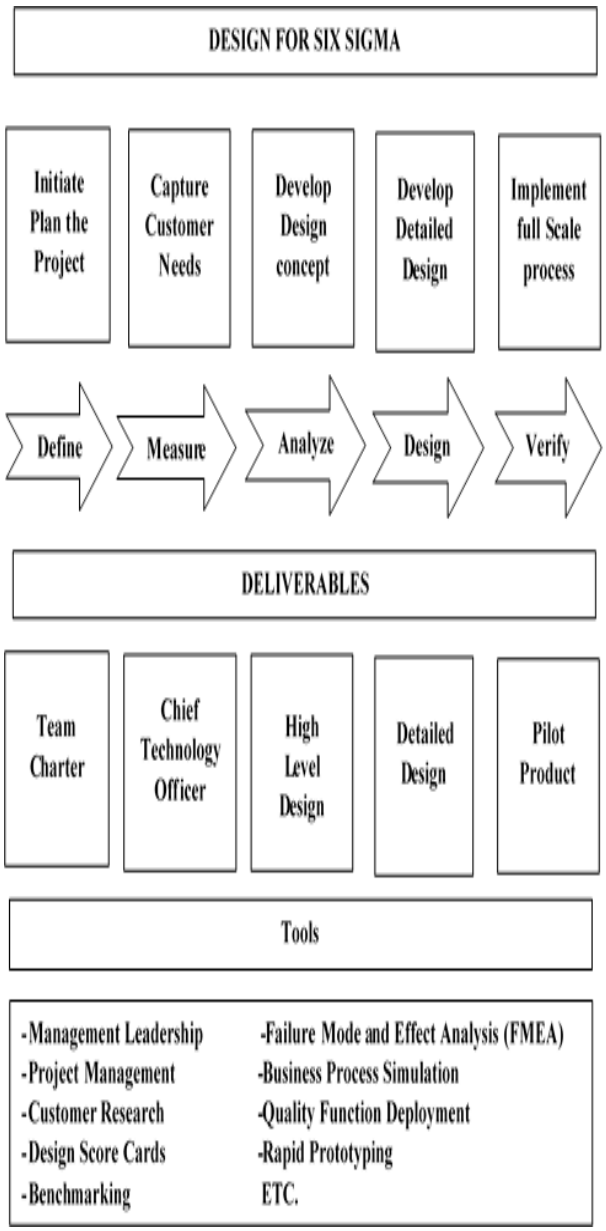

Fig.: 1 Five Step DFSS process (adapted from de Feo & Bar-El, 2002).

Essentially, the DFSS process is focused on new or innovative designs that yield a higher level of performance. De Feo and Bar-El (2002) summarize seven elements of DFSS as follows.

- Drives the customer-oriented design process with six sigma capability
- Predicts design quality at the outset
- Matches top–down requirements flow down with capability flow up
- Integrates cross-functional design involvement
- Drives quality measurement and predictability improvement in early design phases
- Uses process capabilities in making final decisions
- Monitors process variances to verify that customer requirements are met

3. Obstacles of Six Sigma Method

3.1 Issues in training (Belt Program)

Training is a key success factor in implementing six sigma projects successfully and should be part of an integrated approach. The belt program should start from the top and be applied to the entire organization. The curriculum of the belt program should reflect the organization's needs and requirements. It has to be customized to incorporate economical and managerial benefits. Training should also cover both qualitative and quantitative measures and metrics, leadership, and project management practices and skills. It is important to note that formal training is part of the development plan of producing different belt level experts. Participants need to be well informed of the latest trends, tools, and techniques of six sigma, and communicate with actual data analysis. The authors found that selection of less-capable employees for Black Belt assignments was associated with challenges to six sigma projects.

3.2 Issues in strategy

Hammer and Goding (2001) argued that six sigma has been the target of criticism and controversy in the quality community characterizing it as 'Total Quality Management on Steroid'. One of the main criticisms is that six sigma is nothing new and simply repackages traditional principles and techniques related to quality (Catherwood, 2002). Organizations must realize that six sigma is not the universal answer to all business issues, and it may not be the most important management strategy that an organizations feels a sense of urgency to understand and implement six sigma. To ensure the long-term sustainability of the six sigma method, organizations need to analyze and accept its strengths and weaknesses and properly utilize six sigma principles, concepts, and tools.

3.3 Issues in organizational culture

Quality concepts need to be embedded into the process of designing rather than just monitoring the quality at the manufacturing level (McClusky, 2000). The more important issue is the change in organizational culture that puts quality into planning. Addressing the problems and issues that are easy to correct and claiming that the six sigma method is a big success is simply deceiving. Organizations without a complete understanding of real obstacles of six sigma projects or a comprehensive change management plan are likely to fail. Senior management's strong commitment, support, and leadership are essential to dealing with any cultural issues or differences related to six sigma implementation. If the commitment and support of

utilizing various resources do not exist, organization should probably not consider adopting six sigma.

4. Benefits of Implementing Six Sigma

4.1. Manufacturing sector

Motorola was the first organization to use the term six sigma in the 1980s as part of its quality performance measurement and improvement program. Six sigma has since been successfully applied in other manufacturing organizations such as General Electric, Boeing, DuPont, Toshiba, Seagate, Allied Signal, Kodak, Honeywell, Texas Instruments, Sony, etc. The reported benefits and savings are composed and presented from investigating various literatures in six sigma (Weiner, 2004; de Feo and Bar-El, 2002; Antony and Banuelas, 2002; Buss and Ivey, 2001; McClusky, 2000).

4.2. Financial sector

In recent years, finance and credit department are pressured to reduce cash collection cycle time and variation in collection performance to remain competitive. Typical six sigma projects in financial institutions include improving accuracy of allocation of cash to reduce bank charges, automatic payments, improving accuracy of reporting, reducing documentary credits defects, reducing check collection defects, and reducing variation in collector performance (Doran, 2003). Bank of America (BOA) is one of the pioneers in adopting and implementing six sigma concepts to streamline operations, attract and retain customers, and create competitiveness over credit unions. It has hundreds of six sigma projects in areas of cross-selling, deposits, and problem resolution. BOA reported a 10.4% increase in customer satisfaction and 24% decrease in customer problems after implementing six sigma (Roberts, 2004). American Express applied six sigma principles to improve external vendor processes, and eliminate non-received renewal credit cards. The result showed an improved sigma level of 0.3 in each case (Bolt et al., 2000). Other financial institutions including, GE Capital Corp., JP Morgan Chase, and SunTrust Banks are using six sigma to focus on and improve customer requirements and satisfaction (Roberts, 2004). In collection performance to remain competitive. Typical six sigma projects in financial institutions include improving accuracy of allocation of cash to reduce bank charges, automatic payments, improving accuracy of reporting, reducing documentary credits defects, reducing check collection defects, and reducing variation in collector performance (Doran, 2003). Bank of America (BOA) is one of the pioneers in adopting and implementing six sigma concepts to streamline operations, attract and retain customers, and create competitiveness over credit unions. It has hundreds of six sigma projects in areas of cross-selling, deposits, and problem resolution. BOA reported a 10.4% increase in customer satisfaction and 24% decrease in customer problems after implementing six sigma (Roberts, 2004).
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4.3. Healthcare sector

Six sigma principles and the healthcare sector are very well matched because of the healthcare nature of zero tolerance for mistakes and potential for reducing medical errors. Some of the successfully implemented six sigma projects include improving timely and accurate claims reimbursement (Lazarus and Butler, 2001), streamlining the process of healthcare delivery (Ettinger, 2001), and reducing the inventory of surgical equipment and related costs (Revere and Black, 2003). The radiology film library at the University of Texas MD Anderson Cancer Center also adopted six sigma and improved service activities greatly (Benedetto, 2003). Also in the same institution's outpatient CT exam lab, patient preparation times were reduced from 45 min to less than 5 min in many cases and there was a 45% increase in examinations with no additional machines or shifts (Elsberry, 2000).

4.4. Engineering and construction sector

In 2002, Bechtel Corporation, one of the largest engineering and construction companies in the world, reported savings of $200 million with an investment of $30 million in its six sigma program to identify and prevent rework and defects in everything from design to construction to on-time delivery of employee payroll (Eckhouse 2004). For example, six sigma was implemented to streamline the process of neutralizing chemical agents, and in a national telecommunications project to help optimize the management of cost and schedules (Moreton, 2003).

4.5. Research and Development sector

The objectives of implementing six sigma in R&D organizations are to reduce cost, increase speed to market, and improve R&D processes. To measure the effectiveness of six sigma, organizations need to focus on data driven reviews, improved project success rate, and integration of R&D into regular work processes. One survey noted that as of 2003 only 37% of the respondents had formally implemented six sigma principles in their R&D organization (Johnson and Swisher, 2003). Rajagopalan et al. (2004) reported that the development.

5. Conclusion

Given that Six Sigma methodology has been around in industry for over a decade, it now seems unimportant to determine whether Six Sigma is better than other approaches. It is more important to learn how to enhance the Six Sigma methodology and improve implementation issues for the growing number of firms that are choosing to adopt it as a means of process improvement. The primary focus should be on improving overall management performance, not just pinpointing and counting defects. Researchers and practitioners are trying to integrate Six Sigma with other existing innovative management practices that have been around to make Six Sigma method even more attractive to different organizations that might have not started or fully implemented the Six Sigma method. One area of future research is how these Six Sigma practices are adopted in different organizational contexts is needed, since different organizations have different maturity levels of QM implementation and the strengths and weakness of their existing QM systems vary. Another

area suggested for future research is the investigation of how Six Sigma works with other improvement methods such as lean manufacturing. Successful implementation and growing organizational interest in six sigma method have been exploding in the last few years. However, there is still the need for more empirical research into the Six Sigma phenomenon, using rigorous research methods to validate the many uncorroborated Six Sigma claims and to test new theories or models that have been proposed to strengthen the methodology. Yet, the research territory to date has been only found within the North America region with only a few studies in Europe and Asia. Given the globalization of many companies, including those using Six Sigma, study in other parts of the world is needed to gain insights into cultural issues that may affect the theory and practice of Six Sigma. Effective Six Sigma principles and practices are more likely to succeed by refining the organizational culture continuously.

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