

# 1. QUALITY IMPROVEMENT THROUGH SYSTEMATIC APPROACH-SIX SIGMA

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## Abstract

*Six sigma a statistically based quality improvement methodology, leads to breakthrough in product / process quality, customer satisfaction and productivity. The concept of six sigma was pioneered at Motorola in the 1980's and the concept was to reduce the number of defects to as low as 3.4 parts per million opportunities.*

*This paper aims at understanding the concept of six sigma , its statistical meaning and benefits of implementing Six Sigma in various sectors like education, healthcare, finance, manufacturing Engineering and Construction, R&D etc.*

**Keywords:** Six Sigma, Variation, quality Improvement.

## 1. Introduction.

Six Sigma is a statistically-based process improvement methodology that aims to reduce defects by identifying and eliminating causes of variation in business processes. Six Sigma methodologies provide techniques and tools to improve the capability and reduce the defects in any process. An important clarification is that Six Sigma measures defect opportunities and not defective products. The more complex a product, the more defect opportunities it has.

Six Sigma aims for processes to be improved, so that problems don't occur, instead of just finding short term solutions to the problems. Finding short term solutions is improving on the second level of learning. Consequently, what organizations should be aiming at improving on the first level of learning. At its foundation, Six Sigma is teaching everyone in the organization to become more effective and efficient (Eckes, G. 2003).

## 2. What is Six Sigma.

Six Sigma is often defined as: "A quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities or 0.0003%"

Six Sigma is a highly disciplined approach that helps us focus on developing and delivering near-perfect products and services. Why Sigma ? The word is a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma is that if you can measure how many defects you have in a process, you can systematically figure out how to eliminate them and get, as close to zero defects, as possible. The statistical representation of Six Sigma describes quantitatively how a process is performing. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities. The following table summarizes defects per million opportunities corresponding to Sigma level.

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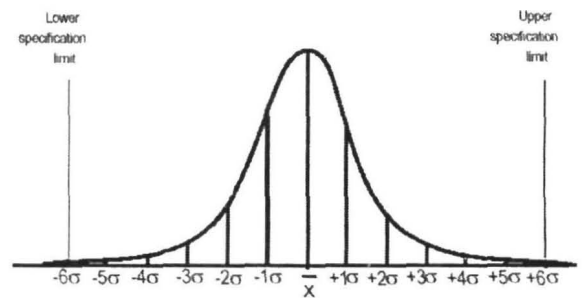
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Sigma Level	Defects per Million Opportunities
0	933,193
1	691,462
2	308,537
3	66,807
4	6,210
5	233
6	3.4

Table 1: Six sigma level and corresponding DPMO

### 3.The Statistical Definition of Six Sigma

The objective in driving for Six Sigma performance is to reduce or narrow variation to such a degree that standard deviation can be squeezed within the limits defined by the customers specification (LSL & USL) as shown in the fig. 1. For many products, services and processes that means, a potential for enormous improvement. The statistics associated with Six Sigma are relatively simple. To define Six Sigma statistically, two concepts are required: specification limits and the normal distribution. Specification limits are the tolerance or performance ranges that customers demand of the products or services they are purchasing. Because variability is so ubiquitous in the real world, the specification limits should be set in a way that permits some degree of imprecision in the work done. The following Figure illustrates specification limits as the two major vertical lines in the figure. The target value, shown in the figure as X, is naturally at the exact center between the upper and lower specification limits. These specification limits are independent of the bell-shaped curve of the normal distribution, also shown in the figure 1. The customer expects the result to fall somewhere between the upper and lower specification limits, if not exactly in the center (X). It is up to the customer to decide whether or not, the extreme values at the specification limits are acceptable quality levels. The values outside the customer specification limits, are considered defects, failures, or nonconformities.



Spec. Limit	Percent
$\pm 1 \sigma$	68.27
$\pm 2 \sigma$	95.45
$\pm 3 \sigma$	99.73
$\pm 4 \sigma$	99.9937
$\pm 5 \sigma$	99.999943
$\pm 6 \sigma$	99.999998

Fig. 1: Normal Distribution between Six sigma limits

The tabular information in Figure 1 indicates the percentage of the area under the normal curve that can be found within  $\pm 1\sigma$  units throughout  $\pm 6\sigma$  units centered about the mean, where  $\sigma$  represents true population standard deviation. For instance,  $\pm 3\sigma$  units of standard deviation represent 99.73% of the total area under the normal distribution curve (100%).

Hence, the main objective of six sigma methodology is to reduce or narrow variation so that output of the process remains within the limits, defined by the customers specification.

### 4.Six Sigma Roadmap:

Six Sigma methodology provides a rigorous roadmap for quality improvement. When the objective is to improve an existing product or process, the roadmap consists of five critical steps DMAIC: Define, Measure, Analyze, Improve and Control, as shown in Figure 2.

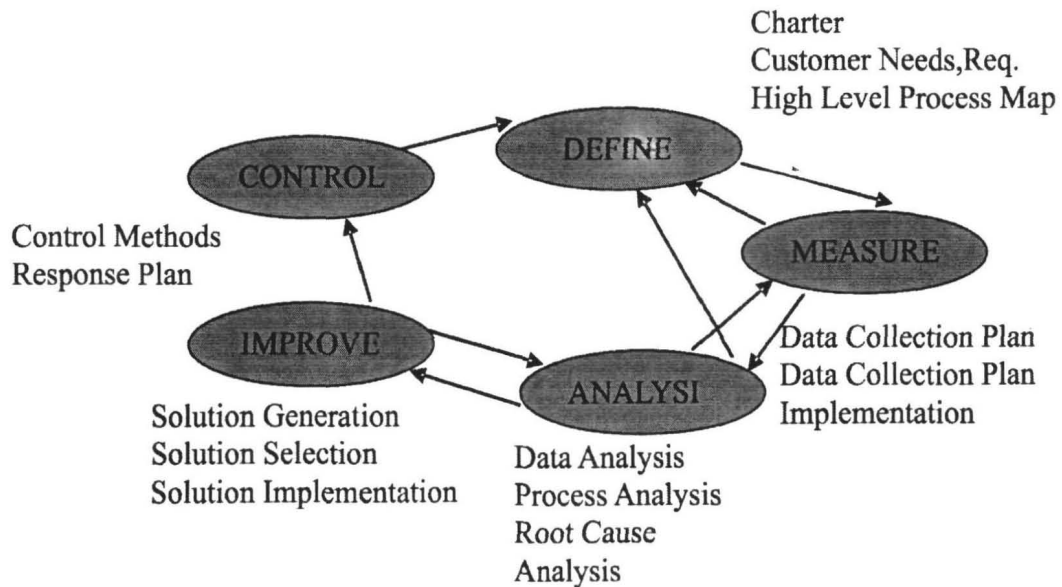


Figure 2. The DMAIC activities

### The process steps in the DMAIC concept are

**Define:** the customers, their Critical to Quality (CTQ) issues, and the processes involved.

**Measure:** the performance of the processes involved.

**Analyze:** the data collected and process map to determine root causes of defects and opportunities for improvement.

**Improve:** the target process by designing creative solutions to fix and prevent problems.

**Control:** the improvements to keep the process on the new course.

### 6. Key Concepts of Six Sigma

At its core, Six Sigma revolves around a few key concepts.

**Critical to Quality(CTQ):** Attributes most important to the customer,

**Defect:** Failing to deliver what the customer wants,

**Process Capability(Cp):** What your process

can deliver,

**Variation:** What the customer sees and feels,

**Stable Operations:** Ensuring consistent, predictable processes to improve what the customer sees and feels.

**Design for Six Sigma:** Designing to meet customer needs & process capability Often, our inside-out view of the business is based on average or mean-based measures of our recent past. Customers don't judge the company on averages, they feel the variance in each transaction, each product company ships. Six Sigma focuses, first on reducing process variation and then on improving the process capability.

Customers value consistent, predictable business processes that deliver, world-class levels of quality. This is what Six Sigma strives to produce.

### 7. Reported Benefits of Implementing Six Sigma

**Education sector:** Education could benefit a

great deal from six sigma theory; therefore, many researchers recommend that six sigma theory should be included in the training programs of the educational leaders to face rapid technological evolutions in globalized scenario.

Although various scholars have written on six sigma in academic institutions, the studies have a very narrow focus. While some studies focus on implementing six sigma to assist university administrators with decision-making on issues such as retaining students in academic programs based on extensive data analysis, others focus on integrating the six sigma methodology in an academic program (engineering, statistics, etc.), school or college (Lawrence O. Jenicke et.al 2008).

Following are some of the key studies by various researchers and their findings about role of six sigma in education.

Several authors examine the role of six sigma to support decision-making in science and engineering programs at two different universities (Burtner, 2004; Hargrove and Burge, 2002). Burtner (2004) recommends using the six sigma methodology at the Mercer University School of Engineering to provide university administrators with the data they need to make effective changes in programming and policy.

Four projects were identified as potential six sigma projects at Mercer University School of Engineering and these projects address issues ranging from retention and success of

students in mathematics classes, reduction in the amount of time taken by students to graduate from an engineering program (Lawrence O. Jenicke & Anil Kumar 2008).

Amitava Mitra (2004), argues that for companies to survive, they need employees who can continuously improve their products and services, and that academic institutions have both, the means and responsibility, to train these personnel because they are "a central

system of knowledge research and its dissemination". Many engineering and business students in European universities develop skills in their own area of study, but largely without any formal training to help them integrate the required skills into a holistic problem-solving framework which requires statistical, management and technical skills. The future engineers and managers should pick up a good blend of statistical, technical and leadership skills for tackling business problems in organizations and Jiju Antony (2008) strongly believes that six sigma and lean strategies can provide solutions to such problems.

Six sigma framework can provide an excellent platform for integrating all six sigma tools and techniques into the curricula of engineering and business schools. Students in academic institutions will be exposed to real-world problems and cases.

A pilot study was conducted by the author to assess & evaluate the student's performance in the curricula and recommend methods for improvement using six sigma methodology.

By applying six sigma methodology, various critical to quality factors for improvement in student performance were identified and it was found that by improving upon the factors identified, students performance can be greatly improved.

On similar lines, many abroad universities have started applying six sigma principles to improve the quality of education.

**Manufacturing Sector:** Motorola was the first organization to use six sigma methodology for quality improvements programs. The other organization such as GE, Sony, Allied signal, Kodak, Honeywell, Boeing, Seagate, DuPont, Texas Instruments, Toshiba have successfully applied the six sigma methodology for quality improvement. Table 2 summarizes, the reported benefits, improvements and saving in these organizations, after six sigma deployment.

Company/Project	Metric/Measures	Benefit/Savings
Motorola (1992)	In process defects levels	150 times reduction
Raytheon /Aircraft Integration Systems	Depot maintenance inspection time	Reduced 88% as measured in days
GE / Railcar leasing business	Turnaround time at repair shops	62% reduction
Allied Signal / Laminates plant in South Carolina	Capacity Cycle time Inventory On-time delivery	Up 50% Down 50% Down 50% Increased to near 100%
Allied Signal / Bendix IQ brake pads	Concept-to-shipment cycle time	Reduced from 18 months to 8 months
Hughes Aircraft's Missiles Systems Group / Wave soldering operations	Quality Productivity	Improved 1000% Improved 500%
General Electric	Financial	\$ 2 billion in 1999
Motorola (1999)	Financial	\$ 15 billion over 11 years
Dow Chemical / Rail delivery project	Financial	Savings of \$2.45 million in capital expenditures
DuPont / Yerkes Plant in New York (2000)	Financial	Savings of more than \$ 2 million
Telefonica de Espana (2001)	Financial	Savings & increases in revenue 30 million euro in the first 10 months
Texas Instruments	Financial	\$ 600 million
Johnson & Johnson	Financial	\$ 500 million
Honeywell	Financial	\$ 1.2 billion

Table 2: Reported benefits and saving from six sigma in the Manufacturing Sector  
(Data compiled from Frank T. Anbari, 2004)

**Financial Sector:** In recent years, finance and credit department were 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 credit defects,

reducing check collection defects, and reducing variation in collector performance (Doran 2003).

Bank of America (BOA) has been one of the pioneers in adopting and implementing the Six Sigma method 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 to 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 Corporation, JP Morgan Chase, and SunTrust Banks are using Six Sigma to focus on and improve customer requirements and satisfaction (Roberts 2004).

**Healthcare Sector:** Six Sigma principles and the healthcare sector are very well matched because of the healthcare nature of very low or zero tolerance to mistakes and potentials 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 M. D. Anderson Cancer Center also adopted the Six Sigma method and improved service activities greatly (Benedetto 2003). Also in the same institution's outpatient exam lab, patient preparation times were reduced from 45 minutes to less than 5 minutes in many cases and there was a 45 percent increase in examinations with no additional machines or shifts (Elsberry 2000).

**Engineering and Construction Sector :** In 2002, Bechtel Corporation, one of the largest engineering and construction companies in the world reported a 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 2003). As examples, Six Sigma was implemented to streamline the process of neutralizing chemical agents and at

a national telecommunications project, to help optimize the management of cost and schedules (Moreton 2003).

### **Research and Development Sector :**

The objectives of implementing Six Sigma in Research and Development (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. (2003) reported that the development and manufacturing of new prototypes at W. R. Grace (Refining Industry) was cut to 8-9 months from 11-12 months by implementing the DFSS process.

### **8. Conclusion**

Six sigma is likely to remain as one of the key initiatives to improve the quality in various spheres of the industries including education sector. Growing organizational interests for six sigma & its successful implementation have been exploding in the last few years and Six sigma concept has become a global trend setter in developing quality improvement strategy.

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