QUALITY IMPROVEMENT FUNDAMENTALS METHODOLOGY AND TOOLS SUMMARY GUIDEBOOK

(PART–I)

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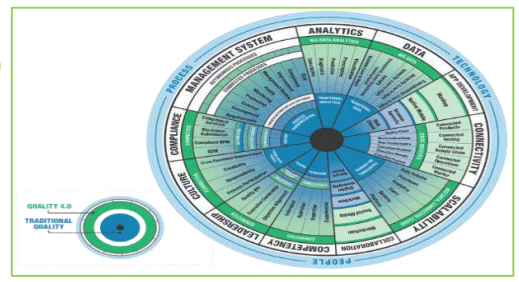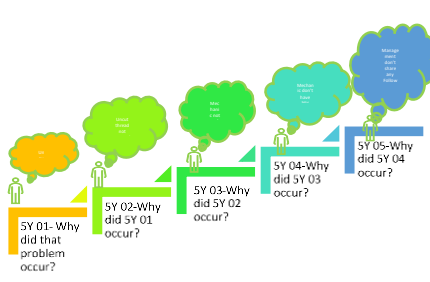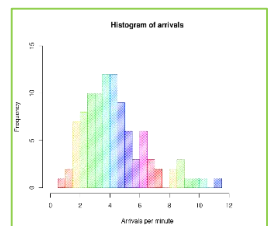
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Purpose of this Guidebook

The purpose of this basic quality improvement methodologies and tools summary guidebook is to share the basic quality concept with apparel industry quality professionals as well as other related stakeholders. I expect it will also be helpful for fresh graduates or new quality professionals who want to know about quality principles and development theories. I've also added references for further study.

With this guidebook, you will only be able to know the theories and a few examples, but the implementation and result part will be shared in Part II.

Also, in this guidebook, I tried to arrange quality theories on a basis for easy understanding. You can also get basic information about how quality theories are developed and modernized day by day.

During reading If you find any mistakes, wrong information, or any other discrepancies, I request that you send them to me for correction via email.

1 Introduction of Quality and Quality pioneers' theories

1.1 Quality Definition

- The degree to which a set of inherent characteristics fulfill requirements - ISO 9000
- A degree of excellence – The Concise Oxford Dictionary
- Fitness for Purpose – Defoe and Juran (2010)
- Quality is a dynamic state associated with products, services, people, processes, and environments that meets or exceeds expectations and helps produce superior value – Goetsch and Davis (2010)
- Conformance to requirements – Phil B. Crosby (1979)

1.2 Quality Pioneers and their most popular theories

Most popular quality pioneers are-Edwards Deming, Dr. Joseph Juran, Dorian Shainin, Kaoru Ishikawa, Genichi Taguchi and Philip Crosby.

1.2.1 Joseph Moses Juran (December 24, 1904 – February 28, 2008)

Joseph Moses Juran known as the "father" of modern-day Quality management. He was a Romanian-born American engineer and management consultant. He was an evangelist for quality and quality management, having written several books on those subjects.

His most popular Quality theories are-

I. Pareto principle-80% of a problem is caused by 20% of the causes.

II. Management theory-Juran is widely acknowledged for the addition of the human dimension to quality management. He advocated the training and education of managers. Juran proposed that human relations problems are supposed to be isolated and that the fundamental cause of quality issues was resistance to change.

III. The Juran trilogy-Juran was one of the first to write about the cost of poor quality. This was illustrated by his "Juran trilogy," an approach to cross-functional management, which is composed of three managerial processes: quality planning, quality control, and quality improvement. Without change, there will be a constant waste; during change there will be increased costs, but after the improvement, margins will be higher, and the increased costs are recouped.

1.2.2 William Edwards Deming (October 14, 1900 – December 20, 1993)

Edwards Deming was an American engineer, statistician, professor, author, lecturer, and management consultant. Educated initially as an electrical engineer and later specializing in mathematical physics, he helped develop the sampling techniques still used by the U.S. Department of the Census and the Bureau of Labour Statistics.

Edwards Deming is considered by many to be the father of the total quality management movement. Edwards Deming's theories are based on the simple concept that continual improvement can help increase quality while decreasing costs, or what we can call total quality management.

Deming's 14 Points on Quality Management, or the Deming Model of Quality Management, a core concept on implementing total quality management (TQM), is a set of management practices to help companies increase their quality and productivity.

Deming's 14 Points for Total Quality Management:

I.   Create constancy of purpose for improving products and services.
II.   Adopt the new philosophy.
III.   Cease dependence on inspection to achieve quality.
IV.   End the practice of awarding business on price alone; instead, minimize total cost by working with a single supplier.
V.   Improve constantly and forever every process for planning, production and service.
VI.   Institute training on the job.
VII.   Adopt and institute leadership.
VIII. Drive out fear.
IX.   Break down barriers between staff areas.
X.   Eliminate slogans, exhortations and targets for the workforce.
XI.   Eliminate numerical quotas for the workforce and numerical goals for management.
XII.   Remove barriers that rob people of pride of workmanship and eliminate the annual rating or merit system.
XIII. Institute a vigorous program of education and self-improvement for everyone.
XIV.   Put everybody in the company to work accomplishing the transformation.

These total quality management principles can be put into place by any organization to implement total quality management more effectively. As a total quality management philosophy, Dr. Deming's work is foundational to TQM and its successor, quality management systems.

1.2.3 Dorian Shainin (September 26, 1914 – January 7, 2000)

Dorian Shainin was an American quality consultant, aeronautics engineer, author, and college professor most notable for his contributions in the fields of industrial problem solving, product reliability, and quality engineering, particularly the creation and development of the "Red X" concept.

Shainin (pronounced SHAY-nin), founder of the technical-problem-solving company Shainin LLC, is responsible for the development of over 20 statistical engineering techniques that have become the core of the "Shainin System" for quality and reliability improvement.

Red x method:

The Shainin System™ for quality improvement was developed over many years under the leadership of the late Dorian Shainin. The Shainin System™ is also referred to as Statistical Engineering and Red X® strategy (in parts of the automotive sector).

Dorian Shainin

Born	September 26, 1914 San Francisco, California
Died	January 7, 2000 (aged 85) Manchester, Connecticut
Nationality	American
Alma mater	Massachusetts Institute of Technology
Known for	Red X

The overall methodology has not been subject to critical review. However, the underlying principles of SS can be placed in two groups:

I.   The belief that there are dominant causes of variation.
II.   The belief that there is a diagnostic journey and a remedial journey (the Shainin System™ algorithm)
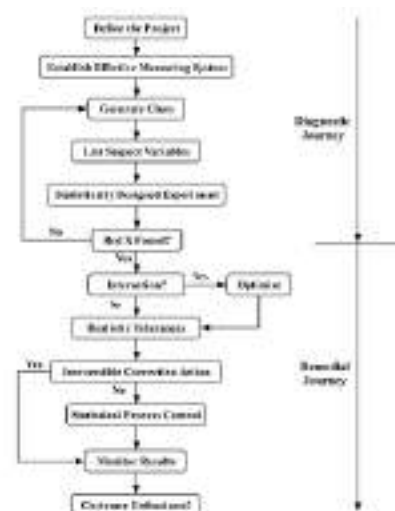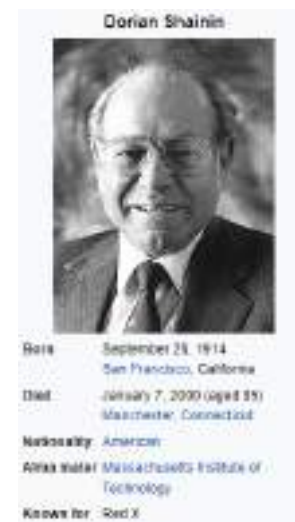
FIGURE 1   The Shainin system™ for quality improvement (from Shainin, 1992).

1.2.4 Kaoru Ishikawa1 (July 13, 1915 – April 16, 1989)

Kaoru Ishikawa was a Japanese organizational theorist and a professor in the engineering faculty at the University of Tokyo noted for his quality management innovations. He is considered a key figure in the development of quality initiatives in Japan, particularly the quality circle. He is best known outside Japan for the Ishikawa or cause and effect diagram (also known as the fishbone diagram), often used in the analysis of industrial processes.

Ishikawa's major contributions in quality control and process improvement can be traced as under:

Fishbone diagram (cause & effect diagram) – This tool created by Kaoru Ishikawa is known as the fishbone diagram owing to its shape. It is one of the seven basic quality control tools. The objective of the six-sigma program is the removal of waste to identify the areas for improvement. A fishbone diagram clusters the roadblocks together to identify which factors have the greatest impact. Ishikawa diagram is commonly used in product design and prevention of quality defects to reveal the factors causing the overall effect.

Implementation of quality circles: A voluntary group of people who meet to identify, analyse, and resolve work-related issues. Improvement in occupational health and safety, product design, manufacturing processes, and the overall culture of the organization are the objectives of a quality circle. In Japan, this concept was first launched in Nippon wireless and telegraph company in the year 1962. The idea of quality circles was described by Edward Deming in 1950 and was later expanded by Ishikawa. Basically, quality circles are formal groups of people trained by specialists in human factors and skills of problem identification, data gathering, and analysis and generation of solutions.

Emphasis on internal customer: Ishikawa suggested that over-reliance on specialists would limit the scope of improvement for all the employees. Therefore, an overall participation was required from workers at all the levels of the organization. every area has the potential for contributing to the overall quality, therefore; all areas should embed statistical techniques in the internal and external audit programmes. The term company-wide does not only include a company's activities focusing on internal quality control, but also the quality of management, human aspects, after sales service, and sensitive customer care.

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[1] https://en.wikipedia.org/wiki/Kaoru_Ishikawa

1.2.5 Genichi Taguchi[2] (January 1, 1924 – June 2, 2012)

Genichi Taguchi was an engineer and statistician. From the 1950's onwards, Taguchi developed a methodology for applying statistics to improve the quality of manufactured goods. Taguchi methods have been controversial among some conventional Western statisticians, but others have accepted many of the concepts introduced by him as valid extensions to the body of knowledge.

Taguchi has made a very influential contribution to industrial statistics. Key elements of his quality philosophy include the following:

I. Taguchi loss function, used to measure financial loss to society resulting from poor quality.

II. The philosophy of off-line quality control, designing products and processes so that they are insensitive ("robust") to parameters outside the design engineer's control.

III. Innovations in the statistical design of experiments, notably the use of an outer array for factors that are uncontrollable in real life, but are systematically varied in the experiment.

$$L_y(Y) = \frac{C_{of\,upper}}{\tau_y^2}(Y - \bar{Y})^2 + \frac{C_{of\,lower}}{\tau_y^2}(Y - \bar{Y})^2$$

τ_y: functional tolerance
C_{of}: cost to functionality if tolerance is exceeded

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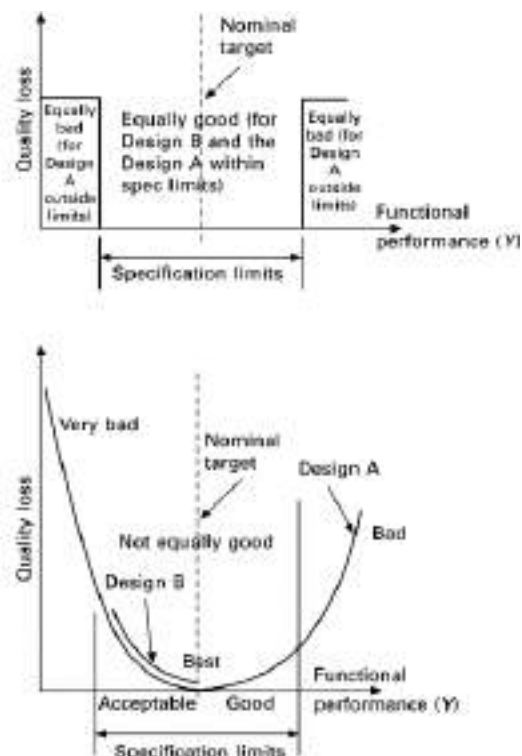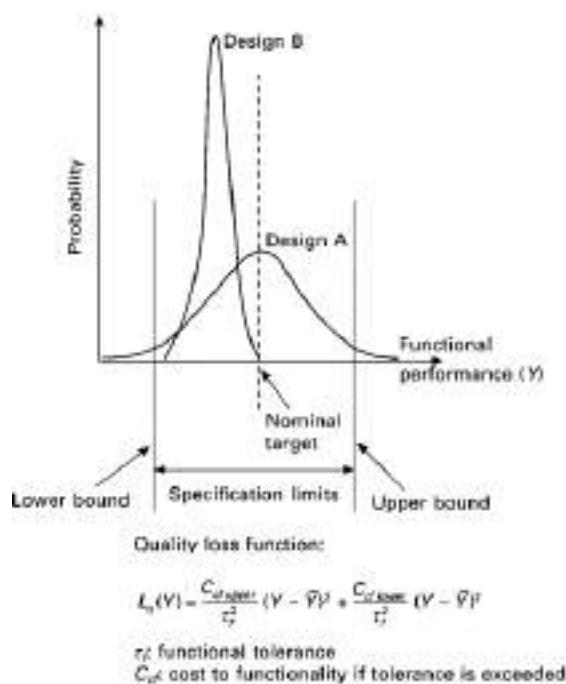
[2] https://en.wikipedia.org/wiki/Genichi_Taguchi

2 [Quality Assurance & Quality Control](#)[3]

Quality assurance (QA) and quality control (QC) are two terms that are often used interchangeably. Although similar, there are distinct differences between the two concepts.

2.1 Differences Between QA And QC

Quality assurance and quality control are two aspects of quality management. While some quality assurance and quality control activities are interrelated, the two are defined differently. Typically, QA activities and responsibilities cover virtually all the quality system in one fashion or another, while QC is a subset of the QA activities. Also, elements in the quality system might not be specifically covered by QA/QC activities and responsibilities but may involve QA and QC.

Quality System, Quality Assurance, and Quality Control Relationships

2.1.1 Quality Assurance

Quality assurance can be defined as "part of quality management focused on providing confidence that quality requirements will be fulfilled." The confidence provided by quality assurance is two fold-internally to management and externally to customers, government agencies, regulators, certifiers, and third parties. An alternate definition is "all the planned and systematic activities implemented within the quality system that can be demonstrated to provide confidence that a product or service will fulfill requirements for quality."

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[3] https://asq.org/quality-resources/quality-assurance-vs-control?

2.1.2 Quality Control

Quality control can be defined as "part of quality management focused on fulfilling quality requirements." While quality assurance relates to how a process is performed or how a product is made, quality control is more the inspection aspect of quality management. An alternate definition is "the operational techniques and activities used to fulfill requirements for quality."

2.1.3 Industry Perspectives on QA And QC

For some service organizations, the concept of quality control may be foreign because there is no tangible product to inspect and control. The quality assurance function in a service organization may not include quality control of the service but may include quality control of any products involved in providing the service.

A service may include products that are documents (such as a report, contract, or design) or tangible products (such as a rental car or units of blood). It may be necessary to control product quality in a service organization to ensure that the service meets customer requirements.

2.1.4 QA, QC, and Inspection

Inspection is the process of measuring, examining, and testing to gauge one or more characteristics of a product or service and the comparison of these with specified requirements to determine conformity. Products, processes, and various other results can be inspected to make sure that the object coming off a production line, or the service being provided, is correct and meets specifications.

2.1.5 Quality Assurance and Audit Functions

Auditing is part of the quality assurance function. It is important to ensure quality because it is used to compare actual conditions with requirements and to report those results to management.

Formal management systems have evolved to direct and control organizations. There are quality management systems (QMS) as well as environmental or other management systems, and each of these systems may be audited.

2.1.6 Seven basic Quality Control tools for process improvement

Quality pros have many names for these seven basic tools of quality, first emphasized by Kaoru Ishikawa, a professor of engineering at Tokyo University and the father of "quality circles." Start your quality journey by mastering these tools, and you'll have a name for them too: indispensable.

I.   Cause-and-effect diagram (also called Ishikawa or fishbone diagrams): Identifies many possible causes for an effect or problem and sorts of ideas into useful categories.

II. Check sheet: A structured, prepared form for collecting and analysing data; a generic tool that can be adapted for a wide variety of purposes.

III. Control chart: Graph used to study how a process changes over time. Comparing current data to historical control limits leads to conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

IV. Histogram: The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs.

V.   Pareto chart: A bar graph that shows which factors are more significant.

VI. Scatter diagram: Graphs pairs of numerical data, one variable on each axis, to look for a relationship.

VII. Stratification: A technique that separates data gathered from a variety of sources so that patterns can be seen (some lists replace stratification with flowchart or run chart).

3 Total Quality Management (TQM)[4]

3.1 Total Quality Management

A core definition of total quality management (TQM) describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work.

3.2 Primary Elements Of TQM

TQM can be summarized as a management system for a customer-focused organization that involves all employees in continual improvement. It uses strategy, data, and effective communications to integrate the quality discipline into the culture and activities of the organization. Many of these concepts are present in modern quality management systems, the successor to TQM. Here are the **8 principles** of Total Quality Management:

I. Customer-focused: The customer ultimately determines the level of quality. No matter what an organization does to foster quality improvement-training employees, integrating quality into the design process-the customer determines whether the efforts were worthwhile.

II. Total employee involvement: All employees participate in working toward common goals. Total employee commitment can only be obtained after fear has been driven from the workplace, when empowerment has occurred, and when management has provided the proper environment. High-performance work systems integrate continuous improvement efforts with normal business operations. Self-managed work teams are one form of empowerment.

III. Process-centered: A fundamental part of TQM is a focus on process thinking. A process is a series of steps that take inputs from suppliers (internal or external) and transforms them into outputs that are delivered to customers (internal or external). The steps required to carry out the process are defined, and performance measures are continuously monitored in order to detect unexpected variation.

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[4] https://asq.org/quality-resources/total-quality-management

IV.Integrated system: Although an organization may consist of many different functional specialties often organized into vertically structured departments, it is the horizontal processes interconnecting these functions that are the focus of TQM.

a) Micro-processes add up to larger processes, and all processes aggregate into the business processes required for defining and implementing strategy. Everyone must understand the vision, mission, and guiding principles as well as the quality policies, objectives, and critical processes of the organization. Business performance must be monitored and communicated continuously.

b) An integrated business system may be modelled after the Baldrige Award criteria and/or incorporate the ISO 9000 standards. Every organization has a unique work culture, and it is virtually impossible to achieve excellence in its products and services unless a good quality culture has been fostered. Thus, an integrated system connects business improvement elements to continually improve and exceed the expectations of customers, employees, and other stakeholders.

V.Strategic and systematic approach: A critical part of the management of quality is the strategic and systematic approach to achieve an organization's vision, mission, and goals. This process, called strategic planning or strategic management, includes the formulation of a strategic plan that integrates quality as a core component.

VI.Continual improvement: A large aspect of TQM is continual process improvement. Continual improvement drives an organization to be both analytical and creative in finding ways to become more competitive and more effective at meeting stakeholder expectations.

VII.Fact-based decision making: To know how well an organization is performing, data on performance measures are necessary. TQM requires that an organization continually collect and analyse data to improve decision making accuracy, achieve consensus, and allow prediction based on past history.

VIII.Communications: During times of organizational change, as well as part of day-to-day operation, effective communications play a large part in maintaining morale and in motivating employees at all levels. Communications involve strategies, method, and timeliness.
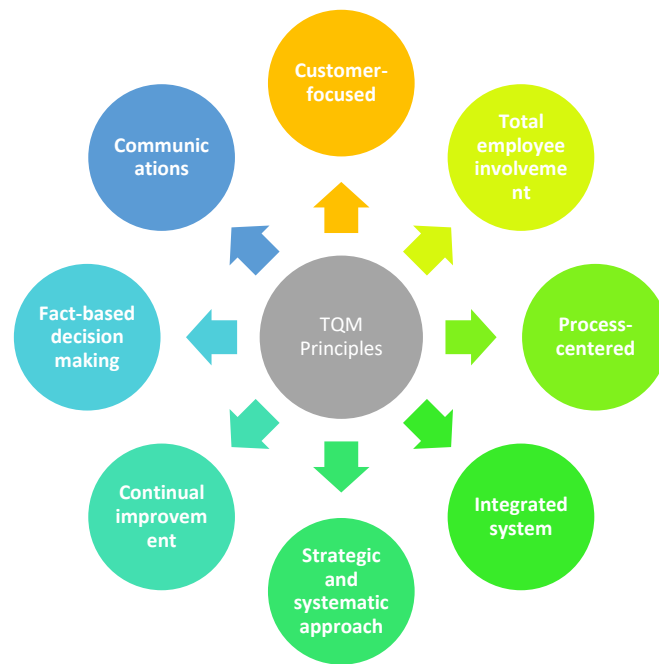
Primary Elements of Total Quality Management (TQM)

These elements are considered so essential to TQM that many organizations define them, in some format, as a set of core values and principles on which the organization is to operate. The methods for implementing this approach come from the teachings of such quality leaders as Philip B. Crosby, W. Edwards Deming, Armand V. Feigenbaum, Kaoru Ishikawa, and Joseph M. Juran.

4   <u>Quality Management System (QMS)</u>[5]

4.1   Quality Management System (QMS):

A Quality Management System (QMS) is defined as a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives. A QMS helps coordinate and direct an organization's activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis.

ISO 9001:2015, the international standard specifying requirements for Quality Management System, is the most prominent approach to Quality Management System. While some use the term "QMS" to describe the ISO 9001 standard or the group of documents detailing the QMS, it actually refers to the entirety of the system. The documents only serve to describe the system.

- The Rise of Quality Management Systems
- Benefits of QMS
- ISO 9001:2015 and other QMS standards
- Quality Management Principles
- Establishing and implementing a QMS
- QMS resources

4.2   The Rise of Quality Management Systems:

The American response to the quality revolution in Japan gave birth to the concept of Total Quality Management (TQM), a method for quality management that emphasized not only statistics but approaches that embraced the entire organization.

In the late 20th century, independent organizations began producing standards to assist in the creation and implementation of Quality Management Systems. It is around this time that the phrase "Total Quality Management" began to fall out of favour. Because of the multitude of unique systems that can be applied, the term "Quality Management System" or "QMS" is preferred.

At the start of the 21st century, QMS had begun to merge with the ideas of sustainability and transparency, as these themes became increasingly important to consumer satisfaction.

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[5] https://asq.org/quality-resources/quality-management-system?

4.3 Benefits of Quality Management Systems:

Implementing a Quality Management System affects every aspect of an organization's performance. Benefits of a documented quality management system include:

- Meeting the customer's requirements, which helps to install confidence in the organization, in turn leading to more customers, more sales, and more repeat business
- Meeting the organization's requirements, which ensures compliance with regulations and provision of products and services in the most cost- and resource-efficient manner, creating room for expansion, growth, and profit.

These benefits offer additional advantages, including:

- Defining, improving, and controlling processes
- Reducing waste
- Preventing mistakes
- Lowering costs
- Facilitating and identifying training opportunities
- Engaging staff
- Setting organization-wide direction
- Communicating a readiness to produce consistent results

4.4 ISO 9001:2015 And Other QMS Standards:

ISO 9001:2015 is the most recognized and implemented quality management system standard in the world. ISO 9001:2015 specifies the requirements for a QMS that organizations can use to develop their own programs.

Other standards related to quality management systems include the rest of the ISO 9000 series (including ISO 9000 and ISO 9004), the ISO 14000 series (environmental management systems), ISO 13485 (quality management systems for medical devices), ISO 19011 (auditing management systems), and ISO/TS 16949 (quality management systems for automotive-related products).

4.5 ISO 9000:2015 and ISO 9001:2015 Quality Management Principles

The ISO 9000:2015 and ISO 9001:2015 standards are based on seven quality management principles. According to ISO, the seven quality management principles are, in no particular order:

    I. Customer focus
    II. Leadership
    III. Engagement of people
    IV. Process approach
    V. Improvement
    VI. Evidence-based decision making
    VII. Relationship management

Let's take a closer look at these quality management principles and how you can adopt them to improve your organization.

I. Customer Focus:

This almost goes without saying. An organization that doesn't focus on customers won't be around for long. Although a customer focus is critical, many times this can be lost in the priorities of a quality system and the various processes involved.

The focus should include current—and future—customers. Besides continuously meeting or exceeding customer expectations, companies should measure customer satisfaction. Conversely, failing to meet customer expectations should also be tracked. Every function and department should be involved.

II. Leadership

As with any quality idea, support must start at the top. Without good leadership, an organization will suffer. Leaders should set a vision and goals for the company.

Think back to an inspiring leader you've met. Perhaps this was at work or even at a quality event. For those who were at the 2014 ASQ conference, Mike Abrashoff, former commander of the USS Benfold, may come to mind. At the event, he described the challenges of taking over an underperforming war ship. Morale was low and turnover was high. By uniting his crew with their common purpose along with praise and appreciation, he was able to transform the ship. This theme continues in the next principle.

III. Engagement of People

An engaged workforce is one that you want to have. This means the abilities of the staff are used and valued. It also enables continuous improvement, learning, and discussion of any issues. With an engaged workforce, staff are held accountable for their actions. Rather being seen as a passive place to clock in every morning, the job requires everyone in the organization to be active and engaged in their work.

IV. Process Approach

As with so many things in quality, a process approach outlines the steps for success.This means activities are managed as processes, measured, and connections between activities are identified. Opportunities for improvement are tracked. Quality doesn't just happen. It requires processes behind the scenes to ensure the success of the organization.

V. Improvement

A strong quality system requires change. Without improvement, companies will eventually be outshined by the competition. Aiming to maintain the status quo does not inspire anyone.

This means the company's performance and capabilities should be developed on an ongoing basis. These improvement activities should align with goals, and staff should be encouraged and empowered to make improvements. When improvements are made, these should be measured. And finally, celebrated! When things go well, it's important to acknowledge it. Quality isn't all stressful audits and data analysis. Sometimes it's formal recognition and praise.

VI. Evidence-based Decision Making

As you may have guessed, gut feelings are not the way forward. Rather, data is king. Of course, this should be no surprise to the quality professional. Organizations should make sure data is accessible, accurate, and reliable. It should be analysed, and decisions made based on it. Still, data analysis should be balanced with practical experience. The numbers tell the story, but it is important not to discount experience as well.

VII. Relationship Management

Finally, the people are the important part of any organization, and the relationships between suppliers and other partners are critical. Suppliers should be selected carefully based on the ability to create value as well as manage costs. Partners should be aware of plans and information that would help them in their work. A spirit of collaboration should be the goal. Coordinating improvement activities can help both parties. Recognizing supplier successes will also go a long way to maintaining a strong relationship.

4.6 Establishing and Implementing A QMS

Before establishing a Quality Management System, your organization must identify and manage various connected, multi-functional processes to help ensure customer satisfaction. The QMS design should be influenced by the organization's varying objectives, needs, and products and services provided. This structure is based largely on the plan-do-check-act (PDCA) cycle and allows for continuous improvement to both the product and the QMS. The basic steps to implementing a quality management system are as follows:

I.   Design
II.   Build
III.   Deploy
IV.   Control
V.   Measure
VI.   Review
VII.   Improve
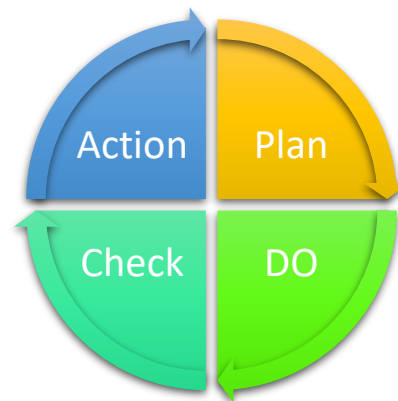
Figure: PDCA Cycle

Design and Build

The design and build portions serve to develop the structure of a QMS, its processes, and plans for implementation. Senior management should oversee this portion to ensure the needs of the organization and the needs of its customers are a driving force behind the systems development.

Deploy

Deployment is best served in a granular fashion by breaking each process down into subprocesses and educating staff on documentation, education, training tools, and metrics. Company intranets are increasingly being used to assist in the deployment of quality management systems.

Control and Measure

Control and measurement are two areas of establishing a QMS that are largely accomplished through routine, systematic audits of the quality management system. The specifics vary greatly from organization to organization depending on size, potential risk, and environmental impact.

Review and Improve

Review and improve detail how the results of an audit are handled. The goals are to determine the effectiveness and efficiency of each process toward its objectives, to communicate these findings to the employees, and to develop new best practices and processes based on the data collected during the audit.

5   Lean, Six Sigma and Lean Six Sigma

5.1 Lean Methodology[6]:

5.1.1 What is Lean?

Lean is a systematic approach to reduce or eliminate activities that don't add value to the process. It emphasizes removing wasteful steps in a process and taking the only value-added steps. The Lean method ensures high quality and customer satisfaction.

It helps in-

- Reducing process cycle time,
- Improving product or service delivery time,
- Reducing or eliminating the chance of defect generation,
- Reducing the inventory levels and
- Optimizing resources for key improvements among others.

It is a never-ending approach to waste removal, thus promotes a continuous chain of improvements.

5.1.2 What is "Value"?

Let's understand what "Value" in the above definition of Lean is:

Depending on the type of business process & industry context, the customer defines "value". "Value" is related to the customer's perception of the product(s) or service(s), which he or she is willing to pay for.

A process is a set of activities, which converts inputs into outputs using resources. In a process, these activities can be classified into three types. They are:

- Non-Value-added Activity: These activities do not add any value to the process or products. They form the wasteful steps. A customer doesn't pay for the costs associated with these activities willingly. Rather, if present excessively they result in customer dissatisfaction.
- Value-added Activity: These activities add value to the process are essential. They improve processes for productivity and quality.
- Enabling value-added Activity: These activities do not add value to a customer. They are necessary for the continuity of a process.

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[6] https://www.greycampus.com/blog/quality-management/a-brief-introduction-to-lean-and-six-sigma-and-lean-six-sigma

In any process, almost 80 – 85% of activities are non-value adding activities. The aim of the LEAN approach is to identify them in the process. And use specific lean tools to eliminate or reduce them. Thus, Lean improves process efficiency.

5.1.3 Types of Waste & Waste Removal

Lean concept obtains its genesis from TPS – Toyota Production system. TPS model typically is well suited for High Volume Production environment. However, Lean finds its application in any environment, where process wastes are witnessed. Lean can be applied to manufacturing as well as service industries. It causes no doubt that Lean, nowadays, is being adopted by service sectors with both arms.

Taiichi Ohno, who started his career working with Toyoda Spinning and rose through the ranks later, believed that the lean approach is a step-by-step reduction of waste. Stemming from the Toyota Production System, the 3M model – Muda, Mura, Muri – exposes inefficient processes that are a hindrance to customer value generation.

Muda: Muda refers to any activity that does not add value to the creation of the product or service for the customer. There were 7 types of lean wastes identified in manufacturing processes. Removing them was believed to be the key to value delivery to customers. Later on, the 8th lean waste was added - Underutilization of Skills.

Mura: Mura refers to inconsistencies in business operations leading to fluctuations in production. Variation in production or process leads to sub-optimal utilization of resources. Uneven workloads, inventory accumulation, and waiting are some examples. The presence of Mura leads to Muda.

Muri: Muri takes place when there are too much stress and strain on people and machines. Overtime data in offices and over-utilization of machinery in plants are some examples. When processes are not scheduled to optimize resources, it can result in dissatisfaction amongst people or downtime for machines. Although outcomes might be met. Muri also leads to Muda.

Using the Lean methodology, you can remove the below mentioned eight types of waste ("DOWNTIME" is the acronym for the eight wastes). These wastes are further explained below:

	Waste	Definition of waste
D	Defects	The efforts involved inspecting for and fixing errors, mistakes through reworks.
O	Overproduction	Producing more products or services that the customer needs or downstream process can use.
W	Waiting	Idle time created when material, information, people, or equipment is not ready. It includes high job set up time in manufacturing. Or excessively high data processing time in the service industry.
N	Non – Utilized Talent	Not adequately leveraging peoples' skills and creativity. Employee empowerment can counter this waste as advocated by Japanese quality pioneers.
T	Transportation	Moving products, equipment, material, information, or people from one place to another, without any value addition to the final product or service.
I	Inventory	Unnecessary/ Unwanted stocking or storage of information and/ or material (eg WIP, WIQ – work in the queue)
M	Motion	Unnecessary movement of people or machines that takes time and uses energy. It may cause fatigue to workmen due to unwanted movement of a body.
E	Extra Processing	Process steps that do not add value to the product or service, including doing work beyond a customer's specification.

5.1.4 The Five Principles of Lean
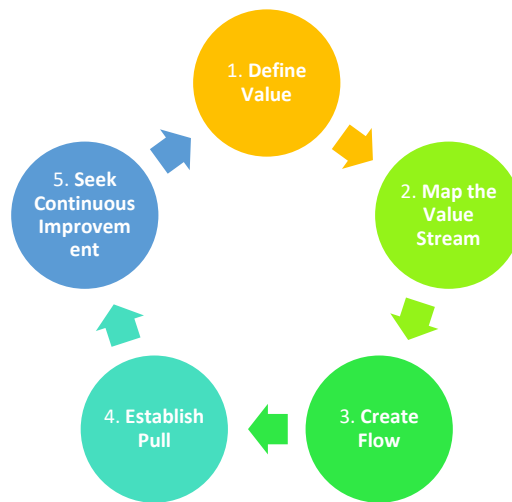
Figure: Lean Principles

I.   **Define Value:** The customer defines the value of a product or service. Hence, the first step is to identify customers. Ask yourself, what does the customer value? Figure out customer's expectations from your products or services. Classify the process activities into non-Value added, Value-added, and Enabling value-added.

II. **Map the Value Stream:** The value stream mapping shows the workflow process steps for a product or service. The value stream mapping helps to identify & eliminate NVA activities. This eventually helps you to reduce the process delays and thereby improves the quality of product/service.

III. **Create Flow:** Create a flow to the customer by ensuring a continuous flow system in producing products or services. The flow will optimize the process to maximize process efficiency.

IV. **Establish Pull:** Establish a pull approach by meeting system beat time. The beat time is the rate at which a product must be ready to meet customer demand. JIT (Just in time) is a tool promoting the Pull system. This ensures the smooth workflow of the process without any disruptions. It also helps to diminish inventory levels.

V.   **Seek Continuous Improvement:** Finally, you must put consistent efforts to improve the existing business processes to cater to ever-changing customer needs. This ensures the elimination of waste and defects of free products & quality service to customers.

5.1.5 Introduction to Some Important Lean Tools

5.1.5.1 VSM (Value Stream Mapping)[7]

Also called: value stream analysis, lean process mapping.

Value stream mapping (VSM) is defined as a lean tool that employs a flowchart documenting every step in the process. Many lean practitioners see VSM as a fundamental tool to identify waste, reduce process cycle times, and implement process improvement.

VSM is a workplace efficiency tool designed to combine material processing steps with information flow, along with other important related data. VSM is an essential lean tool for an organization wanting to plan, implement, and improve while on its lean journey. VSM helps users create a solid implementation plan that will maximize their available resources and help ensure that materials and time are used efficiently.

Creating A Value Stream Map[8]

This is a step-by-step guide to creating a current state value stream map, the first step in working towards your ideal state value stream and a truly lean system. Your current state value stream map is a team effort that is conducted by those people who are involved in the process, at the actual process, not by an expert locked in a room with a pile of procedures.

Below we will go through.

- Selecting the product (family) to map
- VSM Symbols
- Defining the process boundaries
- The Process Steps
- Information Flows
- Process Data
- Calculating the Timeline
- Multiple Suppliers and Customers
- Interpreting the Data
- Next Steps (Ideal and future state maps)

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[7] https://asq.org/quality-resources/lean/value-stream-mapping?

[8] https://leanmanufacturingtools.org/551/creating-a-value-stream-map/?

5.1.5.2 **Kaizen**[9]

"KAIZEN means improvement. Moreover, it means continuing improvement in personal life, home life, social life, and working life. When applied to the workplace KAIZEN means continuing improvement involving everyone – managers and workers alike." Masaaki Imai, Founder of Kaizen Institute.

The Core of KAIZEN:

There are 5 Fundamental KAIZEN Principles that are embedded in every KAIZEN tool and in every KAIZEN behaviour. The 5 principles are: Know your customer, let it Flow, Go to Gemba, Empower People and Be Transparent. The implementation of those 5 principles in any organization is fundamentally important for a successful Continuous Improvement culture and to mark a turning point in the progression of quality, productivity, and labour-management relations.

KAIZEN Core info picture

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[9] https://www.kaizen.com/what-is-kaizen?

5.1.5.3 Just in Time[10]

Just in Time (JIT), as the name suggests, is a management philosophy that calls to produce what the customer wants, when they want it, in the quantities requested, where they want it, without it being delayed in inventory.

So instead of building large stocks of what you think the customer might want you only make exactly what the customer asks for when they ask for it. This allows you to concentrate your resources on only fulfilling what you are going to be paid for rather than building for stock.

Within a Just in Time manufacturing system, each process will only produce what the next process in sequence is calling for.

JIT example for manufacturing units:
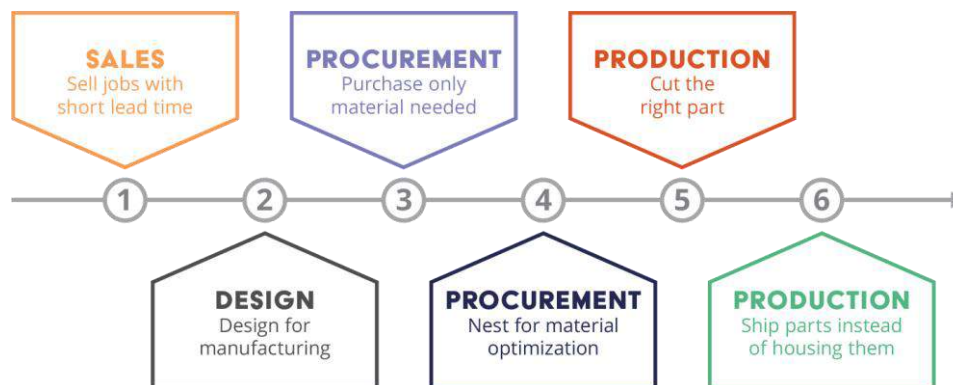
5.1.5.4 SMED (Single minute exchange of dies)[11]

SMED (Single-Minute Exchange of Die) is a system for dramatically reducing the time it takes to complete equipment changeovers. The essence of the SMED system is to convert as many changeover steps as possible to "external" (performed while the equipment is running), and to simplify and streamline the remaining steps. The name Single-Minute Exchange of Die comes from the goal of reducing changeover times to the "single" digits (i.e., less than 10 minutes).
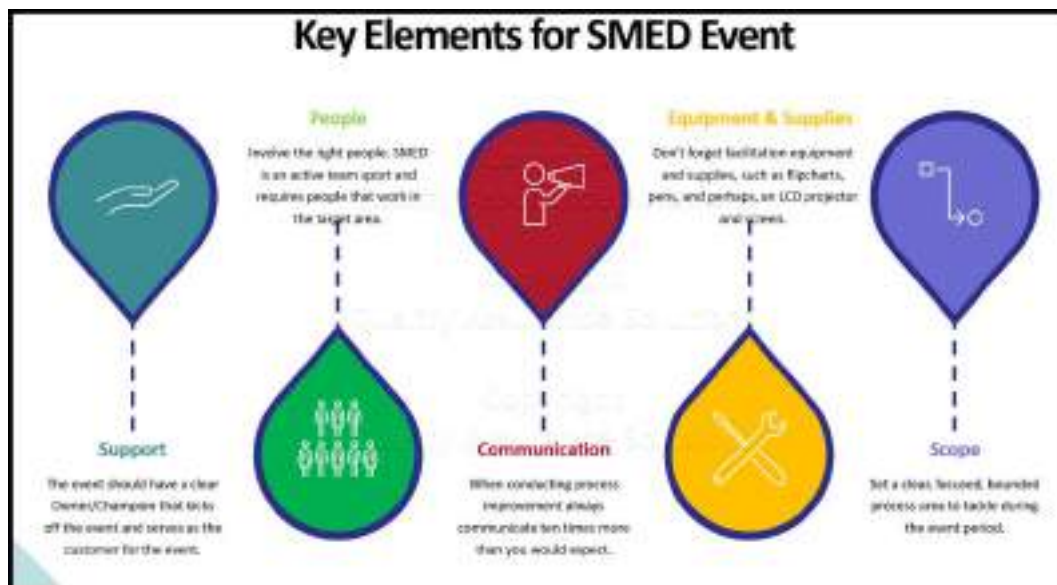
5.1.5.5 Poke Yoke[12]

Poka-yoke (ポカヨケ, [poka joke]) is a Japanese term that means "mistake-proofing" or "inadvertent error prevention". A poka-yoke is any mechanism in a process that helps an equipment operator avoid (yokeru) mistakes (poka) and defects by preventing, correcting, or drawing attention to human errors as they occur. The concept was formalized, and the term adopted, by Shigeo Shingo as part of the Toyota Production System.

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[11] https://www.leanproduction.com/smed/

[12] https://en.wikipedia.org/wiki/Poka-yoke

Benefits of poka-yoke implementation:

A typical feature of poka-yoke solutions is that they don't let an error in a process happen. Other advantages include:

- Less time spent on training workers.
- Elimination of many operations related to quality control.
- Unburdening of operators from repetitive operations.
- Promotion of the work improvement-oriented approach and actions.
- A reduced number of rejects.
- Immediate action when a problem occurs.
- 100% built-in quality control.
- Preventing bad products from reaching customers.
- Detecting mistakes as they occur.
- Eliminating defects before they occur.

5.1.5.6 Jidoka (Autonomation)

Jidoka is a Lean method that is widely adopted in manufacturing and product development. Also known as autonomation, it is a simple way of protecting your company from delivering products of low quality or defects to your customers while trying to keep up your takt time.

Jidoka relies on 4 simple principles to ensure that a company would deliver defect-free products:

- Discover an abnormality
- Stop the process
- Fix the immediate problem
- Investigate and solve the root cause

These 4 steps can be applied in various ways depending on your industry and can serve as a steady foundation for achieving continuous improvement of your process.

The Jidoka Process

1 Discover an abnormality

2 Stop the process

3 Fix the immediate problem

4 Remove the root cause

5.1.5.7 Heijunka[13]

Heijunka (hi-JUNE-kuh) is a Japanese word for leveling. It is part of the lean methodology of process improvement that helps organizations match unpredictable customer demand patterns and eliminate manufacturing waste by leveling the type and quantity of production output over a fixed period of time.
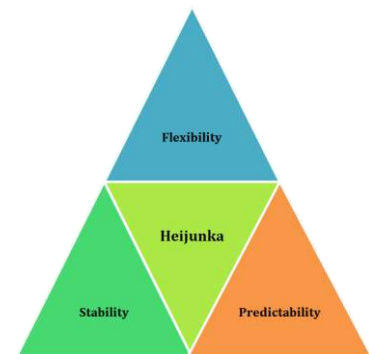
5.1.5.8 Gemba (Go & See)

Gemba (also written as Genba) is a Japanese word meaning "the actual place." In lean practices, the Gemba refers to "the place where value is created," such as the shop floor in manufacturing, the operating room in a hospital, the job site on a construction project, the kitchen of a restaurant, and the workstation of a software programmer.

The term "going to the Gemba" is described by the Japanese term "Genchi Gembutsu"

A popular approach in companies who implement lean principles is called "Gemba walks," which denote the action of going to see the actual process, understand the work, ask questions, and learning from those who do the work (showing respect to them). It is an opportunity for management and support staff to break away from their day-to-day tasks to walk the floor of their workplace to identify wasteful activities.

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[13] https://kanbanize.com/continuous-flow/heijunka

The objective is to understand the value stream and its problems, rather than review results or make superficial comments from their office or conference room

Gemba Walk in 7 steps

5.1.5.9 Kanban

Kanban (Japanese: 看板(Chinese Character reused by Japanese), meaning signboard or billboard) is a scheduling system for lean manufacturing (also called just-in-time manufacturing, abbreviated JIT).Taiichi Ohno, an industrial engineer at Toyota, developed Kanban to improve manufacturing efficiency. The system takes its name from the cards that track production within a factory. Kanban is also known as the Toyota nameplate system in the automotive industry.

Kanban Example for manufacturing unit:
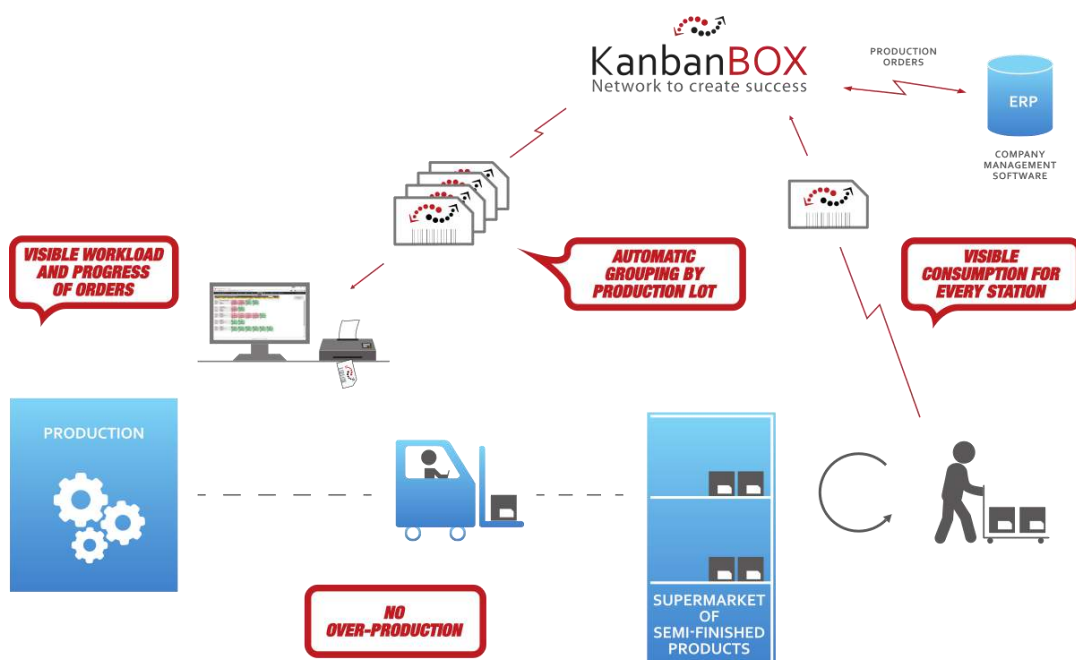
5.2 Six Sigma

5.2.1 What is Six Sigma?

Six Sigma is a data-driven problem-solving methodology. The focus is on process variations and emphasis is given to customer satisfaction. Continuous process improvement with low defects is the goal of this method. Six Sigma has its roots in a 19th Century mathematical theory but Motorola brought Six Sigma into the mainstream by using the methodology to create more consistent quality in the company's products, according to "Six Sigma" by Mikel Harry and Richard Schroeder.

Motorola engineer Bill Smith eventually became one of the pioneers of modern Six Sigma, creating many of the methodologies still associated with Six Sigma in the late 1980s. The system is influenced by, but different than, other management improvement strategies of the time, including Total Quality Management and Zero Defects.

5.2.2 The Goal of Six Sigma

The aim of Six Sigma is to make a process effective with - 99.99996 % defect-free. This means a six-sigma process produces 3.4 defects per million opportunities or less as a result.

There are two major methodologies used within Six Sigma, both of which are composed of five sections, according to the 2005 book "JURAN Institute Six Sigma Breakthrough and Beyond" by Joseph A. De Feo and William Barnard.

I.   DMAIC: Problem-solving in Six Sigma is done using the DMAIC framework. There are five stages in this framework. They are-
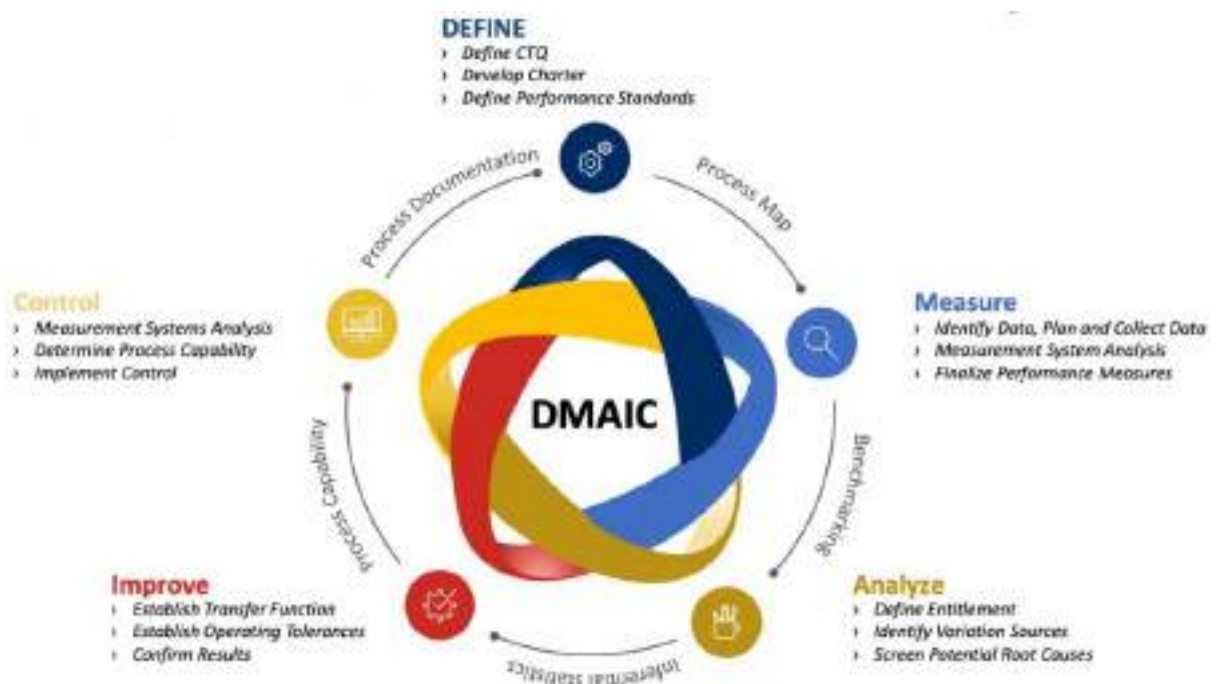
Six Sigma Phase	Description of Phase
Define	In this stage, project objectives are outlined. A project charter is an important component of this phase. A project charter is a blueprint document for a six sigma project. A typical charter contains the following information: • Business case • Problem statement • Goal statement • Project scope • Resources • Timelines • Estimated benefits This chapter gives an overview of a six sigma project and is approved by top management to give a go-ahead to the six sigma project.
Measure	Process variables are measured at this stage. Process data is collected. The baseline is obtained and metrics are compared with final performance metrics. Process capability is obtained.
Analyze	Root cause analysis is done at this stage. Complex analysis tools are utilized to identify the root causes of a defect. Tools like histograms, Pareto charts, fishbone diagrams are used to identify the root causes. Hypotheses tests are conducted to verify and validate root causes, Viz Regression test, ANOVA test, Chi-square, etc.
Improve	Once the final root causes are identified, solutions need to be formed to improve the process. Steps to identify, test, and implement the solutions to eliminate root causes are part of this stage. Simulation studies, Design of experiments, Prototyping are some of the techniques used here to improve and maximize process performance.
Control	After implementing the solutions, the performance of the solutions must be recorded. A control system must be in place to monitor the performance post improvement. And a response plan is developed to handle solution failure. Process standardization through Control plans & work instructions is typically a part of this phase. Control charts show the process performance. Project benefits are discussed and verified against the estimated one. The main purpose of this phase is to ensure holding the gains.

Table 2: Six Sigma Phases and their descriptions

II.   DMADV: The DMADV method is typically used to create new processes and new products or services. The letters stand for:

- **D**efine the project goals
- **M**easure critical components of the process and the product capabilities
- **A**nalyse the data and develop various designs for the process, eventually picking the best one
- **D**esign and test details of the process

Verify the design by running simulations and a pilot program, and then handing over the process to the client

DMAV drives customer needs into product and service design

5.2.3 Introduction to Some Important SIX SIGMA Tools

- 5 Whys
- Statistical and fitting tools (Analysis of variance, General linear model, ANOVA Gauge R&R, Regression analysis, Correlation, Scatter diagram, Chi-squared test)
- Axiomatic design
- Business Process Mapping/Check sheet
- Cause & effects diagram (also known as fishbone or Ishikawa diagram)
- Control chart/Control plan (also known as a swimlane map)/Run charts
- Cost–benefit analysis
- CTQ tree
- Design of experiments/Stratification
- Histograms/Pareto analysis/Pareto chart
- Pick chart/Process capability/Rolled throughput yield
- Quality Function Deployment (QFD)
- Quantitative marketing research through use of Enterprise Feedback Management (EFM) systems
- Root cause analysis
- SIPOC analysis (**S**uppliers, **I**nputs, **P**rocess, **O**utputs, **C**ustomers)
- COPIS analysis (Customer centric version/perspective of SIPOC)
- Taguchi methods/Taguchi Loss Function
- Value stream mapping

Below we describe few Six sigma tools basic information which is mostly used in Apparel manufacturing industries:

5.2.3.1 5 Whys

Five whys (or 5 whys) are an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?". Each answer forms the basis of the next question.

Management don't share any Follow up routine to mechanic to work

Mechanic don't have any structural

Mechanic not set/check machine

Uncut thread not properly trim by

Uncut Threa

5Y 01- Why did that problem occur?

5Y 02-Why did 5Y 01 occur?

5Y 03-Why did 5Y 02 occur?

5Y 04-Why did 5Y 03 occur?

5Y 05-Why did 5Y 04 occur?

So, for resolving the main problem (uncut thread) management need provide a structural Follow up routine to mechanical person for regular machine set/check.

5.2.3.2 Check Sheet

The check sheet is a form (document) used to collect data in real time at the location where the data is generated. The data it captures can be quantitative or qualitative. When the information is quantitative, the check sheet is sometimes called a tally sheet.

The check sheet is one of the so-called Seven Basic Tools of Quality Control.

Fabric inspection report

5.2.3.3 Cause & Effects Diagram[14]

Ishikawa diagrams (also called fishbone diagrams, herringbone diagrams, cause-and-effect diagrams, or Ishikawa) are causal diagrams created by Kaoru Ishikawa that show the potential causes of a specific event.

Common uses of the Ishikawa diagram are product design and quality defect prevention to identify potential factors causing an overall effect. Each cause or reason for imperfection is a source of variation. Causes are usually grouped into major categories to identify and classify these sources of variation.

Exhibit 1.7: Fish Bone diagram for identifying root causes of sewing defects

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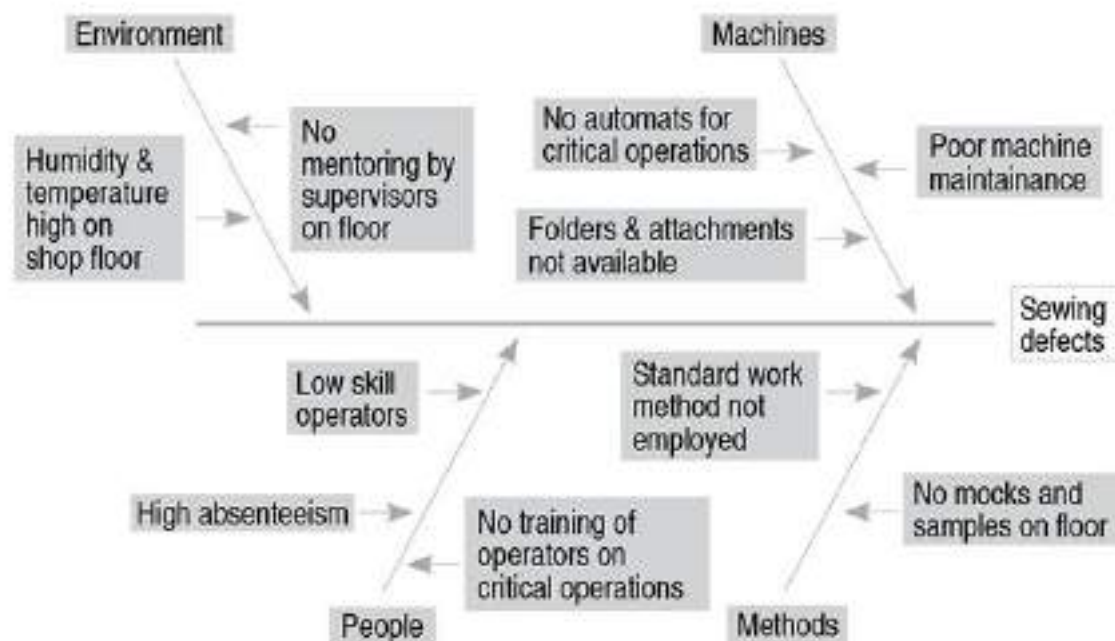
[14] https://en.wikipedia.org/wiki/Ishikawa_diagram

5.2.3.4   Control Chart/ Control Plan / Swim Lane Map/ Run Charts[15]

Also called: Shewhart chart, statistical process control chart

The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit, and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation). This versatile data collection and analysis tool can be used by a variety of industries and is considered one of the seven basic quality tools.
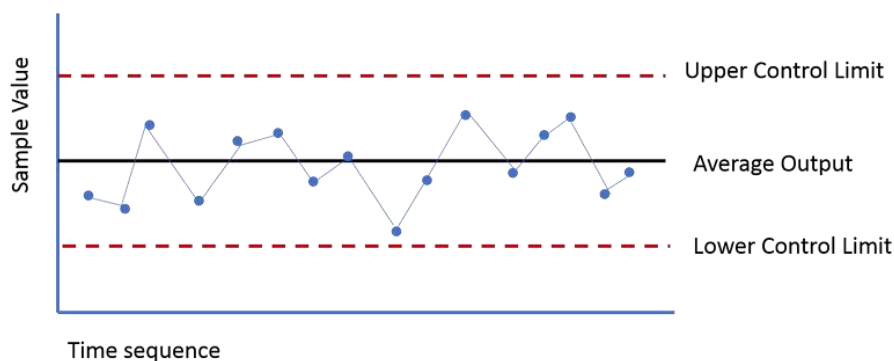
5.2.3.5   Cost–Benefit Analysis[16]

Cost–benefit analysis (CBA), sometimes also called benefit–cost analysis, is a systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings. For example, in transactions, activities, and functional business requirements. A CBA may be used to compare, completed or potential courses of actions. Also, to estimate (or evaluate) the value against the cost of a decision, project, or policy. It is commonly used in commercial transactions, business, or policy decisions (particularly public policy), and project investments. CBA has two main applications:

I.   To determine if an investment (or decision) is sound, ascertaining if- and by how much- its benefits outweigh its costs.

II.   To provide a basis for comparing investments (or decisions), comparing the total expected cost of each option with its total expected benefits.

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[15] https://asq.org/quality-resources/control-chart

[16] https://en.wikipedia.org/wiki/Cost%E2%80%93benefit_analysis

5.2.3.6 CTQ Tree[17]

A Critical to Quality Tree (also known as a CTQ Tree) is a Six Sigma tool used to identify the needs of the customer and translate that information into measurable product and process requirements. It allows organizations to understand the characteristics of a product or service that most drives quality for customers.

Before initiating any process improvement project, it's important for a business to determine the characteristics of the product or service that are critical to quality as judged by customers – this is known as CTQ.

Creating a CTQ Tree determines the drivers behind those characteristics and helps companies find ways to meet them.

3 Components of a CTQ Tree-

The first step to create a CTQ Tree involves listing the customer's needs. Data in this area is typically attained through interaction with the customer. Six Sigma calls for breaking down these needs into three component areas.

I.   Need – What customer need are you fulfilling with your product or service?
II. Drivers – What elements or characteristics will your customers mostly likely consider when judging the quality of your product or service?
III. Requirements – What process or product requirements are needed to make those drivers meet customer standards?

Steps to Create a CTQ Tree:

Now that you understand the three components of the CTQ Tree, there are certain steps to take to fill those areas with useful information. Most CTQ Trees are developed by project teams created explicitly for this task.

I.   Determine the Need – It may be helpful to ask customers directly, or consult with customer service representatives or salespeople who frequently interact with customers
II. Determine at least three drivers – These are the elements that drive quality for customers who have the need you want to satisfy. Keep in mind that these are elements that must be present to satisfy customers.
III. Create the requirements – These are the standards that must be met to meet customers' expectations for each driver.
IV. Once requirements are developed, an organization can then take steps to make the changes or improvements needed.

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[17] https://www.sixsigmadaily.com/critical-to-quality-ctq-tree-definition-example/

5.2.3.7 Histograms/ Pareto Analysis/ Pareto Chart

A frequency distribution shows how often each different value in a set of data occurs. A histogram is the most used graph to show frequency distributions. It looks very much like a bar chart, but there are important differences between them. This helpful data collection and analysis tool is considered one of the seven basic quality tools.

Histogram of arrivals
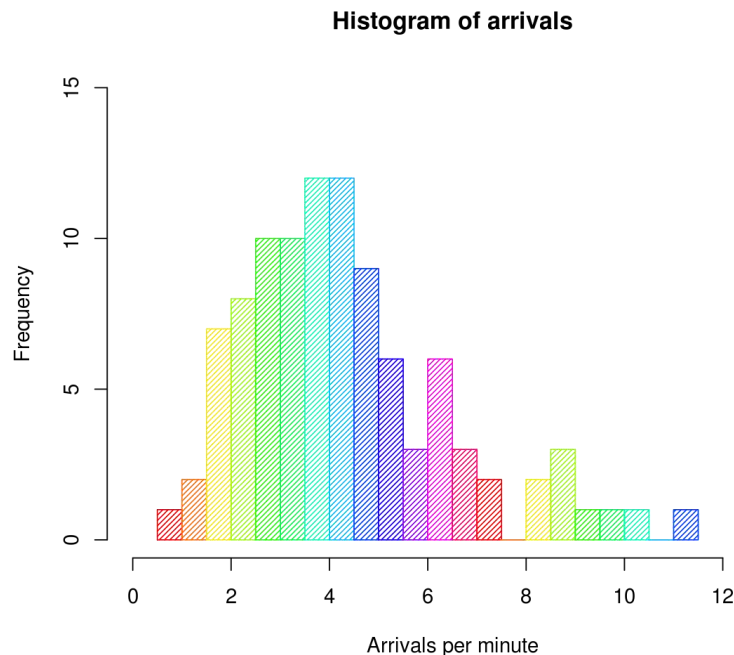
Pareto analysis/Pareto chart:

A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money) and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant. This cause analysis tool is considered one of the seven basic quality tools.
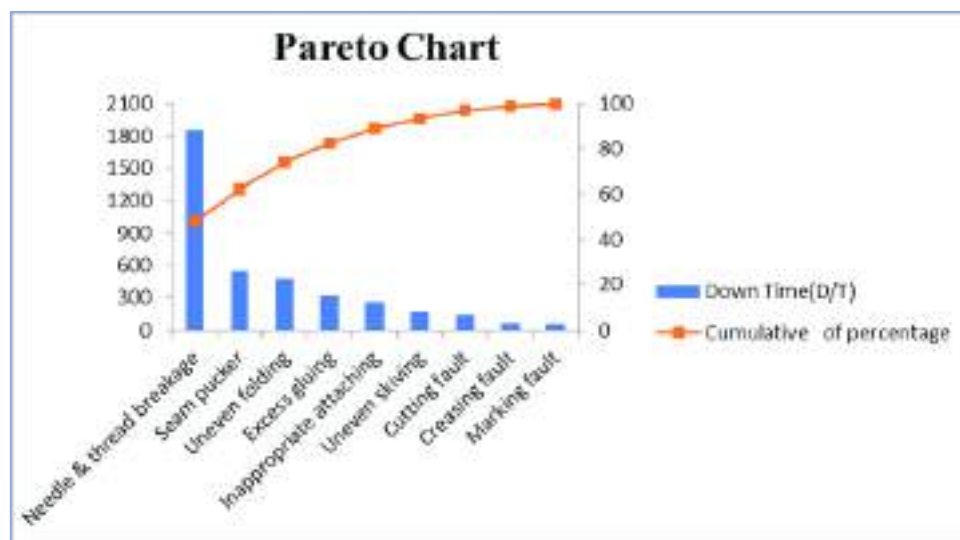
5.2.3.8 Process Capability[18]:

Process Capability (Cp) is a statistical measurement of a process's ability to produce parts within specified limits on a consistent basis. To determine how our process is operating, we can calculate Cp (Process Capability), Cpk (Process Capability Index), or Pp (Preliminary Process Capability) and Ppk (Preliminary Process Capability Index), depending on the state of the process and the method of determining the standard deviation or sigma value. The Cp and Cpk calculations use sample deviation or deviation mean within rational subgroups. The Pp and Ppk calculati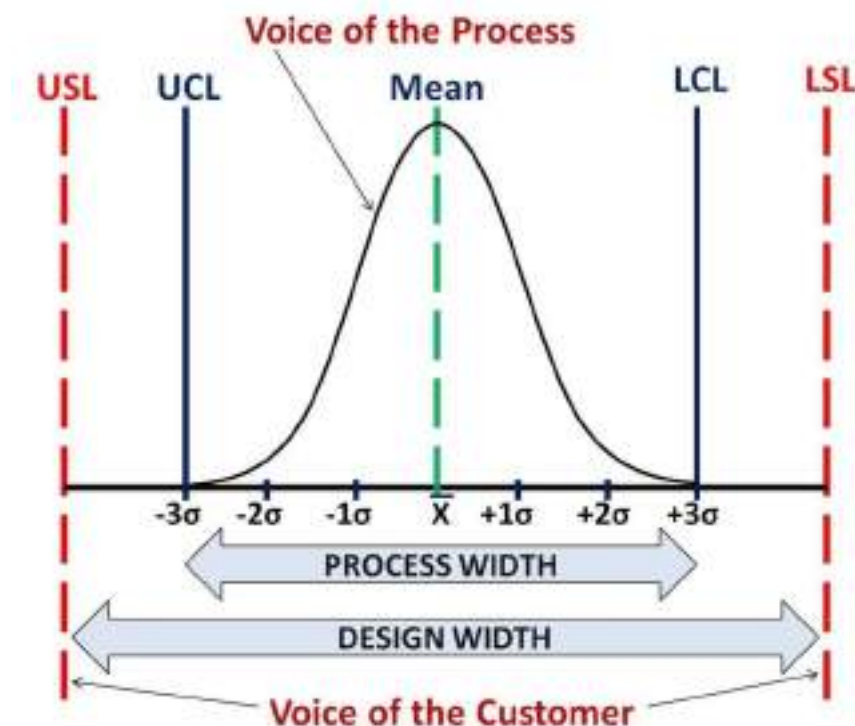ons use standard deviation based on studied data (whole population). The Cp and Cpk indices are used to evaluate existing, established processes in statistical control. The Pp and Ppk indices are used to evaluate a new process or one that is not in statistical control.

5.2.3.9 Quality Function Deployment (QFD):

QFD is a focused methodology for carefully listening to the voice of the customer and then effectively responding to those needs and expectations. First developed in Japan in the late 1960s as a form of cause-and-effect analysis, QFD was brought to the United States in the early 1980s. In QFD, quality is a measure of customer satisfaction with a product or a service. QFD is a structured method that uses the seven management and planning tools to identify and prioritize customers' expectations quickly and effectively.

Beginning with the initial matrix, commonly termed the House of Quality (Figure 1), the QFD methodology focuses on the most important product or service attributes or qualities.

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[18] https://quality-one.com/process-capability/

These are composed of customer *wows, wants,* and *musts.* (See the Kano model of customer perception versus customer reality.)

Once you have prioritized the attributes and qualities, QFD deploys them to the appropriate organizational function for action, as shown in below Figure Thus, QFD is the deployment of customer-driven qualities to the responsible functions of an organization.

Figure 1 — House of quality template and benefits

The house of quality provides:
- A requirements *planning* capability
- A tool for graphic and integrated thinking
- A means to capture and preserve the engineering thought process
- A means to communicate the thought process to new members of the QFD team
- A means to inform management regarding inconsistencies between requirements, risks, and needs of the customer
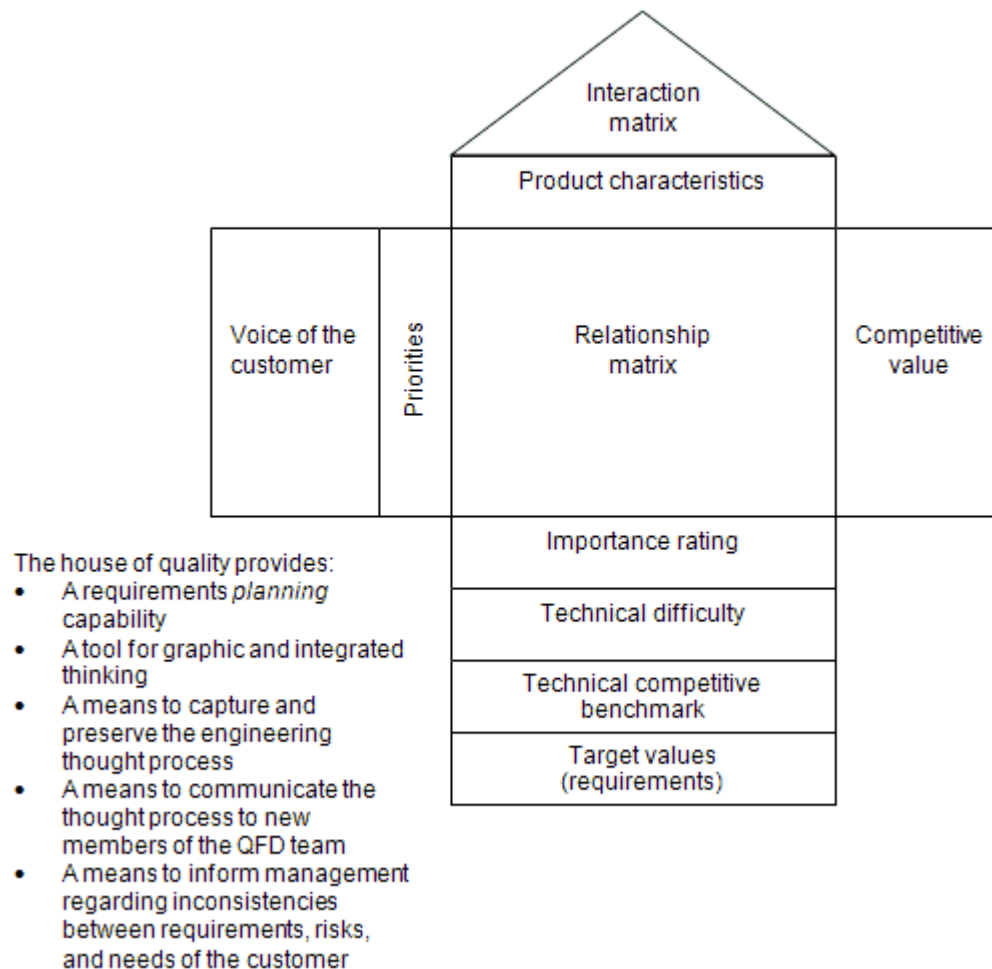
Quality Function Deployment: Most Important Product/Service Attributes or Qualities

5.2.3.10 Root Cause Analysis

A root cause is defined as a factor that caused a nonconformance and should be permanently eliminated through process improvement. The root cause is the core issue- the highest-level cause- that sets in motion the entire cause-and-effect reaction that ultimately leads to the problem(s)[19].

Root cause analysis (RCA) is defined as a collective term that describes a wide range of approaches, tools, and techniques used to uncover causes of problems. Some RCA approaches are geared more toward identifying true root causes than others, some are more general problem-solving techniques, and others simply offer support for the core activity of root cause analysis.

Despite the different approaches among the various schools of root cause analysis and the specifics of each application domain, RCA generally follows the same four steps[20]:

Identification and description: Effective problem statements and event descriptions (as failures, for example) are helpful and usually required to ensure the execution of appropriate root cause analyses.

Chronology: RCA should establish a sequence of events or timeline for understanding the relationships between contributory (causal) factors, the root cause, and the problem under investigation.

Differentiation: By correlating this sequence of events with the nature, the magnitude, the location, and the timing of the problem, and possibly also with a library of previously analysed problems, RCA should enable the investigator(s) to distinguish between the root cause, causal factors, and non-causal factors. One way to trace down root causes consists in using hierarchical clustering and data-mining solutions (such as graph-theory-based data mining). Another consists in comparing the situation under investigation with past situations stored in case libraries, using case-based reasoning tools.

Causal graphing: Finally, the investigator should be able to extract from the sequences of events a subsequence of key events that explain the problem and convert it into a causal graph.

To be effective, root cause analysis must be performed systematically. A team effort is typically required. For aircraft accident analyses, for example, the conclusions of the investigation and the root causes that are identified must be backed up by documented evidence.

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[19] https://asq.org/quality-resources/root-cause-analysis

[20] https://en.wikipedia.org/wiki/Root_cause_analysis

Five common root cause analysis tools, including:

  I.   Pareto Chart
 II.   The 5 Whys
III.   Fishbone Diagram
 IV.   Scatter Diagram
  V.   Failure Mode and Effects Analysis (FMEA)

5.2.3.11 SIPOC Analysis (Suppliers, Inputs, Process, Outputs, Customers)

It is a tool used to identify the input parameter requirements for satisfactory performance of the processes. As indicated in Exhibit 1.8, for each input parameter quantifiable indicators are noted. The shortcomings in these input indicators are worked upon during the Improve Phase[21].

Suppliers	Inputs	Process	Outputs	Customers
	Unstitched cloth	Sampling		
	Machinery	Cutting		
	Thread	Sewing		
Alex Fabrics Ltd. Fabian Group	Needles	Washing	Ladies tops Trousers	NyGard
	Button	Ironing		
	Zipper	Finishing		
	Label	Packaging		

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[21] https://apparelresources.com/business-news/manufacturing/quality-management-system-in-apparel-manufacturing-six-sigma-implementation/

5.2.3.12 COPIS Analysis (Customer Centric Version/Perspective of SIPOC)

The COPIS terminology is a revision of the original model called SIPOC. SIPOC is a high-level process map of your extended process. As you may have noticed, COPIS is just the reverse spelling of SIPOC[22].

Your first step would be to define the process you wish to diagram. What is the scope you wish to include in your COPIS? You should have a definable start and definable stop for the process in question. These process boundaries can be narrow or wide depending on whether you're looking at a macro or micro process.

Here's the sequence to follow:

Customer: This would be the next person or organization you hand your output to. It could be the next functional area. It could be the actual external customer. All of your outputs go to some customer, somewhere, who has expectations and requirements for your output.

CTQ (Critical to Quality) or requirements: These are the key metrics your customer might use to evaluate whether your process is producing output that meets their requirements. It's optional to put it in a separate column of your COPIS diagram but be sure to capture it somewhere.

Output: Next, identify the outputs your customer wants, needs, and values.

Process: Your COPIS will include a high-level description of the process that would meet your customer's requirements. Describe your process in 5-7 high level steps.

Inputs: These are the things your process needs in order to start and produce your outputs, perhaps including the 6 Ms. These would refer to such things as people, materials, equipment, procedures, money, utilities, environmental conditions, data, and anything else your process needs to function.

Suppliers: This is where your inputs come from. They may be internal or external suppliers.
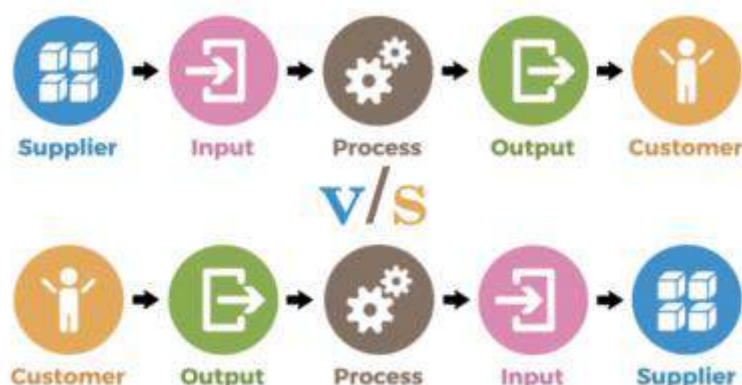
5.3 Lean Six Sigma[23]

5.3.1 What is Lean Six Sigma?

ASQ (The American Society for Quality) states,

"Lean Six Sigma is a fact-based, data-driven philosophy of improvement that values defect prevention over defect detection. It drives customer satisfaction and bottom-line results by reducing variation, waste, and cycle time while promoting the use of work standardization and flow, thereby creating a competitive advantage. It applies anywhere variation and waste exist, and every employee should be involved."

Lean Six Sigma combines the strategies of Lean and Six Sigma. Lean principles help to reduce or eliminate process wastes. Six Sigma focuses on variation - reduction in the process. Thereby, the principles of Lean Six Sigma help to improve the efficiency and quality of the process.

5.3.2 Three Key Elements of Lean Six Sigma

The three key elements comprise of -

Customers: The moment of truth from a customer standpoint arrives at the time when they experience your product or solution. Today's customers have more access to both information and choices. They will demand the best at the lowest and would expect to be supported throughout their product experience. This calls for an outside-in approach to business processes, which is the core of Lean Six Sigma.

Processes: With an outside-in approach comes the need to define the business process value chain. Customers will pay for the product only not for inefficiencies like rework, revisions, and wastages. Lean Six Sigma helps organizations focus on consistently producing quality output and improve the value chain so customers get the best quality within expected timelines.

Employees: Peter Drucker once said, 'Culture eats strategy for breakfast.' Unless a well-defined business process transformation strategy is driven at a grass-roots level, events might tend towards the status quo. Lean Six Sigma has to be driven as DNA within the organization so all stakeholders at all levels speak the same language and practice what is being preached.

5.3.3 Implementation of the Lean Six Sigma Methodology Within Enterprises

So, why do organizations of varied size and levels of maturity use the principles of Lean Six Sigma? For reconnecting to the core goals of a business enterprise like-

- Customer delight
- Improving the bottom line
- Enhanced products/service quality
- Employee satisfaction
- Cost efficiency
- Managing and adapting to change
- Enhancing organizational agility
- Building a culture of Operational Excellence

5.3.4 Lean Six Sigma Principles

An outside-in approach is key to the success of an LSS deployment within organizations. Some fundamental principles to enable this are –

I.   Customer Focus: Defining what 'quality' and 'satisfaction' means to the customer and aligning the business processes and people to achieve the customer and business goals should be at the centre of any LSS deployment.

II.   **Define Roadblocks to Consistent Quality:** Many organizations get excited about doing too many things at the same time without doing a real assessment of what matters most to the customer and the business stakeholders. Define your problem well and set priorities in line with the same. Access to qualitative and quantitative data at this stage enables a more rational approach at this stage.

III.   **Eliminate Inefficiencies:** Define very clearly what is the customer not ready to pay for. Demarcate between non-value added and value-added steps in the business process. Apply a philosophy of eliminating, simplify, or automate across the organization supported by consistent measurement of the outcomes. What gets measured, gets improved.

IV.   **Communicate and Align People:** Consistent and seamless communication and training and handholding of people across the organization is the key to achieve success with any change, especially with the deployment of LSS. Encourage people to fall in love with problems and get excited about solving them. Inculcate a culture of group problem solving using group-think techniques. Ensure behavioral sponsorship to the new way across the organization, especially at leadership and managerial levels.

V.   **Be Flexible and Adaptable:** Change is uncomfortable, to begin with, and each person in the organization will move on the Change Curve at a different pace. Be cognizant of this aspect and ensure organizational structure and management philosophies are aligned to the new realities. Markets are ever-changing and it is important to keep an eye on what customers might demand in the future. With that in mind, keeping the business processes capable of dynamic shifts and building a culture of adaptability and agility across the organization becomes imperative for the deployment of LSS as well.

5.3.5 Benefits of Lean Six Sigma

Lean Six Sigma methodology impacts the core of an organization's approach to delivering customer outcomes. The benefits of deploying LSS are multifarious, some noteworthy ones captured herein.

I.   **Talent Development:** LSS deployment needs every person in the organization to understand the principles and practical application of the techniques. This enhances focus on talent development and embeds learning as a culture within the organization. Growth comes with improved outcomes and continuous learning/upskilling becomes a part of the organizational culture.

II.   **Quality Delivery Enabled Through Efficient Business Processes:** Data-driven decision making, right first time, improved throughput, and increased transparency are direct benefits of LSS. A customer-centric focus on quality ensures that customer voices are continuously heard and product/solution designs plus delivery mechanism quickly attuned to the new market realities.

III.   Scalable Across Different Sectors: Although there used to be a misperception that Lean Six Sigma is more applicable to manufacturing and engineering companies. In the last few decades with the application of these principles within other sectors like BFSI, IT, and Retail have proven that LSS techniques have cross-industry application capabilities.

IV.   Becomes the Basis for Cutting-edge Technology Deployment: LSS drove continuous improvement initiatives blend with digitization and deployment of cutting-edge technology. LSS is vital to a successful Digital Transformation and becomes a subset of the larger Business Transformation strategy for organizations.

V.   Enhances Brand Value: Customers trust organizations that are able to respond to their challenges in a timely manner and resolve the same with integrity. LSS sets-up a culture of people and a sequence of processes and practices that help build upon this customer success quotient, thereby enhancing brand value further.

6 Quality 4.0: The Future of Quality[24]

We are in the midst of what some refer to as Industry 4.0-the fourth industrial revolution. Technological advancements in fields such as data, analytics, collaboration, scalability, and connectivity are driving not just innovation, but true paradigm shifts in manufacturing and the delivery of products and services. Developing technologies such as artificial intelligence and machine learning, big data, cloud computing, augmented and virtual reality, new materials, 3D printing, and the Internet of Things and, perhaps more importantly, the ways in which these various factors can interact- present not just an opportunity, but a necessity for businesses to adapt to a new industrial reality.

Inevitably, these technologically driven shifts will result in a seismic transformation in the way many organizations go about their day-to-day business. This will require a cultural change that will affect the workforce and leadership, and feed into factors such as product innovation, manufacturing efficiency, supply chain performance, compliance and, naturally, quality. This is where Quality 4.0 comes in. The core concept of Quality 4.0 is about aligning the practice of quality management with the emerging capabilities of Industry 4.0; to help drive organizations toward operational excellence.
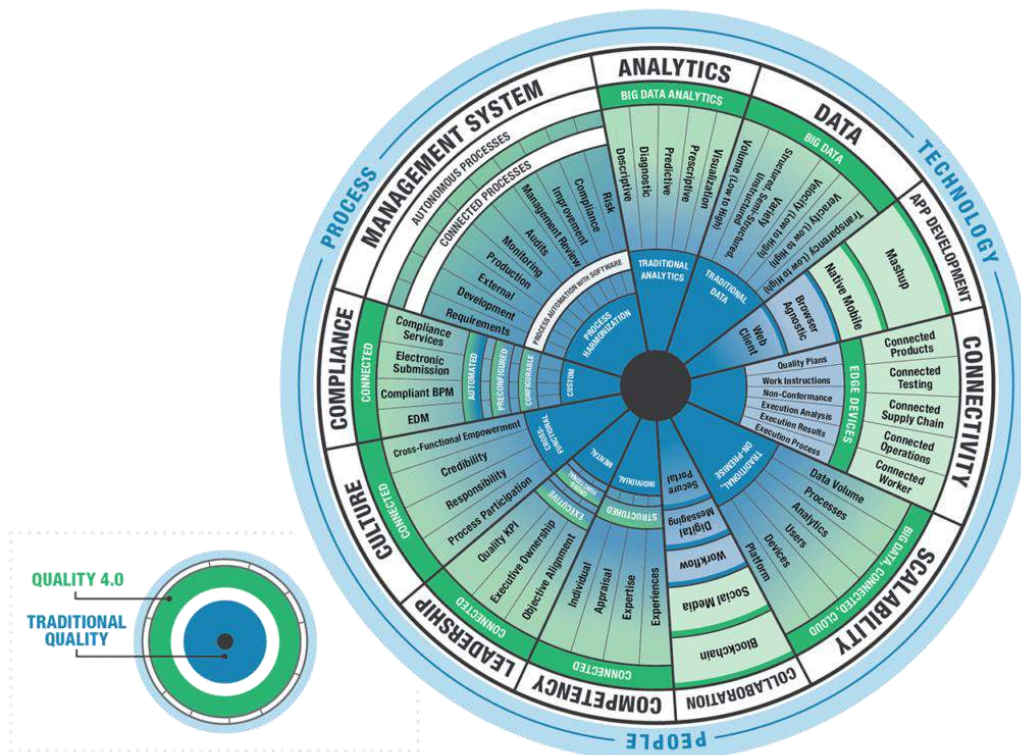
6.1 The 11 Axes of Quality 4.0

Business analysis carried out by LNS Research identifies the 11 key components, or "axes" of the Quality 4.0 framework. Getting to grips with these axes- which include both familiar quality considerations and others that may be less familiar- will help your organization move toward the adoption of Quality 4.0 as the bedrock of your quality management systems.

6.1.1 Data

In the Quality Sphere, data has always been a vital driver for improvement. However, for most organizations there is still a lag in the process of data collection, analysis, and decision-making. Technological advances in Industry 4.0- such as advanced analytics, artificial intelligence and machine learning- can help organizations achieve real-time visibility of vital quality metrics such as internal engineering and manufacturing performance, supplier performance, and customer service. A key element of Quality 4.0 is the swift, effective collation of data from various sources to empower informed and agile decision-making.

6.1.2 Analytics

According to LNS Research, 37% of organizations identify poor metrics as the main roadblock to achieving quality objectives. Current quality metrics are primarily descriptive at their core- they provide information on what happened, why it happened, and use predictive models to say what is likely to happen as a result. Industry 4.0 technologies including big data, machine learning and artificial intelligence allow a fourth category to be added to the current descriptive/ diagnostic/predictive framework: prescriptive. Machine learning and artificial intelligence insights allow prescriptive analytics to predict failure and inform what action to take to change the outcome.

6.1.3 Connectivity

In terms of Quality 4.0, connectivity refers to the connection between business information technology (IT) and operational technology (OT). For context, IT refers to tools such as enterprise Quality Management Systems, enterprise resource planning, and product lifecycle management, while OT is the technology used in manufacturing, laboratory and service environments. Relatively inexpensive sensors can link up connected people (via smart devices or wearables), products (for example, providing performance feedback across their lifecycle), edge devices (which can perform local analytics without overburdening central OT systems), and processes. Leveraging connectivity can allow for the collection of real-time or near real-time feedback.

6.1.4 Collaboration

Enterprise Quality Management System (EQMS) software can help organizations to streamline and synthesize quality practices to improve compliance and increase efficiency. However, according to LNS Research, only 21% of organizations have adopted a core EQMS, leaving the vast majority of businesses utilising emails, automated workflows and portals to manage quality activities. Quality 4.0 can leverage new tools and practices- such as

social listening and blockchain- to gain insights into factors such as customer satisfaction, and greater visibility of parts and products' movement through supply chains.

6.1.5 App development

In a world of smartphones, tablets and wearable devices, apps are increasingly becoming a part of everyday life both for individuals and for organizations agile enough to take advantage of trends. But more than this, apps are an ever more important tool for brands to connect with customers- as well as employees and other stakeholders- and gather vital data and feedback. Advanced apps that utilize tech such as augmented reality and virtual reality have considerable potential in the industry 4.0 workplace.

6.1.6 Scalability

According to LNS Research 37% of organizations cite fragmented data sources and systems as their main challenge in achieving quality objectives. Lack of scalability renders organizations- regardless of whether they adhere to traditional quality management practices or Quality 4.0- unable to reconcile processes, competencies and best practices fully and effectively. One of the principal Industry 4.0 tools that can help in achieving scalability is cloud computing- whether that's software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), or platform-as-a-service (PaaS).

6.1.7 Management Systems

As noted previously, only 21% of organizations have adopted an enterprise Quality Management System- despite the benefits they can deliver in terms of scalability, connecting quality processes and providing centralized analytics. To fully reap the benefits of Quality 4.0, organizations should look to automate processes with software, and harmonize and connect these automated processes with other systems and operations. Improving system autonomy will reduce the time high-value staff and management spend on execution and allow them to shift focus toward improvement and innovation.

6.1.8 Compliance

Quality 4.0 provides a variety of tools and techniques that can be implemented to automate compliance activities. Through social collaboration, organizations can share successful compliance approaches across different divisions and work sites. Meaningful data analytics can alert organizations about potential compliance breaches, allowing for preventative action to be taken. Integration of business information technology and operational technology can help to automate compliance-related tasks and data collection. Quality 4.0 allows organizations to assess current compliance strategies and identify opportunities for improvement.

6.1.9 Culture

Many organizations like to think that they promote and engender a "culture of quality." However, according to LNS Research, only 13% of cross-functional teams clearly understand how quality contributes to strategic success. By connecting data, analytics and processes and

thereby improving visibility, connectivity, collaboration and insights, Quality 4.0 makes a true organization-wide culture of quality more attainable.

6.1.10 Leadership

Those who work in quality roles believe in its importance to organizational success, but that attitude doesn't always permeate up to senior leadership. According to LNS Research, only 37% of organizations believe quality is critical for customer satisfaction, 26% agree that the quality function has a clear and compelling role in delivering corporate strategy, while just 13% said that quality is a priority for top management. Quality 4.0 represents an opportunity for quality teams to clearly align their objectives and practices with strategic aims.

6.1.11 Competency

Quality 4.0 encapsulates a variety of technologies that can be utilized to improve competency. Social media tools can be leveraged to share lessons and experiences across organizations, and even between organizations. Outputs from artificial intelligence and machine learning systems can be utilized to develop new expertise, while artificial reality (AR) and virtual reality (VR) systems can be used to improve workers' expertise. Smart devices and wearables can assist in employee appraisal, while learning management systems, AR and VR can be deployed to improve training delivery.

6.2 Why is Quality 4.0 important?

It would be a mistake to believe that the range of technologies that together contribute to Industry 4.0 are anything less than transformative in nature. Quality 4.0 represents an opportunity to utilize those Industry 4.0 technologies to realign quality functions with broader organizational strategy.

From a base position where only 13% of organizations believe that quality is a priority for top management, Quality 4.0 provides the scope to both redirect quality activities and to alter the perception of the quality function in organizations as being little more than the "quality police."

Developing an effective Quality 4.0 strategy will enable organizations to address long-standing quality issues. For many organizations, these stem from inefficiencies resulting from issues such as lack of cross-functional ownership, ineffective communication, and fragmented traditional quality systems. With some 37% of organizations citing fragmented data sources and systems as a top challenge in achieving quality objectives, the concept of Quality 4.0 presents an opportunity for organizations to review the root causes of current barriers to quality success, and engage in strategic planning to explore how new technologies and the advantages they deliver – such as improved data transparency and high quality data-driven insights – can be leveraged to achieve a culture of excellence.

7 Key Skills require for a Quality professional

Everything starts with a strong quality team. To be successful in an industry where technology and practices are constantly evolving, we need to focus on developing and deploying the correct set of quality assurance skills for our team. The most effective quality assurance teams possess a combination of both technical and interpersonal expertise. What skillsets should you then look for in new hires and aim to cultivate in our existing team to achieve this balance of abilities?

The essential skills that any member of a quality team should possess are:

I.   **Understanding of variation introduced by measurement devices**:

Devices have inherent variability, as does human involvement. An understanding of measurement limitations in accuracy and repeatability is vital to collecting and accurately representing your data.

II. **Effective use of data analysis tools** (e.g., root cause analysis, Pareto charts, and box and whiskers charts):

Our quality team members need a foundation of basic statistical process control tools to grow upon.

III. **Problem solving**:

General intelligence alone is not enough. Involve our team in formal training to learn strategic problem-solving approaches to enhance quality assurance.

IV. **Analytical and research skills**:

The quality of information is more important than quantity. When looking at huge volumes of data, our team needs to determine which information is most valuable and usable.

V.   **Effective interaction with other departments/suppliers**:

For our organization to run smoothly, the quality team needs to foster positive interactions with other internal departments, external customers, and suppliers.

VI. **Leadership**:

Every team needs a member to step up, give the department direction and lead by example. Encourage team members to take ownership of their projects—a vested interest inevitably produces greater results.

VII. **Willingness to learn new methods and systems**:

With technology rapidly evolving in today's world, our quality management team must have a positive attitude when it comes to embracing new tools, ideas, and processes.

VIII. **Ability to manage multiple priorities**:

Many companies are operating with more automation and fewer people. Our team members should be able to balance and effectively manage multiple responsibilities and goals.

IX. **Teamwork**:

With individuals shouldering more priorities and responsibilities, working together to distribute the workload will ensure all our company needs are met.

X. **Communication skills**:

Effective communication and active listening is essential to teamwork. Don't just hear the words; find the meaning behind them. An open dialogue creates mutual understanding.

XI. **Sound judgment and decision making**:

Data is meaningless if our quality department cannot interpret and use the information to make logical choices and changes to optimize your products and processes.

While the hard, analytical skills of numbers one through four are essential to the data collection and statistical aspects of a quality assurance team, they need to work in conjunction with the remaining soft, interpersonal skillsets to fully enhance the efficiency of our team. Hard, technical skills will not yield results if we do not have a team that can work together and communicate effectively.

8 Conclusion

Expecting this guidebook serve your expectations, I hope you are now more enthusiastic about learning further. Quality comes through best practices' implementation and continuation. Implementation of new ideas and thoughts is now a very important part of improvement.

For our garments industry, it's now essential to implement quality improvement fundamentals, methodology, and tools for sustainable progress. Customers now are very conscious about product quality. We need to produce each garment at a quality that meets customer demand.

Thanks for reviewing this guidebook. Now it's time to implement and get results.

"Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skilful execution; it represents the wise choice of many alternatives."
~William A. Foster