Chapter 10

Troubleshooting and Improvement

Traditional Quality Improvement Tool

- They are mostly qualitative and used in qualitative researches.
- Some of the dominant quality improvement techniques are as follows:
    - Pareto chart
    - Ishikawa diagram (cause-and-effect, root cause analysis, fishbone diagram)
    - DMAIC process
    - PDCA cycle
    - FMEA (Failure Modes and Effects) method
    - QFD (Quality Function Deployment) approach
    - 5 Whys
    - 5S
    - Kaizen
    - Kanban

Pareto Chart

- *Definition: A Pareto chart is a type of bar graph that ranks categories in descending order to highlight the most significant factors influencing a particular outcome.*
- *Purpose: To identify and prioritize the factors contributing to a problem or opportunity for improvement.*
- *Named after Italian economist Vilfredo Pareto, who observed the 80/20 principle - 80% of effects come from 20% of causes.*

https://asq.org/quality-resources/pareto

Pareto Chart

- *Components*
  - *Vertical bars representing the frequency or impact of each category.*
  - *Cumulative percentage line showing the cumulative contribution of categories.*
  - *Categories listed in descending order of frequency or impact.*
  - *Y-axis showing frequency or impact, X-axis showing categories.*

Pareto chart of costs / FIGURE 6

https://asq.org/quality-progress/articles/case-studies/budgetary-bandage?id=ed288e642d46433daa92ded28fe97f78

Ishikawa Diagram

- *Definition: An Ishikawa diagram, also known as a fishbone diagram or cause-and-effect diagram, is a visual tool used to identify and analyze the potential causes of a specific problem or effect.*
- *Purpose: To facilitate brainstorming and root cause analysis by organizing potential causes into categories for further investigation.*
- *Named after Japanese quality control expert Kaoru Ishikawa, who developed the diagram in the 1960s.*

Ishikawa Diagram

- *Components*
  - *Main problem or effect placed at the head of the fishbone.*
  - *Major categories (e.g., people, process, equipment, materials, environment) branching off as "bones."*
  - *Subcategories or specific causes under each major category.*
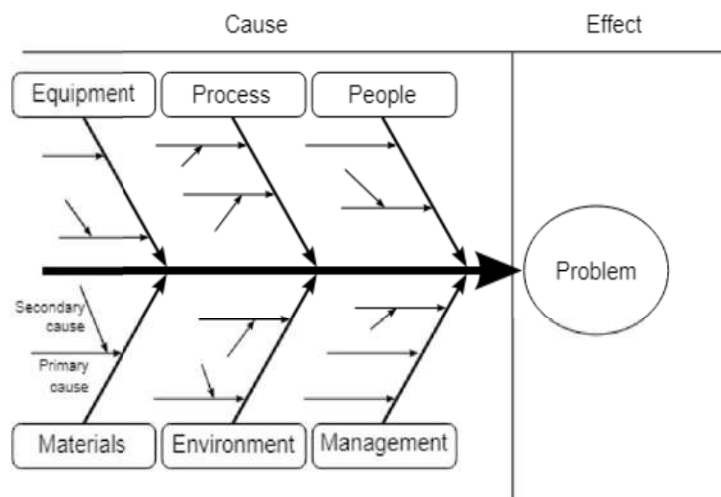
DMAIC process

- *Definition: The DMAIC process, which stands for Define, Measure, Analyze, Improve, and Control, is a structured problem-solving methodology used to improve processes and drive quality improvement in various industries.*

- *Purpose To identify and eliminate defects or inefficiencies in a process by following a systematic approach.*

- *Key elements Each phase of the DMAIC process contributes to the overall goal of reducing variation and enhancing process performance.*

DMAIC process

- *Components*
  - *Define:*
    - *Clearly define the problem or opportunity for improvement.*
    - *Set project goals and objectives.*
  - *Measure:*
    - *Collect data on current process.*
    - *Identify critical metrics for measurement.*
  - *Analyze:*
    - *Analyze data to determine root of issues.*
    - *Identify variations and potential sources of defects.*
  - *Improve:*
    - *Develop solutions to address root causes.*
    - *Implement changes to improve the process.*
  - *Control:*
    - *Establish control measures to sustain improvements.*
    - *Monitor ongoing performance using key metrics.*

DMAIC process

- *Example: A pharmaceutical company faces inconsistent product quality leading to rejections during quality testing stages which hindered time-to-market deadlines*
  - *Define phase: Company defines that they are facing issues because there is considerable variation within their production line causing inconsistent product outcomes up rejections during quality testing stages*
  - *Measure Phase: The team collects data from different production lines regarding temperature fluctuations and raw material composition*
  - *Analyze Phase: Team analyzes collected data using statistical methods like regression analysis identifying key parameters affecting product consistency*
  - *Improve Phase: Based on identified factors modifying equipment parameters and standardizing raw composition leads them towards more consistent products*
  - *Control Phase: Establishment new control measures such as creating tighter specifications around ranges and raw material compositions ensuring continuous monitoring through statistical techniques*

PDCA Cycle

- *Definition: The PDCA Cycle, also known as the Plan-Do-Check-Act Cycle, is a continuous improvement methodology used to address problems, make changes, and improve processes systematically.*

- *Purpose: To identify areas for improvement, implement changes, monitor results, and make adjustments for ongoing improvement.*

- *Key elements: Each phase of the PDCA Cycle contributes to the overall goal of continuous improvement and quality control.*

PDCA Cycle

- *Components*
  - *Plan:*
    - *Identify the problem or opportunity for improvement.*
    - *Set objectives and develop a plan to address the issue.*

  - *Do:*
    - *Implement the plan and carry out the actions outlined in the planning phase.*

  - *Check:*
    - *Assess the results of the actions taken during the "Do" phase.*
    - *Compare actual outcomes to planned objectives.*

  - *Act:*
    - *Take corrective actions based on the results of the "Check" phase.*
    - *Adjust the plan or implement changes to improve processes further.*

FMEA Method

- *Definition: Failure Mode and Effects Analysis (FMEA) is a structured methodology used to identify potential failure modes in a system, process, or product, assess the impact of those failures, and prioritize actions to mitigate risks.*

- *Purpose: To proactively identify and address potential failures, prioritize improvement efforts, and enhance overall quality and reliability.*

- *Key elements: FMEA involves identifying failure modes, determining the severity, occurrence, and detection ratings for each failure mode, calculating risk priority numbers (RPNs), and developing action plans to address high-risk areas.*

https://asq.org/quality-resources/fmea

FMEA Method

- *Components*
  - *Identify potential failure modes: List all possible ways in which a process or product can fail.*
  - *Assess severity: Rate the potential impact of each failure mode on customer satisfaction, safety, and product quality.*
  - *Evaluate occurrence: Determine how frequently each failure mode is likely to occur.*
  - *Analyze detection: Assess the likelihood of detecting each failure mode before it impacts the customer.*
  - *Calculate Risk Priority Numbers (RPNs): Multiply severity, occurrence, and detection ratings to prioritize failure modes.*
  - *Develop action plans: Prioritize high-RPN failure modes and implement actions to reduce risks and improve quality.*

QFD Approach

- *Definition: Quality Function Deployment (QFD) is a systematic method used to translate customer requirements into specific design and production processes. It helps organizations prioritize customer needs, align their processes accordingly, and improve overall quality control.*

- *Purpose: To ensure that products or services meet or exceed customer expectations by integrating customer requirements throughout the entire product development and production process.*

- *Key elements: QFD involves capturing voice of the customer, translating it into design requirements, prioritizing those requirements, and deploying them across various stages of product development.*

https://asq.org/quality-resources/qfd-quality-function-deployment

QFD Approach

- *Components*
  - *Voice of Customer (VoC): Gathering data on customers' needs, preferences, and expectations through surveys, interviews, focus groups etc., to identify key quality characteristics.*
  - *House of Quality (HoQ): A matrix-based tool used to translate VoC into measurable design parameters while also considering relationships between different parameters.*
  - *Prioritization Matrix: Ranking design parameters based on their importance as perceived by customers to guide decision-making during product development.*
  - *Cross-functional Collaboration: Involving various departments like marketing, engineering, manufacturing etc., in the QFD process to ensure alignment between customer needs and internal processes.*

QFD Approach

QFD Approach

- *Example: A software company applies QFD principles to improve quality control in its software development process.*
  - *Voice of the Customer (VoC) Analysis:*
    - *Collecting feedback from end-users on desired features/functionality/quality aspects.*
    - *Analyzing market research data for insights into user preferences.*
  - *House of Quality (HoQ):*
    - *Mapping user requirements onto technical characteristics for software development.*
    - *Identifying correlations between user desires and technical attributes.*
  - *Prioritization Matrix:*
    - *Assigning weights/importance levels to different user requirements based on survey data or expert opinions.*
    - *Assessing trade-offs between conflicting priorities during software development.*
  - *Cross-functional Collaboration:*
    - *Involving developers, testers & designers in collaborative sessions for requirement analysis & planning.*
    - *Sharing knowledge/experience across teams involved in different stages of software production.*

5 Whys

- *Definition: The 5 Whys is a problem-solving technique used to identify the root cause of an issue by asking "why" multiple times to uncover deeper layers of causation.*

- *Purpose: To systematically analyze and address the underlying reasons for quality issues, defects, or failures in processes or products.*

- *Key elements: The 5 Whys method involves asking "why" five times (or more) to trace the cause-and-effect relationships leading to a particular problem, enabling organizations to implement effective corrective actions.*

https://asq.org/quality-resources/five-whys

5 Whys

- *Example: An automotive manufacturing company applies the 5 Whys method to address recurring defects in a specific part of the production process.*
  - ✓ *Problem: Defective parts are being produced.*
  - – *Why? The machine used for shaping the parts is malfunctioning.*
  - – *Why? The machine maintenance schedule has not been followed.*
  - – *Why? The maintenance staff is not adequately trained to perform scheduled maintenance.*
  - – *Why? There is no standardized training program for maintenance staff.*
- *Corrective Actions:*
  - – *Implement a standardized training program for maintenance staff.*
  - – *Develop a robust maintenance schedule and ensure adherence.*
  - – *Regularly monitor machine performance to detect issues early.*

5S

- *Definition: 5S is a methodology for organizing, cleaning, developing and sustaining a productive work environment. It consists of five principles: Sort, Set in Order, Shine, Standardize, and Sustain.*
- *Purpose: To improve efficiency, safety, and quality by creating an organized and standardized work environment.*
- *Key elements: The 5S methodology aims to eliminate waste, reduce errors, and enhance overall workplace effectiveness.*

https://asq.org/quality-resources/lean/five-s-tutorial

5S

- *Components*
  - *Sort (Seiri):* Separating necessary items from unnecessary ones and removing the latter from the work area.
  - *Set in Order (Seiton):* Organizing and arranging necessary items in a logical and efficient manner for easy access.
  - *Shine (Seiso):* Cleaning and maintaining the work area to ensure cleanliness and safety.
  - *Standardize (Seiketsu):* Establishing standardized processes and procedures for maintaining the first three S's.
  - *Sustain (Shitsuke):* Continuously maintaining and improving the 5S practices through employee training and regular audits.

5S

- *Example: A manufacturing facility implements 5S principles to improve quality control in the production process.*
  - *Sort: Identify and remove unnecessary tools and materials from the production area to reduce clutter and improve workflow.*
  - *Set in Order: Organize tools, equipment, and materials in designated locations to minimize search time and enhance efficiency.*
  - *Shine: Implement regular cleaning schedules to maintain a clean and safe working environment, reducing the risk of contamination or defects.*
  - *Standardize: Develop standardized procedures for equipment maintenance, material handling, and workspace organization to ensure consistency.*
  - *Sustain: Train employees on 5S principles and conduct regular audits to ensure continuous adherence to the practices.*

Kaizen

- *Definition: Kaizen is a Japanese business philosophy that focuses on continuous improvement through small, incremental changes in processes, products, and systems.*
- *Purpose: To achieve ongoing improvements in quality, productivity, and efficiency by involving all employees in the process of identifying and implementing improvements.*
- *Key elements: Kaizen emphasizes the importance of employee involvement, standardized processes, and a culture of continuous improvement.*

Kaizen

- *Components*
  - *Continuous Improvement: Encouraging small, ongoing changes to improve processes and systems.*
  - *Standardization: Developing and maintaining standardized processes to ensure consistency and quality.*
  - *Employee Involvement: Engaging all employees in identifying improvement opportunities and implementing changes.*
  - *Elimination of Waste: Identifying and eliminating waste in all forms to improve efficiency and reduce costs.*
  - *Quality Focus: Emphasizing the importance of producing high-quality products and services.*

Kaizen

- *Example: A manufacturing company applies Kaizen principles to enhance quality control in its production processes.*
  - *Continuous Improvement: Implementing small, incremental changes to production processes to reduce defects and improve product quality.*
  - *Standardization: Developing standardized quality control procedures and checklists to ensure consistent product quality.*
  - *Employee Involvement: Encouraging employees to identify quality issues and suggest improvements, fostering a culture of continuous improvement.*
  - *Elimination of Waste: Identifying and reducing waste in production processes to improve efficiency and quality.*
  - *Quality Focus: Emphasizing the importance of meeting quality standards and continuously striving for improvement.*

Kanban

- *Definition: Kanban is a visual scheduling system used to control and manage work as it moves through a process. It helps to optimize workflow, minimize lead time, and improve efficiency.*
- *Purpose: To enable a smooth and continuous flow of work, reduce overproduction, and facilitate just-in-time production.*
- *Key elements: Kanban emphasizes visual management, limiting work in progress, and continuous improvement.*

Kanban

- *Components*
  - *Visual Management: Using visual signals, such as cards or boards, to represent work items and their status in the production process.*
  - *Work in Progress (WIP) Limits: Setting limits on the number of tasks or items that can be in progress at any given time to prevent overloading the system.*
  - *Pull System: Work is pulled into the system based on demand rather than being pushed through the process, ensuring a more efficient flow.*
  - *Continuous Improvement: Encouraging ongoing improvements in the workflow and processes based on feedback and data.*

Kanban

- *Example: A manufacturing company applies Kanban principles to improve quality control in its production processes.*
  - *Visual Management: Using Kanban boards to visualize the status of quality control tasks, such as inspections and testing, at each stage of the production process.*
  - *Work in Progress (WIP) Limits: Setting limits on the number of products in the quality control phase to ensure that resources are not overextended and that each product receives adequate attention.*
  - *Pull System: Quality control tasks are triggered based on demand, ensuring that products move through the quality control process at an optimal pace.*
  - *Continuous Improvement: Using data from Kanban boards to identify bottlenecks or areas for improvement in the quality control process.*

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\text{Troubleshooting and Improvement}
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\text{Qualitative}
\begin{cases}
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\text{DMAIC process}\\
\text{PDCA cycle}\\
\text{FMEA method}\\
\text{QFD approach}
\end{array}\right\} \text{Techniques}\\[1em]
\left.\begin{array}{l}
\text{Pareto chart}\\
\text{Ishikawa diagram}\\
\text{5 Whys}\\
\text{5S}\\
\text{Kaizen}\\
\text{Kanban}
\end{array}\right\} \text{Tools}
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\text{Quantitative}
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\left.\begin{array}{l}
\text{Factorial designs (2^k designs)}\\[2em]
\text{Fractional factorial designs (2^{k-p} designs)}
\end{array}\right\} \text{aka. DOE}
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Applied to the errors detected in Phase I to debug the process for final production