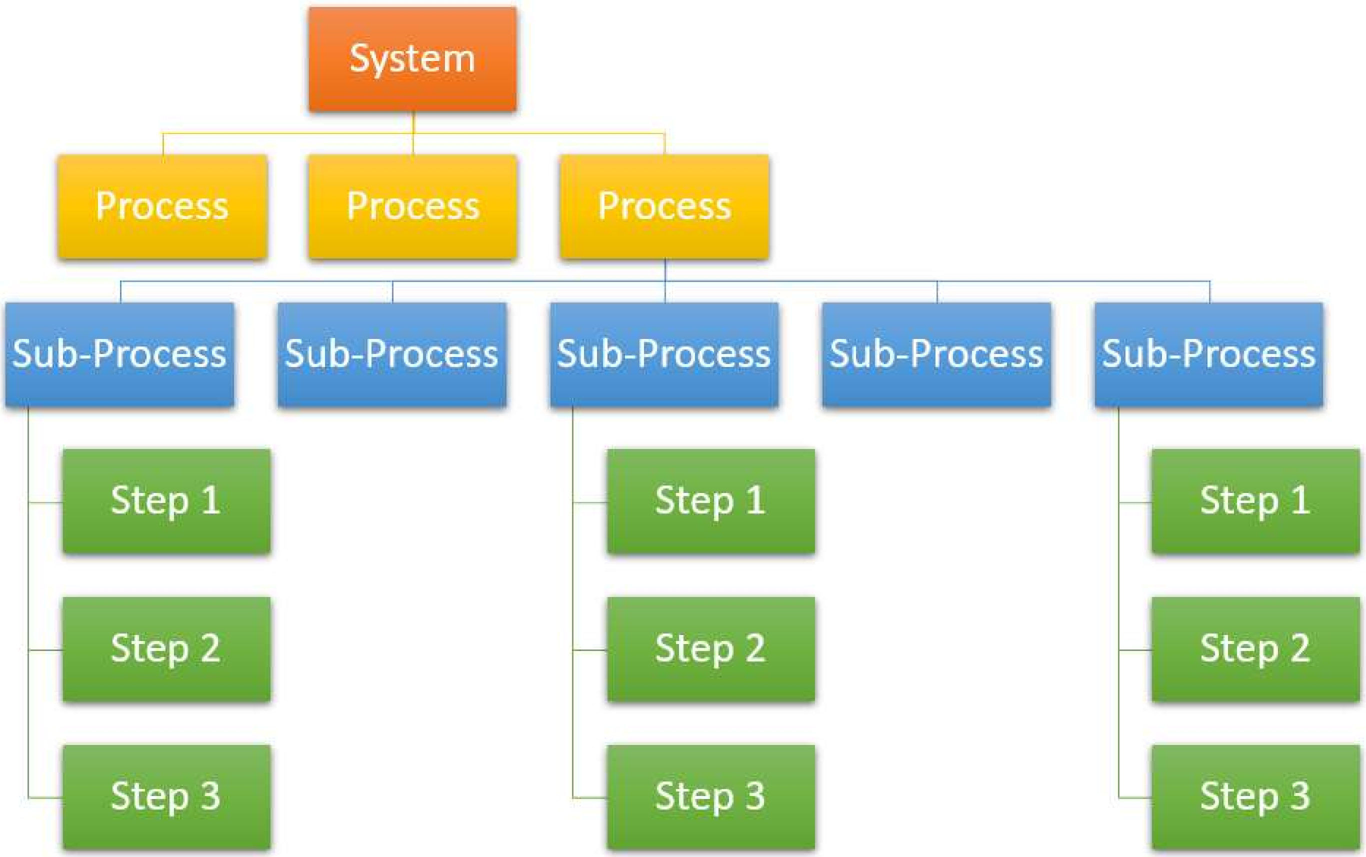
Foundational Principle #1 – Systems

A system is defined as a collection of processes, and those processes often can be broken down into their own sub-processes, which can then be broken down into the specific steps within that process.

This is true for business processes, along with the traditional manufacturing processes that are often analyzed in a six-sigma process.



One reason to start with this high-level picture is to point out a common problem that can occur when improving a process. This is called localized optimization.

This occurs when someone makes an improvement in one process, that ends up having a detrimental effect in another area of the business, which when considered on the whole as a net negative change for the business.

It's important as a green belt to make sure to maintain this system level perspective, so that you don't fall into this common trap of making local optimizations that end up making the entire system worse.

Foundational Principle #2 – The Process

The concept of a process, and **process capability**, is central to Six Sigma and so many other concepts in quality engineering.

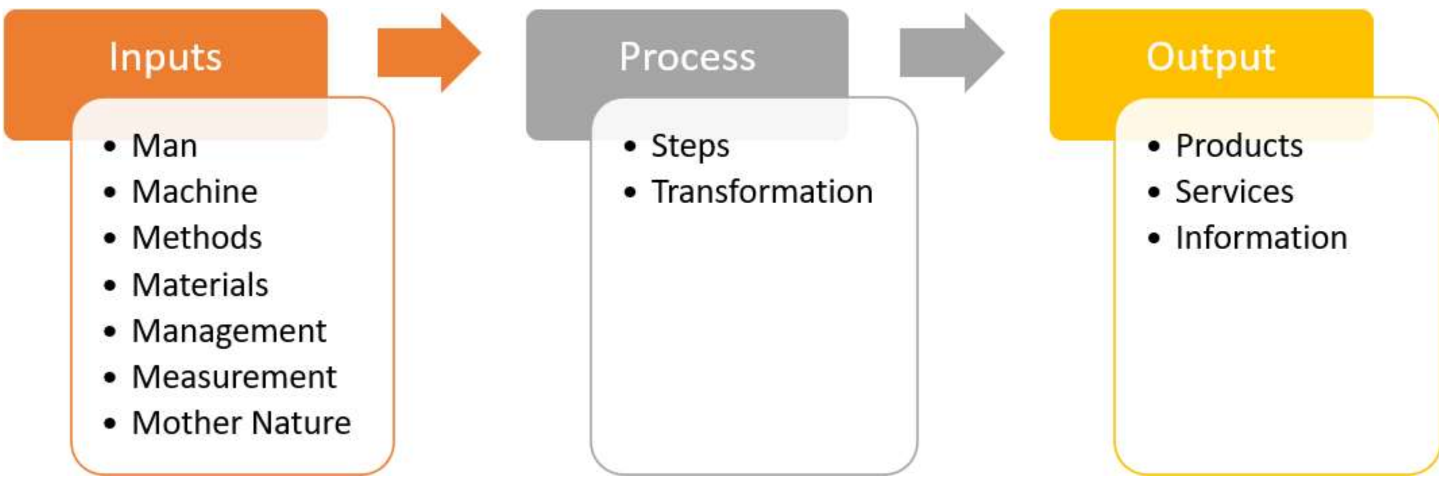
Deming said "*If you can't describe what you're doing as a process, you don't know what you're doing.*"

The six-sigma perspective is that all activities within a business should be viewed as part of a process, and all processes can be improved.

Every process has 3 common features: **inputs**, the **process** and **outputs**.

A **process** is defined as a set of interrelated activities that **transform inputs** into **outputs**.

The **inputs** to a process can span a number of various categories. The M's of the Cause-and-Effect Diagram are a great starting point to think about the potential inputs for a process; man, machine, method, materials, management, measurement and mother nature.

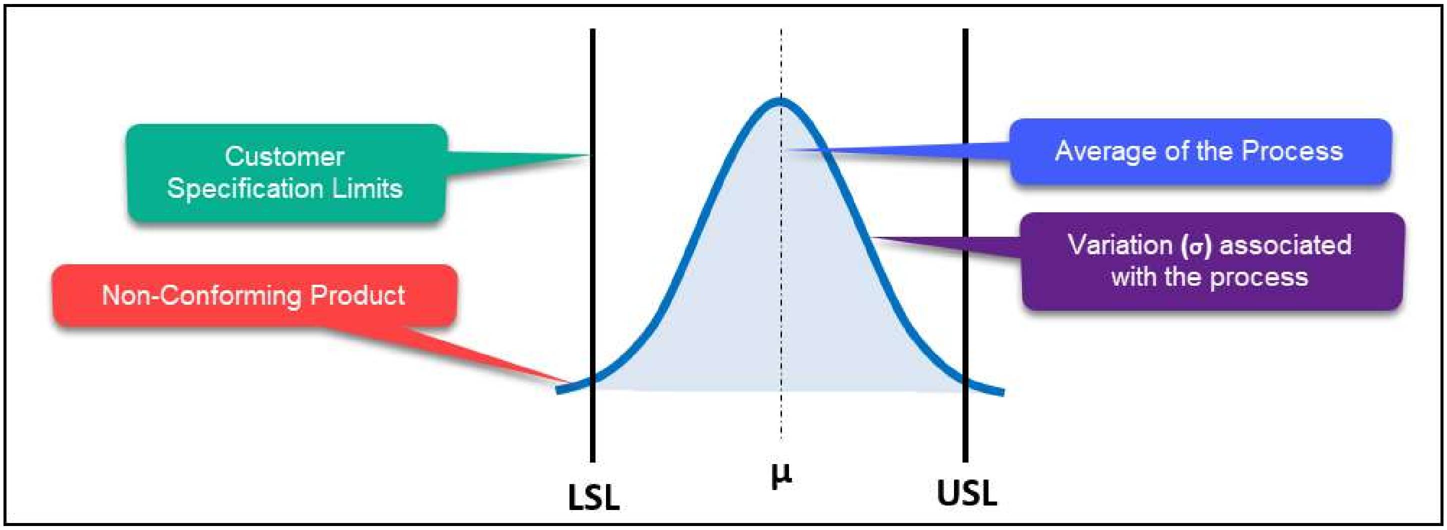


The **outputs** of a process are the **product** and **services** that your **customers desire**. **The quality** of the **product** depends on the **quality of the inputs** and the **quality of the process.**

Processes also have **feedback loops** which can include the key output variables around process performance. This should include process data like yield, OEE DPMO or other key metrics that reflect the health of that process. It is this data that can be measured and analyzed to identify opportunities for improvement.

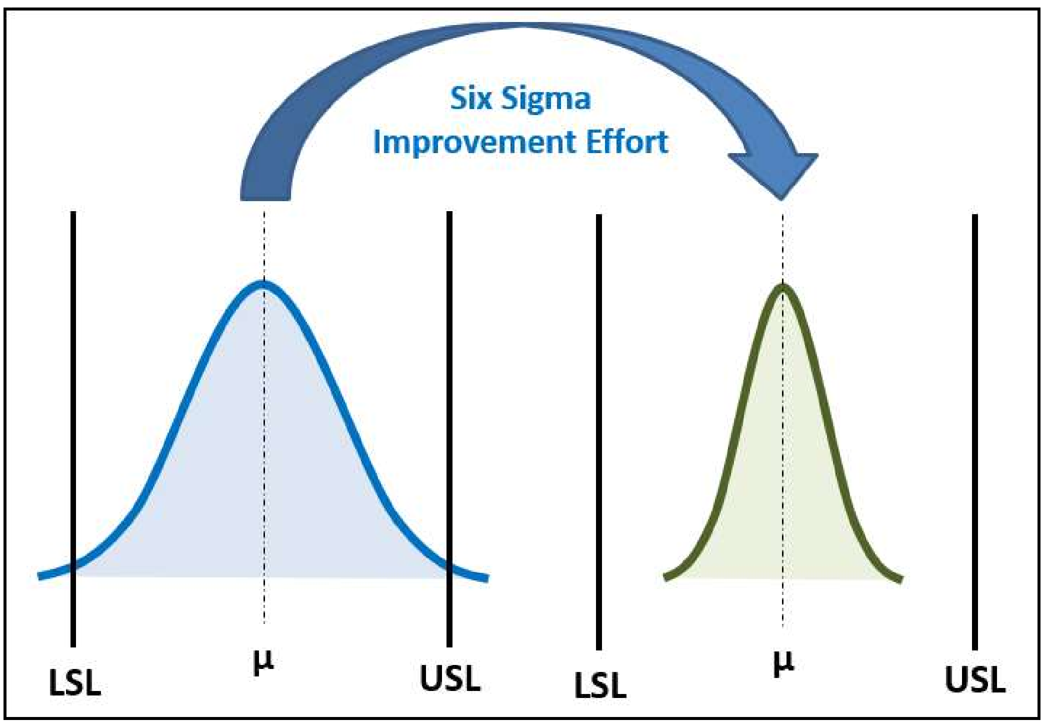
Not only can we analyze the feedback loop from a process, we can study the process outputs directly and compare them against the customers expectations. Below you can see the **output of a process**. This process has an output that's normally distributed and is characterized by its **average value** and the **variation of the distribution**.

To assess the capability of our process we compare the **output of our process** (average and variation), which is often called the **voice of the process**, against the **customer requirements** (voice of the customer).



Based on this analysis you can see that our **process produces non-conforming product** in the tails of the distribution - the portion of the normal distribution that's beyond the specification limit (on both sides of the distribution).

This is poor quality, and is an **opportunity for improvement.** Let's see what happens to the process when we use six sigma tools to eliminate the major sources of variation that are causing poor quality.



You can see that after we've **reduced the variation of the process** the tails of the distribution are well within the specification limits, meaning that we've eliminated some rejects and improved quality.

The **DMAIC** method in six sigma views every process as something that can be studied, measured, analyzed and improved on. We often talk about processes using a tool called a **flow chart**, the **SIPOC tool**, or a **value stream map**. We will discuss this more in chapter 7.

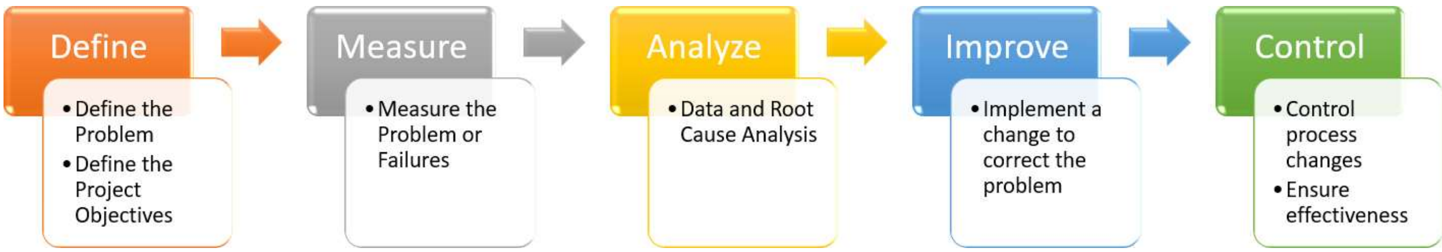
The Basic Six Sigma Process – DMAIC

DMAIC (pronounced duh-MAY-ick), which stands for Define-Measure-Analyze-Improve-Control is a 5-step **improvement process** that is **Six Sigma**'s version of the **PDCA cycle** (and the **scientific method**).

Just like with PDCA, DMAIC can be used to **solve a complex problem**, or make **major improvements** to a process/product.

DMAIC is really the **heart of six sigma**, and like the PDCA cycle, it should be **repeated often** so that improvements build off each other.

Let's go through each step, in detail.



Define of DMAIC

First, we **Define a goal** to be achieved**, a problem** to be solved, or a **process** needing improvement.

Having a **clearly defined problem statement** or project goal is a critical starting point. Similarly, if you're using the improvement kata you would start by **defining the ideal state of your process**.

Below are some other activities that might occur in the **Define** stage:

- Identify the **Critical to quality attributes**, customer needs or other expectations (Voice of the Customer)
- Clearly defined **project objectives** (scoping and timelines) along with boundaries in an A3 (project charter)
- Collect **initial data** that would support the definition of the **problem statement**
- Identify **stakeholders** and needed **cross-functional team** participants
- Determine the **business case** for solving the problem
- Create a **process map, SIPOC** or **value stream** of the current state process
- **Benchmark or Brainstorm** the future state of the process
- Define the **GAP** between the **current state**, and the desired **future state**

Measure of DMAIC

Once we've defined a problem, we must now **Measure the current state of the process or problem**.

This might include measuring the process capability of the current state process. This phase might also include designing an experiment to identify key input variables and output variables.

Below are some other activities that might occur in the **Measure** stage:

- Measure the **process capability** of the current state process
- Define and assess the effectiveness of any **measurement methods (gauge R&R)**
- Design an Experiment (DOE) to test hypotheses or potential root causes
- Implement proposed process changes on a small scale to measure the effect of the change
- Brainstorm the root cause of a problem using the **cause and effect matrix**
- Collect data from other data sources (customer complaints, supplier surveys, etc)

Analyze of DMAIC

Once we've measured our process, it's time to **analyze** the results/data to identify the root cause of problem. This step can also include the identification of key variables within a process that have an impact on the critical outputs.

Below are some other activities that might occur in the **Analyze** stage:

- **ANOVA Analysis** of a completed DOE to identify critical inputs to a process and its outputs
- **Scatter Plot (Linear Regression) analysis** to quantify the relationship between inputs and outputs of a process
- **Pareto Analysis** of various root causes and contributing factors to a problem
- **Process Capability Analysis** of Future State Process (Implemented small scale process change)
- **5 Why Analysis** to determine the root cause and contributing factors associated with the problem
- Assess the impact of an experimental change to a process (future state analysis)
- **Multi-variate** analysis of data to determine the sources of variation

Improve of DMAIC

The **improve** step is when we use the knowledge learned in the first 3 phases to make positive changes to our process.

This might include implementing a corrective action to solve a quality problem, or fully implementing a change to a process to reduce variation or waste, etc.

Below are some other activities that might occur in the **Improve** stage:

- Make changes to a process to **eliminate variation or eliminate waste**
- **Implement corrective actions** to a process and test the results of the future state
- Use **mistake-proofing (poka-yoke)** to eliminate a failure mode within a process
- Implement **standard work** to define the "best way" to perform a task
- **Communicate the proposed changes** to the affected **stakeholders**
- **Train affected employees** and stakeholders on the new process
- **Brainstorm unintended consequences** associated with proposed process changes and any countermeasures and contingencies to mitigate risk

Control of DMAIC

The last step in the improvement process is **Control**. This is often the most **forgotten or overlooked portion of the improvement cycle**. This final step is an improvement over the PDCA cycle because it forces users to consider how they are going to control the changes recently implemented and **sustain the improvement over time**.

With all of the time and attention that the current problem is getting, it's hard to imagine how anyone could forget about it. But with time, memory fades and **successful process changes can degrade**.

So, it's important that we spend time focusing on how we will **Control** the change we made to our process. This will ensure that the **root cause of the problem was eliminated** and that the objectives we achieved will be **sustained over time**.

Below are some other activities that might occur in the **Control** stage:

- Implement **SPC (Control Charts)** to monitor and control the process
- Create or update **a control plan** that maps the relationship between CTQ's and critical process inputs
- Revise **Standard Work** to ensure process changes are captured & lessons learned are captured
- Track improvements after a change and **confirm the benefits originally estimated**
- Brainstorm other potential processes that could benefit from a similar change
- Perform an **After Action Review (AAR)** to determine what went right/wrong along the way
- Plan the **next iteration through the DMAIC process.**

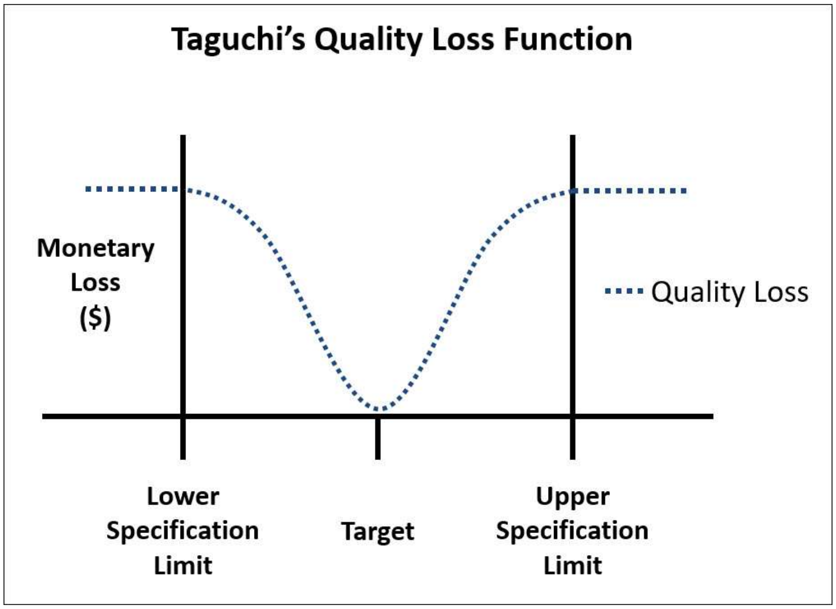
Cost and Six Sigma

It wouldn't be a discussion about six sigma if we didn't spend a moment talking about the relationship between six sigma, quality and cost.

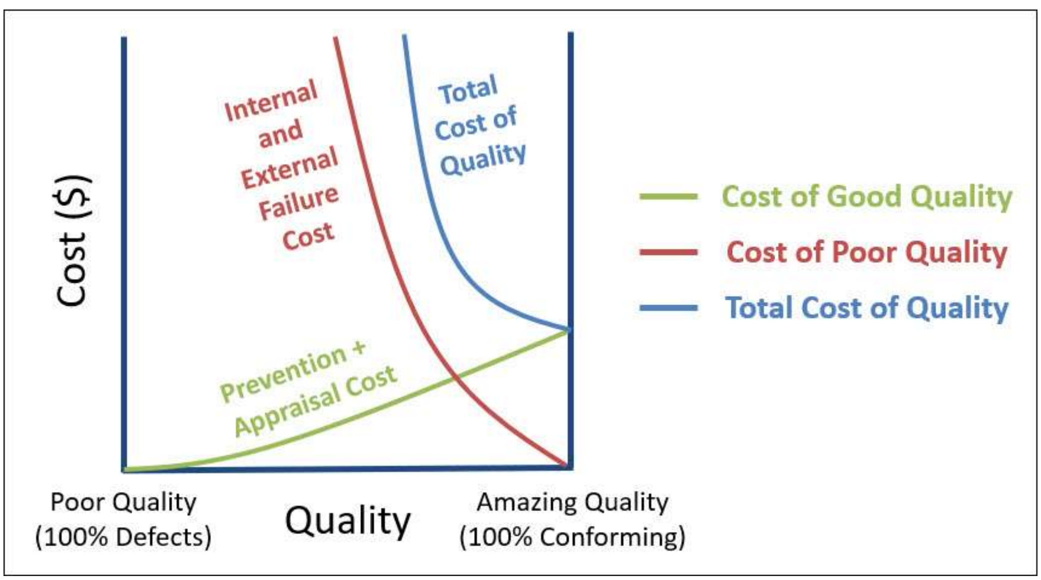
The first Quality / Cost / Improvement concept that we have to talk about is the Taguchi Loss Function.

Genichi Taguchi, a Japanese engineer popularized this idea that any variation (even within the specification limits) that is off target created waste, and loss for the organization. This became a cornerstone concept within Six Sigma.

You can see the Taguchi loss function below where on the Y-axis you can see the monetary loss that occurs when a product is off target.



The next Quality / Cost / Improvement concept that we need to talk about is the Juran Quality Cost Curve (below). What Juran taught us with this curve is that the lowest possible cost occurs when 100% of our product is conforming. You can see this below in the blue line, which represents the total cost of quality, which is at its lowest point when our product is 100% conforming.

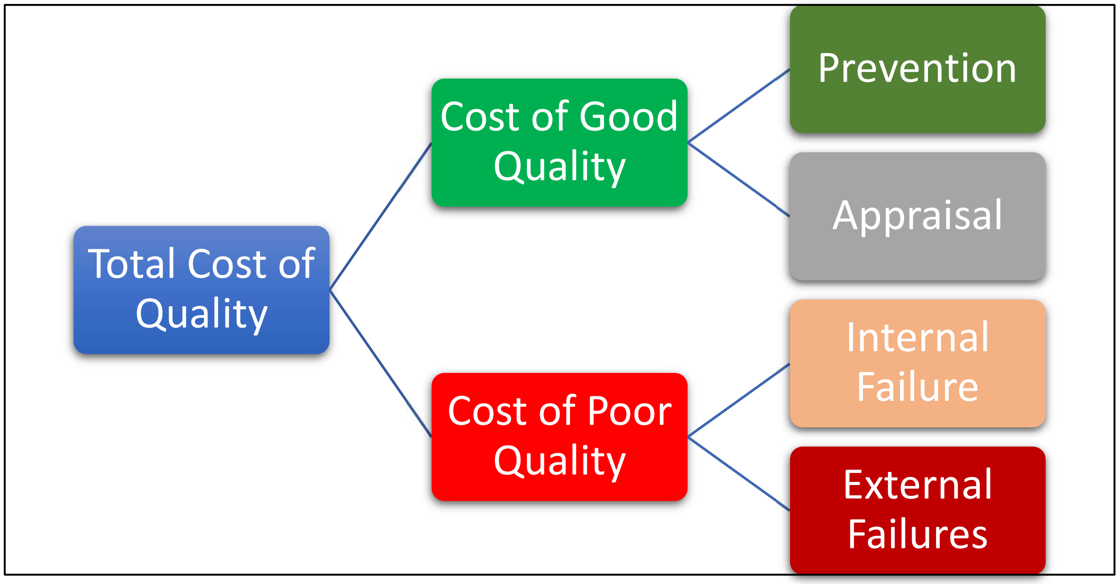


To fully understand this curve, we have to also talk about the Cost of Quality. This concept was introduced to the world by Armand V. Feigenbaum, and built on to it by others like Philip Crosby, W. Edwards Deming and many others!

Below are the 4 quality cost categories that Feigenbaum defined.

Two cost categories are considered the "**cost of good quality**", these include Prevention cost and Appraisal cost.

Two cost categories are considered the "**cost of poor quality**", these include internal failure cost and external failure cost.



Remember, your goal is to eliminate the internal failures and external failures, thus reducing the cost of poor quality, and therefore reducing the total cost of quality associated with your product. Within the world of six sigma, failures can be eliminated through the reduction of variation within a process.