Advancements in Statistical Quality Control Standards

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Abstract

Improvements in quality of customer-centric facilities require changes in the ongoing process of care and providing services to achieve customer satisfaction. Quality analysis is generally complicated by the existence of natural variations, repeated experiments naturally capitulate different values. However, traditional statistical analysis methods interpret for natural variations but require time-dependent collection of observations, which is proportional to further delay in decision making. Statistical quality control (SQC) is a philosophy, a strategy, and a set of scientific methods for ongoing improvement of systems, processes, and outcomes in various sectors including healthcare, industries, manufacturing units and agriculture. Although process execution of every sector is different but a SQC is a common model that plays vital role in managing performance by providing rigorous time series analysis in conjunction with graphical presentation of data to determine if various changes are having significant effect or not. Statistical process control (SPC) is the subsidiary of SQC and its primary tool is the control chart which facilitate researchers and practitioners to get to better understand and communicate data from different sectors. The basis of this paper is to provide overview on SQC and its practical implications.

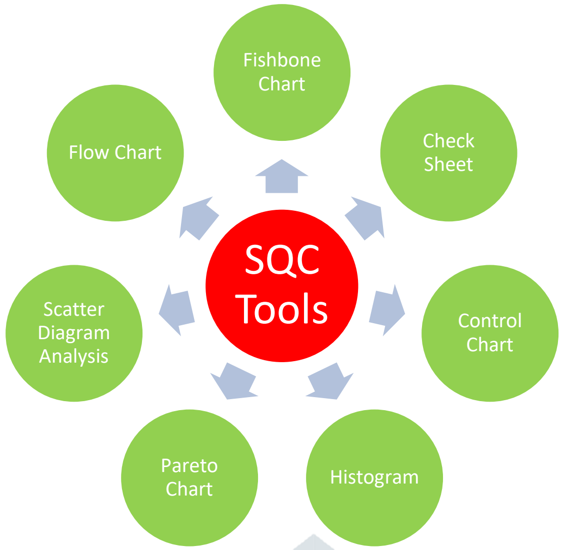
Introduction

Quality has been an indispensable part of practically all services and products. Formal methods for quality control and improvement have been an evolutionary development [1,2]. Statistical methods play a pivotal role in quality control and improvement by implementation of scientific way by which a product is sampled, tested, and evaluated, and the information in relation to data is used to control and improve the process and the product. Furthermore, statistics is a strategy in which development engineers, manufacturing, downstream processing, management, and other functional components of the business communicate about quality [3]. In 1931, Frederick W. Taylor introduced methods to evaluate the process outcome whether state of statistical control is significant or not, statistical process is followed to bring substantial improvements in productivity in various field including agriculture, industries, share market [1,2,3]. SPC provides time series analysis in conjunction with graphical representation of parameters, often capitulating insights analysis more swiftly and presentable to make decisions [4]. SPC methods have also been used in critical care and disease management settings, but not to monitor compliance with care standards [3,4]. Quality is the desired outcome but in limited resources; SQC provides virtual evaluation of all the variables (dependent and independent parameters) before the execution of plan. Quality is considered as a degree of satisfaction which varies from place to place or even from people to people. The satisfaction level varies as one product which satisfies a group of people may not satisfy the others [1,6].The quality in such cases should be set to some universally accepted standards. The steps and activities that are followed to provide assurance to the users that goods and services provided are of good quality is called quality control activities. In 1920, Walter A. Shewhart of the Bell Telephone Laboratories developed the statistical control chart concept, which is often considered as the beginning of statistical quality control, whose work subsequently motivated W. Edward Deming to devote his life to the teaching and improvement of quality methods [2,6,7].

The Statistical Quality Control approach was applied to control factors of defective products (i.e. the 5M's: Manpower, Materials, Machines, Method and Money involved) in the manufacturing process. Statistical Quality Control prevents the occurrence of defectives by exercising control over the process rather than inspecting for conformance after they have been produced. Statistical Quality Control triggered the advancement of quality control in Japan characterized by employee participation and QC circle activities [5,8]. In this era of overburden on the resources and increasing costs of manufacturing, it apparently bound to make decisions based on facts only but not just on opinions or suggestions. Consequently, data must be acquire and analyzed by using specific and endorsed methodology. Statistical process control is a advance method of quality control which uses statistical analysis. SPC is applied in order to monitor and control a process [10,11]. For over 70 years, the manufacturing domain has benefited from the statistical tools analysis which serves in decision-making process by studying various parameters. More specifically, control charts analysis is a continuous activity and used to measure variations at points on the process map to differentiate special sources of variation from common sources. Common sources are an expected part of the process, are of much less concern to the manufacturer than special sources. If no special-cause variation is found to be present, SPC helps define the capability of the stable process to judge whether it is operating at an acceptable level [13,14].

Approaches to Quality control

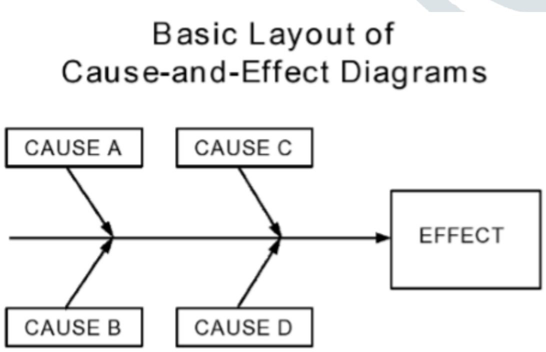
The Seven Basic Tools of Quality is a designed to monitor process behavior, discover issues in internal systems, and find solutions for production issues. It is a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality [21,22]. It helps in problem solving, ranging from simple and easy to used methods to relatively complicate and advance statistical tools. However, the most widely applicable and useful ones for most organization are the "Seven Basic Tools". Problem solving Techniques of "Seven Basic Tools" are given below:



QUALITY CONTROL (7-QC) TOOLS

In 1974, Dr. Kaoru Ishikawa brought together a collection of quality tools known around the world as the seven quality control (7-QC) tools, they are:

1) **Cause-and-effect diagram** is also known as Ishikawa or fishbone char. The fishbone diagram identifies many possible causes for an effect or problem. It is generally handle by using brainstorming session that helps in finding the root cause. It immediately sorts ideas into useful categories. It is used to identify best possible solution for a problem at the dead end [25,26].



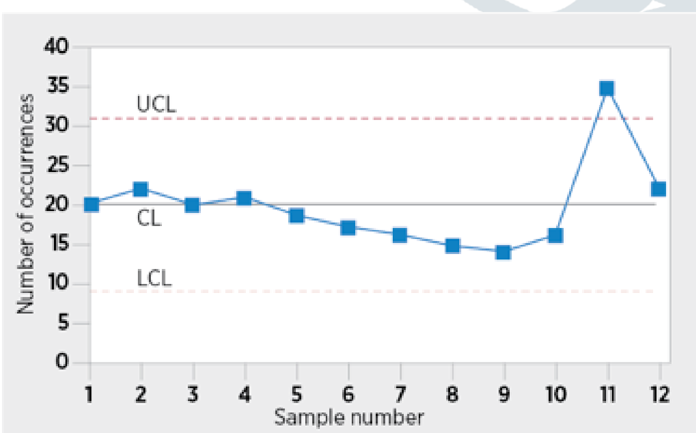
2) Check sheet is a structured, prepared form for collecting and analyzing data. It is widely employed tool for the detection of various possible failures. It is also known as defect concentration diagram. It is used when data can be observed and collected repeatedly by the same person or at the same location. The figure below shows a check sheet used to collect data of Absenteeism [26].

Absenteeism

3)

Reason	Day					
	Mon	Tue	Wed	Thu	Fri	Total
Late	~~IIII~~	II	III	II	II	14
Illness	II	III	I	~~IIII~~	I	12
Tests	~~IIII~~	II	I	~~IIII~~	II	15
Misc	III	I	II	II	IIII	12
Total	15	8	7	14	9	53

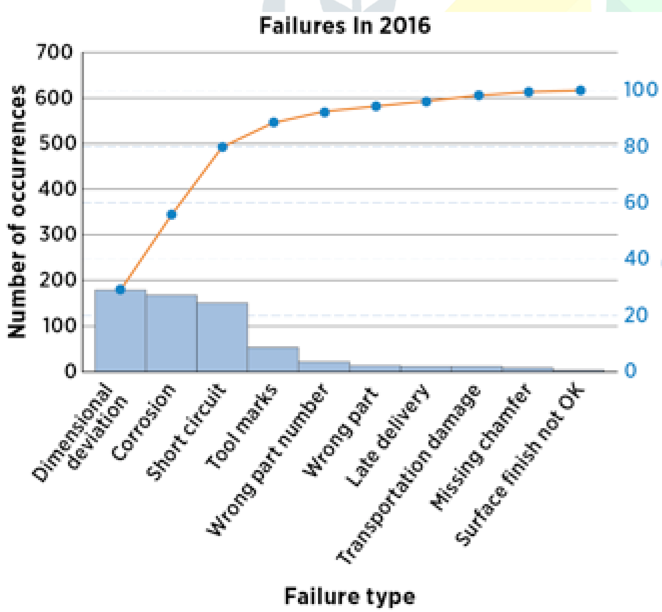
Control chart is also known as statistical process control, a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. Control charts attempt to distinguish between two types of processes and variations. Common cause variation, which is intrinsic to the process and will always, be present in the system. Comparison of data leads to conclusion about consistency or unpredictability of the process. Control charts for variable data are used in pairs. The top chart monitors the average, or the centring of the distribution of data from the process. The bottom chart monitors the range, or the width of the distribution [1,27]. If your data were shots in target practice, the average is where the shots are clustering, and the range is how tightly they are clustered. Control charts for attribute data are used singly. Control charts are used when controlling ongoing processes by finding and correcting problems as they occur. Therefore, use of control charts is most reliable to determine the stability of process by analyzing patterns of process variation from special causes (non-routine events) or common causes (built into the process) [2].



The control chart is designed so that not every item produced needs to be inspected. One of the reasons for using SPC is that you don't need to inspect every part, as you know how much confidence you have in the part produced. Sample sizes (i.e.the number of parts in each subgroup) normally used range from 1 to 10. The limits on the control chart depend on the sample size used [1,2,3].

This follows logically, because if your sample size is 10 then you have a much better chance of gaining parts from the full spread of the process than if the sample size is 1. If you only measure one part, then you have no idea where it lies in the distribution of the variation of the machine.

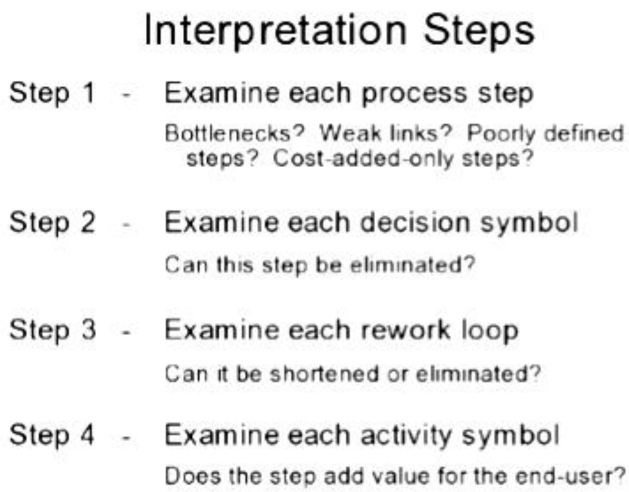
4) Histogram is a frequency based distribution which determines the occurrence each different value in a set of data occurs [4]. It is represented just like a bar chart, but there are important differences between them. This helpful data collection and analysis tool is considered one of the seven basic quality tools. It is used when the data is numerical to see whether a process change has occurred from one time period to another. It is also used to compare whether the outputs of two or more processes are different. It is quick way to communicate the distribution of data quickly and easily to others [4,5].
5) Pareto chart is a bar graph, lengths of the bars denotes the frequency with the arrangement of longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations whether results are more significant or not. It is used to analyze data about the frequency of problems or causes in a process. It is also used in situations problems or causes and you want to focus on the most significant by looking at specific components [2,4].



6) Scatter diagram analysis is a scatter plot, X–Y graph. Scatter Diagrams are used to study and identify the possible relationship between the changes observed in two different sets of variables. For constructing a Scatter Diagram collect two pieces of data and create a summary table of the data. Draw a diagram labeling the horizontal and vertical axes. It is common that the "cause" variable be

labeled on the X axis and the "effect" variable be labeled on the Y axis. Plot the data pairs on the diagram. Finally, Interpret the scatter diagram for direction and strength [1,2].

7) Flow Chart: A diagram that uses graphic symbols to depict the nature and flow of the steps in a process. There are benefits of using flowcharts as it promotes process understanding, provide tool for training and to identify problem areas and improvement opportunities [1].



QC TOOLS THROUGH PDCA-CYCLE

The PDCA Cycle is most commonly used for continuous improvement as shown in "Fig.1.3". PDCA cycle was first developed by Walter Shewhart in the 1920s, later promoted by quality preceptors Dr Edwards Deming [1,4,8]. *PDCA*-cycle is a continuous loop having four consecutive steps, as follows:

❖ Plan – Perception for improvement

❖ Do – Implementation of the changes that is decided in the Plan.

❖ Check –

a) Control and measurement of processes and products in accordance with changes in previous steps

b) Policy, goals and requirements, report on results and decision making

❖ Act -

a) Adoption of the changes or run through *PDCA*-cycle again

b) Repetition of cycle for continuous improvement.

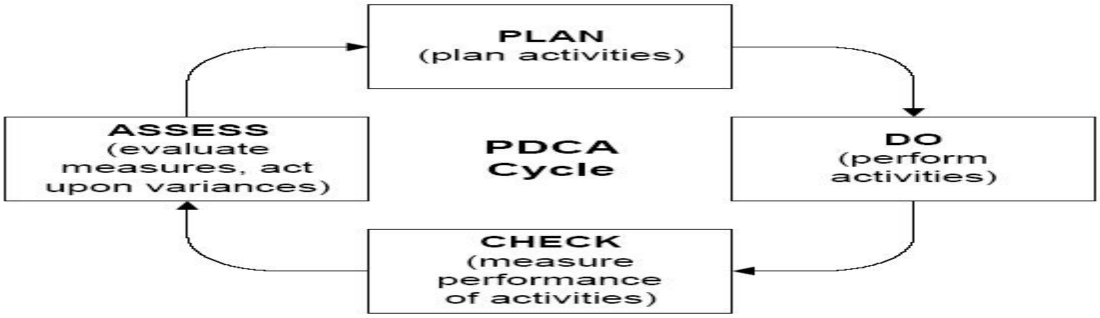


Figure 1.3 PDCA cycle PDCA-cycle is required in process improvement(Pratik, [35]).

PDSA cycle involves application of seven basic quality tools in correlation with four steps of cycle is shown in Table 1. As shown in Table 1, for problem identification Flow chart, Cause-and-Effect diagram, Check sheet, Pareto diagram, Histogram and Control charts can be used. For problem analysis Cause-and-Effect diagram, Check sheet, Pareto diagram, Scatter plot and Control charts tools can be used. When the team is developing a solution for analyzed problem Flow chart and Scatter plot can be useful. For evaluation of results, Check sheet, Pareto diagram, Histogram, Scatter plot and Control charts can be used [1,2,8,12].

Table 1 Seven basic quality tools (7QC tools) in correlation with PDCA-cycle steps

Seven basis quality tools (7QC tools)	Steps of PDCA-cycle			
	Plan	Plan, Check	Plan, Act	Check
	Problem identification	Process analysis	Solutions development	Result evaluation
Flow chart	√		√	
Cause-and-effect diagram	√	√		
Check sheet	√	√		√
Pareto diagram	√	√		√
Histogram	√			√
Scatter plot		√	√	√
Control charts	√	√		√

Conclusion

All improvements require changes but vice-versa may not be true. The key to identify beneficial change is quantitative [1]. The major components of measurement include: (1) identifying & elaborating key indicators; (2) aggregation of data; and (3) analysis and interpretation of data. SQC charts can help both researchers and practitioners to improve quality by determining the effect of changes. An advantage of SQC is that classical statistical methods typically are based on ''time static'' statistical tests with all data aggregated into large samples that ignore their time order—for example, the mean waiting time at intervention sites might be compared with that at non-intervention sites. Large data sets have good statistical power & are very much effectively used in SQC tools [3]. The practitioners may have to restrict to simple bar charts, line graphs, or tables to present the data as sometimes large amount of data collection may lead to delay in accumulation. In this case the improvement by the practitioner can only be a qualitative statement. Inversely, SQC methods combine the inflexibility of classical statistical methods with the time sensitivity of realistic improvement. By integrating the power of statistical significance tests with chronological analysis of graphs of summary data as they are produced, SPC is able to detect process changes and trends earlier. While this may be a less familiar branch of statistics to many researchers, it is no less valid. SPC also distils statistical theory into relatively simple formulae and graphical displays that can easily be used by non-statisticians [1,3,10].

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