International Academy for Quality

Technical and Human Dimensions of Quality

The Premier Memorial Walter E. Masing Lecture

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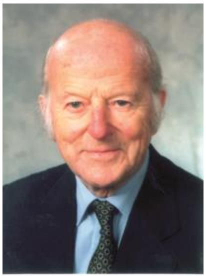
Abstract:

The function of quality is being deployed differently since the time of Walter A. Shewhart in the first half of the last century. The challenge at that time was to reduce the losses of poor quality in manufacturing in an environment where quality levels were masked by measurement error which made it nearly impossible to understand how to control production in a way that assured consistency of results in a predictable way that was economically viable. Thus, quality systems in the first half of the last century had to compensate for measurement errors and tended to use simple inspection procedures to assure quality requirements were met. Judging the financial impact of quality was also simplified to an equation relating quality improvement to the number of inspectors who examined each item produced. These assumptions were all based on the capabilities that were available at the historical moment using then state-of-the-art technological capability and an imperfect understanding of human capacity for performance. Since then major developments in technology and human performance have been achieved so it is time to revisit the assumptions of yesterday and “creatively destroy” all artifacts that remain from that epoch which distort the current body of quality knowledge. This presentation will examine the elements in Shewhart’s Theory of Control that require “heuristic redefinition” and will critique Joseph M. Juran’s concept of quality cost as an inappropriate way to consider the benefits that are obtainable by quality improvement efforts. Revised mental models for both of these concepts will be drawn from the body of quality knowledge to suggest the thinking transformation that should be made to accommodate the significant advances in technology and human understanding.

Walter E. Masing: Europe's Premier Quality Leader



Walter E. Masing
(1915-2004)

- Walter E. Masing was born in St. Petersburg, Russia, raised in Estonia but lived most of his life in Germany.
- Dr. Masing was the founder of the German Society for Quality (Deutsche Gesellshaft für Qualität or DGQ) and he inspired founding the Estonian Quality Association. He served as the President of the DGQ for twenty years and was named Honorary President on his retirement.
- Dr. Masing is the founder of the European Organization for Quality (EOQ) and he served as its first President and subsequently was named an Honorary Member.
- In addition, Dr. Masing was one of three founders of the International Academy for Quality in 1966 along with both Kaoru Ishikawa and Armand V. Feigenbaum. He has been elected an Honorary Member of IAQ and the Academy created the Walter E. Masing Book Prize to honor his memory.

The 20th Century challenge for quality technology:

- The 20th Century commenced with a strong interest in quality. In particular, dealing with measurement error and sampling were the major areas of emphasis in the first half of the Century.
- The 19th Century could be called the Century of the Normal distribution as Carl Friedrich Gauss and Francis Galton made the "bell-shaped curve" an accepted way of interpreting nature.
- It was believed: "every actual observation is affected with error."
- And so, even before the 20th Century, scientists like Galileo took many data recordings and reported only their average result in the scientific reports and studies. This technique compensated for observation and measurement errors and was accepted practice until the 20th Century's need for more precision stimulated new ideas.
- This analytical approach did not well suit the industrial revolution with its interchangeable parts and so a new way needed to be developed.

1. Thorvald Nicolai Thiele (1903), ***Theory of Observations*** (London: Charles and Edwin Layton).
2. Albert de Forest Palmer (1912), ***The Theory of Measurements*** (New York: McGraw-Hill).
3. Stephen M. Stigler (1986), ***The History of Statistics: The Measurement of Uncertainty Before 1900*** (Boston: Harvard University Press).

Operational definitions required for physical meaning:

"The true meaning of a word is to be found by observing what a man does with it, not by what he says about it."

"Any statement about numerical relations between measured quantities must always be subject to the qualification that the relation is valid only within limits."

"We must first guess at what the laws are approximately, then design an experiment … in accordance with that guess."

"We continue to think of the event in the same way as before in terms of a mental model, but the true operational significance now depends on a particular phenomenon under consideration."

"A situation like this merely means that those details which determine the future in terms of the past may lie so deep in the structure that at the present we have no immediate knowledge of them, and we may for the present be compelled to give a treatment for a statistical point of view based on considerations of probability."

1. Percy W. Bridgeman (1927***), The Logic of Modern Physics*** (New York: Macmillan).

20th Century solutions: Sampling and control charts

- Radford (1922): "There is an erroneous but wide-spread belief that quality and high cost go hand in hand." But Radford represented the state of the quality art as "inspection-based quality."
- Dodge and Romig (1929 and 1946) shifted quality activity from the 100% inspection routine as proposed by Radford, to a sampling approach and then further developed sampling plans which were extensively used in the Second World War.
- Shewhart (1931) proposed the substitution of in-process control charts to substitute for inspection and sampling and to assure that a predictable level of quality would be produced by the process as it operates in a state of controlled variation (e.g., elimination of assignable causes of variation by quality control). Shewhart proposed that this would reduce economic losses from quality during the manufacturing process.
- The Shewhart control chart became the basic tool of modern quality.

1. George S. Radford (1922), ***The Control of Quality in Manufacturing*** (New York: Ronald Press).
2. Harold F. Dodge and Harry G. Romig (1929), "A Method of Sampling Inspection," ***Bell System Technical Journal***, 8:4, 613-631.
3. Walter A. Shewhart (1931), ***Economic Control of Quality of Manufactured Product*** (New York: Van Nostrand).
4. Harold F. Dodge and Harry G. Romig (1946), ***Sampling Inspection Tables*** (New York: John Wiley & Sons).

Workers were valued as a pair of hands not as humans:

- "Our experiments showed that it does not pay for men to get too rich too fast…" "… they become more or less shiftless, extravagant and dissipated."
- Worker "is not an extraordinary man difficult to find, he is merely a man more or less of the type of an ox, heavy both mentally and physically. The work which this man does tires him no more than any healthy normal laborer is tired by a proper day's work." "It is not due to this man's initiative or originally that he did his big day's work, but to the knowledge of the science of [work] developed and taught to him by some one else."
- Thus, the workers are treated only as another "pair of hands" or a set of interchangeable parts which render only physical labor and are not considered to be valuable for their thinking capacity.

1. Frederick W. Taylor (1911), ***The Principles of Scientific Management*** (New York: Harper). When Taylor's book was translated into Japanese in 1913, its title was translated as ***The Secrets of Eliminating Wasted Work***.

The development of 'standard cost' accounting – 1:

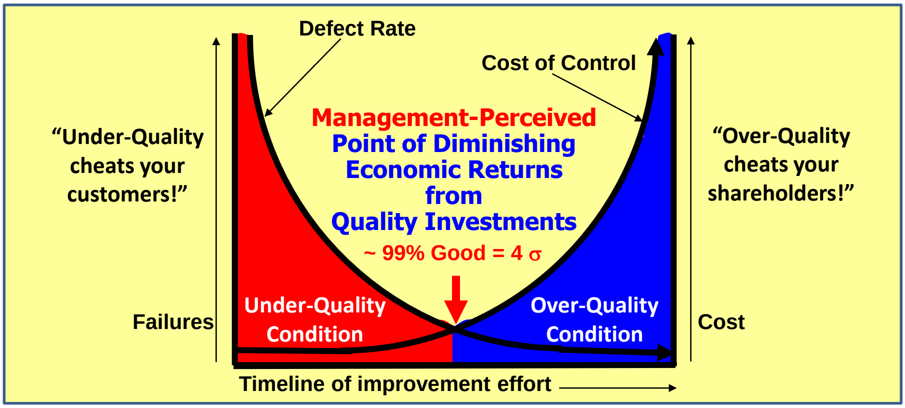
- **Emile O. Garcke** (1856-1930) and **John Manger-Fells** (1858-1925) wrote the first text on cost accounting which integrated cost records into double entry financial bookkeeping and distinguished between fixed and variable costs in their book ***Factory Accounts: Their Principles and Practice*** (1887).
- **Frederick W. Taylor** (1856-1915) emphasized the use of cost information to evaluate the efficiency of work processes and develop 'the one best way' to design work to maximize productivity in his books ***Piece Rate System*** (1895), ***Shop Management*** (1903) and ***The Principles of Scientific Management*** (1911)
- **Harrington Emerson** (1853-1931) wrote that the primary purpose of cost accounting is to aid in the reduction of costs through disclosing the existence of inefficiencies in the operations of a firm and his two principal books ***Efficiency as a Basis for Operations and Wages*** (1909) and ***The Twelve Principles of Efficiency*** (1912) which focused on the use of costing methods for tracking efficiency improvement.
- **Alexander H. Church** (1866-1936) provided accounting structure for work in ***The Proper Distribution of Expense Burden*** (1908) and ***Production Factors in Cost Accounting and Works Management*** (1910). He developed a systems of management principles based on scientific management and accounting that assured that production of efficient parts created a profitable firm in ***The Science and Practice of Management*** (1914).
- **Henry L. Gantt** (1861-1919) interpreted accounting as a means to assign responsibility and measure performance rather than just a means to control expenditures as he taught in his book ***Organizing for Work*** (1919).

The development of 'standard cost' accounting – 2:

- **G. Charter Harrison** (1881-**195X?**) developed the equations to calculate standard cost and accounting procedures for their operation and published them in his book ***Cost Accounting to Aid Production: A Practical Study of Scientific Cost Accounting*** (1921).
- **James O. McKinsey** (1880-1937), founder of the McKinsey & Company consulting firm, in ***Budgetary Control*** (1922) and ***Managerial Accounting*** (1924) developed an ability of financial analysis to provide senior management with methods to support decision making beyond scientific efficiency-producing techniques that were used by managerial and industrial engineers in the manufacturing factory.
- **F. Donaldson Brown** (1885-1965), an accountant, created standard financial ratio analysis techniques (Return on Investment (ROI) and Return on Equity (ROE)) as a flexible approach to budgeting analysis which became known as the du Pont method used by General Motors and named after GM CEO Pierre S. du Pont (1870-1954) who brought Brown from the du Pont company to help oversee a significant investment in GM by du Pont in the early 1920 as du Pont became GM's President.
- **Walter A. Shewhart** (1891-1967) focused on the efficiency side of the economic control of quality by emphasizing how control of the processes of production using statistical methods would produce predictable results at the lowest cost (including the cost of failure in his book ***The Economic Control of Quality of Manufactured Product*** (1931).

Counting monetary costs was also done with averages!

Quality Investments result in diminishing returns where further increases in quality are off-set by additional cost of achieving this quality performance. After this point an economic trade-off must be made to achieve additional quality performance by compromising with higher product cost. This believe generates the idea that there are over-quality and under-quality conditions as shown below:



1. Joseph M. Juran (1954), ***Quality Control Handbook*** (New York: McGraw-Hill).

What is the meaning behind this mental model?

How were these "functions" calculated?

In the original model from the 1950's quality control occurred to a large measure through the inspection process. Mathematical elimination of defects was observed as a function of the relative efficiency of inspectors in finding and sorting out defective types of products from those that had acceptable quality.

- **Defect Rate:** The rate of defect reduction that is achieved by the act of adding additional inspectors to check the same flow of outgoing products for defects and reduce them by sorting.
- **Cost of Control:** The additional budget that must be added in order to pay for the salaries and expenses of inspectors that are added to reduce the outgoing flow of defective products.

However, this is a very expensive solution and does not result in a permanent change to the quality performance of a process!

The 20th Century was really just average …

"Our culture encodes a strong bias either to neglect and ignore variation. We tend to focus instead on measures of central tendency, and as a result we make some terrible mistakes, often with considerable practical import."

~ Stephen Jay Gould (1941-2002)

- The Flaw of Averages states: "Plans based on ***average*** assumptions are wrong on ***average***."

"In everyday life, the Flaw of Averages ensures that plans based on average customer demand, average completion time, average interest rate, and other uncertainties are below projections, behind schedule and beyond budget."

Probability management brings a new transparency to communication of risk and uncertainty and permits the development of the profound knowledge necessary to make improved quality operational decisions.

1. Sam L. Savage (2009), ***The Flaw of Averages: Why We Underestimate Risk in the Face of Uncertainty*** (New York: John Wiley & Sons).

Working assumptions of these solutions were wrong!

However, we did not get exactly what we needed from the quality methods and tools:

- Classical control charts do not help identify rare errors: the control chart needs to be updated to reflect modern measurement systems and data management capabilities.
- Failure require more than mental analysis: investigations must become more comprehensive and obtain an even greater linkage into physical, psychological and system level failure potentialities.
- Interaction effects between functions need to be graphed in addition to identification of the rational sub-groups – so the Fishbone diagram must be expanded.
- Normal distributions do not exist in time-based processes: Poisson is the true type of distribution for all queuing situations which means that we must learn to think differently about how work is done – on average is not good enough when “long tails” are the normal case!
- A common improvement and analysis methodology must be used across all functional disciplines to achieve collaboration in improvements.

21st Century: Need for new technology and humanity!

What elements of quality thinking from the last century require ‘heuristic redefinition’ in order to advance quality in the coming century?

Three components require redefinition:

- The System of Management attributed to Frederick W. Taylor
- The Theory of Control attributed to Walter A. Shewhart
- The Cost-Quality Tradeoff attributed to Joseph M. Juran

Lesson #1: The Need for Inclusive Cooperation

- Perhaps the greatest contribution of Kaoru Ishikawa as a dominant quality thought leader was his displacement of the Taylor approach to managing people. Ishikawa treated people with respect and he valued humanity. His development and promotion of the Quality Control (QC) Circle was the most visible component of the shift that he advocated.
- The cultural shift Ishikawa advocated was to change from treating the worker as "merely an interchangeable pair of hands" to treating workers as thinking human beings who are capable of making their own unique valuable, positive contributions that will increase the productivity and quality of their working processes.
- Ishikawa taught that all people at all levels are responsible for the quality of the work that they produce; however, each level will have a different type of responsibility and must pursue the satisfaction of this responsibility in a different manner. It is the integration of these individual efforts into a mutually defined collaborative system that will yield the productivity and competitiveness necessary to gain and maintain enduring cross-organizational performance capability.

Lesson #2a: The Need to Value Individual Data Items

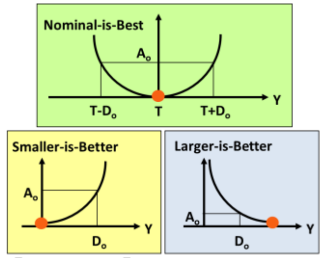
The rationale for the Xbar/R and Xbar/s charts was to use averages to deal with measurement error. However, current measurement systems can be designed with minimal error so this consideration is no longer valid. Thus, using averages has the effect of dampening observed variation and hiding the amount of natural variation that occurs at the level of individual facts or observations of process activity.

Each individual data observation has value – whether it is the Best-of-the-Best (BOB) or the Worst-of-the Worst (WOW). Understanding the extreme limits of performance provides strong process hints as to how controllable a process may become and also the mechanisms by which to gain control.

Therefore individuals control charts (I-Charts) are superior for conducting a process inquiry to investigate and diagnose variation in process results. But two adjustments need to made to the common body of knowledge in order to use the I-Chart more effectively: the inherent nature of process measures needs to be better managed as does the interpretation of the standard rules for interpreting patterns that represent special causes of the process variation.

Lesson #2b: The Need to Value Individual Data Items

All performance measures have an inherent measure of goodness or an expectation for their proper performance. Some should be operated at a maximum or minimum level of performance while others at an average level. Thus, the idea of 'performance goodness' may be interpreted using the rules of the Taguchi Loss Function.



T = Target
A_o = Cost Dimension
D_o = Functional Limit

Rules for Special Cause Variation:

- Shewhart did not invent these rules; they were developed by the AT&T statistics group (Bonnie B. Small was the group's leader) and published in 1956 (probably with the blessing of Shewhart).*
- The rules are defined for an underlying normal probability distribution and combine Boolean logic to identify "improbable run combinations" with the Central Limit Theorem to estimate underlying probabilities.
- These rules need to be adjusted as the I-Chart distributions will most likely not be normal but the Empirical Rule is useful to estimate the probability in combination with the rules for measurement goodness.

* ***Western Electric Statistical Quality Control Handbook*** (1956).

Lesson #3: The Need to Understand Real Process Costs

- There is no single number that represents an organization's real value, nor is there any single number that represents its true level of profitability. These number are not static but change dynamically with respect to the economy and market conditions. However, our use of accounting methods leads us to believe that such fantasy is actually existing in reality!
- Standard cost accounting and its reliance on averaged performance leads business decision makers to the wrong conclusions as has been pointed out with respect to such indicators as 'equipment utilization' and inventory. When accounting numbers cause executives to make bad decision for the sake of summarizing performance results for the investors, which is contrary to the true interests of the investors, then it is tine to change the system of accounting as it no longer can meet its intended purpose.
- To obtain an accounting system with integrity it is necessary to start the process by understanding real process costs at a work level of the activities performed and the costs incurred. Activity based cost analysis must become the new way of managing financial decisions.

Astute transformation requires profound knowledge:

- Profound knowledge develops statistical understanding of the real-world process behavior so that future states may be predicted with some probability.

- Profound knowledge is distinct from profane knowledge which has been formed using average data and deterministic, linear thinking.

- Profound knowledge requires: (1) a systems perspective in order to understand how the holistic nature of the process; (2) statistical thinking about process variation to identify sources of control and improvement; (3) development of objective knowledge about the way things actually work; and (4) understanding of the psychological nature of human interactions and decision processes.

- Achieving this profound knowledge improves the quality of decisions made by an organization by more comprehensively understanding all of the components that will influence the desired transformation.