# QUALITY MANAGEMENT

Tools, Methods, and Standards

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## Tools, Methods, and Standards

Edited by

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# Foreword

Quality: a concept so broad that it still remains rather indeterminate despite the wide literature that concerns it. Perhaps the word that comes closest to him is "improvement." Many of the initiatives that carry this label consist in projects for improvement of the product, processes, internal organization, and connections with the external units.

These quality improvement projects present some characteristic aspects.

First of all, the systemic approach. The conventional name of quality management includes some principles and a group of interconnected and often complementary methodologies. Quality projects can act locally, but they must respond to an integrated logic. In any case, they require a look that is not restricted to the narrow space of a single activity or function: the adjective "total" that sometimes accompanies the word Quality underlines the need for a wide-ranging vision and an action that is not limited to a single technique or a limited company segment.

Second, the dynamic perspective. Quality cannot be (only) a stamp to be displayed when necessary, the snapshot taken on a goal traced by some standards. On the contrary, it is a dynamic process that continuously moves forward to achieve the objectives. In many situations, on the other hand, a quality that is closely linked to the standard, a quality assurance rather than a quality management, continues to prevail. We try to (r)ensure the customer on the internal procedures, considering the certification as a point of arrival rather than a step along the road of joint and continuous improvement.

Third, specificity. Any improvement project starts from an initial state. It improves a starting condition that is different from company to company because it is linked to its history, to the sector and the country in which it operates, and to the reference market. The different starting and boundary conditions impose distinct and specific trajectories. Vice versa, there is often a tendency to think that there is a best way of quality and

that a recipe successfully tested in one company can be rigidly replicated in others. But it is difficult to understand the nature of a presumed best practice if the boundary conditions are not considered and the forms of adoption are evaluated with reference to their own peculiarities.

The editorial project of this book has taken on board these three characteristics. Quality is investigated and illustrated not as a list of principles or a toolbox of independent methodologies, but as a general philosophy that seeks to consistently compose objectives and tools, revealing their interdependencies. It is described not as a static goal, but as a dynamic process that is innervated in the company's metabolism. Finally, the book combines experiences from different realities, extracting cues to adapt policies and practices according to the particularities of the context.

The picture that emerges from this detailed analysis conducted in several voices and from different perspectives offers an effective "improvement" in the understanding of the concept of quality, allowing the reader to move on a path that gradually thins the initial uncertainty and enriches it with a variety of educational and operational supports.

Guido Nassimbeni
*University of Udine, Italy*

# Introduction

The current economic scenario, characterized by a growing international competition, leads to the rethinking of many of the governance mechanisms of our companies: from strategies to relationships with customers and suppliers, from processes to the role of human resources.

In this context, "quality management" – synonymous of efficiency and effectiveness and therefore competitiveness – becomes essential.

Quality has many meanings for the company and the market. Product quality (read as the ability to differentiate the offer from competitors) contributes to the creation of competitive advantages for the company. By increasing trust between the parties, by limiting opportunistic behaviors, and by consolidating cooperation, it is also able to bring improvements in the whole market.

The panorama of books dealing with the topic of "quality management" is quite complex. This volume aims to fill a gap in the current publishing scenario by providing an updated summary of the knowledge of a discipline that has boundless fields of application: from industry to public administration.

The work comes from the deep conviction that quality today (more than ever) represents a great opportunity to be seized for businesses, public administration, and society. An opportunity capable of being translated at company level into the ability to increase market shares, productivity, the ability to reward the capital invested, and at geoeconomic level in employment, development, and improvement of the quality of life.

The editors of the volume are professors of quality management and operations management in industrial/management engineering degrees. The authors are academics and businessmen (managing directors and chairmen of private companies) who have decided to contribute to the volume, synthesizing their own experiences and knowledge.

Starting from the history of quality, the volume accompanies the reader in a rapid review of the main tools and approaches aimed at improving

effectiveness and efficiency in organizations. Balanced scorecard, QFD, and FMEA are some of the solutions that are first introduced theoretically and then described with concrete examples.

Adequate space is also given in the text to the theme of certifications. ISO 9000, ISO 14001, ISO 45001, ISO 27001, and SA8000 are described in their essential features.

Today, we live in a century that burns ideas quickly: new ideas are often surpassed even before having assimilated them. This has led to the need to revise theories that have rapidly evolved over time.

History shows that the interest in quality awakens in crises. Crises offer opportunities for growth and development. At the beginning of the 1980s – when various events (from the oil crises to the appearance of fearsome Asian competitors on the international scene) had led to imbalances between supply and demand – many companies managed the adverse scenario by investing in quality. We trust that this work – contributing to the diffusion of the culture of quality – can offer a contribution in this sense.

Marco Sartor and Guido Orzes

# 1

# History of Quality

*Giovanna Culot*

## 1.1. What is Quality all About?

We have posed the same question many times entering a new class on quality management. How can quality be defined? The answers – be it from undergrads, master students, or executives – tend to converge on a production-oriented kind of understanding, "conformity" and "specification" the words coming up more frequently. Every now and then, someone would try out a different answer, bringing up ideas such as "product performance," "customer satisfaction," or even the "way you do your daily activities."

Conventional wisdom collocates quality in the field of operations management and related engineering disciplines. Reality is that there is no single truth behind the concept. Most certainly, many methods and techniques have been developed in connection with the challenge of manufacturing products without defects. It is also true, however, that quality is an overarching concept which has applications both in the business environment and in everyday life.

The term "quality" is commonly used to mean a degree of excellence in a given product or activity. Most of the people would agree with that. Philosophers have argued that a more precise definition of quality is not possible: building on discussions initiated by Socrates, Aristotle, Plato, and other thinkers in Ancient Greece, quality is understood as a universal value that we learn to recognize only through the experience of being exposed to a succession of objects characterized by it (Buchanen, 1948; Piersing, 1974).

In a business setting, such a general understanding is, however, not sufficient. Where does quality end and non-quality begin? Are there different degrees of quality? If so, is it possible to measure quality? These are only some of the questions that have been raised in academia and in industry, and the answers have been very different (Reeves & Bednar, 1994).

To begin with, quality might refer both to a *product* (or service) or to the *process* that generates it. In terms of *product quality*, there are multiple possible dimensions or elements (Garvin, 1984). Some of these elements refer to the *quality of the technical realization* of the product and are usually objective and measurable, such as conformance. Other elements are instead less objective, as the preferences of the customers might vary in relation to them: they can be measurable, such as product performance or durability, or purely qualitative, as in the case of aesthetics. This last set of elements might be understood as the degree by which the product (or its initial prototype) is fit to customer expectations or the *quality of the idea*. A similar line of reasoning is also applicable to services.

In operations management, the most attention has historically been placed on the *quality of technical realization*, described as conformance of a product to a design or specification (Crosby, 1979; Gilmore, 1974), and the cost of attaining it with respect to the price the customer is willing to pay (Feigenbaum & Vallin, 1961). Vice versa, economists and marketers understanding has mainly been focused on the *quality of the idea*, seen as a precondition to customer satisfaction. In this respect, the main questions have been revolving around the characteristics or attributes a product should have (Abbot, 1955; Leffler, 1982), and their appraisal considering different individual tastes or preferences (Kuehn & Day, 1962; Maynes, 1976; Brown & Dacin, 1997).

Several efforts have been made over the years to combine these two perspectives into all-encompassing conceptualizations and practical approaches. However, even nowadays, it is not unusual to see companies where this dialectic evolves into acrimonious meetings: designers, marketing, and sales executives on one side, production managers on the other. In fact, the relevance of the *quality of the idea* and the *quality of technical realization* (and the understanding of their underlying elements) varies significantly within each company, depending on the responsibilities and goals of each function (e.g., product development, production, and sales), stage in the product life-cycle, and, if present, positioning of the different product lines. The definition of

quality varies significantly also across companies, even in the same industry, based on their value proposition. There are many examples of this. In the piano industry, for instance, Stainway & Sons has built its reputation as quality leader based on the uniqueness of the sound and style of each handcrafted product. On the other hand, Yamaha has also developed a strong reputation for quality emphasizing totally different dimensions more related to reliability and conformance (Garvin, 1984).

The definition of quality shall, however, not be limited to the final product. Again, different dimensions in terms of *process quality* have been investigated over the years. On the one hand, the question has been how to ensure the final *quality of the result* (Reeves & Bednar, 1994). On the other hand, a more comprehensive view has suggested that quality is related not only of processes efficacy (i.e., producing quality products), but also to their effectiveness (i.e., *cost and time* minimization). Process quality has been investigated by several disciplines, including but not limited to operations management (e.g., Anderson et al., 1995; Flynn et al., 1994; Saraph et al., 1989) and organizational behavior (Ivancevich, Matteson, & Konopaske, 1990).

Finally, in recent years, quality has also been related to sustainability and the effects (or, in economic jargon, externalities) of a company's decisions and activities on a broad set of stakeholders, including the society, the environment, and future generations. This dimension is referred to here as quality of impact.

Overall, quality is a multi-faceted concept, whose definition is complex and fundamentally context-dependent (Reeves & Bednar, 1994). Fig. 1 illustrates how the different meanings of quality explained above unfold into concentric circles. At the center, *product quality* in its two dimensions: *quality of the idea* (prototype or design) and *quality of the technical realization* (conformance). Around it, *process quality,* in terms of effectiveness *(quality of the result)* and efficiency *(time/cost minimization)*, which should be considered both at firm and supply-chain level. Finally, the outer circle embraces all previous dimensions of quality and represents the company's and its products' *impact*.

Today, we tend to have a comprehensive understanding of quality. Even though functional (in companies) and disciplinary (in academia) differences in terms of focus and priorities remain, we are aware that a one-dimensional view on the topic is not sufficient. As this historical review will show, however, this has not been the case for most of the modern history.

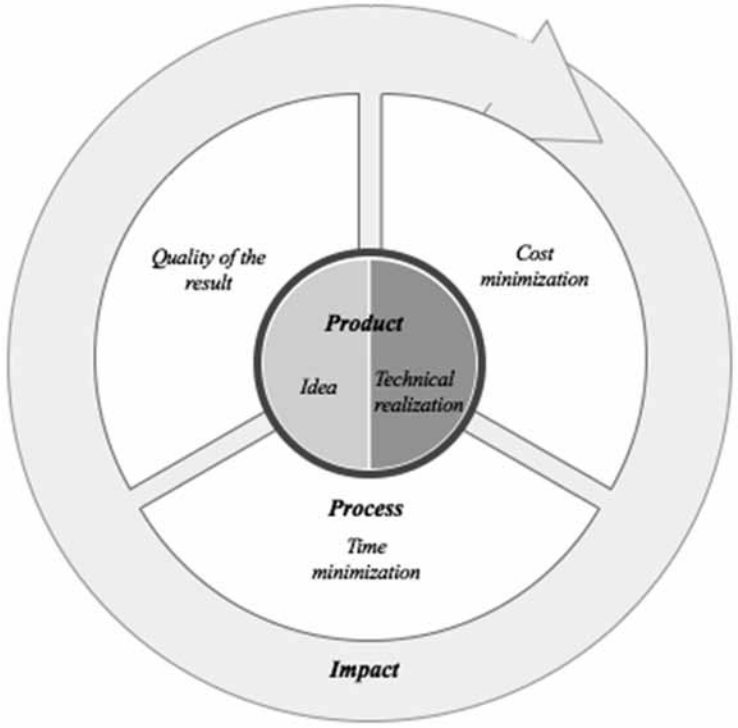


Fig. 1: The Different Meanings of Quality.

## 1.2. Approaching Quality in History

The history of quality extends for millennia, spanning over different geographies and socio-political systems. Throughout the evolution of civilization, many of the methods and tools that constitute the foundations of the current approach to quality have been developed, such as quality warranties, standardization, interchangeability, inspections, and laws for consumer protection. Already in ancient times, trained craftsmen not only provided clothing and tools, including equipment for armed forces, but also built roads, bridges, temples, and other masterpieces of design and construction, some of which endure to this day. Managing for quality is by no means a product of the modern Western world (Juran, 1995).

Industrialization was, however, a real game-changer as, differently than in the past, a more fragmented division of labor and the use of machines made virtually impossible to account the responsibility for the quality of a product to a specific individual (Weckenmann, Akkasoglu, & Wener, 2015). New solutions needed to be found, and this is where, experts

believe, quality management as a discipline was born. This historical review also starts from here.

Since then, many progresses have been made, and quality management practices become mainstream. Many prominent thinkers have punctuated this evolution; however, a review of their publications would not give a realistic view of how quality has been developing over the years. It is not about "inventions." It is rather about how and when these inventions have been adopted consistently with the challenges faced by companies, policy-makers, and individuals at any given time. On this basis, in the following paragraphs the history of quality is presented taking into account the changing context of international competition, customer expectations and technical opportunities. Since the various approaches to quality have been implemented in a different timeframe according to country- or industry-specific situations, the five phases described below do not present a linear evolution, but rather a chronological progression in which contrasting approaches, often in response to different challenges, might have occurred at the same time.

## 1.3. Quality at Time of the Industrial Revolution(s): Quality Inspection

In the age of craft production, there was a comprehensive understanding of the *meaning of quality*. Artisans, and merchants for their part, had strong ties to their local communities and often a personal knowledge of their customers. Laws would enforce the fulfillment of basic demands concerning society, whereas at least since the Middle Age, guilds promoted standards to ensure product quality punishing any deviation considered as fraud. Honor and personal accountability would complement the typical approach of craftsmen to quality. As the precondition for economic trade to be profitable is to meet customers' expectations and do it effectively in terms of time and cost, they also acknowledged that quality needed to be pursued at all levels, from product design to realization and delivery. Both aspects of product quality (the idea and its technical realization) were important, even though the latter was not strictly understood as conformance: details would make a product unique.

This picture changed dramatically with the advent of mechanization. First, between the end of the eighteenth and the beginning of the nineteenth century, steam power and the development of machine tools impacted a first cluster of industries, mostly raw materials and

semi-finished products, including textiles and iron making. One century later, in what is commonly known as Second Industrial Revolution or Mass Production, electrification was introduced to a broader range of industries. New technological opportunities gave rise to a series of managerial innovations, first and foremost, the implementation of the moving assembly line by Henry Ford in 1913 and the conceptualization of scientific management by Frederick W. Taylor (1911).

On the demand side, a new class of industrial workers was born. After the many drawbacks in terms of working conditions and living standards brought about by the First Industrial Revolution, the paradigm changed significantly after the 1910s as workers were now ensured decent-enough wages to make them become potential customers (De Grazia, 2005). In order to serve this increasing customer base better than the competition, companies needed to provide goods fast, in volume, and at a low price.

In this scenario, the *meaning of quality* was entirely related to the *product technical realization*, now decoupled from the *quality of the idea*. As an effort to reduce costs, and thus the price to the customer, companies pursued a low product variety: customer needs were hardly considered and product properties were defined by the will of the organizations (Weckenmann et al., 2015). The words of Henry Ford are famous in this respect: "Any customer can have a car painted any color that he wants so long as it is black."

The game was thus all played in production and related operations. Here, while the division of labor was not a new concept, mechanization and especially the moving assembly line had led to an increasing specialization of the workers, now focused on single repetitive tasks. Workers in such settings failed to see the contribution of their activities to the quality of the final product, and it was no longer possible for managers to trace individual accountability.

In order to ensure the quality of products and avoid complaints from customers, companies started performing activities of *quality inspection (QI)*. Again, QI is not a new concept, being part of every kind of organized production from Ancient China's handicraft industry and mediaeval guilds to quality acceptance inspections of raw materials and semi-finished products at the time of the First Industrial Revolution (Nassimbeni, Sartor, & Orzes, 2014). However, as production volumes were growing to unprecedented levels, traditional QI was not up to speed with increasing labor productivity. Often defective products were delivered to customers and replaced with new ones only after complaints. A new systematic approach to QI was needed in order to reduce cost and complexity. Many companies established thus a separate inspection department: following

Taylor's (1911) recommendations, designated employees would check the quality of the products at the end of the production process in order to verify their compliance with specifications. Should any defect be observed, then the defective component would have been replaced. This was possible thanks to the interchangeability of parts, a practice piloted in Europe since the first years of the nineteenth century and becoming mainstream in the era of mass production: large volumes of individual parts were manufactured and tested within tolerance, ready to be assembled (and re-assembled).

Although QI still plays an important role in current quality practices, its stand-alone application led to several issues. Since the goal was to prevent defective products from leaving the factory, but not to decrease the defect-rate in producing them, there was usually no feedback loop to production managers or workers about failures, and no analysis was carried out about their root causes. Moreover, the repair or replacement of defective components at the end of the process resulted in high waste rates and significant losses of efficiency as many tasks in production needed to be first done, and then redone. In many cases, "hidden factories" operated to correct the output of the obvious factory (Womack, Jones, & Ross, 1991).

As competition was becoming fiercer, a change of pace was needed to ensure that the quality of the final product was met at a reasonable cost.

## 1.4. From Inspection to Control: Quality After World War II

The years following World War II were marked by an unprecedented speed of economic recovery, combined with an impressive strength and scale of international cooperation. This particularly high and sustained growth was experienced in several countries, including the United States, Western Europe, and East Asia, so much that expressions like "boom," "miracle," and "Golden Age" are often used to describe this period. Both demand and productivity were steadily increasing. In the United States, demographic growth and the rise of the middle class, coupled with easier access to consumer credit, gave rise to the phenomenon of "mass consumption" (Ciment, 2007). As a consequence of the Marshall Plan, US companies had secured access to European markets, where again demand was growing. Productivity was benefitting from the commercial adoption of a backlog of technological innovations developed between the two World Wars, including some automation technologies, and the overall infrastructural development.

In this context, the competitive levers were related to how cheap and how fast products could reach yet unserved consumers. Quality was still perceived as a residual dimension in the product, mainly related to its *technical realization*.

The hitherto dominant approach of QI presented several drawbacks in terms of effectiveness (problems were addressed only after they occurred) and cost (products were repaired at the end of the process, generating scraps and loss of efficiency). These drawbacks were also clear in the eyes of Walter Shewhart as in the 1920s, fresh from a Doctorate in Physics, he joined Western Electric to assist their engineers in improving the conformance rate of the hardware produced for Bell Telephone. His solution, statistical process control (SPC), was to consider not only the final product conformance, but also how variations in the *production process* affected the *quality of the result*. In fact, building on mathematical and statistical theories, he concluded that (Shewhart, 1931):

> The object of industry is to set up economic ways of satisfying human wants and in so doing to reduce everything possible to routines requiring a minimum amount of human effort. Through the use of the scientific method, extended to take account of modern statistical concepts, it has been found possible to set up limits within which the results of routine efforts must lie if they are to be economical. Deviations in the results of a routine process outside such limits indicate that the routine has broken down and will no longer be economical until the cause of trouble is removed.

In practice, the approach involved the implementation of control charts in order to detect any variation in the production process affecting product conformance. Samples were taken at various stages of the process and the quality variable of interest plotted on a chart. The pattern of the data points was analyzed with respect to the in-control mean of the parameter, considering an interval of three standard deviations from it, with the aim of isolating variations assignable to a specific cause, as opposed to the ones which are naturally part of a process. Compliance of all products was statistically inferred from the sample.

At the outbreak of World War II, SPC was adopted by the United States for military equipment manufacturing, but spread to the industry only in the late 1940s. Starting from here, a variety of methodologies have been developed over the years under the umbrella of *quality control (QC)*,