SECTION 2
HOW TO THINK ABOUT QUALITY

J. M. Juran

This section deals with the fundamental concepts that underlie the subject of managing for quality. It defines key terms and makes critical distinctions. It identifies the key processes through which quality is managed. It demonstrates that while managing for quality is a timeless concept, it has undergone frequent revolution in response to the endless procession of changes and crises faced by human societies.

WHAT IS QUALITY?

The Meanings of "Quality." Of the many meanings of the word "quality," two are of critical importance to managing for quality:

1. "Quality" means those *features of products* which meet customer needs and thereby provide customer satisfaction. In this sense, the meaning of quality is oriented to income. The purpose of such higher quality is to provide greater customer satisfaction and, one hopes, to increase income. However, providing more and/or better quality features usually requires an investment and hence usually involves increases in costs. Higher quality in this sense usually "costs more."

Product features that meet customer needs	**Freedom from deficiencies**
Higher quality enables companies to: Increase customer satisfaction Make products salable Meet competition Increase market share Provide sales income Secure premium prices The major effect is on sales. Usually, higher quality costs more.	Higher quality enables companies to: Reduce error rates Reduce rework, waste Reduce field failures, warranty charges Reduce customer dissatisfaction Reduce inspection, test Shorten time to put new products on the market Increase yields, capacity Improve delivery performance Major effect is on costs. Usually, higher quality costs less.

FIGURE 2.1 The meanings of quality. [*Planning for Quality, 2d ed. (1990). Juran Institute, Inc., Wilton, CT, pp. 1–10.*]

2. "Quality" means *freedom from deficiencies*—freedom from errors that require doing work over again (rework) or that result in field failures, customer dissatisfaction, customer claims, and so on. In this sense, the meaning of quality is oriented to costs, and higher quality usually "costs less." Figure 2.1 elaborates on these two definitions.

Figure 2.1 helps to explain why some meetings on managing for quality end in confusion.

A meeting of managers is discussing, "Does higher quality cost more, or does it cost less?" Seemingly they disagree, but in fact some of them literally do not know what the others are talking about. The culprit is the word "quality," spelled the same way and pronounced the same way, but with two meanings.

At one bank the upper managers would not support a proposal to reduce waste because it had the name "quality improvement." In their view, higher quality also meant higher cost. The subordinates were forced to relabel the proposal "productivity improvement" in order to secure approval.

Such confusion can be reduced if training programs and procedures manuals make clear the distinction between the two meanings of the word "quality." However, some confusion is inevitable as long as we use a single word to convey two very different meanings. There have been efforts to clarify matters by adding supplemental words, such as "positive" quality and "negative" quality. To date, none of these efforts has gained broad acceptance.

There also have been efforts to coin a short phrase that would clearly and simultaneously define both the major meanings of the word "quality." A popular example is "fitness for use." However, it is unlikely that any short phrase can provide the depth of meaning needed by managers who are faced with choosing a course of action. The need is to understand the distinctions set out in Figure 2.1.

Customer Needs and Conformance to Specification. For most quality departments, the long-standing definition of quality was "conformance to specification." In effect, they assumed that products that conformed to specifications also would meet customer needs. This assumption was logical, since these departments seldom had direct contact with customers. However, the assumption can be seriously in error. Customer needs include many things not found in product specifications: service explanations in simple language, confidentiality, freedom from burdensome paperwork, "one-stop shopping," and so on. (For elaboration and discussion, see AT&T 1990.)

The new emphasis on customer focus has caused the quality departments to revise their definition of "quality" to include customer needs that are not a part of the product specification.

Definitions of Other Key Words. The definitions of "quality" include certain key words that themselves require definition.

Product: The output of any process. To many economists, products include both goods and services. However, under popular usage, "product" often means goods only.

Product feature: A property possessed by goods or services that is intended to meet customer needs.

Customer: Anyone who is affected by the product or by the process used to produce the product. Customers may be external or internal.

Customer satisfaction: A state of affairs in which customers feel that their expectations have been met by the product features.

Deficiency: Any fault (defect or error) that impairs a product's fitness for use. Deficiencies take such forms as office errors, factory scrap, power outages, failures to meet delivery dates, and inoperable goods.

Customer dissatisfaction: A state of affairs in which deficiencies (in goods or services) result in customer annoyance, complaints, claims, and so on.

In the world of managing for quality, there is still a notable lack of standardization of the meanings of key words. However, any organization can do much to minimize internal confusion by standardizing the definitions of key words and phrases. The basic tool for this purpose is a *glossary.* The glossary then becomes a reference source for communication of all sorts: reports, manuals, training texts, and so on.

Satisfaction and Dissatisfaction Are Not Opposites. Customer *satisfaction* comes from those features which induce customers to buy the product. *Dissatisfaction* has its origin in deficiencies and is why customers complain. Some products give little or no dissatisfaction; they do what the producer said they would do. Yet they are not salable because some competing product has features that provide greater customer satisfaction.

The early automated telephone exchanges employed electromagnetic analog switching methods. Recently, there was a shift to digital switching methods, owing to their superior product features. As a result, analog switching systems, even if absolutely free from product deficiencies, were no longer salable.

Big Q And Little Q. Definitions of words do not remain static. Sometimes they undergo extensive change. Such a change emerged during the 1980s. It originated in the growing quality crisis and is called the concept of "Big Q."

Table 2.1 shows how the quality "umbrella" has been broadening dramatically. In turn, this broadening has changed the meanings of some key words. Adoption of Big Q grew during the 1980s, and the trend is probably irreversible. Those most willing to accept the concept of Big Q have been the quality managers and the upper managers. Those most reluctant have been managers in the technological areas and in certain staff functions.

QUALITY: THE FINANCIAL EFFECTS

The Effect on Income. Income may consist of sales of an industrial company, taxes collected by a government body, appropriations received by a government agency, tuitions received by a school, and donations received by a charity. Whatever the source, the amount of the income relates

TABLE 2.1 Contrast, Big Q and Little Q

Topic	Content of little Q	Content of big Q
Products	Manufactured goods	All products, goods, and services, whether for sale or not
Processes	Processes directly related to manufacture of goods	All process manufacturing support; business, etc.
Industries	Manufacturing	All industries, manufacturing, service, government, etc., whether for profit or not
Quality is viewed as:	A technological problem	A business problem
Customer	Clients who buy the products	All who are affected, external and internal
How to think about quality	Based on culture of functional departments	Based on the universal trilogy
Quality goals are included:	Among factory goals	In company business plan
Cost of poor quality	Costs associated with deficient manufactured goods	All costs that would disappear if everything were perfect
Evaluation of quality is based mainly on:	Conformance to factory specifications, procedures, standards	Responsiveness to customer needs
Improvement is directed at:	Departmental performance	Company performance
Training in managing for quality is:	Concentrated in the quality department	Companywide
Coordination is by:	The quality manager	A quality council of upper managers

Source: *Planning for Quality,* 2d ed. (1990). Juran Institute, Inc., Wilton, CT, pp. 1–12.

in varying degrees to the features of the product produced by the recipient. In many markets, products with superior features are able to secure superior income, whether through higher share of market or through premium prices. Products that are not competitive in features often must be sold at below-market prices.

Product deficiencies also can have an effect on income. The customer who encounters a deficiency may take action of a cost-related nature: file a complaint, return the product, make a claim, or file a lawsuit. The customer also may elect instead (or in addition) to stop buying from the guilty producer, as well as to publicize the deficiency and its source. Such actions by multiple customers can do serious damage to a producer's income. Section 7, Quality and Income, is devoted to the ways in which quality can influence income.

The Effect on Costs. The cost of poor quality consists of all costs that would disappear if there were no deficiencies—no errors, no rework, no field failures, and so on. This cost of poor quality is

shockingly high. In the early 1980s, I estimated that within the U.S. manufacturing industries, about a third of the work done consisted of redoing what had already been done. Since then, estimates from a sample of service industries suggest that a similar situation prevails in service industries generally.

Deficiencies that occur prior to sale obviously add to producers' costs. Deficiencies that occur after sale add to customers' costs as well as to producers' costs. In addition, they reduce producers' repeat sales. Section 8, Quality and Costs, is devoted to the ways in which quality can influence costs.

HOW TO MANAGE FOR QUALITY: THE JURAN TRILOGY

To attain quality, it is well to begin by establishing the "vision" for the organization, along with policies and goals. (These matters are treated elsewhere in this handbook, especially in Section 13, Strategic Deployment.) Conversion of goals into results (making quality happen) is then done through managerial processes—sequences of activities that produce the intended results. Managing for quality makes extensive use of three such managerial processes:

- Quality planning
- Quality control
- Quality improvement

These processes are now known as the "Juran trilogy." They parallel the processes long used to manage for finance. These financial processes consist of

Financial planning: This process prepares the annual financial budget. It defines the deeds to be done in the year ahead. It translates those deeds into money. It determines the financial consequences of doing all those deeds. The final result establishes the financial goals for the organization and its various divisions and units.

Financial control: This process consists of evaluating actual financial performance, comparing this with the financial goals, and taking action on the difference—the accountant's "variance." There are numerous subprocesses for financial control: cost control, expense control, inventory control, and so on.

Financial improvement: This process aims to improve financial results. It takes many forms: cost-reduction projects, new facilities to improve productivity, new product development to increase sales, acquisitions, joint ventures, and so on.

These processes are universal—they provide the basis for financial management, no matter what the type of enterprise is.

The financial analogy helps managers realize that they can manage for *quality* by using the same processes of planning, control, and improvement. Since the *concept* of the trilogy is identical to that used in managing for finance, managers are not required to change their conceptual approach. Much of their previous training and experience in managing for finance is applicable to managing for quality.

While the conceptual approach does not change, the procedural steps differ. Figure 2.2 shows that each of these three managerial processes has its own unique sequence of activities.

Each of the three processes is also a universal—it follows an unvarying sequence of steps. Each sequence is applicable in its respective area, no matter what is the industry, function, culture, or whatever.

Figure 2.2 shows these unvarying sequences in abbreviated form. Extensive detail is provided in other sections of this handbook as follows:

Section 3, The Quality Planning Process

Section 4, The Quality Control Process

Section 5, The Quality Improvement Process

Quality planning	Quality control	Quality improvement
Establish quality goals	Evaluate actual performance	Prove the need
Identify who the customers are	Compare actual performance with quality goals	Establish the infrastructure
Determine the needs of the customers	Act on the difference	Identify the improvement projects
Develop product features that respond to customers' needs		Establish project teams
Develop processes able to produce the product features		Provide the teams with resources, training, and motivation to: Diagnose the causes Stimulate remedies
Establish process controls; transfer the plans to the operating forces		Establish controls to hold the gains

FIGURE 2.2 The three universal processes of managing for quality. [*Adapted from Juran, J. M. (1989). The Quality Trilogy: A Universal Approach to Managing for Quality. Juran Institute, Inc., Wilton, CT.*]

The Juran Trilogy Diagram. The three processes of the Juran trilogy are interrelated. Figure 2.3 shows this interrelationship.

The Juran trilogy diagram is a graph with time on the horizontal axis and cost of poor quality on the vertical axis. The initial activity is quality planning. The planners determine who the customers are and what their needs are. The planners then develop product and process designs to respond to those needs. Finally, the planners turn the plans over to the operating forces: "You run the process, produce the product features, and meet the customers' needs."

Chronic and Sporadic. As operations proceed, it soon emerges that the process is unable to produce 100 percent good work. Figure 2.3 shows that over 20 percent of the work must be redone due to quality deficiencies. This waste is *chronic*—it goes on and on. Why do we have this chronic waste? Because *the operating process was planned that way.*

Under conventional responsibility patterns, the operating forces are unable to get rid of this planned chronic waste. What they can do is to carry out *quality control*—to prevent things from getting worse. Figure 2.3 also shows a sudden *sporadic* spike that has raised the defect level to over 40 percent. This spike resulted from some *unplanned* event such as a power failure, process breakdown, or human error. As a part of their job of quality control, the operating forces converge on the scene and take action to restore the status quo. This is often called "corrective action," "troubleshooting," "putting out the fire," and so on. The end result is to restore the error level back to the planned chronic level of about 20 percent.

The chart also shows that in due course the chronic waste was driven down to a level far below the original level. This gain came from the third process in the trilogy—*quality improvement.* In effect, it was seen that the chronic waste was an opportunity for improvement, and steps were taken to make that improvement.

The Trilogy Diagram and Product Deficiencies. The trilogy diagram (Figure 2.3) relates to *product deficiencies.* The vertical scale therefore exhibits units of measure such as cost of poor quality, error rate, percent defective, service call rate, and so on. On this same scale, perfection is at zero,

and *what goes up is bad.* The results of reducing deficiencies are to reduce the cost of poor quality, meet more delivery promises, reduce customer dissatisfaction, and so on.

The Trilogy Diagram and Product Features. When the trilogy diagram is applied to product features, the vertical scale changes. Now the scale may exhibit units of measure such as millions of instructions per second, mean time between failures, percent on-time deliveries, and so on. For such diagrams, *what goes up is good,* and a logical, generic vertical scale is "product salability." (For elaboration on the Juran trilogy, see Juran 1986.)

Allocation of Time within the Trilogy. An interesting question for managers is, "How do people allocate their time relative to the processes of the trilogy?" Figure 2.4 is a model designed to show this interrelationship in a Japanese company (Itoh 1978).

In Figure 2.4 the horizontal scale represents the percentage allocation of any person's time and runs from zero to 100 percent. The vertical scale represents levels in the hierarchy. The diagram shows that the upper managers spend the great majority of their time on planning and improvement. They spend a substantial amount of time on strategic planning. The time they spend on control is small and is focused on major control subjects.

At progressively lower levels of the hierarchy, the time spent on strategic planning declines, whereas the time spent on control and maintenance grows rapidly. At the lowest levels, the time is dominated by control and maintenance, but some time is still spent on planning and improvement.

QUALITY: A CONTINUING REVOLUTION

A young recruit who joins an organization soon learns that it has in place numerous processes (systems) to manage its affairs, including managing for quality. The recruit might assume that humans have always used those processes to manage for quality and will continue to so in the future. Such

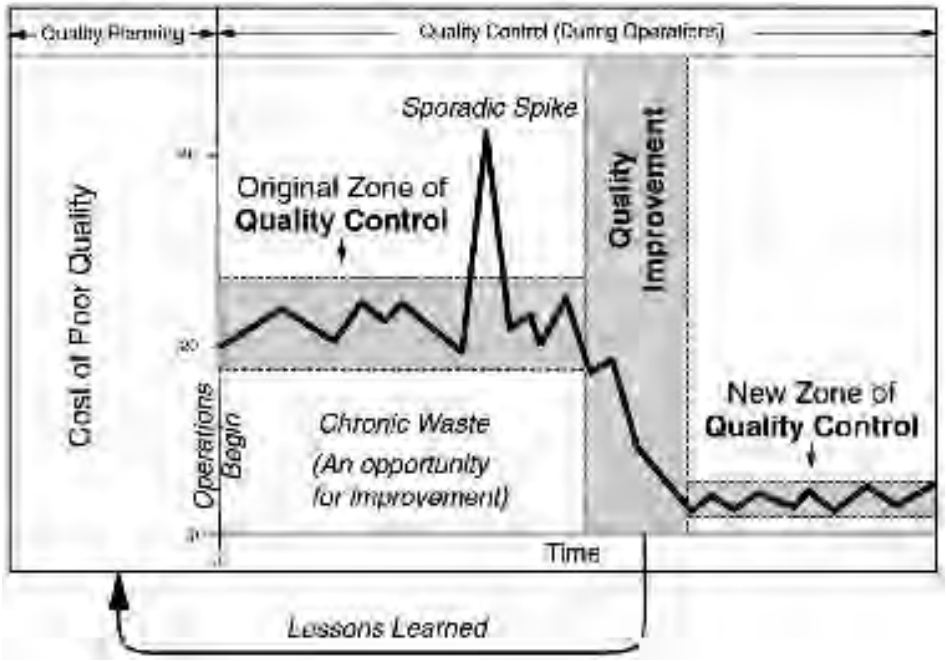

FIGURE 2.3 The Juran trilogy diagram. [*Adapted from Juran, J. M. (1989). The Quality Trilogy: A Universal Approach to Managing for Quality. Juran Institute, Inc., Wilton, CT.*]

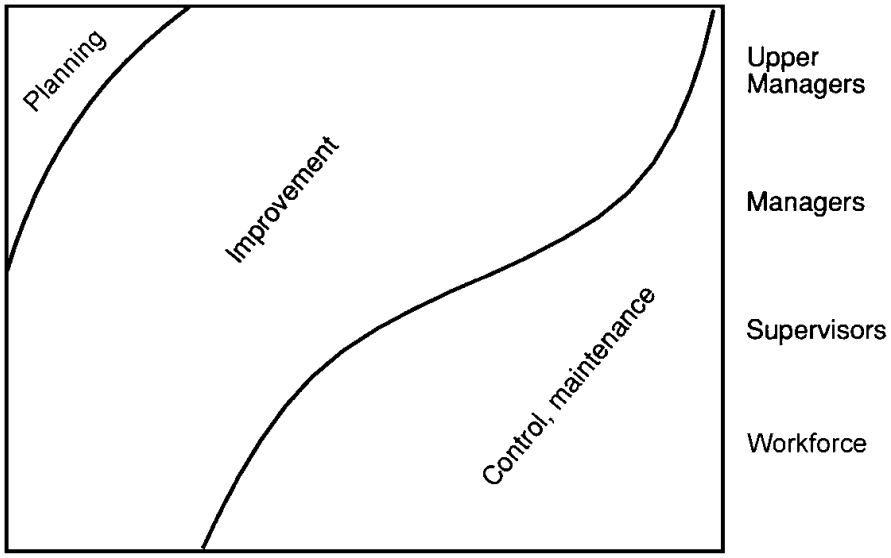

FIGURE 2.4 The Itoh model. [*Adapted from Management for Quality, 4th ed. (1987). Juran Institute, Inc., Wilton, CT, p. 18.*]

assumptions would be grossly in error. The processes used to manage for quality have undergone extensive change over the millennia, and there is no end in sight.

Primitive Societies

The Family. Quality is a timeless concept. The origins of ways to manage for quality are hidden in the mists of the ancient past. Yet we can be sure that humans have always faced problems of quality. Primitive food-gatherers had to learn which fruits were edible and which were poisonous. Primitive hunters had to learn which trees supplied the best wood for making bows or arrows. The resulting know-how was then passed down from generation to generation.

The nuclear human organizational unit was the family. Isolated families were forced to create self-sufficiency—to meet their own needs for food, clothing, and shelter. There was division of work among family members. Production was for self-use, so the design, production, and use of a product were all carried out by the same persons. Whereas the technology was primitive, the coordination was superb. The same human beings received all inputs and took all remedial action. The limiting factor for achieving quality was the primitive state of the technology.

The Village: Division of Labor. Villages were created to serve other essential human requirements such as mutual defense and social needs. The village stimulated additional division of labor and development of specialized skills. There emerged farmers, hunters, fishermen, and artisans of all sorts—weavers, potters, shoemakers. By going through the same work cycle over and over again, the artisans became intimately familiar with the materials used, the tools, the steps in the process, and the finished product. The cycle included selling the product to users and receiving their feedback on product performance. The experience derived from this intimate familiarity then enabled human ingenuity to take the first steps toward the evolution of technology.

The Village Marketplace: Caveat Emptor. As villages grew, the village marketplace appeared, where artisans and buyers met on scheduled market days. In this setting, producer and user met face to face with the goods between them. The goods typically were natural products or were made from natural materials. The producers and purchasers had long familiarity with the products, and the quality of the products could to a high degree be judged by the unaided human senses.

Under such a state of affairs, the village magistrates tended to avoid being drawn into quality disputes between seller and buyer. This forced buyers to be vigilant so as to protect themselves against poor quality. In effect, the seller was responsible for supplying the goods, but the buyer became responsible for supplying the quality "assurance." This arrangement was known as *caveat emptor*—"let the buyer beware." Thus buyers learned to beware by use of product inspection and test. They looked closely at the cloth, smelled the fish, thumped the melon, tasted a grape. Their failure to beware was at their own peril. In the village marketplace, *caveat emptor* was quite a sensible doctrine. It is widely applied to this day in villages all over the world.

A further force in the village marketplace was the fact of common residence. Producer and buyer both lived in the same village. Each was subject to scrutiny and character evaluation by the villagers. Each also was subject to village discipline. For the artisan, the stakes were high. His status and livelihood (and those of his family) were closely tied to his reputation as a competent and honest artisan. In this way, the concept of craftsmanship became a quiet yet powerful stimulus to maintain a high level of quality.

Effects of the Growth of Commerce. In due course villages expanded into towns and cities, and improved transport opened the way to trade among regions.

> A famous example of organized multiregional trade was the Hanseatic League which was centered among the cities of northern Europe from about the 1200s to the 1600s. Its influence extended into Scandinavia and Russia as well as to the Mediterranean and Black seas (von der Porten 1994).

Under trade among regions, producer and user could no longer meet face to face in the marketplace. Products were now made by chains of suppliers and processors. Marketing was now done by chains of marketers. The buyers' direct point of contact was now with some merchant rather than with the producer. All this reduced the quality protections inherent in the village marketplace to a point requiring invention of new forms of quality assurance. One such invention was the quality warranty.

Quality Warranties. Early quality warranties were no doubt in oral form. Such warranties were inherently difficult to enforce. Memories differed as to what was said and meant. The duration of the warranty might extend beyond the life of the parties. Thus the written warranty was invented.

> An early example was on a clay tablet found amid the ruins of Nippur in ancient Babylon. It involved a gold ring set with an emerald. The seller guaranteed that for twenty years the emerald would not fall out of the gold ring. If it did fall out of the gold ring before the end of twenty years, the seller agreed to pay to the buyer an indemnity of ten *mana* of silver. The date is the equivalent of 429 B.C. (Bursk et al. 1962, vol. I, p. 71).

Quality warranties are now widely used in all forms of trade and commerce. They stimulate producers to give priority to quality and stimulate sellers to seek out reliable sources of supply. So great is their importance that recent legislation has imposed standards to ensure that the wording of warranties does not mislead the buyers.

Quality Specifications. Sellers need to be able to communicate to buyers the nature of what they have to sell. Buyers need to be able to communicate to sellers the nature of what they want to buy. In the village marketplace, oral communication could take place directly between producer and buyer. With the growth of commerce, communication expanded to include chains of producers and chains of merchants who often were widely separated. New forms of communications were needed, and a major invention was the written quality specification. Now quality information could be communicated directly between designer and producer or between seller and buyer no matter how great the distance between them and how complex the nature of the product.

Like warranties, written specifications are of ancient origin. Examples have been found in Egyptian papyrus scrolls over 3500 years old (Durant 1954). Early specifications focused on defining products and the processes for producing them. In due course the concept was extended to defining the materials from which the products were made. Then, as conflicts arose because sellers and buyers used different methods of test, it became necessary to establish inspection and test specifications as well.

Measurement. The emergence of inspection and test specifications led to the evolution of measuring instruments. Instruments for measuring length, volume, and time evolved thousands of years ago. Instruments have continued to proliferate, with ever-increasing precision. In recent centuries, the precision of measurement of time has increased by over ten orders of magnitude (Juran 1995, Chapter 10).

Artisans and Guilds. The artisan's possession of the skills of a trade was a source of income and status as well as self-respect and respect from the community. However, as villages grew into towns and cities, the numbers of artisans grew as well. The resulting competition became destructive and threatened the benefits derived from craftsmanship.

To perpetuate their benefits, the artisans within a trade organized trade unions—guilds. Each guild then petitioned the city authorities to confer on the guild members a monopoly on practicing their trade.

Guilds flourished for centuries during the Middle Ages until the Industrial Revolution reduced their influence. They used their monopolistic powers chiefly to provide a livelihood and security for their members. The guilds also provided extensive social services to their members. (For elaboration, see Bursk et al. 1962, vol. III, pp. 1656–1678.)

The Guild Hierarchy. Each guild maintained a hierarchy of (usually) three categories of workers: the apprentice, the journeyman, and the master. Considerable formality surrounded the entry into each category.

At the bottom was the apprentice or novice, whose entry was through an indenture—a formal contract that bound the apprentice to serve a master for a specified period of years. In turn, the master became responsible for teaching the trade to the apprentice.

To qualify for promotion, the apprentice was obliged to serve out the full term of the indenture. In addition, he was required to pass an *examination* by a committee of masters. Beyond the oral part of the examination, the apprentice was required to produce a perfect piece of work—a *masterpiece*—that was then inspected by the examination committee. Success in the examination led to a ceremonial admission to the status of journeyman.

The journeyman's right to practice the trade was limited. He could become an employee of a master, usually by the day. He also could *journey* to other towns, seeking employment in his trade. Only after admission to the rank of master could he set up shop on his own.

Admission to the rank of master required first that there be an opening. Guilds imposed limits on the numbers of masters in their areas. On the death or retirement of an active master, the guild would decide whether to fill that opening. If so, a journeyman would be selected and admitted, again through a formal ceremony.

Guilds and Quality Planning. Guilds were active in managing for quality, including quality planning. They established specifications for input materials, manufacturing processes, and finished products, as well as for methods of inspection and test.

Guilds and Quality Control. Guild involvement in quality control was extensive. They maintained inspections and audits to ensure that artisans followed the quality specifications. They established means of "traceability" to identify the producer. In addition, some applied their "mark" to finished products as added assurance to consumers that quality met guild standards.

Control by the guilds also extended to sales. The sale of poor-quality goods was forbidden, and offenders suffered a range of punishments—all the way from fines to expulsion from membership. The guilds also established prices and terms of sale and enforced them.

Guilds and Quality Improvement. An overriding guild policy was solidarity—to maintain equality of opportunity among members. To this end, internal competition among members was limited to "honest" competition. Quality improvement through product or process innovation was *not* considered to be "honest" competition. This limitation on quality improvement did indeed help to maintain equality among members, but it also made the guild increasingly vulnerable to competition from other cities that did evolve superior products and processes.

Guilds and External Forces. The guilds were able to control internal competition, but external competition was something else. Some external competition came in the form of jurisdictional disputes with other guilds, which consumed endless hours of negotiation. More ominous was competition from other cities, which could be in quality as well as in price and value.

The policy of solidarity stifled quality improvement and thereby became a handicap to remaining competitive. Thus the guilds urged the authorities to restrict imports of foreign goods. They also imposed strict rules to prevent their trade secrets from falling into the hands of foreign competitors. (The Venetian glass industry threatened capital punishment to those who betrayed such secrets.)

Inspection and Inspectors. The concepts of inspection and inspectors are of ancient origin. Wall paintings and reliefs in Egyptian tombs show the inspections used during stone construction projects. The measuring instruments included the square, level, and plumb bob for alignment control. Surface flatness of stones was checked by "boning rods" and by threads stretched across the faces of the stone blocks:

> As shops grew in size, the function of inspection gave rise to the full-time job of inspector. In due course, inspectors multiplied in numbers to become the basis for inspection departments, which in turn gave birth to modern quality departments. (Singer et al. 1954, vol. I, p. 481).

Government Involvement in Managing for Quality. Governments have long involved themselves in managing for quality. Their purposes have included protecting the safety and health of citizens, defending and improving the economics of the state, and protecting consumers against fraud. Each of these purposes includes some aspect of managing for quality.

Safety and Health of the Citizens. Early forms of protection of safety and health were after-the-fact measures. The Code of Hammurabi (c. 2000 B.C.) prescribed the death penalty for any builder of a house that later collapsed and killed the owner. In medieval times, the same fate awaited the baker who inadvertently had mixed rat poison with the flour.

Economics of the State. With the growth of trade between cities, the quality reputation of a city could be an asset or a liability. Many cities took steps to protect their reputation by imposing quality controls on exported goods. They appointed inspectors to inspect finished products and affix a seal to certify as to quality. This concept was widely applied to high-volume goods such as textiles.

Continued growth of commerce then created competition among nations, including competition in quality. Guilds tended to stifle quality improvement, but governments favored improving the quality of domestic goods in order to reduce imports and increase exports. For example, in the late sixteenth century, James VI of Scotland imported craftsmen from the Low Countries to set up a textile factory and to teach their trade secrets to Scottish workers (Bursk et al. 1962, vol. IV, pp. 2283–2285).

Consumer Protection. Many states recognized that as to some domestic trade practices, the rule of *caveat emptor* did not apply. One such practice related to measurement. The states designed official standard tools for measuring length, weight, volume, and so on. Use of these tools was then mandated, and inspectors were appointed to ensure compliance. (See, for example, Juran 1995, chap. 1.) The twentieth century witnessed a considerable expansion in consumer protection legislation. (For elaboration, see Juran 1995, chap. 17.)

The Mark or Seal. A mark or seal has been applied to products over the centuries to serve multiple purposes. Marks have been used to

Identify the producer, whether artisan, factory, town, merchant, packager, or still others: Such identification may serve to fix responsibility, protect the innocent against unwarranted blame, enable buyers to choose from among multiple makers, advertise the name of the maker, and so on.

Provide traceability: In mass production, use of lot numbers helps to maintain uniformity of product in subsequent processing, designate expiration dates, make selective product recalls, and so on.

Provide product information, such as type and quantities of ingredients used, date when made, expiration dates, model number, ratings (such as voltage, current), and so on.

Provide quality assurance: This was the major purpose served by the marks of the guilds and towns. It was their way of telling buyers, "This product has been independently inspected and has good quality."

An aura of romance surrounds the use of seals. The seals of some medieval cities are masterpieces of artistic design. Some seals have become world-renowned. An example is the British "hallmark" that is applied to products made of precious metals.

The Industrial Revolution. The Industrial Revolution began in Europe during the mid-eighteenth century. Its origin was the simultaneous development of power-driven machinery and sources of mechanical power. It gave birth to factories that soon outperformed the artisans and small shops and made them largely obsolete.

The Factory System: Destruction of Crafts. The goals of the factories were to raise productivity and reduce costs. Under the craft system, productivity had been low due to primitive technology, whereas costs had been high due to the high wages of skilled artisans. To reach their goals, the factories reengineered the manufacturing processes. Under the craft system, an artisan performed every one of the numerous tasks needed to produce the final product—pins, shoes, barrels, and so on. Under the factory system, the tasks within a craft were divided up among several or many factory workers. Special tools were designed to simplify each task down to a short time cycle. A worker then could, in a few hours, carry out enough cycles of his or her task to reach high productivity.

Adam Smith, in his book, *The Wealth of Nations,* was one of the first to publish an explanation of the striking difference between manufacture under the craft system versus the factory system. He noted that pin making had been a distinct craft, consisting of 18 separate tasks. When these tasks were divided among 10 factory workers, production rose to a per-worker equivalent of 4800 pins a day, which was orders of magnitude higher than would be achieved if each worker were to produce pins by performing all 18 tasks (Smith 1776). For other types of processes, such as spinning or weaving, power-driven machinery could outproduce hand artisans while employing semiskilled or unskilled workers to reduce labor costs.

The broad economic result of the factory system was mass production at low costs. This made the resulting products more affordable and contributed to economic growth in industrialized countries, as well as to the associated rise of a large "middle class."

Quality Control under the Factory System. The factory system required associated changes in the system of quality control. When craft tasks were divided among many workers, those workers were no longer their own customers, over and over again. The responsibility of workers was no longer to provide satisfaction to the buyer (also customer, user). Few factory workers had contact with buyers. Instead, the responsibility became one of "make it like the sample" (or specification).

Mass production also brought new technological problems. Products involving assemblies of bits and pieces demanded interchangeability of those bits and pieces. Then, with the growth of technology and of interstate commerce, there emerged the need for standardization as well. All this required

greater precision throughout—machinery, tools, measurement. (Under the craft system, the artisan fitted and adjusted the pieces as needed).

In theory, such quality problems could be avoided during the original planning of the manufacturing processes. Here the limitation rested with the planners—the "master mechanics" and shop supervisors. They had extensive, practical experience, but their ways were empirical, being rooted in craft practices handed down through the generations. They had little understanding of the nature of process variation and the resulting product variation. They were unschooled in how to collect and analyze data to ensure that their processes had "process capability" to enable the production workers to meet the specifications. Use of such new concepts had to await the coming of the twentieth century.

Given the limitations of quality planning, what emerged was an expansion of inspection by departmental supervisors supplemented by full-time inspectors. Where inspectors were used, they were made responsible to the respective departmental production supervisors. The concept of a special department to coordinate quality activities broadly also had to await the coming of the twentieth century.

Quality Improvement. The Industrial Revolution provided a climate favorable for continuous quality improvement through product and process development. For example, progressive improvements in the design of steam engines increased their thermal efficiency from 0.5 percent in 1718 to 23.0 percent in 1906 (Singer et al. 1958, vol. IV). Inventors and entrepreneurs emerged to lead many countries into the new world of technology and industrialization. In due course, some companies created internal sources of inventors—research laboratories to carry out product and process development. Some created market research departments to carry out the functions of entrepreneurship.

In contrast, the concept of continuous quality improvement to reduce chronic waste made little headway. One likely reason is that most industrial managers give higher priority to increasing income than to reducing chronic waste. The guilds' policy of solidarity, which stifled quality improvement, also may have been a factor. In any event, the concept of quality improvement to reduce chronic waste did not find full application until the Japanese quality revolution of the twentieth century.

The Taylor System of Scientific Management. A further blow to the craft system came from F. W. Taylor's system of "scientific management." This originated in the late nineteenth century when Taylor, an American manager, wanted to increase production and productivity by improving manufacturing planning. His solution was to separate planning from execution. He brought in engineers to do the planning, leaving the shop supervisors and the work force with the narrow responsibility of carrying out the plans.

Taylor's system was stunningly successful in raising productivity. It was widely adopted in the United States but not so widely adopted elsewhere. It had negative side effects in human relations, which most American managers chose to ignore. It also had negative effects on quality. The American managers responded by taking the inspectors out of the production departments and placing them in newly created inspection departments. In due course, these departments took on added functions to become the broad-based quality departments of today. (For elaboration, see Juran 1995, chap. 17.)

The Rise of Quality Assurance. The anatomy of "quality assurance" is very similar to that of quality control. Each evaluates actual quality. Each compares actual quality with the quality goal. Each stimulates corrective action as needed. What differs is the prime purpose to be served.

Under quality control, the prime purpose is to serve those who are directly responsible for conducting operations—to help them regulate current operations. Under quality assurance, the prime purpose is to serve those who are not directly responsible for conducting operations but who have a need to know—to be informed as to the state of affairs and, hopefully, to be assured that all is well.

In this sense, quality assurance has a similarity to insurance. Each involves spending a small sum to secure protection against a large loss. In the case of quality assurance, the protection consists of an early warning that may avoid the large loss. In the case of insurance, the protection consists of compensation after the loss.

Quality Assurance in the Village Marketplace. In the village marketplace, the buyers provided much of the quality assurance through their vigilance—through inspection and test before buying the product. Added quality assurance came from the craft system—producers were trained as apprentices and were then required to pass an examination before they could practice their trade.

Quality Assurance through Audits. The growth of commerce introduced chains of suppliers and merchants that separated consumers from the producers. This required new forms of quality assurance, one being quality warranties. The guilds created a form of quality assurance by establishing product and process standards and then auditing to ensure compliance by the artisans. In addition, some political authorities established independent product inspections to protect their quality reputations as exporters.

Audit of Suppliers' Quality Control Systems. The Industrial Revolution stimulated the rise of large industrial companies. These bought equipment, materials, and products on a large scale. Their early forms of quality assurance were mainly through inspection and test. Then, during the twentieth century, there emerged a new concept under which customers defined and mandated *quality control systems.* These systems were to be instituted and followed by suppliers as a condition for becoming and remaining suppliers. This concept was then enforced by audits, both before and during the life of the supply contracts.

At first, this concept created severe problems for suppliers. One was the lack of standardization. Each buying company had its own idea of what was a proper quality control system, so each supplier was faced with designing its system to satisfy multiple customers. Another problem was that of multiple audits. Each supplier was subject to being audited by each customer. There was no provision for pooling the results of audits into some common data bank, and customers generally were unwilling to accept the findings of audits conducted by personnel other than their own. The resulting multiple audits were especially burdensome to small suppliers.

In recent decades, steps have been taken toward standardization by professional societies, by national standardization bodies, and most recently, by the International Standards Organization (ISO). ISO's 9000 series of standards for quality control systems is now widely accepted among European companies. There is no legal requirement for compliance, but as a marketing matter, companies are reluctant to be in a position in which their competitors are certified as complying to ISO 9000 standards but they themselves are not.

There remains the problem of multiple audits. In theory, it is feasible for one audit to provide information that would be acceptable to all buyers. This is already the case in quality audits conducted by Underwriters' Laboratories and in financial audits conducted by Dun & Bradstreet. Single audits may in the future become feasible under the emerging process for certification to the ISO 9000 series.

Extension to Military Procurement. Governments have always been large buyers, especially for defense purposes. Their early systems of quality assurance consisted of inspection and test. During the twentieth century, there was a notable shift to mandating quality control systems and then using audits to ensure conformance to the mandated systems. The North Atlantic Treaty Organization (NATO) evolved an international standard—the Allied Quality Assurance Publications (AQAP)—that includes provisions to minimize multiple audits. (For elaboration, see Juran 1977.)

Resistance to Mandated Quality Control Systems. At the outset, suppliers resisted the mandated quality control systems imposed by their customers. None of this could stop the movement toward quality assurance. The economic power of the buyers was decisive. Then, as suppliers gained experience with the new approach, they realized that many of its provisions were simply good business practice. Thus the concept of mandated quality control systems seems destined to become a permanent feature of managing for quality.

Shift of Responsibility. It should be noted that the concept of mandating quality control systems involves a major change of responsibility for quality assurance. In the village marketplace, the pro-

ducer supplies the product, but the buyer has much of the responsibility for supplying the quality assurance. Under mandated quality control systems, the producer becomes responsible for supplying both the product and the quality assurance. The producer supplies the quality assurance by

- Adopting the mandated system for controlling quality
- Submitting the data that prove that the system is being followed

The buyers' audits then consist of seeing to it that the mandated system is in place and that the system is indeed being followed.

The Twentieth Century and Quality. The twentieth century witnessed the emergence of some massive new forces that required responsive action. These forces included an explosive growth in science and technology, threats to human safety and health and to the environment, the rise of the consumerism movement, and intensified international competition in quality.

An Explosive Growth in Science and Technology. This growth made possible an outpouring of numerous benefits to human societies: longer life spans, superior communication and transport, reduced household drudgery, new forms of education and entertainment, and so on. Huge new industries emerged to translate the new technology into these benefits. Nations that accepted industrialization found it possible to improve their economies and the well-being of their citizenry.

The new technologies required complex designs and precise execution. The empirical methods of earlier centuries were unable to provide appropriate product and process designs, so process yields were low and field failures were high. Companies tried to deal with low yields by adding inspections to separate the good from the bad. They tried to deal with field failures through warranties and customer service. These solutions were costly, and they did not reduce customer dissatisfaction. The need was to prevent defects and field failures from happening in the first place.

Threats to Human Safety and Health and to the Environment. With benefits from technology came uninvited guests. To accept the benefits required changes in lifestyle, which, in turn, made quality of life dependent on continuity of service. However, many products were failure-prone, resulting in many service interruptions. Most of these were minor, but some were serious and even frightening—threats to human safety and health, as well as to the environment.

Thus the critical need became quality. Continuity of the benefits of technology depended on the quality of the goods and services that provided those benefits. The frequency and severity of the interruptions also depended on quality—on the continuing performance and good behavior of the products of technology. This dependence came to be known as "life behind the quality dikes." (For elaboration, see Juran 1970.)

Expansion of Government Regulation of Quality. Government regulation of quality is of ancient origin. At the outset, it focused mainly on human safety and was conducted "after the fact"—laws provided for punishing those whose poor quality caused death or injury. Over the centuries, there emerged a trend to regulation "before the fact"—to become preventive in nature.

This trend was intensified during the twentieth century. In the field of human health, laws were enacted to ensure the quality of food, pharmaceuticals, and medical devices. Licensing of practitioners was expanded. Other laws were enacted relating to product safety, highway safety, occupational safety, consumer protection, and so on.

Growth of government regulation was a response to twentieth-century forces as well as a force in its own right. The rise of technology placed complex and dangerous products in the hands of amateurs—the public. Government regulation then demanded product designs that avoided these dangers. To the companies, this intervention then became a force to be reckoned with. (For elaboration, see Juran 1995, chap. 17.)

The Rise of the Consumerism Movement. Consumers welcomed the features offered by the new products but not the associated new quality problems. The new products were unfamiliar—most

consumers lacked expertise in technology. Their senses were unable to judge which of the competing products to buy, and the claims of competing companies often were contradictory.

When products failed in service, consumers were frustrated by vague warranties and poor service. "The system" seemed unable to provide recourse when things failed. Individual consumers were unable to fight the system, but collectively they were numerous and hence potentially powerful, both economically and politically. During the twentieth century, a "consumerism" movement emerged to make this potential a reality and to help consumers deal more effectively with these problems. This same movement also was successful in stimulating new government legislation for consumer protection. (For elaboration, see Juran 1995, chap. 17.)

Intensified International Competition in Quality. Cities and countries have competed for centuries. The oldest form of such competition was probably in military weaponry. This competition then intensified during the twentieth century under the pressures of two world wars. It led to the development of new and terrible weapons of mass destruction.

A further stimulus to competition came from the rise of multinational companies. Large companies had found that foreign trade barriers were obstacles to export of their products. To get around these barriers, many set up foreign subsidiaries that then became their bases for competing in foreign markets, including competition in quality.

The most spectacular twentieth-century demonstration of the power of competition in quality came from the Japanese. Following World War II, Japanese companies discovered that the West was unwilling to buy their products—Japan had acquired a reputation for making and exporting shoddy goods. The inability to sell became an alarm signal and a stimulus for launching the Japanese quality revolution during the 1950s. Within a few decades, that revolution propelled Japan into a position of world leadership in quality. This quality leadership in turn enabled Japan to become an economic superpower. It was a phenomenon without precedent in industrial history.

QUALITY TO CENTER STAGE

The cumulative effect of these massive forces has been to "move quality to center stage." Such a massive move logically should have stimulated a corresponding response—a revolution in managing for quality. However, it was difficult for companies to recognize the need for such a revolution—they lacked the necessary alarm signals. Technological measures of quality did exist on the shop floors, but managerial measures of quality did not exist in the boardrooms. Thus, except for Japan, the needed quality revolution did not start until very late in the twentieth century. To make this revolution effective throughout the world, economies will require many decades—the entire twenty-first century. Thus, while the twentieth century has been the "century of productivity," the twenty-first century will be known as the "century of quality."

The failure of the West to respond promptly to the need for a revolution in quality led to a widespread crisis. The 1980s then witnessed quality initiatives being taken by large numbers of companies. Most of these initiatives fell far short of their goals. However, a few were stunningly successful and produced the lessons learned and role models that will serve as guides for the West in the decades ahead.

Lessons Learned. Companies that were successful in their quality initiatives made use of numerous strategies. Analysis shows that despite differences among the companies, there was much commonality—a lengthy list of strategies was common to most of the successful companies. These common strategies included

Customer focus: Providing customer satisfaction became the chief operating goal.

Quality has top priority: This was written into corporate policies.

Strategic quality planning: The business plan was opened up to include planning for quality.

Benchmarking: This approach was adopted in order to set goals based on superior results already achieved by others.

Continuous improvement: The business plan was opened up to include goals for quality improvement. It was recognized that quality is a moving target.

Training in managing for quality: Training was extended beyond the quality department to all functions and levels, including upper managers.

Big Q was adopted to replace little Q.

Partnering: Through cross-functional teams, partnering was adopted to give priority to company results rather than to functional goals. Partnering was extended to include suppliers and customers.

Employee empowerment: This was introduced by training and empowering the work force to participate in planning and improvement, including the concept of self-directed teams.

Motivation: This was supplied through extending the use of recognition and rewards for responding to the changes demanded by the quality revolution.

Measurements were developed to enable upper managers to follow progress toward providing customer satisfaction, meeting competition, improving quality, and so on.

Upper managers took charge of managing for quality by recognizing that certain responsibilities were *not delegable*—they were to be carried out by the upper managers, personally.

These responsibilities included

- Serve on the quality council
- Establish the quality goals
- Provide the needed resources
- Provide quality-oriented training
- Stimulate quality improvement
- Review progress
- Give recognition
- Revise the reward system

Inventions Yet to Come. Many of the strategies adopted by the successful companies are without precedent in industrial history. As such, they must be regarded as experimental. They did achieve results for the role model companies, but they have yet to demonstrate that they can achieve comparable results in a broader spectrum of industries and cultures. It is to be expected that the efforts to make such adaptations will generate new inventions, new experiments, and new lessons learned. There is no end in sight.

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