TQM: The Essential Concepts

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Abstract
This is an introduction to the major concepts in total quality management, a loose collection of management approaches that focus on continuous improvement of processes, guided by routine data collection and adjustment of the processes. Customer focus and involvement of all members of an organization are also characteristics commonly found in TQM. The seventy-five-year history of the movement is sketched from its beginnings in statistical work on quality assurance through the many improvements and redefinitions added by American and Japanese thinkers. Essential concepts covered include: control cycles, focus on the process rather than the defects, the GEAR model, importance of the customer, upstream quality, just-in-time, kaizen, and service quality.

Management fads like re-engineering, emotional intelligence, and empowerment lasts only a few years—just long enough for all who are interested to read the books. Movements, or major ways of looking at the whole field such as scientific management, social relations, or quantitative approaches, tend to have a twenty to twenty-five year cycle. There is also a special class of management theories that we just can’t shake. Maslow’s hierarchy of needs and MBO have been with us half a century; never fully implemented—always present in one form or another.

Another example of this category is the quality movement. With roots tracing back sixty or more years, quality constantly reinvents itself, assuming new forms and promoting new heroes. Each generation has added something to the quality movement; it is something like a stew.

The complex character of quality gives it vigor but also confounds precise definition. We are not even certain what to call it. For 1998, the most serviceable term is probably total quality management (TQM). The essential components of TQM include (1) a comprehensive and integrated approach, (2) being customer driven, (3) disciplined control of both work design and work practices based on constant measurement which is understood by all employees, and (4) continuous improvement—good enough just never is.

Sometimes one encounters the abbreviation QC. This stands for quality control, that part of TQM where measurement and statistical methods are used to ensure uniformity of results. QA (quality assurance) is part of QC. Another frequently heard term is continuous quality improvement (CQI or sometimes the Japanese term kaizen) when the emphasis is on always doing better. The current preference for TQM as a label for the quality movement stresses the “T” to show that it is everyone’s job and the “M” to emphasis a comprehensive and integrated approach.

TQM in America
The development of TQM has been a joint venture between the United States and Japan, with the U.S. taking the lead in the early years of research and the Japanese excelling later, bringing these ideas into practical industrial applications.

The origins of the quality movement are normally traced to the 1930s and a statistician working at Bell Laboratories named W. A. Shewhart (1931)—although the first book on the topic appeared nine years earlier (Radford, 1922). Shewhart was interested in the pattern of errors in the manufacturing process. It wasn’t enough to find and correct the defects, he also wanted to know which defects where most likely to occur and what could be done to prevent them. He conceptualized a simple model of SDCA—standards-do-check-act. By repeating this cycle, it is possible to drive down the number of surprises and rejects in any system. This is known as a control cycle because product improvement comes from increased likelihood that each product will be exactly as planned. Early in the Second World War, the War Department began working with Bell Labs to...
promote acceptance of quality standards and training in these methods. This lead, in 1945, to the creation of the American Society for Quality Control and the first journal, *Industrial Quality Control*.

The two American giants of quality to emerge in the ’40s were J. M. Juran, an engineer, and W. Edwards Deming, a physicist who worked on statistics for much of his early career. Juran systematized Shewhart’s thinking and made it accessible to engineers involved in industrial production. He also deserves credit as the first strong proponent of the notion that quality is defined by the customer. He has continued to write into the 1980s and ’90s, and his works are perhaps the most accessible to the serious American student of quality (Juran, 1988a, 1988b, 1989).

The best known name in quality is W. Edwards Deming (Aguayo, 1990; Gitlow & Gitlow, 1987). This may be a historical accident attributed to the Japanese naming a prize in his honor. His own writings are very loosely structured and sometimes dogmatic (Deming, 1950, 1972, 1975, 1976, 1982, 1986). For example, he showed that all production systems, including those that are under control, have variance. This means that a certain number of errors are inherent in any system. He dramatized this in his famous “red bead experiment.” A number of red beads are added to white ones in proportion to the variance in a production system. Executives and engineers responsible for this system are invited to fill a scoop with a predetermined number of beads. The process continues until inevitably one of the scoops contains enough red beads to show that the operation is defective. In mock sternness, Deming would berate the luckless executive in whose hands the scoop happened to be at the moment. Then he would explain his belief that employees should not be criticized for discovering the design errors in production systems.

Deming also argued for a salary cap on executives, one pegged as a multiple of the lowest paid individual in the firm. Management principles such as these have not been popular in the United States for the first forty years following the Second World War, and they are by no means widely accepted today. This helps to explain Deming’s greater popularity in Japan and his more recent rediscovery here.

Another early American contributor to quality was Philip Crosby (1979, 1984). For many years he was director of quality at ITT and later, like Juran and Deming, opened his own consulting organization. Crosby downplayed the statistical foundations of quality and popularized quality as a management philosophy. He was the first to drive home the paradoxical notion that good quality costs less to produce and maintain than does poor quality. But in characteristic Crosby style, he exaggerated this point in his well known book *Quality is Free*. He also oversimplified the statistical notions of variance and their impact on the shipment of defectives or the improvement of manufacturing processes. His alternative was the notion of “zero defects.” He defined quality as conformance with specifications (revealing his engineering background) and stressed programs and slogans. Today, his quality assurance approach—if it works, it’s good enough—is considered superficial.

The most significant contribution in the early part of the quality movement was to use statistical patterns to identify the causes of poor quality. The old model was to inspect the output of a process and improve its average quality by finding the defects and destroying or reworking them. In the TQM model, defects are signals that point to parts of the process that must be improved so that quality is the result of fewer defects being produced.

**TQM in Japan**

The story of how the quality movement came to Japan and how it revolutionized that country’s economy has been told repeatedly, from both the American point of view (Garvin, 1988; Juran, 1989; Gitlow & Gitlow, 1987) as well as from the Japanese perspective (Easley, 1994; Ishikawa, 1985). Following the Second World War, the Japanese economy was in a shambles, particularly its infrastructure. The U.S. Army, assisting in the reconstruction, took a particular interest in the telephone system in Japan and brought over experts from Bell Laboratories, including Drs. Juran and Deming and Armand Feigenbaum (1983).

Western versions of the success of quality in Japan stress social and cultural values such as patriotic pride in workmanship, company loyalty, and cultural hegemony. Japanese writers on the subject acknowledge these forces but also point to the practical power of an impoverished economy. In the late 1940s and for years to follow, Japan could not afford defects, or even afford to correct them—they had to get the process right from the beginning. With no powerful industrial interests and little functioning capacity, it was an opportune time to create meaningful, country-wide industrial standards. There were neither the resources nor the time for comprehensive and sophisticated product development testing, so new engineering methods were developed to bring products online faster. And there wasn’t enough money.
to buy training manuals for all workers on the shop floor. This lead to buying a single copy to be shared in a group meeting, hence the origin of quality circles.

Fifty years ago in Japan the timing was right for the quality message: use data to find and fix those places in the production process where defectives are detracting the most from value added. But circumstances in Japan have left their own distinct mark on the movement. The “total” part of TQM is a Japanese contribution. In the United States, quality has historically been the territory of specialists in the quality department. In Japan, it is everybody's business. CEOs are suppose to understand Pareto graphs, control charts, and fishbone diagrams; and so are drill press operators. Japan has also contributed the notion of continuous incremental improvement. In the West, we value “new” and mean by it that a radical change was thought through by a special group who produced something distinct from what preceded it. The Japanese notion of progress involves continual small enhancements, even making this a habit or lifestyle. The impact of everyone in an organization making constant improvements can be very dramatic.

**GEAR**

A fundamental concept in quality is that processes can be managed through a four-part cycle. Sometimes this cycle is abbreviated SDCA (for standardize-do-check-act); sometimes the cycle is called PDCA where the “P” stands for plan and the “S” stands for study. In its most generic form, the four parts are GEAR, as shown in Figure 1 (Glassman & Chambers, 1998).

In the GEAR cycle a **goal** is agreed upon—either a maintenance standard for a steady state or a planned improvement. Activities are **executed** with the intent of reaching the goal (“experienced” is a more appropriate word than “executed” when referring to service or education in the TQM model). Next, the impact or outcome of the execution is **assessed** and compared against the goal. Differences are reconciled in the **response** phase of the four-part model.

There are six responses which can be taken. (1) The goal can be **reconsidered**—experience may show that it is inappropriately high or low. (2) The execution can be **redesigned**. This is the most common response in TQM model because it is usually (but not always) the least expensive in the long run. (3) Sometimes the assessment mechanism is inappropriate because it is too vague, too inconsistent, or even biased. Corrections at this point are referred to as **reassessment**. (4) Another common alternative is **rework**—making minor adjustments on individual pieces of work necessary to bring them up to standard but without changing the production process. When TQM is applied in the service economy, this response is called “recovery” (Hart, Heskett, & Sasser, 1990); when applied in education it is called “remediation.” (5) The old model of quality was called “inspecting defectives out.” The idea is to sample the results and identify those that do not meet standard and **reject** them. This is still one of the alternative responses that must be considered in the GEAR model. (6) The final response is the “hidden treasure” in GEAR. The **residual** of experience is learning. It is the know how that leads to faster, more accurate, and innovative responses on the next cycle. It is the foundation upon which the learning organization is based (Edvinsson & Malone, 1997; Schön, 1987; Senge, 1990; Stewart, 1997; von Hippel, 1988).

The GEAR cycle is not a term that can be found in the established literature on quality. It is the author's attempt to generalize several similar, but sometimes confused, concepts within the field. For example, many who are familiar with

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**Figure 1. GEAR Model for Continuous Growth.**

![GEAR Model](image)

**Responses:**

- Reconsideration of the goal
- Redesign of the execution, experience
- Reassessment
- Rework, recovery, remediate
- Reject
- Residual, learning

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**The most significant contribution in the early part of the quality movement was to use statistical patterns to identify the causes of poor quality.**
TQM do not realize that Shewhart's SDCA model is different from the PDSA model developed by the Deming and the Japanese. The first is called a control cycle; the latter is an innovation cycle.

In TQM, control has a special meaning. The American statistical approach to quality begins by identifying the "normal" variation inherent in each process. Superimposed on the natural variation are the "special" factors that produce excessive numbers of defects. For example, airplane landings normally range from the smooth to the bumpy; pilot or equipment error, often combined with unusual weather circumstances, cause the extreme variations which lead to severely uncomfortable and dangerous landings or worse. Deming and others arbitrarily defined three standard deviations above and three standard deviations below the standard as the boundaries of "normal variation." (In a normal distribution, approximately 1% of observations fall outside of plus-or-minus three standard deviations.) This is the origin of the six sigma standard (6σ) that has become a motto for several quality improvement programs.

The early phases of the quality movement focused on the control process, using the SDCA cycle to drive each process to 6σ—to bring each process "under control." The impact of gaining control over production processes is enormous, but it is not enough. Markets change constantly and technological innovation is accelerating. Therefore, an innovation cycle is necessary in TQM, where the "P" in the PDSA process denotes a planned improvement or raising of the standard.

Quality control engineers at Hewlett-Packard have developed a useful way of integrating and extending these two quality cycles. The principle is known as "USA," standing for understand, standardize, and automate. Any innovative process goes through the three life stages where we first struggle to understand the factors influencing the process; then we standardize it using something like the control cycle; and finally we automate it or delegate it to those with lower levels of training. Companies will suffer competitively if they fail to take advantage of the economies of standardization and

Summary of Deming's Fourteen Points (Deming, 1982).

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.
3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.
5. Improve constantly and forever the system of production and service, to improve quality and productivity, thus constantly decrease costs.
6. Institute training on the job.
7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.
10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.
11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.
12a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.
12b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. The means, inter alia, abolition of the annual or merit rating and of management by objective.
13. Institute a vigorous program of education and self-improvement.
14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.
Total Quality Management in Dentistry

automation. Similarly, they will suffer competitively if they attempt to standardize those processes they do not understand or to automate or delegate those things which have not been standardized.

The Importance of the Customer
There are a few writers in the quality movement who focus on the quality of products, but they are rare. It is generally agreed that quality is the privilege of the customer. Juran says “The most effective way to identify customers is to follow the production process—that is, anyone who must try to work with the product or service that you hand off to them.

“Upstream” Quality
The best-known examples of TQM are application of the control cycle of production on the manufacturing shop floor. Some have said that the success of Japanese industry over the past thirty years is attributable to an army of dedicated workers who understand and religiously apply quality control techniques. As important as that may be, another powerful factor is “upstream” quality or the quasi-ethical belief that Japanese managers are responsible for the defectives produced by their employees is partially cultural and partially a very profound understanding of the production process. Rapid control in the production process can best be achieved by designing products that are easy to produce because they do not depend on sophisticated equipment, complex processes, or highly trained individuals.

Adding quality “upstream”—also called “off-line quality”—is considerably more cost effective than trying to achieve it during production. “Adding quality at the production stage, in turn, is more cost effective than is the approach based on inspection or quality control; and this in turn is still less expensive than correcting mistakes once they have been delivered to the customer” (Gavin, 1988, p. 32).

The name most often associated with the design aspect of quality is Genichi Taguchi (Ealey, 1994; Taguchi, 1992, 1993). Taguchi is a Japanese engineer who has devoted his life to the statistical properties of product development. He defines quality as freedom from economic loss suffered by customers during the normal use of products—sometimes called “robustness.” This economic loss function can actually be calculated through marketing research and has been found to take the predictable form of a quadratic equation. As a product (and presumably a service as well) deviates from the optimal design, the loss of value increases at an accelerating rate. If Taguchi is correct, there is no minimum standard of “good enough,” there is only “better and better.” Taguchi does, however, demonstrate mathematically how to calculate the tolerance value for production quality based as the ratio of the economic loss function to customers and the cost of rework— a concept which is probably intuitively understood by most dentists in practice. Finally, Taguchi is justly famous for his saying “to improve quality, don’t measure it.” At first this seems counterintuitive. What Taguchi really means is that quality can only be achieved by identifying those factors that control the things customers value most (these are known as “drivers”) and then measuring and controlling them (see also Ishikawa, 1985). It is analogous to saying one can’t lose weight by buying a scale, but can lose weight by measuring and controlling fat intake and exercise.

JIT
One of the more popular components of quality is just-in-time productivity, also called the “Ohno method” after its founder (Taiichi Ohno) or the “Toyota Production System” (Imai, 1986). JIT means much more than arriving for work one minute before necessary. The basic concept is to reduce waste by pulling work through the production system based on customer demand rather than pushing it through the system based on efficiencies in productivity. JIT rewards people and their processes based on what is delivered and not on what is produced.

In the traditional American system, both suppliers and customers are treated at arms length and often assumed to be adversaries were the gain of one necr-
sarily means the loss of another. In this system, the smart move is to stockpile raw materials and work in progress, pit one supplier against another in competitive bidding, standardize everything, and compete on price. The producer pushes the market, but this is inefficient because of the warehoused resources and finished product needed to protect against the uncertainties of supplier and consumer behavior.

In the JIT model, suppliers, producers, and customers cooperate to form a smooth chain with as little waste as possible. Producers, often because some of their own employees are working with customers on the design of needed new products, know in a timely fashion what needs to be produced, how much of it will be required, and when it is to be delivered. Similarly, producers have cooperative relations with suppliers who will deliver high-quality raw materials in the quantities needed at precisely the times they are required. This drives down the waste in the entire process, and the resulting economic advantage is shared by suppliers, producers, and customers. In addition to the change of attitude required to implement JIT, computer technology and industry-wide standards and a robust infrastructure are all required to make the system effective.

**Kaizen**

Sometimes the quality movement is presented as an elaboration of statistical procedures. Often it is portrayed as a management philosophy. Of course there are marketing, engineering, and human resources components of quality as well. Yet another aspect of quality comes close to personal discipline or culture. The name for quality when looked at from this perspective is *kaizen*. This is a Japanese term which can be roughly translated as the discipline of continuous improvement (Imai, 1986, 1997). The American phrase “continuous quality improvement (CQI) points in the same direction, but lacks the overtones of personal discipline.

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**Malcolm Baldrige Award Criteria for Performance Excellence**

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<th>Category</th>
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<tr>
<td><strong>Leadership</strong></td>
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<td>Leadership system</td>
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<td>Company responsibility and citizenship</td>
<td>30</td>
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<td><strong>Strategic planning</strong></td>
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<td>Strategy development process</td>
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<td>Company strategy</td>
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<td><strong>Customer and market focus</strong></td>
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<td>Customer and market knowledge</td>
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<td>Customer satisfaction and relationship</td>
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<td><strong>Information and analysis</strong></td>
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<td>Selection, use of comparative information</td>
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<td>Analysis of company performance</td>
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<td>Work systems</td>
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<td>Employee education, training</td>
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<td>Employee well-being and satisfaction</td>
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<tr>
<td><strong>Process management</strong></td>
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<td>Management of product processes</td>
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<td>Management of support processes</td>
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One of the key elements in *kaizen* is the concept of waste (the Japanese term is *muda*) which means roughly anything which reduced the value added in a production process. Typical examples of waste include overproduction, inventory that is not in use, rework, defectives, superfluous movement, waiting, and moving things unnecessarily. Eliminating waste, in the TQM sense, is more than the traditional time and motion studies popular in America seventy years ago.
and somewhat popular in dentistry today. Quality looks at degradation of value added from the customer's perspective not efficiency of isolated operations.

A second example of kaizen is the "five Ss of good housekeeping." The five Ss stand for Japanese words which roughly translate as follows: (1) sort—separate the necessary from the unnecessary items in the workplace and eliminate the latter; (2) straighten—put everything essential in order so that it can be easily accessed; (3) scrub—keep everything clean; (4) systematize—make orderliness and cleanliness a routine; (5) standardize—this is a poor translation since the Japanese word (shitsuke) really means to build self-discipline.

Other components of kaizen include quality circles, publicly visible charts and graphs of progress, written procedures for all tasks, reports of unsafe practices or conditions, and regularly scheduled meetings for public autopsies of failures, with examples of the actual failures (known as geminatu in Japanese) physically present.

Service Quality
The vast majority of work on TQM has been in the manufacturing or production segment of the market. There are significant problems in extrapolating the findings there to the service sector of the economy, and to health and education in particular. Nonetheless, some promising work has been done in the field of service quality (Albrecht & Zemke, 1985; Lovelock, 1981).

The residual of experience is learning.

For example, Zeithaml and her colleagues (1990) have developed and empirically validated a model of service quality based on minimizing the difference between what a customer expects service to be and what they think of the service actually delivered. Their approach uses something like the GEAR cycle to continuously reduce the gap between expected and perceived service. In particular, they urge that a corrective response should be taken if there is a problem at any of the following gaps: (1) are the customers' expectations accurately understood?, (2) are there specific standards for meeting customer expectations?, (3) do services meet or exceed the established standard?, and (4) is accurate information given to customers about the services they receive?

Another development in the service area that closely parallels development in quality, especially JIT, is the blurring of distinctions between customers and employees with regard to service. Now customers are being asked to perform some duties previously reserved for employees—self service everything and computerized banking are examples. The education of customers and the physical arrangement of service facilities so that customers can effectively perform their functions are also a growing part of service quality.

The Payoff and the Prizes
Arguably, too much credit for Japan's economic success during the past fifty years has been given to TQM. Other factors have been at play and Japan's success in manufacturing has not been copied in every country or across diverse industries. But there is compelling evidence that the careful and correct application of TQM can return handsome results on the corporate bottom line.

Numerous studies of American industry, summarized by Harvard's David Gavin (1988) show that investments in quality positively affect both market share, net profit, and return on investment. The logic is simple and compelling. First, give customers what they want and make it as good or better than expected, and you will have many loyal customers. Second, pushing quality "upstream" decreases the number of defects and decreases the cost of correcting them.

The U.S. government has recognized the importance of quality as a contribution to the national economy by establishing a national prize for quality. Each year the Malcolm Baldrige prize (National Institute of Standards and Technology, 1998) can be awarded to as many as two for-profit companies in the United States in each of the three categories of manufacturing, service, and small business. The criteria for this prestigious award are shown in the side bar.

On the other hand, there are some characteristics common among dentists that are antithetical to the central concepts in quality. The first obstacle is customer focus. Dentists are "patient-centered." That means they have a deep-seated service ethic of doing what they believe is best for anyone who will put themselves in the professional care of the dentist. That is quite different from letting the customer define quality. Some dentists place such a high value on per-
sonal control that inviting employees to participate in shared office responsibility for management of care is uncomfortable. Many dentists resemble their counterparts in industry with the inclination to blame the employee holding the defect rather than the one who designed a system that allows defects to occur. The all-too-common preference for replacement rather than the one who designed a system that allows defects to occur. Deming, W. E. (1950). Service America! Doing business in the new economy. Homewood, IL: Dow Jones-Irwin.


