

BOYER/VERMA, *OPERATIONS AND
SUPPLY CHAIN MANAGEMENT FOR THE
21ST CENTURY*, 1E

INSTRUCTOR RESOURCE MANUAL

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CHAPTER TWO: QUALITY MANAGEMENT

LEARNING OBJECTIVES

1. Define the meaning of quality.
2. Explain why it is necessary to improve the quality of goods and services.
3. Define the components of quality in goods and services.
4. Summarize the history of quality management.
5. Summarize the teachings of quality gurus W. Edwards Deming, Philip Crosby, Armand Feigenbaum, Kaoru Ishikawa, Joseph M. Juran, Genichi Taguchi, and Walter Shewhart.
6. Describe commonly used quality management approaches, such as total quality management (TQM), the ISO 9000 and ISO 14000 standards, and the Malcolm Baldrige Criteria for Performance Excellence.
7. Describe the Six Sigma quality management approach and the steps in implementing it.

TALKING POINTS FOR THE OPENING VIGNETTE

This vignette discusses quality management at American Express.

Key points to emphasize:

- American Express has to ensure the quality of the credit card itself (the *physical good* in this instance) and the related *services* (the telephone call centers, the credit card approval process).
- Important quality characteristics for credit card itself include the magnetic stripe on the card being readable and containing correct information.
- Important quality characteristics for call centers include wait time (time “on hold”), time to resolve the customer’s issue, and politeness of the phone representative.
- Important quality characteristics for the approval process include timeliness and making sure the right customers get approved (and rejected).
- American Express’ processes are executed “millions of times every few minutes.” This means that even if a process is defective only 1 percent of the time, there will be ten thousand defects every few minutes (1 million times 1 percent). This demonstrates that American Express needs very high levels of quality. As a result, it needs systems and tools to ensure that processes are done right and that problems are detected when they do occur. That is the subject of this chapter.
- The vignette emphasized checking for defects. That is important. However, as we will see, companies must also set up systems that prevent defects from being created in the first place.

LECTURE OUTLINE

I. Defining Quality

Quality is the ability of a product (a good or a service) to consistently meet or exceed customer expectations.

- i. *Ability* refers to the competence, either native or acquired, that enables one to do something well.
- ii. *Consistently* refers to a reliable or steady pattern of performance.
- iii. *Expectations* refer to a state of anticipation about a future outcome.

Discussion Starter

Refer to the opening vignette. For the credit card itself, the application and approval process, the billing process, and the customer service process, what are the quality characteristics (such as amount of time on hold on the telephone) that matter to you as a customer? Note that some of these are mentioned in the vignette and some are not. Many are given in the second to fourth point above.

Best Practices in Operations Management**The Evolving Definition of Quality at Ritz-Carlton**

Ritz-Carlton is a two-time winner of the Malcolm Baldrige National Quality Award (a prestigious quality award bestowed by the U.S. Department of Commerce). The text reproduces Ritz-Carlton's quality motto, credo, and three steps to service. These illustrate that achieving quality requires much more than telling employees to "take care of the customers." Rather, systems are necessary, and, at Ritz-Carlton, these documents are key parts of the system. They are taught to all employees and reinforced constantly. Ritz-Carlton has recently transitioned from 20 "service rules" to 12 "service values." What is the difference between a rule and a value? A rule is a directive whereas a value is more of a statement of what the company wants to achieve. Using values, rather than rules, encourages employees to determine for themselves how to satisfy customers, at the same time guiding employees as to what is important. Employees who are encouraged to be creative and who are given real responsibility are likely to be more motivated and are thus more likely to go out of their way to satisfy customers.

Discussion Starter

Ask students to recall the times when they were managed in a top-down, directive fashion versus when they were given some objectives along with latitude in how to act. Which did they find more motivating? What are some quality-related outcomes of having motivated employees?

II. Why Firms Undertake Quality

Firms undertake quality and process improvement efforts to achieve multiple goals, including these four reasons:

B. Cost reduction

- i. Quality gurus emphasize that doing things right the first time adds nothing to the cost of a product or service and improving quality.
- ii. Reductions in costs lead to increased profitability in the long run, and company survivability and prosperity.
- iii. Quality improvement involves costs such as the effort and investment in better employees, raw materials, production processes, and all support activities. The different types of costs associated with quality improvement are the following:
 1. Internal failure cost—the cost of poor quality if the error is caught within the production facility.
 2. External failure cost—the cost of poor quality if the error is caught after the product has been sold to the customer.
 3. Assurance costs—the costs necessary to ensure that the product or service meets quality standards.

- 4. Prevention costs—all costs and efforts associated with preventing quality problems.
- C. Customer satisfaction enhancement
 - i. The quality of products and services can have a big impact on customer satisfaction, which is an indication of the long-term profitability of a company.
 - ii. American Customer Satisfaction Index (ACSI) is an ongoing index for tracking customer satisfaction for a wide range of products and services in the United States.
- D. Customer loyalty, word of mouth, and enhancement of the firm's reputation
 - i. It is less costly to continue serving existing customers than to increase market share.
 - ii. Companies that continue to provide high-quality products and services realize high customer loyalty.
- E. Increase in profitability and market share
 - i. Companies that produce higher-quality products and services are rewarded by enhanced financial performance.

III. Determinants of Quality

Determining the underlying components of quality can be difficult because customers often think of many different characteristics of a good or a service when they think about quality.

- F. The quality of goods is determined by the following dimensions:
 - i. Performance. This refers to the primary purpose of a tangible good.
 - ii. Special features. These are additional characteristics of a tangible good that enhance the value or usefulness of the primary purpose of the product.
 - iii. Reliability. Consistency in the performance of a good is measured by its reliability. A good with higher reliability is considered to have higher quality than a good with lower reliability.
 - iv. Conformance. This is the degree to which a good matches the specified standards or guidelines.
 - v. Durability. This refers to the useful life of a good. The longer the useful life, the higher the quality.
 - vi. Serviceability. The ability of the good to perform with ease is also a measure of its quality.
 - vii. Aesthetics. A good's appearance is often considered to be a dimension of its quality.
 - viii. Brand equity or reputation. Often customers associate the quality of a good with the image of the company, its brand name, or its past reputation. These indirect measures of quality are collectively called brand equity.
- G. Service quality is determined by multiple dimensions:
 - i. Reliability—a measure of consistent performance and dependability.
 - ii. Responsiveness—the willingness of the service provider to assist customers.
 - iii. Competence—the knowledge and skills of the provider needed to perform the service.
 - iv. Access—the approachability and the ease of contacting the service provider.
 - v. Courtesy—the service providers' politeness, respect, consideration, and friendliness.

- vi. Communication—the use of understandable language so that customers can understand the different facets of the service.
 - vii. Credibility—the service provider’s trustworthiness, believability, and honesty, collectively known as its credibility.
 - viii. Security—confidentiality, and personal and financial security.
 - ix. Understanding/knowing the customer—the provider’s efforts to understand the needs of its customers.
 - x. Tangibles—the physical characteristics (e.g., facilities, appearance of personnel) of the service.
- H. Customer expectations are influenced by many different factors, such as personal needs, word of mouth or the reputation of the company, and individuals’ own past experiences.
- i. Customers compare the objective quality of a product (the quality of a good/service based entirely on set dimensions described above) with their expectations.
 - ii. Based on such comparisons, the perceived quality (the quality as perceived by the customer) of the product is thought to be higher or lower than expectations.
 - iii. Quality excellence means improving the dimensions of both objective and perceived product quality.

Discussion Starter

Customer Expectations

Ask students to describe a time when a newly purchased product or service did not meet their expectations. Where did their expectations come from—word of mouth, reputation, advertising, or past experience? A lot of the gaps having to do with past experience versus the current experience will probably be from services. For example, “My slice of pizza at the food court yesterday was twice as big as the one I got today.” This illustrates the importance—and the difficulty—in delivering consistency in services.

IV. History Of Quality Management

- I. Early development of quality management
- Prior to the industrial periods, craftsmen generally had direct contact with their customers, and products were created on the basis of specifications provided by customers. The practice of quality management changed dramatically with industrialization and the growth of mass production in the early twentieth century.
- i. Companies began using sampling and inspection to check product quality.
 - 1. Sampling is the selection of randomly selected products from the production line for quality checks.
 - 2. Inspection is the process of comparing a sampled product with established guidelines.
 - 3. Walter A. Shewhart developed the control charts and principles of modern statistical process control that were used in American companies in the period leading up to and during World War II.
 - 4. Edward Deming taught the quality control concepts of continuous improvement and statistical process control to the Japanese after the war. Joseph Juran also taught quality principles about the same time.

Japanese companies rigorously followed these teachings, and their manufacturing carried a mark of excellence within the next two decades. The Deming Prize was established to recognize companies that have exerted immeasurable influence on the development of quality control/management in Japan.

J. Recent advances in quality management

The quality movement went through a rebirth in American companies during the 1980s. A TV documentary, "If Japan Can, Why Can't We?" is often credited with making American executives aware of structured quality management practices in Japan.

- i. The Malcolm Baldrige National Quality Award (www.baldrige.org) was created by the U.S. government in 1987 to help improve the quality and competitiveness of American companies. It recognizes the highest-performing organizations in the manufacturing, service, health care, education, and small business categories.
- ii. ISO 9000 standards were created that certify companies on the basis of their adherence to quality management principles through their use of documented operational procedures.
- iii. ISO 14000 was also developed to certify companies on the basis of their commitment to environmental quality management.
- iv. Companies around the world now actively pursue quality-related best practices in the management of their daily operations.
- v. Companies are also paying greater attention to service quality, customer satisfaction, and customer loyalty.

V. The Teachings of the Quality Gurus

K. Dr. W. Edwards Deming

- i. Perhaps had the most significant impact on the practice of quality management; he is often called the father of modern quality management.
- ii. Emphasized the philosophy of continuous improvement, whereby organizations continuously search for ideas for improving the quality of products and services.
- iii. Created simple examples and visuals for teaching quality management concepts and summarized:
 1. His teachings on quality and process improvements in 14 points, which continue to be used today by practicing managers (see Table 2.1).
 2. His continuous improvement philosophy using a simple diagram of a wheel with four activities: Plan, Do, Check, and Act (see Figure 2.5).

L. Philip Crosby

- i. Is widely known for his management book "*Quality Is Free.*"
- ii. Proposed that management create a system striving for zero defects.
- iii. Defined quality as containing four absolutes:
 1. Quality is defined as conformance to requirements.
 2. The system for causing quality is prevention, not appraisal.
 3. The performance standard must be zero defects.
 4. The measurement of quality is the price of nonconformance.

M. Armand Feigenbaum

- i. Developed the concept of total quality control (TQC), which later evolved as part of total quality management.
- ii. Believed that management and everyone in the organization must commit to quality.

N. Kaoru Ishikawa

- i. Created a cause-and-effect diagram (fishbone diagram) that allows a user to visualize all possible causes of a result and hopefully find the root cause of process imperfections.
- ii. Explored and popularized the concept of a quality circle—a small group of employees responsible for similar or related work functions that meets regularly to identify, analyze, and solve quality and production problems related to its work.

O. Joseph M. Juran

- i. His *Quality Control Handbook* is a classic reference work for quality engineers.
- ii. He was one of the first to incorporate the human aspect of quality management, which is commonly referred to as total quality management.
- iii. Juran summarized his quality teachings as
 1. Quality planning—includes activities such as identifying the customer, determining customer needs, translating customer needs into production language, and optimizing product features to meet customer needs.
 2. Quality improvement—means developing and optimizing a process that is able to produce a high-quality product.
 3. Quality control—means proving that the process can operate under normal conditions without the need for inspection.
- iv. Juran devised the four costs of quality described earlier.

P. Genichi Taguchi

- i. Created and developed two concepts:
 1. Quality loss function—a mathematical formula for determining the cost of poor quality
 2. Robust quality—an experimental design-based statistical approach for identifying the optimum product design configuration.

Q. Walter Shewhart

- i. Is considered the grandfather of quality management.
- ii. Preached the importance of adapting management processes to create profitable situations for both businesses and consumers.
- iii. Promoted the utilization of his creation, statistical process control (SPC) charts. (Chapter 11 further discusses SPC charts.)

VI. Quality Management Frameworks

R. Total quality management (TQM) is a quality management framework that addresses all areas and all employees of an organization, emphasizes customer satisfaction, and uses continuous improvement tools and techniques.

- i. The approach builds on the Japanese quality improvement practices and also encompasses many of the teaching and techniques of the gurus previously described.

- ii. The essential elements of TQM, as described in Figure 2.6, are
 - 1. Top management commitment
 - 2. Employee participation
 - 3. Customer focus
 - 4. Management by fact
 - 5. Continuous improvement
- S. ISO 9000 and ISO 14000 standards
 - i. The ISO (International Organization for Standardization) is a nongovernmental organization encompassing the national standards institutes of 157 countries.
 - 1. The primary objective of ISO standards is to make the development, manufacturing, and supply of products and services more efficient, safer, and cleaner.
 - ii. ISO 9000 has become an international benchmark for assessing quality requirements.
 - 1. ISO 9000 standards consist of a series of documents that describe the requirements and guidelines for quality improvement.
 - 2. The guidelines for ISO 9000 standards are based on eight principles, as outlined in Figure 2.7.
 - 3. Scholars debate the effectiveness of ISO 9000 as a quality management tool; some see it simply as a document management system.
 - iii. ISO 14000 helps organizations with environmental quality management.
 - 1. It focuses on minimizing an organization's harmful effects on the environment and on achieving continual improvement in environmental performance.
 - iv. Both ISO 9000 and ISO 14000 are known as "generic management system standards" because they are not specific to a particular product, process, or material.

Teaching Tip
ISO Standards

The importance of standards in our economy is not appreciated by the typical student. Ask students to think about the number of standards used even in a highly innovative and unique product, such as Apples iPhone or the Nintendo Wii. These include communication protocols and many of the physical parts (which are off the shelf electronic components used in many other products).

Teaching Tip
ISO 9000 and the Baldrige Award

Perhaps the key difference between these two programs is that one is a certification and the other, an award. There is no limit on how many firms can be certified, but, of course, only a small number of organizations can win an award. In spite of the differences, the similarities are great. This can be seen by showing the ISO 9000 criteria side-by-side with the Baldrige criteria and asking students to discuss the differences and similarities. This is a good way to get students thinking about the critical elements of a quality system.

T. Baldrige Framework for Performance Excellence

- i. The Malcolm Baldrige National Quality Award (MBNQA) is an annual award given to high-performing organizations within the United States. (<http://www.baldrige.gov>).
 1. The guiding framework of MBNQA can be considered an excellent model for implementing TQM.
 2. The Baldrige framework is based on 11 core values and concepts, as seen in Figure 2.8.

Best Practices in Operations Management

Setting High Quality Standards for French Wine

The AOC (*Appellation d'Origine Contrôlée*) standards protect French wines sold under well-known monikers such as Beaujolais and Bordeaux by setting standards for wines with these labels. This attests to the market value of quality. Wine makers are interested in protecting the integrity of these names precisely because customers will pay a premium for them. This is a great example of the relationship between quality and loyalty, reputation, and profitability discussed earlier in the chapter. Note that AOC means that products are *produced* in a consistent and traditional manner with ingredients from specifically classified producers in designated geographical areas. In other words, the standards are concerned with *how* the products are made, suggesting that a quality process yields a quality product. This is reflected in many other places in the chapter, such as Deming's *fourteen points* and Crosby's second *quality absolute*.

Best Practices in Operations Management

Profile of a Baldrige Award Winner: IBM Rochester

IBM Rochester embarked on a quality improvement journey before winning the Malcolm Baldrige National Quality Award 1990. During this journey, the following benefits were realized:

- 30 percent increase in productivity
- 50 percent reduction in product development time
- 60 percent reduction in manufacturing cycle time
- 300 percent increase in product reliability
- 400 percent increase in the warranty period and a decrease in the cost of owning and operating an IBM computer

This illustrates the many benefits of quality besides “reduction in defects.” It is also worth noting that many of the benefits, such as decrease in product development time, are internal improvements, rather than ones that are directly apparent to the customer.

VII. Six Sigma Quality Management Approach

Six Sigma is a comprehensive and flexible system for achieving, sustaining, and maximizing business success that is uniquely driven by a close understanding of customer needs; disciplined use of facts, data, and statistical analysis; and diligent attention to managing, improving, and reinventing business processes.

- U. Six Sigma has rapidly emerged as the dominant quality management framework used in manufacturing and service organizations in the last decade. Its basic concepts are as follows:
- i. It emphasizes the structured use of quantitative and data-driven quality improvement techniques.
 - ii. It is organized around DMAIC, a five-step plan, which stands for define, measure, analyze, improve, and control.
 - iii. The term *sigma* refers to standard deviation, a measure of variation from the perfect outcome. The number *six* refers to the objective that no measure should be less than six standard deviations from the desired standard to achieve almost perfection.

Best Practices in Operations Management
Motorola and the Genesis of Six Sigma

The use of Six Sigma concepts contributed heavily to Motorola's winning the Malcolm Baldrige National Quality Award in 1988. It is important to point out that Six Sigma is not limited to the production floor. Rather, Motorola uses Six Sigma in processes including research and development, product design, production, and support services.

Teaching Tip

The text points out that one reason Six Sigma process are key is that many processes are repeated millions of times per day. Thus, even low defect rates result in high absolute numbers of defects. (See the comments on the opening vignette in the instructor's guide, earlier in this chapter.) Another way to think about this (using Motorola as an example) is that there are approximately 200 components in a phone. It only takes one bad component for the entire phone to be bad. If every component has a 1 percent chance of being bad (a defect rate of 1 in 100), then the chances of any single phone having no bad components are $.99^{200}$. By contrast, if each component's quality is at the Six Sigma level, the chances are $.999997^{200}$. If students crunch these two numbers, they will see the big difference Six Sigma makes (13.3 percent of all phones good versus 99.9 percent good phones).

- V. The conceptual framework of Six Sigma: The major themes of the Six Sigma approach are the following:
- i. Genuine focus on customer needs and preferences.
 - ii. Management by fact.
 - iii. The unit of analysis is a process.
 - iv. A proactive management style is necessary.
 - v. Collaboration between employees working within different functional areas is necessary for the approach to succeed.
 - vi. Six Sigma strives for perfection.
- W. The technical goal of Six Sigma is to ensure that the variations that are present within a product process, a product, or a service become so small that the distance of six standard deviations to either side of the mean is still within the acceptable quality range.

- i. The acceptable quality range can be specified by a variety of sources, such as the customers, government regulations, industry standards, competition, or the organization itself.
 - ii. The acceptable quality range is usually represented by upper and lower tolerance limits (UTL and LTL). These two values represent the highest and the lowest value that a product, service, or process can have and still be considered to have acceptable quality.
- X. Implementing Six Sigma
- i. The Six Sigma approach is implemented using a structured five-step plan known as DMAIC (define, measure, analyze, improve, and control).
 - ii. Employees trained in the methodology go through a rigorous curriculum that focuses on the quality improvement philosophies, TQM, and advanced qualitative and quantitative techniques.

Problem-Solving Tip**Solved Example 1: Calculation of Sigma Level and Percentage of Defective Products**

As the text shows, there are two calculations for process sigma. This is often confusing for students. Here is the rationale. If the process average is the same as the midpoint between the UTL and LTL, then either calculation yields the same number. This is the case when the process average is the same as the midpoint of the specification. However, for many processes the process average is consistently closer to one tolerance limit or the other. In this problem, the process average is 3.5 units from the UTL and 4.5 units from the LTL—closer to the UTL. Thus, if the process goes out of spec, it is more likely to do so on the high side. The high side is the “risky” side for this process. In most cases, managers would be concerned with the computation that corresponds to this side of the process—the computation involving the UTL in this case.

ADDITIONAL EXERCISE**Understanding Multistage Production Processes**

This exercise is designed to help students understand the concepts in production processes.

Let's start with a *single-stage* process:

Use a deck of cards. Let's say hearts are defects. Shuffle the deck and draw 20 cards. As you draw, use a sheet of paper with 20 lines to record whether each card is defective (heart) or good. Count the number of defects (hearts). It should be about five. Divide by the total number of cards you drew. You will get a number close to .25, or 25 percent. Correspondingly, the proportion of nondefects is about .75.

Now let's consider a *multistage* process.

You need two decks of cards. Shuffle both decks (separately). Deck one is the first stage in our process. Deck two is the second stage. Take another sheet of paper with at least 20 lines and create three columns: a column for stage one, a column for stage two, and a column for the entire process. Draw a card from each deck and record whether each is defective (heart) or good (non-heart) in the

appropriate column. How many stages have to be good for the entire process to be good? They all do. So, in the third column mark “good” in each line for which BOTH stages were good and mark “defective” when EITHER stage one or two was bad. Total the columns, compute the defect rates, and compare them. Even though each stage is about 25 percent defective (75 percent good), the portion of times BOTH stages were good is much less than 75 percent. how would we estimate the proportion error free if we know that each stage is error free 75 percent of the time? Answer: $.75 \times .75$.

Now try a *three-stage* process.

If you repeat with three decks, you will again see that each stage has nondefective output (non-heart) about 75 percent of the time (proportion nondefective of $.75$). However, the proportion of the time that the entire production system produces error-free output is now very small. Per Solved Example 3, how would we estimate the proportion error free if we know that each stage is error free 75 percent of the time? Answer: $.75 \times .75 \times .75$

As you can see, the more complex the process, the more important it is to have high quality levels at each stage of the process. If you want to see this for yourself, repeat the three-deck experiment using kings, rather than hearts, as defectives.