



Quality Management

Learning Objectives

After completing this chapter, you should be able to:

- Define quality from both an internal and an external orientation.
- List the dimensions of service quality and quality for manufacturing.
- Understand how to gather customer expectations to ensure that the firm has captured the voice of the customer.
- Summarize the philosophies of W. Edwards Deming, Joseph Juran, Philip Crosby, and Genichi Taguchi.
- Explain how quality is built into a good or service.
- List and explain the components of total quality management (TQM).
- Describe the purpose and use of quality function deployment.

4.1 Introduction to Quality Management

Price and quality are two critical dimensions when deciding to purchase a good or service because these are key elements in the **value proposition**. That is, what does the buyer give up versus what does the buyer receive? When value proposition is high the benefits to the buyer substantially exceed the costs. Quality is a critical element in the purchasing decision because quality involves critical factors such as the safety of an airplane flight, the effectiveness of a surgical procedure, or the performance of an automobile. Quality is multifaceted because the quality of a service or good is judged on several factors. For example, the quality of an airplane flight not only includes the safety factor; it also includes departing and arriving on time, the comfort of the surroundings, and baggage handling. For an automobile, quality is not only performance; it also includes safety and specific features such as video entertainment systems and global positioning devices.

While quality is essential for organizational success, for many companies it is difficult to use quality to differentiate their products from their competitors' products for two reasons. First, customers may not consider products for purchase that do not have high quality.

Second, competitors have recognized the value that customers place on quality, and are striving for high quality by continuously monitoring customer expectations, investigating and implementing new technologies that enhance quality, and quickly imitating competitors' improvements in features and performance. To use an analogy from poker, high quality has become the ante, or minimum bet, to play at the table. Despite these challenges, companies such as Apple, FedEx, and Google have been able to develop and maintain very strong reputations for high quality while some of their competitors have not. RIM has fallen behind Apple; FedEx has

taken package delivery from the U.S. Postal Service; and Google is well ahead of Yahoo!. Simply put, companies that have a strong reputation for quality have been able to integrate quality throughout the organization, adopting an approach that infuses quality into company decision making. This approach has a variety of names; the one used here is quality management. The purpose of this chapter is to explain the nature of quality and how an emphasis on quality can be spread throughout the organization.



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From electronics and automobiles to clothing and produce, quality control is important to ensure that only the best items reach the consumer.

Perspectives on Quality

When asked, customers can articulate some of the criteria that determine whether a product has high quality. For example, a hotel room should be clean and comfortable, and the guest should feel safe. A washing machine should get the clothes clean. However, defining

quality is not always that simple. The factors included in quality assessment of a hotel room depends, at least in part, on its use. For a resort hotel, the pool, restaurants, beaches, and workout facilities are part of the quality decision. For a person who is stopping for one night at a hotel while driving on the interstate, the amenities included in the resort hotel do not matter. Traveling guests only care whether or not the room is clean, comfortable, and convenient. In the earlier example of the washing machine, one customer may want a large capacity washer that minimizes water use, while another may want a small, stackable washer-drier unit that is quiet. As a result, it is not possible to fully define quality, because quality is determined by the customer and how the customer will use a product. As a result, the definition of quality has both an internal orientation—quality from the company's perspective, and an external orientation—quality from the customer's perspective.

Internally Oriented Definitions of Quality

Definitions of quality that have an internal orientation directly measure characteristics of the product, such as the number of packages delivered on time or the thickness of an engine part. Two examples of internally oriented definitions of quality are:

1. Quality is the degree to which a specific product conforms to its design characteristics or specifications. Surgeons must follow the proper procedure as the surgical team closes the incision, thereby ensuring that no sponges or other items are left in the patient. Robots must place the spot welds in the proper location on the body of the automobile in order to maximize its strength.
2. Quality can be measured as the amount of a specific, desired attribute, such as window tint or cheese on a pizza.

One shortcoming of internally oriented definitions is the company's assumption that the product specifications match what the customer wants—an assumption that may not be correct.

Externally Oriented Definitions of Quality

Quality with an external orientation focuses on the customer, and typically includes a discussion of "fitness for use." In other words, quality cannot be effectively measured in the abstract. For example, a resort hotel with the finest food, cleanest rooms, best beaches, and friendliest staff does not meet the needs of the cross-country traveler who will spend only a few hours in the room. When quality is measured by customer wants, the resort hotel does not have the right fit for the cross-country traveler, so it is not the right quality. Quality is the capacity to satisfy customers' needs.

In some cases, customers may not know that they have a need for a product because customers may not imagine what is possible. A few years ago, when Ford Motor Company introduced the SYNC system to manage mobile phone, music, and other digital technology in its vehicles, it was done to satisfy a desire from car owners, but one that was not clearly articulated. SYNC set new expectations for communication and entertainment systems in vehicles.



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Consumers have different expectations when staying in a motel or when staying in a 5-star resort. The level of quality will be evaluated differently for each of these locales because quality is based upon meeting or exceeding the customer's needs and expectations.

Although it may appear that externally oriented definitions of quality are still somewhat vague, companies known for high-quality goods and services specifically define the parameters of quality. **Quality** means consistently meeting or exceeding the customer's needs and expectations. Quality begins with an external process that identifies the customers' needs and expectations. Then, those needs and expectations are translated into an internal process to guarantee they are met or exceeded. One way of formalizing that process is called quality function deployment, which is discussed later in this chapter. Quality function deployment takes customer expectations and transforms them into specific actions designed to meet those expectations.

Understanding Customer Expectations

It would seem that a company that wants to achieve excellent external quality would simply ask its customers what they want and provide these things to them. Asking customers what they want is useful and provides important information, however, it is not sufficient for the following reasons. First, customers often have unspoken desires. If you survey customers and ask open-ended questions such as what they want on an airplane flight, they are much more likely to say on-time arrivals and departures, faster check-in times, and better and faster security screening by

TSA. It is not likely they would say they do not want to crash. Customers assume that the airline understands safe transportation as a basic need, so it is unspoken despite that it is the most important need of the customer. Referring to the poker analogy used earlier, safety is part of the ante that every airline must have to remain in the game. Second, customers operate in the environment of what is known, and often do not think about what is possible. If a company operating 200 years ago asked its customer how they might like to communicate in the future, it is unlikely that the customers would have described voice over wire telephones. If customers were asked 50 years ago about the future of person-to-person communication, it is unlikely that customers would have mentioned wireless communication devices, the Internet, and high-speed data services. Twenty years ago, few customers would have thought to ask for the ability to download video to their wireless device. Mobile phones were large, clumsy devices that could only make phone calls and were unreliable. Organizations must go beyond asking customers what they want and understand what their customers value, such as how they do their work and what makes customers happy. If companies understand these needs, firms are able to see how new ideas and new technology may help customers do more work or enjoy a better lifestyle. Firms should ask the following questions when they want to understand customers' expectations:

1. Ask customers what they want.
2. Ask customers specific questions about attributes of the product that are not mentioned by the customer: Probing the customers with specific questions about their needs may lead to unspoken expectations.
3. Ask customers about their operations or how they will use the product: Knowing how the customer functions and how they use the product can lead to a better understanding of what and how new ideas and technologies could help them. The success of Facebook, Twitter, and Apple are based on creating services and goods that customers would use despite the customer not understanding the product and its application prior to product launch.
4. Ask customers how their customers use the products: Knowing the needs of the customers' customers can help the organization better understand the impact of its product on the value-creation chain and, therefore, meet the needs of the final customer in this chain.

4.2 Dimensions of Quality

Understanding the dimensions of quality is an important step in transforming customers' needs and expectations into internal processes. The differences between goods-based and service-based organizations have some significant impacts on the way quality is determined and measured. For example, because services are intangible, the quality of services will be based much more on human perception. As a result, the dimensions of service quality are somewhat different than the characteristics of quality for manufactured products.

Service Quality

The following five dimensions of quality are often used by customers to judge service quality. Understanding these dimensions helps firms to define quality and determine what steps are needed to improve quality.

1. Reliability—ability to perform the promised service dependably and accurately.
2. Responsiveness—willingness to help customers and provide prompt service.
3. Assurance—knowledge and courtesy of employees and their ability to convey trust and confidence.
4. Empathy—provision of caring, individualized attention to customers.
5. Tangibles—appearance of physical facilities, equipment, personnel, and communication materials, including access and effectiveness of Internet-based information.

Some examples of these five dimensions are shown in Table 4.1. The reliability and responsiveness of a service are at the core of how customers evaluate service quality. This is because customers expect the service to be performed well and to be complete at the time demanded by the customer. Most services rely on people to design the operation systems and to do the work. A hairdresser's reliability and responsiveness clearly impacts the client served in a beauty shop. Likewise, it is people who determine how the system of service providers for mobile devices works, including the likelihood of dropped calls, clarity of voice, and speed of data downloads. If a company fails to provide reliability and

responsiveness, it is more likely to lose a customer than if other factors or services fail. In other words, it does not matter how nice the furniture in your hotel room looks if the staff is rude.

Table 4.1: Examples of service quality dimensions

Reliability	• Did the express package arrive on time? • Was my DVR repaired correctly?
Responsiveness	• Did the florist deliver the flowers as ordered? • Does the hotel send up an extra pillow as requested? • Does the credit card company respond quickly when I have a question about my statement? • When an employee says he will call me right back, does he?
Assurance	• Can the salesperson answer my questions about the computer on sale? • Does the car mechanic appear to know about my car? • Does my physician politely and knowledgeably answer my questions?
Empathy	• Does someone in the restaurant recognize me as a regular customer? • Is the salesperson willing to spend the time to understand my particular needs? • Does my advisor work with me to develop a program of courses for my specific career goals?
Tangibles	• Is the hotel room furniture clean and modern? • Does the auto repair shop appear neat and tidy? • Is my bank statement easy to understand?

Real World Scenarios: Southwest Airlines

Southwest Airlines combines reliability with subjective quality dimensions for a winning combination in the airline industry. The dire situation for many airlines has been demonstrated by bankruptcy filings, companies closing, mergers, and record losses. While legacy companies such as United, American, and Delta have been losing money, Southwest has maintained profitability and also has remained at the top of customer satisfaction rankings. Southwest does this by maintaining a clear focus on the customer and meeting the customers' needs. Customers want low fares and reliable, high-value service, and Southwest provides fares that are consistently below those of competitors. In addition, fees are not charged for luggage transport. Southwest often resists attempts by its competitors to raise prices because it is a low-cost provider. It keeps costs low primarily because its employees are motivated, energetic, and are stakeholders in the company. In addition, Southwest empowers its employees to do what they can to solve any customer problems that arise.

Quality of Goods

In examining the dimensions of quality for goods, it is important to recall that a good is tangible, and therefore, direct contact between the customer and the employees who make the good does not often occur. As a result, the factors that comprise the quality of goods are quite different from the factors that comprise quality service. People at all levels of the manufacturing organization are still critical when determining quality because they design and build the product. The impact of these employees on the customer, therefore, is transmitted through the customers' use of the product. The following list describes the

factors that determine quality for goods. As can be expected, these focus on specific attributes of the product and do not include human factors, with the exception of serviceability:

- Performance—primary operating characteristics of a product.
- Features—secondary characteristics that supplement the product's basic functioning.
- Reliability—length of time a product will function before it fails, or the probability it will function for a stated period of time.
- Conformance—degree to which a product's design and operating characteristics match pre-established standards.
- Durability—ability of a product to function when subjected to hard and frequent use.
- Serviceability—speed, courtesy, and competence of repair.
- Aesthetics—how a product looks, feels, sounds, tastes, or smells.
- Perceived Quality—image, advertising, or brand name of a product.

For the quality of goods, performance and features are important dimensions of the product. These are often key elements in the purchase decision whether the product is a mobile device, a vehicle, or an appliance. Reliability is common to both services and goods, but as expected with a good, it is linked directly to how the product performs. Conformance is a positive dimension in some applications, but may be negative in other applications. When purchasing paint that is to match an existing color, a replacement door, or new brakes for a car, conformance to specifications is vital. Conversely, non-conformance may be desirable for other items such as clothing or furniture. Durability is another trait of goods that can be measured and assessed, and is often more important for goods that provide function rather than form, such as markers for white boards, hand mixers, and can openers. Most people want these products at low cost and want them to last a long time. The last three characteristics are more subjective in nature. With serviceability, the customer often interacts directly with the employee who is doing the work, so this factor has similar characteristics to service quality. Aesthetics refers to how a product looks, which is subject to individual tastes, and is often difficult to assess. Perceived quality is similar to aesthetics because customers may have different expectations.

Costs of Quality

Traditionally, companies thought of quality costs only as those that were necessary to produce higher quality. In fact, as many companies have discovered, higher quality can mean reduced costs because of savings from reduced scrap, rework, and customer warranty claims. Whether performing a medical test or assembling a mobile device, correctly completing a job the first time improves quality and lowers costs. Identifying and eliminating steps in a process that do not add value for a customer has the potential to reduce selling price. While it may not be true in every instance, there is truth in the statement that "quality is free." Consider the following three categories of the costs of quality:

1. Failure costs—can be internal to the organization or external involving the customer.
2. Appraisal costs—investment in measuring quality and assessing customer satisfaction.
3. Prevention costs—put a stop to the quality problem.

Failure Costs

Failure costs are incurred whenever any product or component of a product fails to meet requirements. Such costs can be divided into two categories: internal or external. **Internal failure costs** are those associated with defects found before the product reaches the customer. Examples of this include the costs of correcting errors in a customer's bank account, discarding food that was improperly cooked, scrapping defective parts, or reworking products that contain defects. In some cases internal failures can be dangerous to employees, such as when a building collapses while under construction because of defective materials.

External failure costs are incurred after a product has reached the customer. This can include the cost of warranty repair work, handling complaints, or replacing products. The costs of lost goodwill and possible liability if someone is injured or killed because of an external failure can be considerable. The costs of external failure can be especially devastating if customers are lost.

Highlight: Product Liability

There are huge costs associated with quality problems when products reach customers. There are dozens of examples, including sudden acceleration in Toyota's vehicles, tread separation on Firestone tires, mistakes in surgeries, and structures that unexpectedly collapse because of poor design or construction. These problems can generate lawsuits that are expensive to combat (and more expensive to settle), and negatively affect the reputation of the company. Another example is Boeing's attempts to deal with problems that arose soon after the release of its 787 Dreamliner. Worries about the potential for battery fires led to jet's grounding soon after its release. The company's ability to address the problems will impact the demand for its products and the profitability of the company.

Appraisal Costs

Appraisal costs are the costs incurred to measure quality, assess customer satisfaction, and inspect and test products. Activities that are designed to improve quality by better understanding the current performance level of a product are included in appraisal costs. Appraisal costs could include the cost of conducting a customer satisfaction survey, hiring an individual to visit, and inspect each property in a hotel chain, or testing new notebook computers to be sure they will operate as intended. In electronic components, most failures take place during the first 90–180 days of operations or during the wear-out period at the end of the product's life, and the defect rate between these two events is very low.

Highlight: Feedback for Hotels

Hotels such as Marriott, Hyatt, and Sheraton have resorts across the United States and around the world. These firms want to know what their customers like and dislike so that each hotel can make sure that a guest's stay is enjoyable. Hotel managers spend much time and effort to collect feedback from their customers. They examine past patterns of use in an effort to make the next stay even better. These firms search their records to determine what customers purchased in their gift shops and restaurants, which tours were booked through the concierge, and which room service requests were made. In this way, these hotels can attempt to ensure a satisfied customer and another stay at the hotel chain. Because there is a large investment in a hotel's facility, a room that is not booked for one day loses revenues that can never be recovered. This is unlike a washing machine that does not sell today but can be sold tomorrow. In addition to the physical facilities, there is substantial management overhead within a hotel and at its headquarters. This overhead must be paid whether or not a room is booked. The labor at the hotel that cares for the grounds, prepares the food, and checks in guests is paid whether or not the room is rented. Most of the costs associated with running a hotel are fixed and are not alleviated when a room is not rented. Thus, customer satisfaction is critical for success.

Prevention Costs

Prevention costs result from activities designed to prevent defects from occurring. Prevention costs can include activities such as employee training, quality control procedures, special efforts when designing products, or administrative systems to prevent defects. One example is the cost of modifying a bank's computer system to request confirmation whenever a teller's entries are unusually large or unusually small. Electronic confirmations are also seen on entry screens for online purchases and other applications. For example, an error message will appear if a digit in a telephone number is missing, and the customer will not be able to advance to the next screen. Conversely, if an extra keystroke is made in an attempt to enter a phone number, the system will not accept it. Critical information, such as e-mail addresses, require the customer to enter the data into these systems twice. The two entries are compared, and if they are the same, the user can advance to the next screen. Double-entry greatly reduces the chance of an incorrect entry. There are many examples of this in manufacturing as well, but customers do not see them. Manufacturers design assembly systems so that a part can only be assembled in one correct way. If it fits or snaps in place, it is correct. Parts are color-coded to ensure they are placed correctly on the right product. Thousands of preventative measures have been implemented to reduce the cost of maintaining quality in manufacturing.

Highlight: Poka-Yoke: Mistake Proofing

Poka-yoke is an approach adopted by many companies to prevent defects. This term is a rough approximation of Japanese words that mean “mistake proofing.” For example, Dell uses color-coding on its connections so that when customers set up their computers at home, they are less likely to plug the printer cable into the monitor connection. This results in a better experience for the customer and higher customer satisfaction.

At one time there was a philosophy that companies should trade off the costs of prevention for the costs of failure. This resulted in the belief that companies should be willing to accept an optimum level of defects. Many companies now find that a reputation for high quality has benefits that far outweigh any additional prevention and appraisal costs associated with achieving high quality.

Six Sigma

For many years, companies accepted a 1% to 3% rate of defects in goods and services, which is as many as three defects per hundred units. A few years ago, Motorola, a world-recognized quality leader, set for itself a goal of **Six Sigma** quality. Six Sigma relates to the firm’s ability to produce error free products. For the statistician that is six standard deviations rather than three standard deviations, which is often discussed when applying the normal distribution. While three standard deviations equals approximately 2.6 defects per 1,000 units, or 99.74% error free, six standard deviations equals 3.4 defects per 1 million units, or 99.9966% error free. The old standard of 1% to 3% defects, which is not very restrictive, would generate about 34,000 defects per 1 million. Six Sigma increases expectations and attempts to slash defects drastically.

Six Sigma is a collection of ideas and programs that are intended to improve the quality of a service or a good by using tools that identify the root cause of the defects and then implement programs to eliminate the underlying problem that caused the defects. Tools such as a **fishbone chart** allow the firm to trace a problem that the customer sees to the root cause of the problem. For example, long delays in baggage delivery at the airport could be the result of insufficient staffing, insufficient baggage handling equipment, or poor loading procedures that make it difficult to find the right bags. Then, tools such as simulation or mathematical modeling (which are discussed in a later chapter) can be applied to determine how the problem may be solved and the baggage handling process improved. Six Sigma helps the firm make its processes consistent because when Six Sigma is achieved a defect (late baggage delivery) occurs only 3.4 times out of 1,000,000. Six Sigma may be good enough for baggage delivery, but sometimes, Six Sigma is not enough. Passengers on the airlines want results that are better than 3.4 crashes for every 1,000,000 airline flight, or about one crash in 300,000 flights. There would be several crashes each day if a three sigma standard was used, and dozens of crashes per day if a 3% defect rate was allowed.

Six Sigma develops a cadre of specialists within an organization called “Black Belts” and “Green Belts,” who are experts in specific methods. Six Sigma follows a set of steps that investigates the operations process and leads the team toward outcomes that can be measured, analyzed, improved, and controlled. The effectiveness of the baggage handling

process is measured by customer wait time, and the airline should have a performance target. The outcomes of these processes are important to the company and, ultimately, to the customer.

Six Sigma is based upon the implementation of ongoing, well-documented, and highly visible activities. It is common for highly placed executives in the firm to be Black Belts and to train new Green Belts and Black Belts. These firms want their employees to live and breathe quality, so that quality improvement efforts are sustainable.

4.3 Foundations of Quality Management

The groundwork for today's philosophies about quality was implemented over a long period by many different people. Some of the best-known individuals working in quality control have been writing, teaching, and lecturing for many years. In fact, two, W. Edwards Deming and Joseph M. Juran, are credited with major influence on the approach to quality in Japanese organizations.

W. Edwards Deming

Until his death in 1993 at the age of 93, W. Edwards Deming was probably the most influential individual within the specialty of quality. Deming began his career as a statistician and became involved in quality when he worked with Walter Shewhart, the founding father of statistical process control. **Statistical process control (SPC)** is the use of statistical methods to determine when a process that produces a good or service is getting close to producing an unacceptable level of defects. When the process crosses a particular threshold, it is moving out of control. After World War II, Deming went to Japan under the auspices of the U.S. government as part of an effort to rebuild Japan's economy. His influence on the Japanese was so great that today, Japan's highest prize for quality is the Deming Prize. Surprisingly, Deming was largely ignored in the United States until the 1980s. Beginning in the 1980s, Deming lectured extensively to large audiences throughout the country until his death in 1993.

Deming's philosophy is illustrated by his well-known 14 points for the transformation of management, shown in Table 4.2. Today, there is still confusion and disagreement about what is meant by some of Deming's points; however, Deming's basic premise notes that the system, *not* employees, causes defects. Management is responsible for changing the system, and must



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American statistician W. Edwards Deming was highly influential in the development of quality management.

accept that responsibility instead of blaming employees when defects occur. Because of his background, Deming also stressed the use of statistical process control, and encouraged training all employees in its use.

Table 4.2: Dr. W. Edwards Deming's 14 points for the transformation of management

1. Create constancy of purpose toward improvement of product and service. Aim to become competitive and to stay in business, and provide jobs.
2. Adopt the new philosophy. We are in a new economic age. Awaken to the challenge. Learn the responsibilities, and take on leadership for change.
3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection. Build 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 on 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 and thus constantly decrease cost.
6. Institute training on the job.
7. Institute leadership.
8. Drive out fear, so everyone may work effectively for the company.
9. Break down barriers between departments.
10. Eliminate slogans, exhortations, and targets for the workforce asking for zero defects and new levels of productivity.
11a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.
11b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.
12a. Remove barriers robbing the hourly worker of his right to pride of workmanship. Change the responsibility of supervisors from sheer numbers to quality.
12b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. Abolish the annual or merit rating and 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.

Source: Deming, W. E. Out of the crisis. Cambridge, MA: MIT Center for Advanced Engineering Study, 1986.

Joseph M. Juran

Joseph M. Juran, who was an active lecturer until 1995 when he retired, was also a colleague of Walter Shewhart, and lectured and taught in Japan after World War II. Some have argued that Juran's contribution to Japan's quality efforts was even greater than Deming's. Like Deming, Juran emphasized management's responsibility for ensuring quality. Juran, however, focused on the customer by defining quality as "fitness for use."

He also emphasized the need for continuous improvement and stressed that quality must be built on three elements: quality planning, quality control, and quality improvement.

Philip Crosby

Philip Crosby became internationally recognized with the publication of his 1979 book, *Quality Is Free*. In that book, and in later publications, he argues that failure costs are much greater than most companies had thought. By reducing failure costs, companies can save money, hence the title of Crosby's book. Crosby is most often recognized for emphasizing the importance of considering all costs of quality. He is also responsible for promoting the idea that all errors must be eliminated, indicated by his slogan "do it right the first time," and the concept of zero defects.

Genichi Taguchi

Japanese companies were among the world's first to place a strong emphasis on quality, so it is not surprising that several people from Japan have made significant contributions to the field of quality. Genichi Taguchi's ideas are particularly important. Taguchi first gained prominence shortly after World War II, working with research facilities to develop Japan's telephone system. After noticing that considerable time and effort were expended in experimentation and testing, Taguchi developed procedures for designing experiments so that more information could be obtained with fewer experiments. Taguchi has also contributed an entire philosophy about how products should be designed, and that philosophy now forms an important part of quality management.

Taguchi argues that quality must be designed into a product. His point is that quality cannot be achieved through inspections after the good is made or the service is provided. Thus, an important part of Taguchi's philosophy is based on the concept of **robust design**—designs that guarantee high quality regardless of variations (such as employee errors) that may occur during the processes that produce the product. For example, McDonald's has designed a ketchup dispenser that puts precisely the right amount of ketchup on each burger, eliminating variations in product quality that may result from employees dispensing too much or too little.

Building Quality into Product

Design for manufacture and assembly (DFMA) emphasizes that products should be designed so they are simple and inexpensive to produce. This concept has also been applied to service operations under the term **design for operations (DFO)**. Both concepts underscore that the design of the product and the process by which the product is made are key factors when determining quality. Quality inspection does not improve the underlying quality of the product or the process. Building quality into a product, rather than trying to inspect it into the product, is described in the following:

1. *Product Design*: This is how the product, either a good or a service, functions. It determines the features, functions, aesthetics, and performance of a product, which are essential parts of the product's quality. For example, the capabilities of an electronic device such as a notebook computer are determined by product design. The product design determines the capability of the display, the size and

- performance of the processor, and Wi-Fi accessibility. Product design also determines the reliability, durability, serviceability, and other key quality elements. The ability of Travelocity to provide robust and reliable service depends upon how it designs its servers, the user interface, and access to travel data. In large measure, the cost to produce the good or to provide the service is determined when the product is designed. Product design is one of the most important decisions a firm will make.
2. *Process Design:* This is how the product, either a good or a service, is produced. Process design includes the methods that the firm uses to transform the product ideas created in the product design into the good or service that the customer is purchasing. In manufacturing, process design includes selecting the materials, facilities, and equipment used to make the product as well as determining the labor skills needed to execute the process plan. In restaurants, decisions regarding the quality of the purchased food are important. In health care, facilities and equipment selection are also a very important decision. In banking, materials are really not an issue and facilities and equipment are limited to office space, ATMs, and basic office equipment. By their nature, process design for service operations heavily depends upon people skills. In many service operations, labor costs represent 70% or more of the cost of providing a service.
 3. *Work Execution:* This is the performance of the plan created in the product and process design. If the product design and the process design represent the football game plan, then playing the game is the work execution. The success of this depends on how well the plan is communicated to the workforce, whether the workforce has been selected so it has the basic skills to execute the plan, and how well the workforce has been trained to do the work. When these functions are performed well, the product and process designs should be well executed and a high-quality product should be produced.
 4. *Inspection:* This is an assessment of the quality of the good or service. If the first three steps are properly performed, then inspection is, theoretically, unnecessary. Inspection provides feedback about how well the product is designed and built. Its primary benefit is to identify quality problems and connect them to their sources. Defects may be caused by a poor product design (such as a defective software interface), a poor process design (such as equipment that is unsuitable for the product), or poor work execution (such as an untrained worker or poorly executed maintenance plan). Inspection does not increase the quality of the products being produced, but it may prevent defective products from reaching the customer. The primary purpose of inspection is gaining information that helps the firm improve quality by changing design and work execution.

4.4 Total Quality Management

Total quality management (TQM) is an approach to quality management that originated in Japan and was adopted successfully by many companies throughout the world, including American Express and GE. TQM is an organization-wide philosophy that embodies the following components:



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American Express utilizes the total quality management (TQM) approach that emphasizes continuous improvement and customer focus, among other things.

- Focus on the customer
- Quality function deployment
- Responsibility for quality
- Team problem solving
- Employee training
- Fact-based management
- Philosophy of continuous improvement

Each of these components is discussed next, in detail. It should be stressed, however, that they apply to all aspects of a company's operation, from design of products and processes to distribution and after-the-sale service. Further, all parts of the company must be involved, including those which do not usually interact with external customers, but instead serve other parts of the company.

Focus on the Customer

Customers are usually those outside a company, specifically the people or the organizations that purchase the good or service the company produces. However, it is also possible to think of internal customers as parts of an organization that utilize information or other outputs from another functional area inside the organization, such as accounting. In a hospital, the laboratory could think of the physician who requests lab work as its customer. Thus, a customer can be anyone, whether inside or outside an organization, who receives the output from an activity or process.

Juran's definition of quality as fitness for use provides the groundwork for focusing on the customer. Unfortunately, many companies in the past have identified what they thought the customer wanted without actually asking the customer. Companies that use TQM rely on what is called the voice of the customer.

The **voice of the customer** describes what customers want and what they like and do not like. Listening to the voice of the customer is essential to be successful. To do this, many companies get to know their customers personally. For example, some companies hold focus groups, in which customers are contacted to discuss their wants, needs, and expectations, and to respond to proposals to change the good or service produced. Companies ask questions about how the customer uses their product. If a company understands its customers, it can better meet or exceed their needs and expectations. Listening to the voice of the customer is more than providing customers with what they request. Simply stated, customers are likely to verbalize what it is with which they are familiar. If a new technology is available and customers are not aware of it, they will not know how to describe their need. If the company understands the customer and the customers' wants, it may

have ideas and technologies that could be applied to meet a future need. For example, which customers told Apple that they wanted a small portable device that could download and play music on the run (the iPod)? Apple has succeeded by anticipating what technology customers may want and how they could use these products.

Quality Function Deployment

The quality of a product, whether that product is a manufactured good or a service, is largely dependent upon how well the product and the processes for producing it were designed. Listening to the voice of the customer provides a company with valuable information. That information, however, usually describes the customer's needs or expectations, such as the need for transactions at a bank to be handled quickly and accurately, or the expectation that a room reserved at a hotel will be available when the guest arrives. Those needs and expectations must be transformed into design characteristics for the product and process. **Quality function deployment (QFD)** is one method that can be used to make that transformation by relating customer needs and expectations to specific design characteristics through a series of grids or matrices.

Figure 4.1 shows the basic form of the matrix used in QFD, which is often called the **house of quality** because of its shape. The customer needs, or "WHATs," are listed along the left-hand side of the matrix. Design characteristics related to these needs are listed along the top as "HOWs." The relationship matrix in the middle (WHAT versus HOW) indicates the nature of the relationship between each customer need and each design characteristic. Figure 4.2 shows the house of quality for a limited set of customer needs related to an automobile. As shown, the need for good gas mileage is positively related to the design characteristic of fuel economy, negatively related to acceleration, and has no relationship to turning radius. In some cases, the simple plus or minus signs used in Figure 4.2 are replaced by other symbols indicating the strength of the relationship, from strongly negative to strongly positive.

Figure 4.1: The house of quality

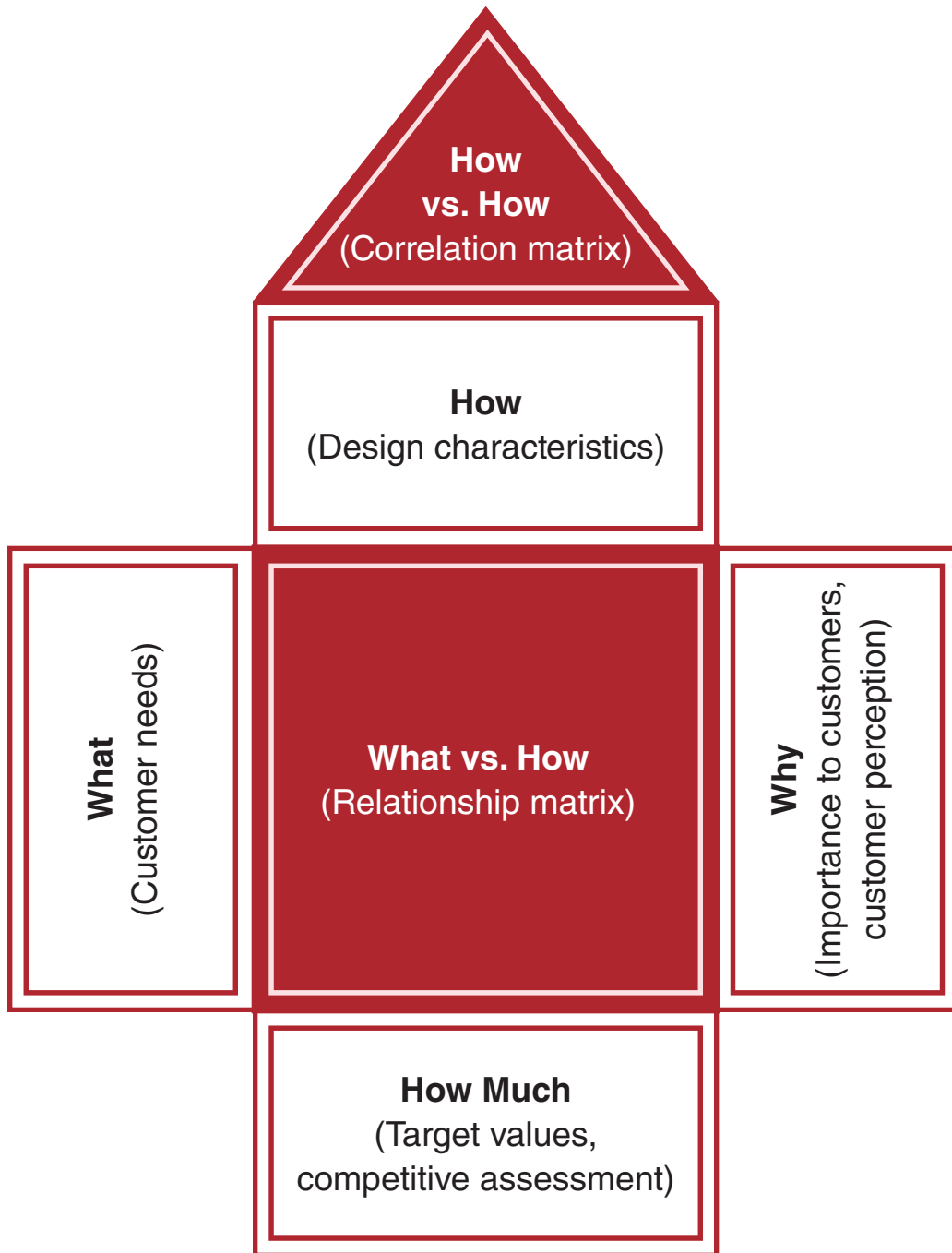
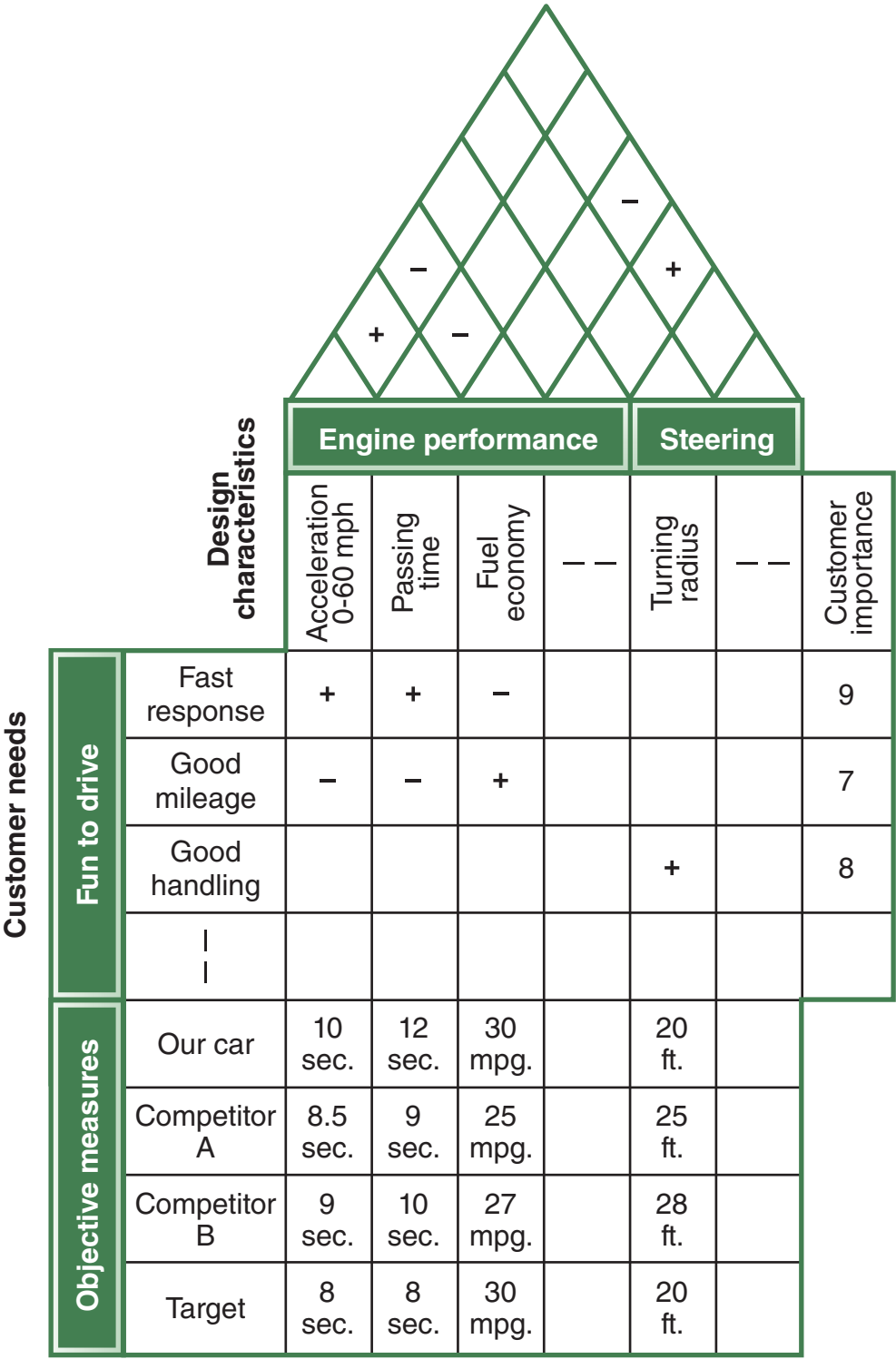


Figure 4.2: House of quality for an automobile

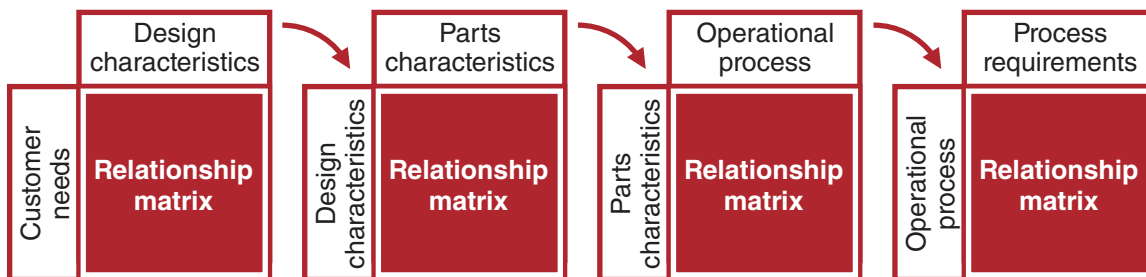


When designing products and processes, companies often face trade-offs, such as that between fuel economy and acceleration. The house of quality can help a company evaluate trade-offs. The roof part of the house shows how each design characteristic affects other design characteristics. The right-hand side of the house shows the importance of each customer need, and can also indicate customer perceptions about how well the company is performing relative to competitors. Performance on each design characteristic can be compared against competitors along the bottom. Thus, less emphasis may be placed on a customer need that is not very important, or on a design characteristic in which the company already outperforms the competition. The house of quality shown here is only a simple example; those developed by companies can be very complex.

This first house of quality translates the voice of the customer into design characteristics, but characteristics alone will not indicate to the firm how to make a car. Those design characteristics must be transformed into parts characteristics, as shown in the second house in Figure 4.3. Parts characteristics define how the engineering characteristics will be achieved, but the parts characteristics can only be achieved when the process is planned to do so. Thus, a third house is required to convert the parts characteristics into operational processes that describe how the parts are to be produced to obtain the required characteristics. In the fourth house, the operational process is the basis for determining the production requirements, which specify inspection details, measuring methods, operator training, and related details.

Using the four steps shown in Figure 4.3, the voice of the customer has been deployed throughout the entire organization. Further, all parts of the organization have worked together to achieve that deployment.

Figure 4.3: Successive houses of quality deploy the voice of the customer throughout the organization



Responsibility for Quality

In the past, many companies used quality control (QC) departments to ensure quality. Unfortunately, this practice allowed others in the organization to assume that the QC department was solely responsible for quality. Organizations that embrace TQM have realized that everyone must accept responsibility, from the company CEO to the person who cleans the parking lot. Each individual contributes to quality (or lack thereof) in some way. In addition, company suppliers must also accept responsibility for their role in quality. It is essential that TQM have top management support and commitment in order for it to succeed.

Real World Scenarios: Ritz-Carlton: Quality-Infused

The recent experiences of one person who stayed at the Ritz-Carlton in Georgia demonstrate the value of infusing quality into the organization. One night, the guest wanted a newspaper, but the gift shop was closed. During her late dinner (the hotel employees insisted on keeping the kitchen open past its closing time to serve her), she asked if any customers had left a newspaper behind. The waiter returned in three minutes with copies of the *Atlanta Constitution*, *USA Today*, *New York Times*, and *Wall Street Journal*. Of course, the guest was not charged for the papers.

This attention to meeting the needs of the customer and also to delighting the customer is directly ordered from the head of Ritz-Carlton Hotels. Because of its top-level commitment to customer care, Ritz-Carlton has won the Malcolm Baldrige Award, a national quality award. Quality, however, extends to every activity at the hotel.

When this guest stayed at the same Ritz-Carlton on another occasion, the hotel's concierge had located a special store for her. When no taxis were available, a doorman was summoned to drive her in a hotel car. Along the way, the doorman explained that he had just completed three days of training before being allowed to open the door for customers. Of course, once again, the guest was not charged for the car service to and from the store. As may be expected, the customer was delighted by this service.

Team Problem Solving

Problems are often encountered when attempting to meet or exceed customers' needs and expectations. For example, a hospital may find that emergency room patients with problems that are not life-threatening complain they have to wait too long for service, or an automobile manufacturer may find that its customers want an increasing number of product options but want prices to remain low. Problems like these can be solved better by a team than by one individual. Team efforts to problem solve allows for different viewpoints and also enables the team members to split the workload and to brainstorm possible solutions with one another. When an organization faces a complex problem, a team approach to decision making may be more effective than relying on one individual to make the necessary decisions. One person may not have access to all the information, nor have the broad range of knowledge needed to understand the problem, design alternative solutions, and select the best approach. Group decision making is also very useful when building commitment to the selected alternative. When top management makes decisions, commitment to make alternative solutions work may be low, thereby making implementation very difficult. Convincing people to use a new approach is easier when each person is involved in the decision-making process. When a group is involved, each member will find ways to make the new approach work, rather than find excuses for why it will not.

Employee Training

Deming emphasized the importance of training employees to use the tools of statistical process control. As organizations have adopted a team approach to problem solving, it has also been determined that employees need training to work effectively in groups, and to use group problem-solving tools. Pareto charts that identify the most frequent causes of quality problems, cause and effect diagrams that illustrate the root cause for a

problem, and quality control charts that assess quality conformance are just three of many techniques.

Fact-Based Management

Companies that use TQM must determine what their customers' needs and expectations really are, not what the company thinks they are. This philosophy of basing decisions on facts, data, and analysis—instead of intuition or inference—extends to other areas of the TQM company. Companies today are beginning to operate with a new saying: "What gets measured gets attention." This has always been true as employees concentrated on the criteria they knew would be used to judge them. Now companies are realizing that those criteria must tie into the company's competitive strategy. As a result, some of the most important measurements today are those related to quality. These measurements of quality include not only internal measures, such as the number of customer complaints received or the percent of products reworked, but also external measures, such as customer satisfaction. In many cases, firms are taking quality to the next level. They are seeking to know more about their suppliers' satisfaction at working with them, as well as the suppliers' capabilities. If the firms know something about the suppliers' capabilities, they may be able to use those capabilities in new ways. Product quality and satisfaction of the final customer are determined by all of the participants in the supply chain, so knowing something about suppliers is important to quality improvement. For example, the equipment supplier for a medical test such as a CAT scan, or the supplier of hardware for a furniture manufacturer impact the quality of the service or good purchased by the customer.

Benchmarking

Benchmarking is a process by which a company compares its performance to the performance of other companies. Those other companies need not be competitors, nor be within the same industry. Instead, the purpose of benchmarking is to set a standard based upon the company that is recognized as the best at a certain activity. As an example, many companies use L.L. Bean as a benchmark for online ordering and order fulfillment. To be effective at benchmarking, firms must understand that a benchmark does not define the best possible outcome; it only identifies what a company has achieved. Choosing the wrong companies to benchmark can lead to setting standards that are too low. As a result, a benchmark is only one piece of information that companies should use to set performance goals for quality or any other important outcome.

Broader Measures of Performance

Companies have traditionally measured their performance using the accounting standards of cost and profit. Today, those standards alone are insufficient. Quality is an important performance measure that must be used, especially by companies using TQM. Customers' needs may include other factors such as delivery speed, flexibility, or innovation, therefore, the performance measurement system must also include these factors.

Philosophy of Continuous Improvement

The philosophies of Deming, Juran, and Crosby all include the concept of **continuous improvement**. No matter how good a company is, it must always work to do better. This

philosophy of continuous improvement is an extremely important part of TQM. Companies adopting continuous improvement as an organizational philosophy have found that the following key components are necessary:

- Standardize and document procedures.
- Assign teams to identify areas for improvement.
- Use methods analysis and problem-solving tools.
- Use the Plan-Do-Check-Act cycle (see Figure 4.4).
- Document improved procedures.

Standardizing and Documenting Procedures

Standardization and documentation form the basis of continuous improvement as shown in the preceding list, which begins and ends with documentation. Standardization involves developing a preset procedure for performing an activity or job. Documentation is the act of putting that procedure into writing. Standardization and documentation are necessary for continuous improvement so the organization knows exactly how something is being completed now (the “as is” condition). After the process has been improved, the firm should document the new procedure (the “should be” condition) so that it becomes the new standard procedure. Documentation and standardization are especially important for companies that want to become registered under ISO 9000:2000, which is a widely-used international quality standard. It should be noted, however, that the purposes of documentation and standardization are not to prevent change in the process, but to ensure that within a given process, each person performs a task the same way every time. As better ways are found, the documentation and standardization are changed to promote continuous improvement. For example, service organizations rely extensively on documentation and standardization to ensure consistent service. Fast-food restaurants have established procedures for everything—from cooking hamburgers to taking orders. Airline pilots follow a prescribed checklist each time they land or take off. This procedure ensures a high level of customer safety and consistent service.

Identify Areas for Improvement

Teams of employees from different departments work together as cross-functional teams to understand the current conditions and prepare a method to improve the performance of an organizational activity. If a firm needs to improve its product development process so it is faster, lower-cost, and higher-quality, it is important to have various experts examine and improve the process. These experts should understand the roles of marketing, production, and information technology. They should also understand the accounting and financial aspects of this complicated process.

Methods Analysis and Problem-Solving Tools

Continuous improvement efforts require a set of methods or problem-solving tools. The type and application of these tools depends upon the outcome measures that need to be enhanced. For example, to improve the quality of an assembly, root-cause analysis and poka-yoke may be the tools. It allows the team to understand the problem and create a solution that should be error proof. To reduce the number of processing errors and the cost of evaluating life insurance applications, it would be useful to determine the process flow,

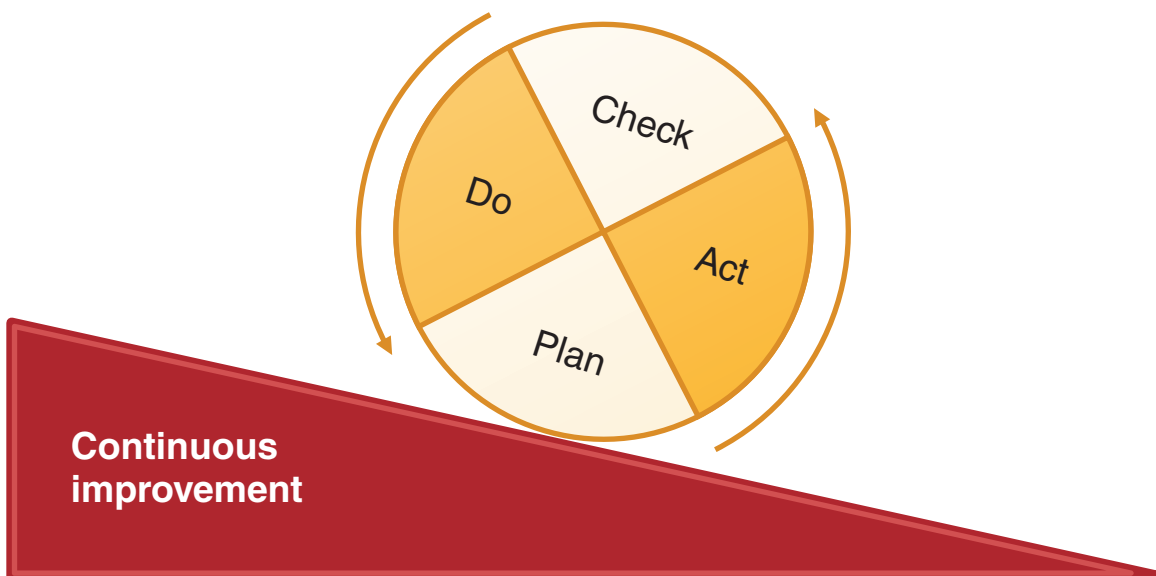
identify essential tasks, and note tasks that can be reduced in length or eliminated completely. It would also be useful to identify which quality problems are the most common and to overlay those on the process flow to see how cost and quality interact.

The Plan-Do-Check-Act Cycle

The **Plan-Do-Check-Act cycle**, shown in Figure 4.4, is also referred to as the Deming Wheel or Shewhart cycle. The shape of a wheel embodies the philosophy of continuous improvement; the cycle is repeated over and over without end. Each part of the cycle is explained as follows:

- *Plan*—Before making any changes, be sure everything is documented and standardized. Use appropriate tools to identify problems or opportunities for improvement. Develop a plan to make changes.
- *Do*—Implement the plan and document any changes made.
- *Check*—Analyze the revised process to determine if goals have been achieved.
- *Act*—If the goals have been achieved, then standardize and document the changes. Communicate the results to others that could benefit from similar changes. If the goals have not been achieved, determine why not, and proceed accordingly.

Figure 4.4: The Plan-Do-Check-Act cycle



Document Improved Procedures

The process for continuous improvement ends in the same place it begins with a documented process, so that future review for the purpose of process improvement commences again here. Documents are also valuable for training new employees. Finally, documentation is essential to achieve quality certification.

Chapter Summary

- Quality has many definitions, both internal and external. Today, most companies define quality as consistently meeting or exceeding the customer's needs and expectations.
- The characteristics of service quality include reliability, responsiveness, assurance, empathy, and tangibles.
- The characteristics of quality for goods include performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality.
- It is vital to understand what customers want, but this involves more than just asking the customer. Customers often have unspoken wants that will not be apparent without probing. Customers operate in a known environment and are often unaware of new ideas or technologies that create new products they would find very useful.
- Individuals who have had a significant impact on the field of quality include W. Edwards Deming, Joseph Juran, Philip Crosby, and Genichi Taguchi.
- Design for manufacture and assembly (DFMA) and design for operations (DFO) are ways to focus on quality and cost during the design of goods and services. Product quality is a function of product design, process design, and employee execution. The better a firm is at these functions, the better it will be at building high-quality products. Inspection does not enhance quality; it provides feedback about the level of quality achieved and the potential source of quality problems.
- Every employee is responsible for quality. It should be an organization-wide effort.
- Quality function deployment is used to translate the voice of the customer into product and process design characteristics.
- The components of TQM include a focus on the customer, quality function deployment, responsibility for quality, team problem solving, employee training, fact-based management, and a philosophy of continuous improvement.

Case Studies

Memorial Hospital

Memorial Hospital is a privately owned 600-bed facility. The hospital provides a broad range of health care services, including complete laboratory and X-ray facilities, an emergency room, an intensive care unit, a cardiac care unit, and a psychiatric ward. Most of these services are provided by several other hospitals in the metropolitan area. Memorial has purposely avoided getting involved in any specialized fields of medicine or obtaining very specialized diagnostic equipment because it was felt that such services would not be cost-effective. The General Hospital, located only a few miles from Memorial, is affiliated with the local School of Medicine and offers up-to-date services in those specialized areas. Instead of trying to compete with General Hospital to provide special services, Memorial Hospital has concentrated on offering high-quality general health care at an affordable price. Compared with the much larger General Hospital, Memorial stresses close personal attention to each patient from a nursing staff that cares about its work. In fact, the hospital has begun to place ads in newspapers and on television, stressing its patient-oriented care.

However, the hospital's administrator, Janice Fry, is concerned about whether the hospital can really deliver on its promises, and worries that failure to provide the level of health care patients expect could drive patients away. Janice met recently with the hospital's managerial personnel to discuss her concerns. The meeting raised some questions about how the hospital's quality of health care could be assured. Jessica Tu, director of nursing, raised the question, "How do we measure the quality of health care? Do we give patients a questionnaire when they leave, asking if they were happy here? That does not seem to answer the question because we could make a patient happy, but give them lousy health care." Several other questions were asked concerning the hospital's efforts to keep costs down. Some people were concerned that an emphasis on costs would be detrimental to quality. They argued that when a person's life is at stake, costs should not be of concern.

After the meeting, Janice began thinking about these questions. She remembered reading recently that some companies were using total quality management (TQM) to improve their quality. She liked the idea—if it could be used in a hospital.

1. Discuss some ways that a hospital might measure quality.
2. What are the potential costs of quality for Memorial Hospital? How could the value of a human life be included?
3. Are there any ideas or techniques from TQM that Janice could use to help Memorial focus on providing quality health care?
4. What measures could Memorial use to assess the quality of health care it is providing?

Discussion Questions

1. What are the similarities between internally and externally oriented definitions of quality?
2. Describe the approach that a company should use in order to understand customers' expectations.
3. List the characteristics for service quality and those for manufacturing quality. What are the commonalities and differences?
4. What assumptions about the relationship between the company standards and those of the customer are made by internally-oriented definitions of quality?
5. What are the differences and similarities among the philosophies of Deming, Juran, Crosby, and Taguchi?
6. What important organizational activities enable a firm to build quality into its products? Explain each of these.
7. Is it possible for a company to implement TQM if top management delegates responsibility to middle managers? Why or why not?
8. List the components of quality management, and briefly describe a few of the ideas, concepts, or techniques that are included in each.
9. List some customer needs associated with home theater equipment, and group these together by category. Suggest some possible engineering characteristics that could measure achievement of these attributes.

10. One quality myth is that increased quality means increased costs. Use your own personal knowledge or experiences to describe how this may not be true.
11. List the three categories of quality costs, and briefly define each.
12. Explain how the idea of quality function deployment may be applied to a service organization that is not providing a tangible good as its product.

Key Terms

appraisal costs The costs incurred to measure quality, assess customer satisfaction, inspect and test products.

benchmarking A process by which a company compares its performance and methods for a certain activity against that of a recognized leader or an outstanding competitor.

continuous improvement The concept that no matter how good a company is, it must always work to do better.

design for manufacture and assembly (DFMA) Designing products so they are easy to manufacture or assemble, resulting in high quality and low cost.

design for operations (DFO) Designing services so that operations function can provide high quality and low cost.

external failure costs Costs of quality incurred after a product has reached the customer.

fishbone chart A diagram that is used in problem-solving to list all the possible causes of a problem, usually divided into materials, equipment, methods, and personnel.

house of quality A diagram used to convert customer attributes desired in a product to engineering characteristics, parts characteristics, and process details.

internal failure costs Costs of quality associated with defects found before the product reaches the customer.

Plan-Do-Check-Act cycle A problem-solving process used for continuous improvement; also called Deming Wheel or Shewhart cycle.

poka-yoke An approach adopted by many companies to prevent defects. The term is a rough approximation of Japanese words that mean “mistake proofing.”

prevention costs Quality costs that result from activities to prevent defects from occurring, such as employee training, quality control procedures, special efforts in designing products, or administrative systems to prevent defects.

quality May have definitions that are either internal or external to a company, but defined most often as consistently meeting or exceeding customers’ needs and expectations.

quality function deployment (QFD) A procedure for spreading the voice of the customer throughout a company when determining how products should be designed and processes operated.

robust design Product design that guarantees high quality regardless of variations that may occur during the processes that make the product and provide it to the customer.

Six Sigma A measure of process performance that means only 3.4 defects will occur in every 1 million units produced, or 99.99966% error free. The term Six Sigma refers to a broad range of defect prevention strategies.

statistical process control (SPC) The use of statistical methods to determine when a process that produces a good or service is getting close to producing an unacceptable level of defects.

total quality management (TQM) An organizational commitment to continuously improve on meeting or exceeding customers' needs and expectations.

value proposition A measure of what the buyer gives up compared to what the buyer receives. When the value proposition is high, the benefits are significantly greater than the costs.

voice of the customer A concept in product design to determine what the customer wants, likes, and doesn't like in the product.

