Operations Management

Total Quality Management

8.1 Defining Quality

The definition of quality depends on the point of view of the people defining it. Most consumers have a difficult time defining quality, but they know it when they see it. For example, although you probably have an opinion as to which manufacturer of athletic shoes provides the highest quality, it would probably be difficult for you to define your quality standard in precise terms. Also, your friends may have different opinions regarding which athletic shoes are of highest quality.

The difficulty in defining quality exists regardless of product, and this is true for both manufacturing and service organizations. Think about how difficult it may be to define quality for products such as airline services, child day-care facilities, college classes, or even OM textbooks. Further complicating the issue is that the meaning of quality has changed over time. Today, there is no single, universal definition of quality. Some people view quality as "performance to standards." Others view it as "meeting the customer's needs" or "satisfying the customer." Let's look at some of the more common definitions of quality.

● **Conformance to specifications** measures how well the product or service meets the targets and tolerances determined by its designers. For example, the dimensions of a machine part may be specified by its design engineers as 3 _ 0.05 inches. This would mean that the target dimension is 3 inches, but the dimensions can vary between 2.95 and 3.05 inches. Similarly, the wait for hotel room service may be specified as 20 minutes, but there may be an acceptable delay of an additional 10 minutes. Also, consider the amount of light delivered by a 60-watt light bulb. If the bulb delivers 50 watts, it does not conform to specifications. As these examples illustrate, conformance to specification is directly measurable, though it may not be directly related to the consumer's idea of quality.

● **Fitness for use** focuses on how well the product performs its intended function or use. For example, a Mercedes-Benz and a Jeep Cherokee both meet a fitness for use definition if one considers transportation as the intended function. However, if the definition becomes more specific and assumes that the intended

use is for transportation on mountain roads and carrying fishing gear, the Jeep Cherokee has a greater fitness for use. You can also see that fitness for use is a user-based definition in that it is intended to meet the needs of a specific user group.

● **Value for price paid** is a definition of quality that consumers often use for product or service usefulness. This is the only definition that combines economics with consumer criteria; it assumes that the definition of quality is price sensitive. For example, suppose that you wish to sign up for a personal finance seminar and discover that the same class is being taught at two different colleges at significantly different tuition rates. If you take the less expensive seminar, you will feel that you have received greater value for the price.

● **Support services** provided are often how the quality of a product or service is judged. Quality does not apply only to the product or service itself; it also applies to the people, processes, and organizational environment associated with it. For example, the quality of a university is judged not only by the quality of staff and course offerings but also by the efficiency and accuracy of processing paperwork.

● **Psychological criteria** is a subjective definition that focuses on the judgmental evaluation of what constitutes product or service quality. Different factors contribute to the evaluation, such as the atmosphere of the environment or the perceived prestige of the product. For example, a hospital patient may receive average healthcare, but a very friendly staff may leave the impression of high quality. Similarly, we commonly associate certain products with excellence because of their reputation; Rolex watches and Mercedes-Benz automobiles are examples.

8.2 Differences between Manufacturing and Service Organizations

Defining quality in manufacturing organizations is often different than it is for service organizations. Manufacturing organizations produce a tangible product that can be seen, touched, and directly measured. Examples include cars, CD players, clothes, computers, and food items. Therefore, quality definitions in manufacturing usually focus on tangible product features.

The most common quality definition in manufacturing is *conformance*, which is the degree to which a product characteristic meets preset standards. Other common definitions of quality in manufacturing include *performance*, such as acceleration of a vehicle; *reliability*, meaning that the product will function as expected without failure; *features*, the extras that are included beyond the basic characteristics;

durability, the expected operational life of the product; and *serviceability*, how readily a product can be repaired. The relative importance of these definitions is based on the preferences of each individual customer. It is easy to see how different customers can have different definitions in mind when they speak of high product quality. In contrast to manufacturing, service organizations produce a product that is intangible.

Usually, the complete product cannot be seen or touched. Rather, it is experienced. Examples include delivery of healthcare, the experience of staying at a vacation resort, and learning at a university. The intangible nature of the product makes defining quality difficult. Also, since a service is experienced, perceptions can be highly subjective. In addition to tangible factors, quality of services is often defined by perceptual factors. These include responsiveness to customer needs, *courtesy* and *friendliness* of staff, *promptness* in resolving complaints, and *atmosphere*. Other definitions of quality in services include *time*, the amount of time a customer has to wait for the service; and *consistency*, the degree to which the service is the same each time. For these reasons, defining quality in services can be especially challenging.

Today's customers demand and expect high quality. Companies that do not make quality a priority risk long-run survival. World-class organizations such as General Electric and Motorola attribute their success to having one of the best quality management programs in the world. These companies were some of the first to implement a quality program called Six Sigma, where the level of defects is reduced to approximately 3.4 parts per million. To achieve this level, everyone in the company is trained in quality. For example, individuals highly trained in quality improvement principles and techniques receive a designation called "Black Belt." The full-time job of Black Belts is to identify and solve quality problems. In fact, Motorola was one of the first companies to win the prestigious Malcolm Baldrige National Quality Award in 1988 due to its high focus on quality.

Both GE and Motorola have had a primary goal of achieving total customer satisfaction. To this end, the efforts of these organizations have included eliminating almost all defects from products, processes, and transactions. Both companies consider quality to be the critical factor that has resulted in significant increases in sales and market share, as well as cost savings in the range of millions of dollars.

8.3 Cost of Quality

The reason quality has gained such prominence is that organizations have gained an understanding of the high cost of poor quality. Quality affects all aspects of the organization and has dramatic cost implications. The most obvious consequence occurs when poor quality creates dissatisfied customers and eventually leads to loss of business. However, quality has many other costs, which can be divided into two categories.

- The first category consists of costs necessary for achieving high quality, which are called *quality control costs*. These are of two types: *prevention costs* and *appraisal costs*.

- The second category consists of the cost consequences of poor quality, which are called *quality failure costs*. These include *external failure costs* and *internal failure costs*.

8.3.1 Prevention Costs are all costs incurred in the process of preventing poor quality from occurring. They include quality planning costs, such as the costs of developing and implementing a quality plan. Also included are the costs of product and process design, from collecting customer information to designing processes that achieve conformance to specifications. Employee training in quality measurement is included as part of this cost, as well as the costs of maintaining records of information and data related to quality.

8.3.2 Appraisal Costs are incurred in the process of uncovering defects. They include the cost of quality inspections, product testing, and performing audits to make sure that quality standards are being met. Also included in this category are the costs of worker time spent measuring quality and the cost of equipment used for quality appraisal.

8.3.3 Internal Failure Costs are associated with discovering poor product quality before the product reaches the customer site. One type of internal failure cost is *rework*, which is the cost of correcting the defective item. Sometimes the item is so defective that it cannot be corrected and must be thrown away. This is called *scrap*, and its costs include all the material, labor, and machine cost spent in producing the defective product. Other types of internal failure costs include the cost of machine downtime due to failures in the process and the costs of discounting defective items for salvage value.

8.3.4 External Failure Costs are associated with quality problems that occur at the customer site. These costs can be particularly damaging because customer faith and loyalty can be difficult to regain. They include everything from customer complaints, product returns, and repairs to warranty claims, recalls, and even litigation costs resulting from product liability issues. A final component of this cost is lost sales and lost customers. For example, manufacturers of lunch meats and hot dogs whose products have been recalled due to bacterial contamination have had to struggle to regain consumer confidence.

Other examples include auto manufacturers whose products have been recalled due to major malfunctions such as problematic braking systems and airlines that have experienced a crash with many fatalities. External failure can sometimes put a company out of business almost overnight. Companies that consider quality important invest heavily in prevention and appraisal costs in order to prevent internal and external failure costs. The earlier defects are found, the less costly they are to correct. For example, detecting and correcting defects during product design and product production is considerably less expensive than when the defects are found at the customer site.

8.4 The Evolution of Total Quality Management (TQM)

The concept of quality has existed for many years, though its meaning has changed and evolved over time. In the early twentieth century, quality management meant inspecting products to ensure that they met specifications. In the 1940s, during World War II, quality became more statistical in nature. Statistical sampling techniques were used to evaluate quality, and quality control charts were used to monitor the production process.

In the 1960s, with the help of so-called quality gurus, the concept took on a broader meaning. Quality began to be viewed as something that encompassed the entire organization, not only the production process. Since all functions were responsible for product quality and all shared the costs of poor quality, quality was seen as a concept that affected the entire organization.

The meaning of quality for businesses changed dramatically in the late 1970s. Before then quality was still viewed as something that needed to be inspected and corrected. However, in the 1970s and 1980s, many U.S. industries lost market share to foreign competition. In the auto industry, manufacturers such as Toyota and Honda became major players. In the consumer goods market, companies such as Toshiba and Sony led the way. These foreign competitors were producing lower-priced products

with considerably higher quality. To survive, companies had to make major changes in their quality programs. Many hired consultants and instituted quality training programs for their employees. A new concept of quality was emerging. One result was that quality began to have a strategic meaning. Today, successful companies understand that quality provides a competitive advantage. They put the customer first and define quality as meeting or exceeding customer expectations. Since the 1970s, competition based on quality has grown in importance and has generated tremendous interest, concern, and enthusiasm. Companies in every line of business are focusing on improving quality in order to be more competitive. In many industries quality excellence has become a standard for doing business.

Companies that do not meet this standard simply will not survive. As you will see later in the chapter, the importance of quality is demonstrated by national quality awards and quality certifications that are coveted by businesses. The term used for today's new concept of quality is *total quality management* or *TQM*. You can see that the old concept is *reactive*, designed to correct quality problems after they occur. The new concept is *proactive*, designed to build quality into the product and process design. Next, we look at the individuals who have shaped our understanding of quality.

8.5 Customer Focus

The first, and overriding, feature of TQM is the company's focus on its customers. Quality is defined as meeting or exceeding customer expectations. The goal is to first identify and then meet customer needs. TQM recognizes that a perfectly produced product has little value if it is not what the customer wants. Therefore, we can say that quality is *customer driven*. However, it is not always easy to determine what the customer wants because tastes and preferences change. Also, customer expectations often vary from one customer to the next. For example, in the auto industry trends change relatively quickly, from small cars to sports utility vehicles and back to small cars. The same is true in the retail industry, where styles and fashion are short-lived.

Companies need to continually gather information by means of focus groups, market surveys, and customer interviews in order to stay in tune with what customers want. They must always remember that they would not be in business if it were not for their customers.

8.5.1 Continuous Improvement

Another concept of the TQM philosophy is the focus on **continuous improvement**. Traditional systems operated on the assumption that once a company achieved a certain level of quality, it was successful and needed to make no further improvements. We tend to think of improvement in terms of plateaus that are to be achieved, such as passing a certification test or reducing the number of defects to a certain level. Traditionally, for American managers change involves large magnitudes, such as major organizational restructuring.

The Japanese, on the other hand, believe that the best and most lasting changes come from gradual improvements. To use an analogy, they believe that it is better to take frequent small doses of medicine than to take one large dose. Continuous improvement, called **kaizen** by the Japanese, requires that the company continually strive to be better through learning and problem solving. Because we can never achieve perfection, we must always evaluate our performance and take measures to improve it.

8.5.2 The Plan–Do–Study–Act Cycle (PDSA)

The plan–do–study–act (PDSA) cycle describes the activities a company needs to perform in order to incorporate continuous improvement in its operation. The circular nature of this cycle shows that continuous improvement is a never-ending process. Let's look at the specific steps in the cycle.

● **Plan** The first step in the PDSA cycle is to *plan*. Managers must evaluate the current process and make plans based on any problems they find. They need to document all current procedures, collect data, and identify problems. This information should then be studied and used to develop a plan for improvement as well as specific measures to evaluate performance.

● **Do** The next step in the cycle is implementing the plan (*do*). During the implementation process managers should document all changes made and collect data for evaluation.

● **Study** The third step is to *study* the data collected in the previous phase. The data are evaluated to see whether the plan is achieving the goals established in the *plan* phase.

● **Act** The last phase of the cycle is to *act* on the basis of the results of the first three phases. The best way to accomplish this is to communicate the results to other members of the company and then implement the new procedure if it has

been successful. Note that this is a cycle; the next step is to plan again. After we have acted, we need to continue evaluating the process, planning, and repeating the cycle again.

8.6 Benchmarking

Another way companies implement continuous improvement is by studying business practices of companies considered "best in class." This is called **benchmarking**. The ability to learn and study how others do things is an important part of continuous improvement. The benchmark company does not have to be in the same business as long as it excels at something that the company doing the study wishes to emulate. For example, many companies have used Lands' End to benchmark catalog distribution and order filling because Lands' End is considered a leader in this area. Similarly, many companies have used American Express to benchmark conflict resolution.

8.6.1 Employee Empowerment

Part of the TQM philosophy is to empower all employees to seek out quality problems and correct them. Under the old concept of quality, employees were afraid to identify problems for fear that they would be reprimanded. Often, poor quality was passed on to someone else in order to make it "someone else's problem." The new concept of quality, TQM, provides incentives for employees to identify quality problems. Employees are rewarded for uncovering quality problems, not punished.

In TQM, the role of employees is very different from what it was in traditional systems. Workers are empowered to make decisions relative to quality in the production process. They are considered a vital element of the effort to achieve high quality. Their contributions are highly valued, and their suggestions are implemented. In order to perform this function, employees are given continual and extensive training in quality measurement tools.

To further stress the role of employees in quality, TQM differentiates between *external* and *internal customers*. *External customers* are those that purchase the company's goods and services. *Internal customers* are employees of the organization who receive goods or services from others in the company. For example, the packaging department of an organization is an internal customer of the assembly department. Just as a defective item would not be passed to an external customer, a defective item should not be passed to an internal customer.

8.6.2 Team Approach

TQM stresses that quality is an organizational effort. To facilitate the solving of quality problems, it places great emphasis on teamwork. The use of teams is based on the old adage that "two heads are better than one." Using techniques such as brainstorming, discussion, and quality control tools, teams work regularly to correct problems. The contributions of teams are considered vital to the success of the company. For this reason, companies set aside time in the workday for team meetings.

Teams vary in their degree of structure and formality, and different types of teams solve different types of problems. One of the most common types of teams is the **quality circle**, a team of volunteer production employees and their supervisors whose purpose is to solve quality problems. The circle is usually composed of eight to ten members, and decisions are made through group consensus. The teams usually meet weekly during work hours in a place designated for this purpose. They follow a preset process for analyzing and solving quality problems. Open discussion is promoted, and criticism is not allowed. Although the functioning of quality circles is friendly and casual, it is serious business. Quality circles are not mere "gab sessions." Rather, they do important work for the company and have been very successful in many firms.

8.7 Use of Quality Tools

You can see that TQM places a great deal of responsibility on all workers. If employees are to identify and correct quality problems, they need proper training. They need to understand how to assess quality by using a variety of quality control tools, how to interpret findings, and how to correct problems. In this section we look at seven different quality tools, often called the seven tools of quality control.

They are easy to understand, yet extremely useful in identifying and analyzing quality problems. Sometimes workers use only one tool at a time, but often a combination of tools is most helpful.

8.7.1 Cause-and-Effect Diagrams Cause-and-Effect Diagrams

Cause-and-effect diagrams cause-and-effect diagrams identify potential causes of particular quality problems. They are often called fishbone diagrams because they look like the bones of a fish. The "head" of the fish is the quality problem, such as damaged zippers on a garment or broken valves on a tire. The "spine" of the fish connects the "head" to the possible cause of the problem. These causes could be related to the machines, workers, measurement, suppliers, materials, and many other aspects of the production process. Each of these possible causes can then

have smaller "bones" addressing specific issues that relate to each cause. For example, a problem with machines could be due to a need for adjustment, old equipment, or tooling problems. Similarly, a problem with workers could be related to lack of training, poor supervision, or fatigue. Cause-and-effect diagrams are problem-solving tools commonly used by quality control teams. Specific causes of problems can be explored through brainstorming. The development of a cause-and-effect diagram requires the team to think through all the possible causes of poor quality.

8.7.2 Flowcharts

A **flowchart** is a schematic diagram of the sequence of steps involved in an operation or process. It provides a visual tool that is easy to use and understand. By seeing the steps involved in an operation or process, everyone develops a clear picture of how the operation works and where problems could arise.

8.7.3 Checklists

A **checklist** is a list of common defects and the number of observed occurrences of these defects. It is a simple yet effective fact-finding tool that allows the worker to collect specific information regarding the defects observed. The checklist in Figure 5-7 shows four defects and the number of times they have been observed. It is clear that the biggest problem is ripped material. This means that the plant needs to focus on this specific problem—for example, by going to the source of supply or seeing whether the material rips during a particular production process.

A checklist can also be used to focus on other dimensions, such as location or time. For example, if a defect is being observed frequently, a checklist can be developed that measures the number of occurrences per shift, per machine, or per operator. In this fashion we can isolate the location of the particular defect and then focus on correcting the problem.

8.7.4 Control Charts

Control charts are a very important quality control tool. We will study the use of control charts at great length in the next chapter. These charts are used to evaluate whether a process is operating within expectations relative to some measured value such as weight, width, or volume. For example, we could measure the weight of a sack of flour, the width of a tire, or the volume of a bottle of soft drink.

When the production process is operating within expectations, we say that it is "in control." To evaluate whether or not a process is in control, we regularly measure the variable of interest and plot it on a control chart. The chart has a line down the

center representing the average value of the variable we are measuring. Above and below the center line are two lines, called the upper control limit (UCL) and the lower control limit (LCL). As long as the observed values fall within the upper and lower control limits, the process is in control and there is no problem with quality. When a measured observation falls outside of these limits, there is a problem.

● **Customer Requirements** Remember that our goal is to make a product that the customer wants. Therefore, the first thing we need to do is survey our customers to find out specifically what they would be looking for in a product—in this case, a backpack for students. To find out precisely what features students would like in a backpack, the marketing department might send representatives to talk to students on campus, conduct telephone interviews, and maybe conduct focus groups

● **Competitive Evaluation** On the far right of our relationship matrix is an evaluation of how our product compares to those of competitors. The evaluation scale is from 1 to 5—the higher the rating, the better. The important thing here is to identify which customer requirements we should pursue and how we fare relative to our competitors. For example, you can see that our product excels in durability relative to competitors, yet it does not look as nice. This means that we could gain a competitive advantage by focusing our design efforts on a more appealing product.

● **Product Characteristics** Specific product characteristics are on top of the relationship matrix. These are technical measures. In our example they include the number of zippers and compartments, the weight of the backpack, the strength of the backpack, the grade of the dye color, and the cost of materials.

● **The Relationship Matrix** The strength of the relationship between customer requirements and product characteristics is shown in the relationship matrix. For example, you can see that the number of zippers and compartments is negatively related to the weight of the backpack. A negative relationship means that as we increase the desirability of one variable, we decrease the desirability of the other.

At the same time, roominess is positively related to the number of zippers and compartments, as is appearance. A positive relationship means that an increase in desirability of one variable is related to an increase in the desirability of another. This type of information is very important in coordinating the product design.

● **The Trade-off Matrix** You can see how the relationship matrix is beginning to look like a house. The next step in our building process is to put the "roof " on the house. This is done through a trade-off matrix, which shows how each product characteristic is related to the others and thus allows us to see what trade-offs we need to make. For example, the number of zippers is negatively related to the weight of the backpack.

● **Setting Targets** The last step in constructing the house of quality is to evaluate competitors' products relative to the specific product characteristics and to set targets for our own product. The bottom row of the house is the *output* of quality function deployment. These are specific, measurable product characteristics that have been formulated from general customer requirements.

The house of quality has been very useful. You can see how it translates everyday terms like "lightweight," "roominess," and "nice looking" into specific product characteristics that can be used in manufacturing the product. Note also how the house of quality can help in the communication between marketing, operations, and design engineering.

8.7.5 Reliability An important dimension of product design is that the product functions as expected. This is called **reliability**, the probability that a product, service, or part will perform as intended for a specified period of time under normal conditions. We are all familiar with product reliability in the form of product warranties. We also know that no product is guaranteed with 100 percent certainty to function properly.

However, companies know that high reliability is an important part of customer oriented quality and try to build this into their product design. Reliability is a probability, a likelihood, or a chance. For example, a product with a 90 percent reliability has a 90 percent chance of functioning as intended. Another way to look at it is that the probability the product will fail is 1 _ 0.90 _ 0.10, or 10 percent. This also means that 1 out of 10 products will not function as expected.

The reliability of a product is a direct function of the reliability of its component parts. If all the parts in a product must work for the product to function, then the reliability of the system is computed as the *product* of the reliabilities of the individual components.

8.7.6 Process Management

According to TQM, a quality product comes from a quality process. This means that quality should be built into the process. **Quality at the source** is the belief that it is far better to uncover the source of quality problems and correct it than to discard defective items after production. If the source of the problem is not corrected, the problem will continue. For example, if you are baking cookies you might find that some of the cookies are burned. Simply throwing away the burned cookies will not correct the problem. You will continue to have burned cookies and will lose money when you throw them away. It will be far more effective to see where the problem is and correct it. For example, the temperature setting may be too high; the pan may be curved, placing some cookies closer to the heating element; or the oven may not be distributing heat evenly.

Quality at the source exemplifies the difference between the old and new concepts of quality. The old concept focused on inspecting goods after they were produced or after a particular stage of production. If an inspection revealed defects, the defective products were either discarded or sent back for reworking. All this cost the company money, and these costs were passed on to the customer. The new concept of quality focuses on identifying quality problems at the source and correcting them.

8.7.7 Managing Supplier Quality

TQM extends the concept of quality to a company's suppliers. Traditionally, companies tended to have numerous suppliers who engaged in competitive price bidding. When materials arrived, they were inspected for quality. TQM views this practice as contributing to poor quality and wasted time and cost. The philosophy of TQM extends the concept of quality to suppliers and ensures that they engage in the same quality practices. If suppliers meet preset quality standards, materials do not have to be inspected upon arrival. Today, many companies have a representative residing at their supplier's location, thereby involving the supplier in every stage from product design to final production.