CHAPTER

2

Foundations of Quality Management

OUTLINE

In the 1890s, Caesar Ritz defined the standards for a luxury hotel; these evolved into the quality responsibilities of the employees—the "Ladies and Gentlemen Serving Ladies and Gentlemen"—of today's Ritz-Carlton Hotel Company: anticipating the wishes and needs of the guests, resolving their problems, and exhibiting genuinely caring conduct toward guests and each other. The Ritz-Carlton management recognized that the key to ensuring that these responsibilities are realized was to create a "Skilled and Empowered Work Force Operating with Pride and Joy." The concept of "pride and joy" in work—and its impact on quality—is one of the foundations of the philosophy of W. Edwards Deming. Deming, along with Joseph M. Juran and Philip B. Crosby, are regarded as true "management gurus" in the quality revolution. Their insights into measuring, managing, and improving quality have had profound impacts on countless managers and entire corporations around the world.

This chapter presents the quality management philosophies of these three leaders, their similarities and differences, and also examines their individual contributions to modern practice. In addition, it discusses the contributions of other key individuals who have helped to shape current thinking in quality management. Their contributions established the principles of total quality and the implementation of quality management systems, such as ISO 9000, which we also introduce in this chapter.

quality**profiles**

Texas Nameplate Company, Inc. and MEDRAD

Founded in 1946, Texas Nameplate Company, Inc. (TNC), with only 43 employees, manufactures and sells identification and information labels that are affixed to refrigerators, oil-field equipment, high-pressure valves, trucks, computer equipment, and other products made by more than 1,000 customers throughout the United States and in nine foreign countries. TNC has honed the raw attributes inherent to its small size—from streamlined communications and rapid decision-making to shared goals and accessible leaders—into competitive advantages. It started by changing the traditional, hierarchical leadership structure into a flatter, team-based structure built on mutual respect and guided by the philosophy that "Fear is useless; what is needed is trust." The result is a close-knit organization that is finely tuned to the requirements of its customers. TNC aims to create a continuous learning environment that enables empowered teams of workers to take charge of processes and to deliver products and services with a "star quality." Customer contact employees are empowered to resolve customer complaints without consulting management, and production workers are responsible for tailoring processes to optimize contributions to company goals and to meet team-set standards. TNC reduced its defects from 3.65 percent to about 1 percent in four years. Customers consistently give the company an "excellent" rating (5 to 6 on a scale of 6) in 12 key business areas, including product quality, reliable performance, on-time delivery, and overall satisfaction. In its employee survey, satisfaction rates in five areas employees say are the most important: fair pay, job content satisfaction, recognition, fairness/respect, and career development, exceed national norms by a significant margin.

For more than 40 years, MEDRAD has been committed to improving patient outcomes by developing, marketing, and servicing innovative, cost-efficient medical imaging and other devices for diagnosing and treating diseases. MEDRAD has created an environment of distributed decision making in support of a culture of high performance. Decision making is done at the point of customer interaction, where the customer can be a client, an employee, or any other stakeholder of MEDRAD. This model allows the organization to respond with agility and speed to the needs of the business units, clients, and employees. The company uses systematic approaches to capture customers' expectations and preferences through various listening posts, trade associations, and other mechanisms and communicates them to the appropriate sales team for analysis. The Customer Complaint Process focuses on timely response and successful resolution of customer issues and ensures that the organization determines causes and completes corrective actions. Because of its customer-focused practices, MEDRAD's overall Net Promoter (NP) scores (a loyalty metric defined by the level of repeat sales and referrals) have been consistently 60 percent or higher, compared to the 50 percent or higher marks for other organizations over the same time periods. In the area of service support, MEDRAD consistently scored 80 percent or higher compared to 50 percent for the best-in-class benchmark.

Sources: Malcolm Baldrige National Quality Award, Profiles of Winners, and 2002 Quest for Excellence video script, National Institute of Standards and Technology, Department of Commerce.

THE DEMING PHILOSOPHY

No individual has had more influence on quality management than Dr. W. Edwards Deming (1900–1993). Deming received a Ph.D. in physics and was trained as a statistician, so much of his philosophy can be traced to these roots. He worked for Western Electric during its pioneering era of statistical quality control in the 1920s and 1930s. Deming recognized the importance of viewing management processes statistically. During World War II he taught quality control courses as part of the U.S. national defense effort, but he realized that teaching statistics only to engineers and factory workers would never solve the fundamental quality problems that manufacturing needed to address. Despite numerous efforts, his attempts to convey the message of quality to upper-level managers in the United States were ignored.

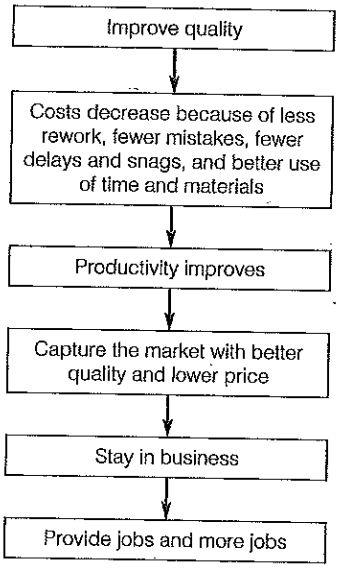
Shortly after World War II, Deming was invited to Japan to help the country take a census. The Japanese had heard about his theories and their usefulness to U.S. companies during the war. Consequently, he soon began to teach them statistical quality control. His thinking went beyond mere statistics, however. Deming preached the importance of top management leadership, customer/supplier partnerships, and continuous improvement in product development and manufacturing processes. Japanese managers embraced these ideas, and the rest, as they say, is history. Deming's influence on Japanese industry was so great that the Union of Japanese Scientists and Engineers established the Deming Application Prize in 1951 to recognize companies that show a high level of achievement in quality practices. Deming also received Japan's highest honor, the Royal Order of the Sacred Treasure, from the emperor. The former chairman of NEC Electronics once said, "There is not a day I don't think about what Dr. Deming meant to us."

Although Deming lived in Washington, D.C., he remained virtually unknown in the United States until 1980, when NBC telecast a program entitled "If Japan Can ... Why Can't We?" The documentary highlighted Deming's contributions in Japan and his later work with Nashua Corporation. Shortly afterward, his name was frequently on the lips of U.S. corporate executives. Companies such as Ford, GM, and Procter & Gamble invited him to work with them to improve their quality. To their surprise, Deming did not lay out "a quality improvement program" for them. His goal was to plant the seeds of quality knowledge from which managers could learn, allowing them to develop effective quality management systems. Deming worked with passion until his death in December 1993 at the age of 93, knowing he had little time left to make a difference in his home country. When asked how he would like to be remembered, Deming replied, "I probably won't even be remembered." Then after a long pause, he added, "Well, maybe ... as someone who spent his life trying to keep America from committing suicide."[1]

Just how influential was Deming? The 60th anniversary issue of* Motor Trend *magazine listed eight "automotive events that changed the world."[2] One of them was "1950: W. Edwards Deming lectures the Japanese Union of Scientists and Engineers." The magazine observed that Toyota, Honda, Nissan "all owe their success to the sage America ignored."

Unlike other management gurus and consultants, Deming never defined or described quality precisely. In his last book, he stated, "A product or a service possesses quality if it helps somebody and enjoys a good and sustainable market."[3] In Deming's view, variation is the chief culprit of poor quality. In mechanical assemblies, for example, variations from specifications for part dimensions lead to inconsistent performance and premature wear and failure. Likewise, inconsistencies in human behavior in service frustrate customers and damage companies' reputations. To reduce variation, Deming advocated a never-ending cycle of continuous improvement supported by statistical analysis.

FIGURE 2.1
The Deming Chain Reaction



Source: Based on Deming, W. Edwards, Out of the Crisis, figures: Fourteen Points, condensed and expanded versions, pages 23–24, © 2000 Massachusetts Institute of Technology.

The Deming philosophy focuses on continuous improvements in product and service quality by reducing uncertainty and variability in design, manufacturing, and service processes, driven by the leadership of top management. Deming also postulated that higher quality leads to higher productivity, which in turn leads to long-term competitive strength. The **Deming Chain Reaction** theory (see Figure 2.1) summarizes this view. The theory is that improvements in quality lead to lower costs because they result in less rework, fewer mistakes, fewer delays and snags, and better use of time and materials. Lower costs, in turn, lead to productivity improvements. With better quality and lower prices, a firm can achieve a higher market share and thus stay in business, providing more and more jobs. Deming stressed that top management must assume the overriding responsibility for quality improvement.

Deming's 14 Points

In his early work in the United States, he preached the **14 Points** (see Table 2.1), which represented a radical departure from management thinking and practice. At that time (in the 1960s and 1970s), manufacturing was driven by quotas and strict work measurement, with adversarial relationships between labor and management. Many organizations were ruled by autocratic managers who had little interest in listening to customers, engaging the workforce, or improving quality. Deming believed that companies could not prosper and grow with this type of management, and proposed the 14 Points for achieving quality excellence. Although management practices today are vastly different from when Deming first began to preach his philosophy, the 14 Points still convey important insights and provide guidance for managing effective organizations. We will briefly consider the key lessons of each.

TABLE 2.1
Deming's 14 Points

1. Create and publish to all employees a statement of the aims and purposes of the company or other organization. The management must demonstrate constantly their commitment to this statement.
2. Learn the new philosophy, top management and everybody.
3. Understand the purpose of inspection, for improvement of processes and reduction of cost.
4. End the practice of awarding business on the basis of price tag alone.
5. Improve constantly and forever the system of production and service.
6. Institute training.
7. Teach and institute leadership.
8. Drive out fear. Create trust. Create a climate for innovation.
9. Optimize toward the aims and purposes of the company the efforts of teams, groups, staff areas.
10. Eliminate exhortations for the workforce.
11. (a) Eliminate numerical quotas for production. Instead, learn and institute methods for improvement.
    (b) Eliminate MBO [management by objective]. Instead, learn the capabilities of processes and how to improve them.
12. Remove barriers that rob people of pride of workmanship.
13. Encourage education and self-improvement for everyone.
14. Take action to accomplish the transformation.

Source: Deming, W. Edwards, Out of the Crisis, figures: Fourteen Points, condensed and expanded versions, pages 23–24, © 2000 Massachusetts Institute of Technology, by permission of The MIT Press.

Point 1: Create a Vision and Demonstrate Commitment An organization must define its values, mission, and vision of the future to provide long-term direction for its management and employees. Deming believed that businesses should not exist simply for profit; they are social entities whose basic purpose is to serve their customers and employees. To fulfill this purpose, they must take a long-term view, invest in innovation, education, and training, and take responsibility for providing jobs and improving a firm's competitive position. This responsibility lies with top management. Effective leadership begins with commitment, but making a commitment to quality and performance excellence is still difficult for managers. Even when managers have conducted a thorough assessment of their organization and know what they need to change, many do not effectively follow up on opportunities.[4] Reasons range from denial ("We can't be that bad!") to excuses ("We have a lot of irons on the fire right now.").

Point 2: Learn the New Philosophy Historical ways of managing built on outdated twentieth century practices such as numerical quotas or motivational slogans will not work in today's global business environment. Nevertheless, some organizations, such as call centers, are still managed like this. To survive in today's competitive environment, companies must take a customer-driven approach to quality. To accomplish this, everyone, from the boardroom to the stockroom, must learn and understand the principles of quality and performance excellence. However, people change jobs and organizations generally have a short memory—both need to continually renew themselves to learn new approaches and relearn many older ones. This is often called "organizational learning," and will be addressed in a later chapter.

Point 3: Understand Inspection In the twentieth century, inspection had been the principal means for quality control; companies employed dozens or even hundreds of inspectors, sometimes as many as regular production workers. Routine inspection acknowledges that defects are present, encourages a lack of attention to quality by production workers, and does not add value to the product. The rework and disposition of defective material decreases productivity and increases costs. Deming encouraged workers to take responsibility for their work, rather than leave the problems for someone else down the production line. He advocated more in-process inspection and the use of statistical tools that would help to eliminate post-production inspection. Thus, inspection should be used as an information-gathering tool for improvement, not as a means of "assuring" quality. Today, this new role of inspection has been integrated into the quality management practices of most companies. However, few managers truly understand variation in production and how to leverage in-process data for improvement. By understanding and seeking to reduce variation, managers can eliminate many sources of unnecessary inspection, thus reducing non-value-added costs associated with operations.

Point 4: Stop Making Decisions Purely on the Basis of Cost Purchasing departments have long been driven by cost minimization and competition among suppliers without regard for quality. In 1931, Walter Shewhart noted that price has no meaning without quality.[5] (Think about the value based definition of quality from Chapter 1.) Yet purchasing managers have typically been evaluated by the amount of money they spend. Deming recognized that the direct costs associated with poor quality materials that arise during production or during warranty periods, as well as the loss of customer goodwill, can far exceed the cost "savings" perceived by purchasing. Thus, purchasing must understand its role as a supplier to production and its impact on the system.

Deming also urged businesses to establish long-term relationships with fewer suppliers, leading to loyalty and opportunities for mutual improvement. Management previously justified multiple suppliers for reasons such as providing protection against strikes or natural disasters, while ignoring "hidden" costs such as increased travel to visit suppliers, loss of volume discounts, increased setup charges resulting in higher unit costs, and increased inventory and administrative expense. Most importantly, constantly changing suppliers solely on the basis of price increases the variation in the material supplied to production, because each supplier's process is different. In contrast, a reduced supply base decreases the variation coming into the process, thus reducing scrap, rework, and the need for adjustment to accommodate this variation. A long-term relationship strengthens the supplier–customer bond, allows the supplier to produce in greater quantity, improves communication with the customer, and therefore enhances opportunities for process improvement. Today's emphasis on supply chain management (SCM) reflects the achievement of Point 4. SCM focuses heavily on a system's view of the supply chain with the objective of minimizing total supply chain costs and developing stronger partnerships with suppliers.

Point 5: Improve Constantly and Forever Improvements are necessary in both design and operations. Improved design of goods and services comes from understanding customer needs and continual market surveys and other sources of feedback, and from understanding the manufacturing and service delivery process. Improvements in operations are achieved by reducing the causes and impacts of variation, and engaging all employees to innovate and seek ways of doing their jobs more efficiently and effectively. When quality improves, productivity improves and costs decrease, as the Deming

chain reaction (Figure 2.1) suggests. Today, continuous improvement is recognized as a necessary means for survival in a highly competitive and global business environment. The tools for improvement are constantly evolving, and organizations need to ensure that their employees understand and apply them effectively, which requires training, the focus of the next Point.

Point 6: Institute Training People are an organization's most valuable resource; they want to do a good job and require training to do it well. Not only does training improve quality and productivity, but it adds to worker morale, and demonstrates to workers that the company is dedicated to investing in their future. Training must transcend such basic job skills as running a machine or following the script when talking to customers. Training should include tools for diagnosing, analyzing, and solving quality problems and identifying improvement opportunities. Today, many companies have excellent training programs for technology related to direct production, but still fail to enrich the ancillary skills of their workforce. Here is where some of the most lucrative opportunities exist to make an impact on key business results.

Point 7: Institute Leadership Deming recognized that one of biggest impediments to improvement was a lack of leadership. The job of management is leadership, not supervision. Supervision is simply overseeing and directing work; leadership means providing guidance to help employees perform better. Leadership can help to eliminate the element of fear from the job and encourage teamwork. Leadership was, is, and will continue to be, a challenging issue in every organization, particularly as new generations of managers replace those who have learned to lead. Thus, this Point of Deming's will always be relevant to organizations.

Point 8: Drive Out Fear Fear is manifested in many ways: fear of reprisal, fear of failure, fear of the unknown, fear of relinquishing control, and fear of change. No system can work without the mutual respect of managers and workers. Workers are often afraid to report quality problems because they might not meet their quotas, their incentive pay might be reduced, or they might be blamed for problems in the system. Managers are also afraid to cooperate with other departments, because the other managers might receive higher performance ratings and bonuses, or because they fear takeovers or reorganizations. Creating a culture without fear is a slow process but can be destroyed in an instant with a transition of leadership and a change in corporate policies. Therefore, today's managers need to continue to be sensitive to the impact that fear can have on their organizations.

Point 9: Optimize the Efforts of Teams Teamwork helps to break down barriers between departments and individuals. Barriers between functional areas occur when managers fear they might lose power. Internal competition for raises and performance ratings inhibits teamwork and cooperation. This leads to poor quality because other departments cannot understand what their internal customers want and do not get what they need from their internal suppliers. Training and employee involvement are important means of removing such barriers.

Point 10: Eliminate Exhortations Many early attempts to improve quality focused solely on behavioral change. However, posters, slogans, and motivational programs are directed at the wrong people. They assume that all quality problems are due to the workforce and overlook the major source of problems—the systems that management designs.

A well-designed system that provides workers with the right tools and environment will lead to higher levels of trust and motivation than slogans and goals can achieve.

Point 11: Eliminate Numerical Quotas and Management by Objective (MBO) Many organizations manage by goals and arbitrary objectives. Standards and quotas do not encourage improvement, particularly if rewards or performance appraisals are tied to meeting quotas. Workers may short-cut quality to reach the goal, and this still happens more than you might think. Then once a goal is reached, little incentive remains for workers to continue; they will often do no more than they are asked to do. Arbitrary goals, such as increasing sales by 5 percent next year or decreasing costs next quarter by 10 percent, have no meaning without a method to achieve them. Deming acknowledged that goals are useful, but numerical goals set for others without incorporating a method to reach the goal generate frustration and resentment. Management must understand the system and continually try to improve it, rather than focus on short-term goals.

Point 12: Remove Barriers to Pride in Workmanship People on the factory floor and even in management were often treated as, in Deming's words, "a commodity." Factory workers are often given monotonous tasks; provided with inferior machines, tools, or materials; told to run defective items to meet sales pressures; and report to supervisors who know little about the job—and then are blamed when problems occur. Effective organizations need to understand the factors that motivate and engage workers and build an environment in which workers take pride in what they do, understand the meaning of their work, and are rewarded for their accomplishments.

Point 13: Encourage Education and Self-Improvement The difference between this Point and Point 6 is subtle. Point 6 refers to training in specific job skills; Point 13 refers to continuing, broad education for self-development. Organizations must invest in their people at all levels to ensure success in the long term. A fundamental mission of business is to provide jobs as stated in Point 1, but business and society also have the responsibility to improve the value of the individual. Developing the worth of the individual is a powerful motivation method. Today, many companies understand that elevating the general knowledge base of their workforce—outside of specific job skills—returns many benefits. However, others still view this task as a cost that can be easily cut when financial trade-offs must be made.

Point 14: Take Action Any cultural change begins with top management and includes everyone. Changing an organizational culture generally meets with skepticism and resistance that many firms find difficult to deal with, particularly when many of the traditional management practices Deming felt must be eliminated are deeply ingrained in the organization's culture.

Many firms have used Deming's principles and organized their quality approaches around his philosophy. Some companies, such as 1991 Baldrige Award winner Zytec Corporation, now a part of Artesyn Technologies, and Hillerich & Bradsby used Deming's principles with great success.

Many people criticized Deming because his philosophy is just that: a philosophy. It lacked specific directions and approaches that told managers "how to do it," and it did not fit into the traditional American business culture. But as Deming often stated, "There is no instant pudding." Quality excellence takes learning, hard work, and dedication, and many are unwilling to make the commitment.

QUALITYSPOTLIGHT

Hillerich & Bradsby

Hillerich & Bradsby Co. (H&B) has been making the Louisville Slugger brand of baseball bat since 1884.[6] In the mid-1980s, the company faced significant challenges from market changes and competition. CEO Jack Hillerich attended a four-day Deming seminar, which provided the basis for the company's current quality efforts. Returning from the seminar, Hillerich decided to see what changes that Deming advocated were possible in an old company with an old union and a history of labor/management problems. Hillerich persuaded union officials to attend another Deming seminar with five senior managers. Following the seminar, a core group of union and management people developed a strategy to change the company. They talked about building trust and changing the system "to make it something you want to work in." Employees were interested, but skeptical. To demonstrate their commitment, managers examined Deming's 14 Points, and picked several they believed they could make progress on through actions that would demonstrate a serious intention to change. One of the first changes was the elimination of work quotas that were tied to hourly salaries and a schedule of warnings and penalties for failures to meet quotas. Instead, a team-based approach was initiated. Although only a few workers took advantage of the change, overall productivity actually improved as rework decreased because workers were taking pride in their work to produce things the right way first. H&B also eliminated performance appraisals and commission-based pay in sales. The company also focused its efforts on training and education, resulting in an openness to change and capacity for teamwork. Today, the Deming philosophy is still the core of H&B's guiding principles.

Profound Knowledge

The 14 Points caused some confusion and misunderstanding among businesspeople, because Deming did not provide a clear rationale for them. Near the end of his life, however, he synthesized the underlying foundations of the 14 Points into four simple elements that he called a **System of Profound Knowledge**:

1. Appreciation for a system
2. Understanding variation
3. Theory of knowledge
4. Psychology

Systems A **system** is a set of functions or activities within an organization that work together for the aim of the organization. A system is composed of many smaller, interacting subsystems. For example, a McDonald's restaurant is a system that includes the order-taker/cashier subsystem, grill and food preparation subsystem, drive-through subsystem, and order fulfillment subsystem. These subsystems are linked together as internal customers and suppliers. Likewise, every organization is composed of many individual functions, which are often seen as separate units on an organization chart. However, as we noted in Chapter 1, most processes are cross-functional. Thus, managers should focus on the interactions of parts and of the system with other systems, rather than the actions of parts taken separately.

The aim of any system should be for all stakeholders—stockholders, employees, customers, community, and the environment—to benefit over the long term. To manage

any system, managers must understand the interrelationships among the systems' components and among the stakeholders who are involved. Russell Ackoff, a noted authority in systems thinking, explained the importance of systems thinking in the following way:

> *... a combination of the best practices by each part of a system taken separately does not yield the best system. We may not even get a good one. A company that has 12 facilities, each producing the same variations of the same type of beverage, had broken the production process down into 15 steps. It produced a table showing each factory (a column) and each of the 15 steps (rows). The company then carried out a study to determine the cost of each step at each factory (a costly study), which identified for each step the factory with the lowest cost. At each factory, the company tried to replace each of its steps that was not the lowest cost with the one used in the factory that had the lowest cost. Had this succeeded, each factory would be producing with steps that had each attained the lowest cost in any factory. It did not work! The lowest-cost steps did not fit together. The result was only a few insignificant cosmetic changes that did not justify the cost of the exercise.*[7]

Suboptimization (doing the best for individual components) results in losses to everybody in the system. For example, to purchase materials at the lowest price will often result in excessive costs in scrap and repair during manufacturing and increase overall costs; minimizing the cost of manufacturing alone might result in products that do not meet designers' specifications and customer needs. Such situations lead to a win–lose effect. Purchasing wins, manufacturing loses; manufacturing wins, customers lose; and so on.

Systems thinking applies also to managing people. Pitting individuals or departments against each other for resources is self-destructive to an organization. The individuals or departments will perform to maximize their own expected gain, not that of the entire firm. Therefore, optimizing the system requires internal cooperation. Likewise, traditional performance appraisals do not consider interactions within the system. Many factors affect an individual employee's performance, including the following:

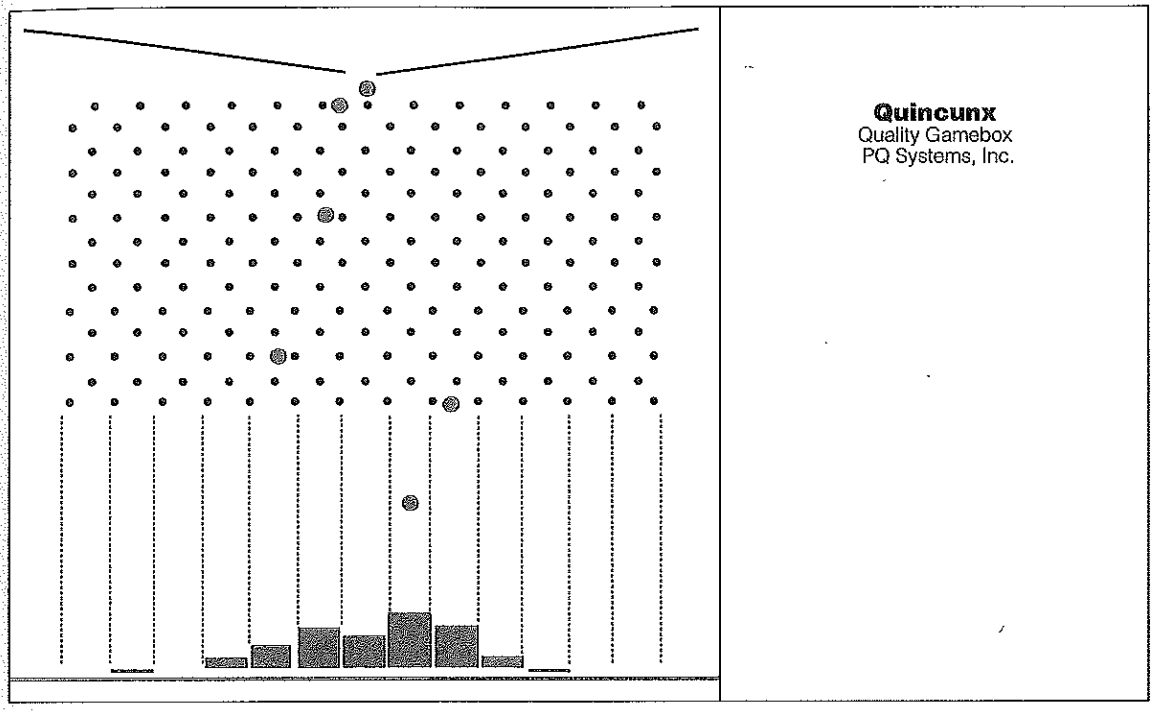
- The training received
- The information and resources provided
- The leadership of supervisors and managers
- Disruptions on the job
- Management policies and practices

Few performance appraisals recognize such factors and often place blame on individuals who have little ability to control their environment.

Variation The second part of Profound Knowledge is a basic understanding of statistical theory and variation. We see variation everywhere, from hitting golf balls to the meals and service in a restaurant. A device called a *quincunx* illustrates a natural process of variation. In a quincunx, small balls are dropped from a hole in the top and hit a series of pins as they fall toward collection boxes. The pins cause each ball to move randomly to the left or the right as it strikes each pin on its way down. (If you have ever watched the television show *The Price is Right*, you have seen a quincunx in the plinko game! If not, Google "plinko.")

A computer-simulated quincunx is shown in Figure 2.2.[8] Figure 2.3 shows the frequency distribution of where the balls landed in one simulation. Note that most balls end up toward the middle of the box, resulting in a symmetrical bell-shaped distribution similar to a normal distribution. Even though all balls are dropped from the same position, the end result shows variation.

FIGURE 2.2 A Quincunx in Action



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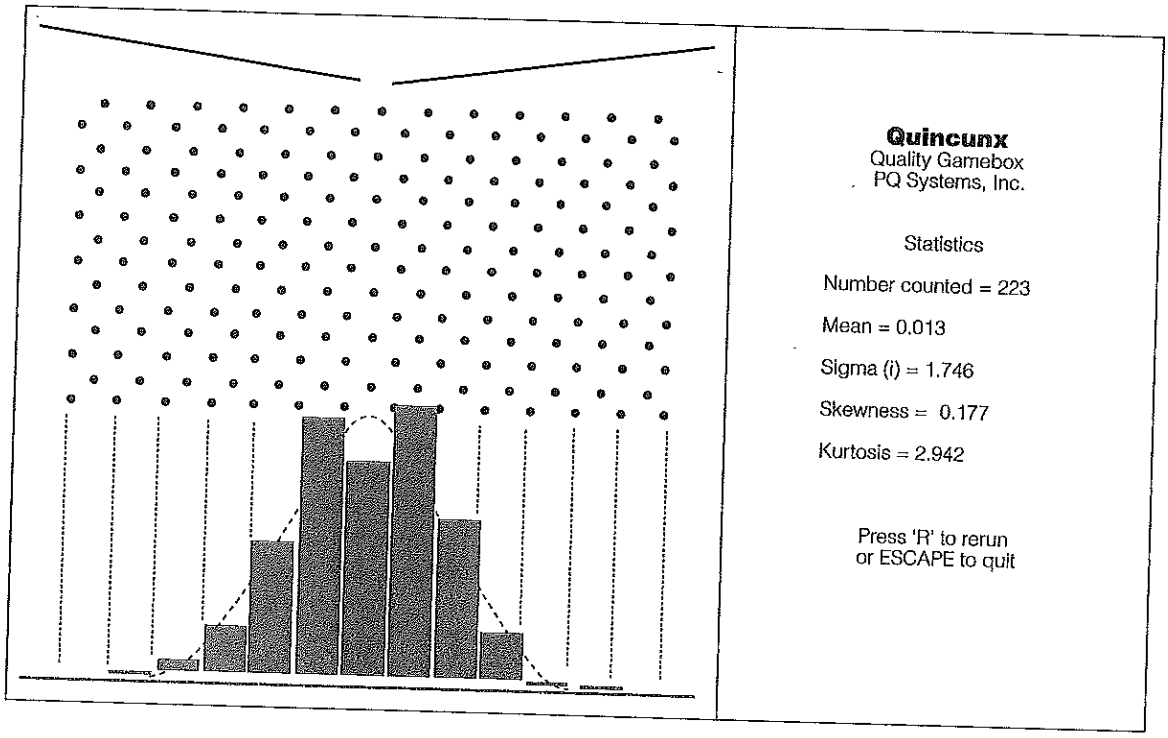
The same kind of variation exists in any production and service process, generally due to factors inherent in the design of the system, which cannot easily be controlled. Excessive variation results in products that fail or perform erratically and inconsistent service that does not meet customers' expectations. Statistical methods are the primary tools used to identify and quantify variation. Deming proposed that every employee in the firm be familiar with statistical techniques and other problem-solving tools. Statistics is a common language that every employee—from top executives to line workers—can use to communicate with one another. Its value lies in its objectivity; statistics leaves little room for ambiguity or misunderstanding.

Today, modern technology has improved our ability to produce many physical parts with very little variation; however, the variation that stems from human behavior and performance continues to hamper quality efforts. Deming suggested that management first understand, and then work to reduce variation through improvements in technology, process design, and training. With less variation, both the producer and consumer benefit. The producer benefits by needing less inspection, experiencing less scrap and rework, and having more consistent human performance, resulting in higher productivity and customer satisfaction. The consumer has the advantage of knowing that all products and services have similar quality characteristics and will perform or be delivered consistently. This advantage can be especially critical when the consumer is another firm using large quantities of the product in its own manufacturing or service operations.

FIGURE 2.3 Results from a Quincunx Experiment



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Theory of Knowledge The third part of Profound Knowledge is the **theory of knowledge**, the branch of philosophy concerned with the nature and scope of knowledge, its presuppositions and basis, and the general reliability of claims to knowledge. Basically, managers need to understand how things work and why decisions that affect the future should be effective. Any rational plan, however simple, requires prediction concerning conditions, behavior, and comparison of performance, and such predictions should be grounded in theory.

> ***Deming was influenced greatly by Clarence Irving Lewis, author of* Mind and the World, *who stated, "There is no knowledge without interpretation. If interpretation, which represents an activity of the mind, is always subject to the check of further experience, how is knowledge possible at all?... An argument from past to future at best is probable only, and even this probability must rest upon principles which are themselves more than probable."[9]***

For example, it is easy to learn a "cookbook" approach to applying a statistical formula, or using a Microsoft Excel Data Analysis tool. Doing so, however, runs the risk of using the tools inappropriately. Understanding the assumptions and theory behind statistical tools and techniques is vital to applying them correctly. Countless managers use a similar cookbook approach to managing by reading the latest self-help book and blindly following the author's recommendations. Many companies jump on popular approaches advocated by business consultants, only to see the approach fail. Copying an example of success, without understanding it with theory, may lead to disaster.

Deming emphasized that knowledge is not possible without theory, and experience alone does not establish a theory.

Experience only describes—it cannot be tested or validated—and alone it is of no help in management. Theory, on the other hand, helps one to understand cause-and-effect relationships that can be used for prediction and rational management decisions. It is one reason why Deming never gave managers any "solutions" or prescriptions for achieving quality. He wanted them to learn and discover what works and what is appropriate for their individual organizations and to rationalize their decisions, rather than simply copying others.

Psychology Psychology helps us understand people, interactions between people and circumstances, interactions between leaders and employees, and any system of management. It is critical to designing a work environment that promotes employee satisfaction and well-being. Much of Deming's philosophy is based on understanding human behavior and treating people fairly. Most managers operate under the assumption that all people are alike. However, people differ from one another. A true leader must be aware of these differences and work toward optimizing everybody's abilities and preferences.

People can be motivated intrinsically and extrinsically; however, the most powerful motivators are intrinsic. People are born with a need for love and esteem in their relationships with other people. Some circumstances provide people with dignity and self-esteem. Conversely, circumstances that deny people these advantages will smother intrinsic motivation. Fear does not motivate people; instead, it prevents the system from reaching its full potential. If people cannot enjoy their work, they will not be productive and focused on quality principles. Psychology helps us to nurture and preserve these positive innate attributes of people; otherwise, we resort to carrots and sticks that offer no long-term values.

One of Deming's more controversial beliefs is that pay is not a motivator, which industrial psychologists have been saying for decades. The chairman of General Motors once stated if GM doubled the salary of every employee, nothing would change. Monetary rewards are a way out for managers who do not understand how to manage intrinsic motivation. When joy in work becomes secondary to getting good ratings, employees are ruled by external forces and must act to protect what they have and avoid punishment.

Impacts of Profound Knowledge Peter Scholtes, a noted consultant, makes some salient observations about the failure to understand the components of Profound Knowledge:[10]

When people don't understand systems:

- They see events as individual incidents rather than the net result of many interactions and interdependent forces.
- They see the symptoms but not the deep causes of problems.
- They don't understand how an intervention in one part of [an organization] can cause havoc in another place or at another time.
- They blame individuals for problems even when those individuals have little or no ability to control the events around them.
- They don't understand the ancient African saying, "It takes a whole village to raise a child."

When people don't understand variation:

- They don't see trends that are occurring.
- They see trends where there are none.
- They don't know when expectations are realistic.
- They don't understand past performance so they can't predict future performance.
- They don't know the difference between prediction, forecasting, and guesswork.

- They give others credit or blame when those people are simply either lucky or unlucky, which usually occurs because people tend to attribute everything to human effort, heroics, frailty, error, or deliberate sabotage, no matter what the systemic cause.
- They are less likely to distinguish between fact and opinion.

When people don't understand psychology:

- They don't understand motivation or why people do what they do.
- They resort to carrots and sticks and other forms of induced motivation that offer no positive effect and impair the relationship between the motivator and the one being motivated.
- They don't understand the process of change and the resistance to it.
- They revert to coercive and paternalistic approaches when dealing with people.
- They create cynicism, demoralization, demotivation, guilt, resentment, burnout, craziness, and turnover.

When people don't understand the theory of knowledge:

- They don't know how to plan and accomplish learning and improvement.
- They don't understand the difference between improvement and change.
- Problems will remain unsolved, despite their best efforts.

Little of Deming's system of Profound Knowledge is original. Walter Shewhart developed the distinction between common and special causes of variation in the 1920s; business schools began to teach many of the behavioral theories to which Deming subscribed in the 1960s; management scientists refined systems theory in the 1950s through the 1970s; and scientists in all fields have long understood the relationships among prediction, observation, and theory. Deming's major contribution was to tie these concepts together in the context of business. He recognized their synergy and developed them into a unified universal theory of management.

Deming's legacy lives on through the W. Edwards Deming Institute (http://deming.org).

THE JURAN PHILOSOPHY

Joseph Juran (1904–2008) was born in Romania and came to the United States in 1912. He joined Western Electric in the 1920s as it pioneered in the development of statistical methods for quality. He spent much of his time as a corporate industrial engineer and, in 1951, did most of the writing, editing, and publishing of the *Quality Control Handbook*. This book, one of the most comprehensive quality manuals ever written, has been revised several times and continues to be a popular reference.

Like Deming, Juran taught quality principles to the Japanese in the 1950s and was a principal force in their quality reorganization. Among the steps taken by Japanese organizations as a result of Juran's leadership were:

- Directing quality from the senior management level
- Training the entire management hierarchy in quality principles
- Striving to improve quality at a revolutionary rate
- Reporting progress on quality goals to executive levels
- Involving the workforce in quality
- Revising the reward and recognition structure to include quality[11]

During the quality revolution in the second half of the twentieth century, Juran echoed Deming's conclusion that U.S. businesses faced a major crisis in quality due to the

huge costs of poor quality and the loss of sales to foreign competition. Both men felt that the solution to this crisis depends on new thinking about quality that includes all levels of the managerial hierarchy. Upper management in particular requires training and experience in managing for quality. Even into this century, Juran continued to warn the United States that it faces losing its status as an economic superpower unless it improves the quality of its goods and services.

Unlike Deming, however, Juran did not propose a major cultural change in the organization, but rather sought to improve quality by working within the system familiar to managers. Thus, his programs were designed to fit into a company's strategic business planning process with minimal risk of rejection. He argued that employees at different levels of an organization speak in their own "languages." (Deming, on the other hand, believed statistics should be the common language.) Juran stated that top management speaks in the language of dollars; workers speak in the language of things; and middle management must be able to speak both languages and translate between dollars and things. Thus, to get top management's attention, quality issues must be cast in the language they understand—dollars. Hence, Juran advocated the use of quality cost accounting and analysis to focus attention on quality problems. At the operational level, Juran focused on increasing conformance to specifications through elimination of defects, supported extensively by statistical tools for analysis. Thus, his philosophy fit well into existing management systems.

Juran suggested that quality should be viewed from both external and internal perspectives; that is, quality is related to (1) product performance that results in customer satisfaction, and (2) freedom from product deficiencies, which avoids customer dissatisfaction. Juran proposed the user-based definition of quality we introduced in Chapter 1: "fitness for use." How products and services are designed, manufactured and delivered, and serviced in the field all contribute to fitness for use. Thus, the pursuit of quality is viewed on two levels: (1) the mission of the firm as a whole is to achieve high design quality; and (2) the mission of each department in the firm is to achieve high-conformance quality. Like Deming, Juran advocated a never-ending spiral of activities that includes market research, product development, design, planning for manufacture, purchasing, production process control, inspection and testing, and sales, followed by customer feedback. The interdependency of these functions emphasizes the need for competent companywide quality management. Senior management must play an active and enthusiastic leadership role in the quality management process.

Juran's prescriptions focus on three major quality processes, called the **Quality Trilogy**: (1) *quality planning*—the process of preparing to meet quality goals; (2) *quality control*—the process of meeting quality goals during operations; and (3) *quality improvement*—the process of breaking through to unprecedented levels of performance. At the time he proposed this structure, few companies were engaging in any significant planning or improvement activities. Thus, Juran was promoting a major cultural shift in management thinking.

Quality planning begins with identifying customers, both external and internal, determining their needs, translating customer needs into specifications, developing product features that respond to those needs, and developing the processes capable of producing the product or delivering the service. Thus, like Deming, Juran wanted employees to know who uses their products, whether in the next department or in another organization. Quality goals based on meeting the needs of customers and suppliers alike at a minimum combined cost are then established. Next, the process that can produce the product to satisfy customers' needs and meet quality goals under operating conditions must be designed. Strategic planning for quality—similar to the firm's financial planning process—determines short-term and long-term goals, sets priorities, compares results with previous plans, and meshes the plans with other corporate strategic objectives.

As a parallel to Deming's emphasis on identifying and reducing sources of variation, Juran stated that quality control involves determining what to control, establishing units of measurement to evaluate data objectively, establishing standards of performance, measuring actual performance, interpreting the difference between actual performance and the standard, and taking action on the difference.

Unlike Deming, however, Juran specified a detailed program for quality improvement. According to Juran, all breakthroughs follow a commonsense sequence of discovery, organization, diagnosis, corrective action, and control, which he formalized as the **breakthrough sequence**, and which can be summarized as follows:

- *Proof of the Need:* Managers, especially top managers, need to be convinced that quality improvements are simply good economics. Through data collection efforts, information on poor quality, low productivity, or poor service can be translated into the language of money—the universal language of top management—to justify a request for resources to implement a quality improvement program.
- *Project Identification*: All breakthroughs are achieved project-by-project, and in no other way. By taking a project approach, management provides a forum for converting an atmosphere of defensiveness or blame into one of constructive action. Participation in a project increases the likelihood that the participant will act on the results.
- *Organization for Breakthrough*: Organization for improvement requires a clear responsibility for guiding the project. The responsibility for the project may be as broad as an entire division with formal committee structures or as narrow as a small group of workers at one production operation. These groups provide the definition and agreement as to the specific aims of the project, the authority to conduct experiments, and implementation strategies. The path from problem to solution consists of two journeys: one from symptom to cause (the diagnostic journey) and the other from cause to remedy (the remedial journey), which must be performed by different individuals with the appropriate skills.
- *Diagnostic Journey:* Diagnosticians skilled in data collection, statistics, and other problem-solving tools are needed at this stage. Some projects will require full-time, specialized experts (such as Six Sigma Black Belts) while the workforce can perform others. Management-controllable and operator-controllable problems require different methods of diagnosis and remedy.
- *Remedial Journey*: The remedial journey consists of several phases: choosing an alternative that optimizes total cost (similar to one of Deming's points), implementing remedial action, and dealing with resistance to change.
- *Holding the Gains*: This final step involves establishing the new standards and procedures, training the workforce, and instituting controls to make sure that the breakthrough does not die over time.

Juran's approaches are reflected in the practices of a wide variety of organizations today.

The Juran Institute, founded by Dr. Juran, provides substantial training in the form of seminars, videos, and other materials (http://www.juran.com).

Many aspects of the Juran and Deming philosophies are similar. The focus on top management commitment, the need for improvement, the use of quality control techniques, and the importance of training are fundamental to both philosophies. However, they did not agree on all points. For instance, Juran believed that Deming was wrong to tell management to drive out fear; he noted: "Fear can bring out the best in people."[12]

THE CROSBY PHILOSOPHY

Philip B. Crosby (1926–2001) was corporate vice president for quality at International Telephone and Telegraph (ITT) for 14 years after working his way up from line inspector. After leaving ITT, he established Philip Crosby Associates in 1979 to develop and offer training programs. He also authored several popular books. His first book, *Quality Is Free*, sold about one million copies and was largely responsible for bringing quality to the attention of top corporate managers in the United States. The essence of Crosby's quality philosophy is embodied in what he calls the **Absolutes of Quality Management** and the **Basic Elements of Improvement**. Crosby's Absolutes of Quality Management include the following points:

- *Quality means conformance to requirements, not elegance.* Crosby's definition of quality is similar to the manufacturing perspective that we discussed in Chapter 1. Quality is judged solely on whether requirements have been met; nonconformance is the absence of quality. Requirements are ironclad and must be clearly stated so that they cannot be misunderstood. Requirements act as communication devices. Setting requirements is the responsibility of management. Once requirements are established, then one can take measurements to determine conformance to those requirements.
- *There is no such thing as a quality problem.* Problems originate in functional departments. Thus, a firm may experience accounting problems, manufacturing problems, design problems, technical support problems, and so on. In Crosby's view, these are all quality problems, but the burden of responsibility for solving them falls on these functional departments and not in the quality department. The role of the quality department should be to measure conformance, report results, and provide leadership and support to drive quality improvement. This Absolute is similar to Deming's third Point.
- *There is no such thing as the economics of quality; doing the job right the first time is always cheaper.* Crosby supports the premise that "economics of quality" has no meaning. Quality is free; what costs money are all actions that involve not doing jobs right the first time. The Deming chain reaction sends a similar message.
- *The only performance measurement is the cost of quality, which is the expense of nonconformance.* Crosby noted that most companies spend 15 percent to 20 percent of their sales dollars on quality costs. A company with a well-run quality management program can achieve a cost of quality that is less than 2.5 percent of sales, primarily in the prevention and appraisal categories. Crosby suggested that organizations measure and publicize the cost of poor quality. This helps to call problems to management's attention, to select opportunities for corrective action, and to track quality improvement over time. Juran also supported this concept.
- *The only performance standard is "Zero Defects (ZD)."* He explained it as follows:

  Zero Defects is a performance standard. It is the standard of the craftsperson regardless of his or her assignment ... The theme of ZD is do it right the first time. That means concentrating on preventing defects rather than just finding and fixing them.

  People are conditioned to believe that error is inevitable; thus they not only accept error, they anticipate it. It does not bother us to make a few errors in our work ... to err is human. We all have our own standards in business or academic life—our own

points at which errors begin to bother us. It is good to get an A in school, but it may be OK to pass with a C.

We do not maintain these standards, however, when it comes to our personal life. If we did, we should expect to be shortchanged every now and then when we cash our paycheck; we should expect hospital nurses to drop a constant percentage of newborn babies ... We as individuals do not tolerate these things. We have a dual standard: one for ourselves and one for our work.

Most human error is caused by lack of attention rather than lack of knowledge. Lack of attention is created when we assume that error is inevitable. If we consider this condition carefully, and pledge ourselves to make a constant conscious effort to do our jobs right the first time, we will take a giant step toward eliminating the waste of rework, scrap, and repair that increases cost and reduces individual opportunity.[13]

Juran and Deming, on the other hand, would point out that despite workers' good intentions, the overwhelming majority of quality problems stem not from human error, but from poorly designed systems that are the responsibility of management.

Crosby's Basic Elements of Improvement were *determination*, *education*, and *implementation*. Determination means that top management must take quality improvement seriously. Everyone should understand the Absolutes, which can be accomplished only through education. Finally, every member of the management team must understand the implementation process.

Philip Crosby Associates (http://www.philipcrosby.com) continues Crosby's legacy and consults with numerous organizations in quality implementation and training.

Crosby's approach to quality was primarily behavioral, and emphasized management and organizational processes to change corporate culture and attitudes rather than statistical techniques and improvement methodologies. Like Juran, his approach fit well within existing organizational structures.

Comparing Deming, Juran, and Crosby

Despite their significant differences to implementing organizational change, the philosophies of Deming, Juran, and Crosby are more alike than different. Each views quality as imperative to future competitiveness in global markets; makes top management commitment an absolute necessity; demonstrates that quality management practices will save, not cost money; places responsibility for quality on management, not the workers; stresses the need for continuous, never-ending improvement; acknowledges the importance of the customer and strong management/worker partnerships; and recognizes the need for and difficulties associated with changing the organizational culture.

Although each of these philosophies can be highly effective by itself, the choice is not always clear. An organization must understand the nature and differences of the philosophies and how they fit into their own unique culture. More often than not, organizations develop an approach specifically tailored to their own culture and management style, which incorporates many of the ideas from all three philosophies.

OTHER QUALITY PHILOSOPHERS

Two other notable figures in the quality arena include A. V. Feigenbaum and Kaoru Ishikawa. In this section we briefly review the accomplishments of these individuals.[14]

A. V. Feigenbaum

A. V. Feigenbaum (1920–2014) began his career in quality over a half century ago. For 10 years, he was the manager of worldwide manufacturing and quality control at General Electric. In 1968, he founded General Systems Company of Pittsfield, Massachusetts, and served as its president and CEO until his death. Feigenbaum traveled and spoken to various audiences and groups around the world over the years. He was elected as the founding chairman of the board of the International Academy of Quality, which has attracted active participation from the European Organization for Quality Control, the Union of Japanese Scientists and Engineers (JUSE), as well as the American Society for Quality.

Feigenbaum is best known for coining the phrase *total quality control*, which he defined as "an effective system for integrating the quality development, quality maintenance, and quality improvement efforts of the various groups in an organization so as to enable production and service at the most economical levels which allow full customer satisfaction," and explained in his book *Total Quality Control*, which was first published in 1951 under the title *Quality Control: Principles, Practice, and Administration*. He viewed quality as a strategic business tool that requires involvement from everyone in the organization, and promoted the use of quality costs as a measurement and evaluation tool.

Feigenbaum's philosophy is summarized in his **Three Steps to Quality**:

1. *Quality Leadership*: A continuous management emphasis is grounded on sound planning rather than reaction to failures. Management must maintain a constant focus and lead the quality effort.
2. *Modern Quality Technology*: The traditional quality department cannot resolve 80 percent to 90 percent of quality problems. This task requires the integration of office staff as well as engineers and shop-floor workers in the process who continually evaluate and implement new techniques to satisfy customers in the future.
3. *Organizational Commitment*: Continuous training and motivation of the entire workforce as well as an integration of quality in business planning indicate the importance of quality and provide the means for including it in all aspects of the firm's activities.

Feigenbaum also popularized the term *hidden factory*, which described the portion of plant capacity wasted due to poor quality. Many of his ideas remain embedded in contemporary thinking, and have become important elements of the Malcolm Baldrige National Quality Award criteria. These aspects include the principles that the customer is the judge of quality; quality and innovation are interrelated and mutually beneficial; managing quality is the same as managing the business; quality is a continuous process of improvement; and customers and suppliers should be involved the process. This is summed up in his statement that "Quality is, in essence, a way of managing the organization." In 2008, he received the prestigious National Medal of Technology and Innovation.[15]

Feigenbaum and Ishikawa were both awarded the title of Honorary Members of the American Society for Quality in 1986. At that time, the society had only four living honorary members, two of whom were W. Edwards Deming and Joseph M. Juran.

Kaoru Ishikawa

An early pioneer in the quality revolution in Japan, Kaoru Ishikawa was the foremost figure in Japanese quality until his death in 1989. He was instrumental in the development of the broad outlines of Japanese quality strategy, and without his leadership, the Japanese quality movement would not enjoy the worldwide acclaim and success that it has today. Dr. Ishikawa was a

professor of engineering at Tokyo University for many years. As a member of the editorial review board for the Japanese journal *Quality Control for Foremen*, founded in 1962, and later as the chief executive director of the QC Circle Headquarters at the Union of Japanese Scientists and Engineers (JUSE), Dr. Ishikawa influenced the development of a participative, bottom-up view of quality, which became the trademark of the Japanese approach to quality management. However, Ishikawa was also able to get the attention of top management and persuade them that a companywide approach to quality control was necessary for total success.

Ishikawa built on Feigenbaum's concept of total quality and promoted greater involvement by all employees, from the top management to the front-line staff, by reducing reliance on quality professionals and quality departments. He advocated collecting and analyzing factual data using simple visual tools, statistical techniques, and teamwork as the foundations for implementing total quality. Like others, Ishikawa believed that quality begins with the customer and therefore, understanding customers' needs is the basis for improvement, and that complaints should be actively sought. Some key elements of his philosophy are summarized here.

1. Quality begins with education and ends with education.
2. The first step in quality is to know the requirements of customers.
3. The ideal state of quality control occurs when inspection is no longer necessary.
4. Remove the root cause, not the symptoms.
5. Quality control is the responsibility of all workers and all divisions.
6. Do not confuse the means with the objectives.
7. Put quality first and set your sights on long-term profits.
8. Marketing is the entrance and exit of quality.
9. Top management must not show anger when facts are presented by subordinates.
10. Ninety-five percent of problems in a company can be solved with simple tools for analysis and problem solving.
11. Data without dispersion information (i.e., variability) are false data.

Dr. Ishikawa is best known for developing a popular quality improvement tool called a cause-and-effect diagram, which often bears his name (see Chapter 9).

PRINCIPLES, PRACTICES, AND TECHNIQUES OF QUALITY MANAGEMENT

In a classic research article, James W. Dean, Jr. and David E. Bowen characterize total quality by its principles, practices, and techniques.[16] **Principles** are the foundation of the philosophy, **practices** are activities by which the principles are implemented, and **techniques** are tools and approaches that help managers and workers make the practices effective. All are vital for achieving high quality and performance excellence.

Quality Management Principles

The TQ philosophy was based initially on three core principles: *customer focus*, *teamwork*, and *continuous improvement*. Despite their obvious simplicity, these principles represented a significant departure from traditional management practices. Historically, firms did little to understand external customer requirements, much less those of internal customers. Products were designed from a "market out" perspective (build it and they will come) rather than from a "market in" perspective that seeks to meet customer

expectations and requirements. Managers and specialists controlled and directed production systems; workers were told what to do and how to do it, and rarely were asked for their input. Teamwork and the soliciting of ideas from the workforce were virtually nonexistent. A certain amount of waste and error was tolerable and was controlled by postproduction inspection. Improvements in quality generally resulted from technological breakthroughs instead of a relentless mindset of continuous improvement. With TQ, organizations began to actively identify customer needs and expectations, build quality into the organization by tapping the knowledge and experience of the workforce, and continually improve its processes and systems.

The quality management principles underlying ISO 9000:2000 were derived from the collective experience and knowledge of international experts who participate in ISO Technical Committee ISO/TC 176, Quality Management and Quality Assurance, *which is responsible for developing and maintaining the ISO 9000 standards.*

As the discipline evolved, the principles that define modern quality management have also naturally evolved as we have learned more about what it takes to build and sustain quality in an organization. Table 2.2 is a list of the quality management principles that underlie the international quality standards known as ISO 9000:2000, which we describe later in this chapter. These are "comprehensive and fundamental rules or beliefs for leading and operating an organization" that better reflect the basic principles and practices of total quality. In addition to customer focus, involvement of people (teamwork), and continual improvement, important principles of quality management are leadership, process approach, a system approach to management, a factual approach to decision making, and mutually beneficial supplier relationships. These principles are evident within the philosophies of Deming, Juran, and Crosby, and will be reflected in our discussions, examples, and cases throughout the rest of this book.

The Quality Profile features at the beginning of each chapter show how many of the quality management practices in Table 2.3 are used to achieve exceptional results in many organizations.

Quality Management Practices

Quality management practices represent the approaches that organizations use to achieve the principles. Table 2.3 summarizes representative practices associated with each of the principles in Table 2.2. Again, we will be discussing and illustrating these throughout the rest of this book.

Quality Management Techniques

Techniques include a wide variety of tools to plan work activities, collect data, analyze results, monitor progress, and solve problems. For instance, an Excel chart showing trends in manufacturing defects as workers progress through a training program is a simple tool to monitor the effectiveness of the training; the statistical technique of experimental design can be used to optimize process settings to reduce scrap or increase yield. Throughout this book, and particularly in Part II, we will introduce many techniques that are useful in quality planning, control, and improvement activities.

One of the most important techniques is basic statistics. As we have discussed, Deming emphasized the importance of using statistical methods for quality. Although we formally discuss statistical tools and methods in Chapter 6, the ability to view data and information from a statistical perspective is a vital skill. We introduce this next, as it also relates closely to the Deming philosophy and experiments that he used in his teaching activities.

TABLE 2.2 Quality Management Principles

Principle 1: Customer Focus
Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements, and strive to exceed customer expectations.

Principle 2: Leadership
Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

Principle 3: Involvement of People
People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

Principle 4: Process Approach
A desired result is achieved more efficiently when activities and related resources are managed as a process.

Principle 5: System Approach to Management
Identifying, understanding, and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.

Principle 6: Continual Improvement
Continual improvement of the organization's overall performance should be a permanent objective of the organization.

Principle 7: Factual Approach to Decision Making
Effective decisions are based on the analysis of data and information.

Principle 8: Mutually Beneficial Supplier Relationships
An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

Source: http://www.iso.org/iso/qmp. Reprinted with permission.

TABLE 2.3 Practices for Implementing Quality Management Principles[17]

Principle 1: Customer Focus

- Researching and understanding customer needs and expectations.
- Ensuring that the objectives of the organization are linked to customer needs and expectations.
- Communicating customer needs and expectations throughout the organization.
- Measuring customer satisfaction and acting on the results.
- Systematically managing customer relationships.
- Ensuring a balanced approach between satisfying customers and other interested parties (such as owners, employees, suppliers, financiers, local communities and society as a whole).

Principle 2: Leadership

- Considering the needs of all interested parties including customers, owners, employees, suppliers, financiers, local communities and society as a whole.
- Establishing a clear vision of the organization's future.
- Setting challenging goals and targets.
- Creating and sustaining shared values, fairness and ethical role models at all levels of the organization.
- Establishing trust and eliminating fear.
- Providing people with the required resources, training and freedom to act with responsibility and accountability.
- Inspiring, encouraging, and recognizing people's contributions.

(continued)

TABLE 2.3 Practices for Implementing Quality Management Principles (*Continued*)

Principle 3: Involvement of People

- People understanding the importance of their contribution and role in the organization.
- People identifying constraints to their performance.
- People accepting ownership of problems and their responsibility for solving them.
- People evaluating their performance against their personal goals and objectives.
- People actively seeking opportunities to enhance their competence, knowledge, and experience.
- People freely sharing knowledge and experience.
- People openly discussing problems and issues.

Principle 4: Process Approach

- Systematically defining the activities necessary to obtain a desired result.
- Establishing clear responsibility and accountability for managing key activities.
- Analyzing and measuring of the capability of key activities.
- Identifying the interfaces of key activities within and between the functions of the organization.
- Focusing on the factors such as resources, methods, and materials that will improve key activities of the organization.
- Evaluating risks, consequences, and impacts of activities on customers, suppliers, and other interested parties.

Principle 5: System Approach to Management

- Structuring a system to achieve the organization's objectives in the most effective and efficient way.
- Understanding the interdependencies between the processes of the system.
- Structured approaches that harmonize and integrate processes.
- Providing a better understanding of the roles and responsibilities necessary for achieving common objectives and thereby reducing cross-functional barriers.
- Understanding organizational capabilities and establishing resource constraints prior to action.
- Targeting and defining how specific activities within a system should operate.
- Continually improving the system through measurement and evaluation.

Principle 6: Continual Improvement

- Employing a consistent organization-wide approach to continual improvement of the organization's performance.
- Providing people with training in the methods and tools of continual improvement.
- Making continual improvement of products, processes, and systems an objective for every individual in the organization.
- Establishing goals to guide, and measures to track, continual improvement.
- Recognizing and acknowledging improvements.

Principle 7: Factual Approach to Decision Making

- Ensuring that data and information are sufficiently accurate and reliable.
- Making data accessible to those who need it.
- Analyzing data and information using valid methods.
- Making decisions and taking action based on factual analysis, balanced with experience and intuition.

Principle 8: Mutually Beneficial Supplier Relationships

- Establishing relationships that balance short-term gains with long-term considerations.
- Pooling of expertise and resources with partners.
- Identifying and selecting key suppliers.

(*continued*)

TABLE 2.3 Practices for Implementing Quality Management Principles *(Continued)*

- Clear and open communication.
- Sharing information and future plans.
- Establishing joint development and improvement activities.
- Inspiring, encouraging, and recognizing improvements and achievements by suppliers.

VARIATION AND STATISTICAL THINKING

Brian Joiner, a noted quality management consultant, relates the following scenario:[18]

> *Ed was a regional VP for a service company that had facilities around the world. He was determined that the facilities in his region would get the highest customer satisfaction ratings in the company. If he noticed that a facility had a major drop in satisfaction ratings in one month or had "below average" ratings for three months in a row, he would call the manager and ask what had happened—and make it clear that next month's rating had better improve. And most of the time, it did!*

As the average satisfaction score dropped from 65 to 60 between February and March, Ed's memo to his managers read:

> *Bad news! We dropped five points! We should all focus on improving these scores right away! I realize that our usage rates have increased faster than anticipated, so you've really got to hustle to give our customers great service. I know you can do it!*

As Joiner observed, "Do you look at data this way? This month versus last month? This month versus the same month last year? Do you sometimes look at the latest data point? The last two data points? I couldn't understand why people would only want to look at two data points. Finally, it became clear to me. With any two data points, it's easy to compute a trend: 'Things are down 2 percent this month from last month. This month is 30 percent above the same month last year.' Unfortunately, we learn nothing of importance by comparing two results when they both come from a stable process . . . and most data of importance to management are from stable processes."

Brian Joiner's scenario points to the need for managers to think statistically. Unfortunately, most do not, and often make decisions based on a single data point or two, see trends when they don't exist, or try to manipulate financial or operational results they cannot truly control.

Statistical thinking is a philosophy of learning and action based on these principles:

1. All work occurs in a system of interconnected processes.
2. Variation exists in all processes.
3. Understanding and reducing variation are keys to success.[19]

With the enormous wealth of information that is available to organizations today, being able to understand variability in data and to think statistically are vital to managing modern enterprises.

Understanding Variation

Figure 2.4 shows the sources of variation that affect most manufacturing processes. Different lots of material may vary in strength, thickness, or moisture content, for example. Cutting tools have inherent variation in their strength and composition. During

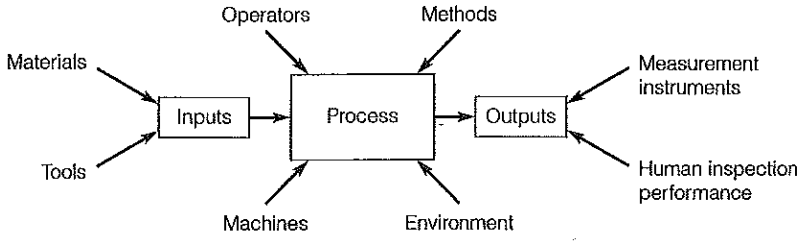


FIGURE 2.4
Sources of Variation in a Production Process

manufacturing, tools experience wear, vibrations cause changes in machine settings, and electrical fluctuations cause variations in power. Operators may not position parts on fixtures consistently, and physical and emotional stress affect operators' consistency. In addition, measurement gauges and human inspection capabilities are not uniform. Even when measurements of several items by the same instrument are the same, it is due to a lack of precision in the measurement instrument; extremely precise instruments always reveal slight differences.

Some of the operational problems created by variation include the following:[20]

- *Variation Increases Unpredictability*: If we don't understand the variation in a system, we cannot predict its future performance.
- *Variation Reduces Capacity Utilization:* If a process has little variability, then managers can increase the load on the process because they do not have to incorporate slack into their production plans.
- *Variation Contributes to a "Bullwhip" Effect*: This well-known phenomenon occurs in supply chains; when small changes in demand occur, the variation in production and inventory levels becomes increasingly amplified upstream at distribution centers, factories, and suppliers, resulting in unnecessary costs and difficulties in managing material flow.
- *Variation Makes It Difficult to Find Root Causes*: Process variation makes it difficult to determine whether problems are due to external factors such as raw materials or reside within the processes themselves.
- *Variation Makes It Difficult to Detect Potential Problems Early*: Unusual variation is a signal that problems exist; if a process has little inherent variation, then it is easier to detect when a problem actually does occur.

The complex interactions of these variations in materials, tools, machines, operators, and the environment are not easily understood. Variation due to any of these individual sources appears at random; individual sources cannot be identified or explained. However their combined effect is stable and can usually be predicted statistically. These factors are present as a natural part of a process and are referred to as **common causes of variation.** Common causes are a result of the design of the product and production system and generally account for about 80 to 95 percent of the observed variation in the output of a production process. Therefore, common cause variation can only be reduced if the product is redesigned, or if better technology or training is provided for the production process. For example, Wilson Sporting Goods Company acknowledged that small irregularities in golf balls can cause the heavier core of golf balls to be off center, resulting in balls that don't roll straight, with up to 1 in 12 high-end balls having this problem. To solve the problem, Wilson introduced a new ball design, with a lighter core and heavier cover.[21]

The remaining variation in a production process is the result of **special causes**, often called **assignable causes of variation**. Special causes arise from external sources that are not inherent in the process. They appear sporadically and disrupt the random pattern of common causes. Hence, they tend to be easily detectable using statistical methods and are usually economical to correct. Common factors that lead to special causes could be a bad batch of material from a supplier, a poorly trained substitute machine operator, a broken or worn tool, or a miscalibration of measuring instruments. Unusual variation that results from such isolated incidents can be explained or corrected.

The failure to distinguish between these two types of variation can lead to two fundamental management mistakes in attempting to improve a process:

1. To treat as a special cause any fault, complaint, mistake, breakdown, accident, or shortage when it actually is due to common causes.
2. To attribute to common causes any fault, complaint, mistake, breakdown, accident, or shortage when it actually is due to a special cause.

In the first case, tampering with a stable system can increase the variation in the system. In the second case, the opportunity to reduce variation is missed because the amount of variation is mistakenly assumed to be uncontrollable.

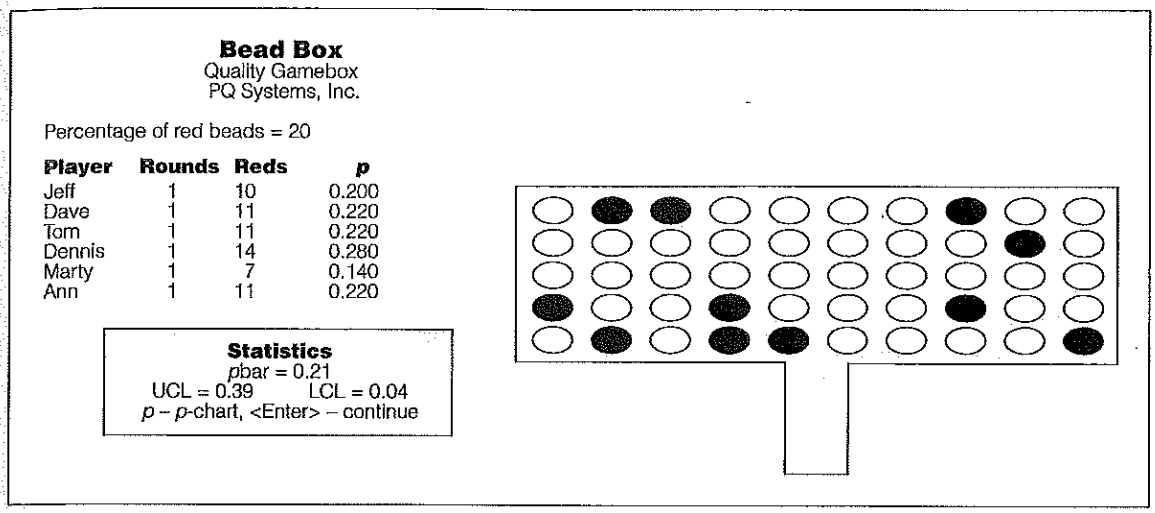
Deming's Red Bead and Funnel Experiments[22]

Statistical thinking lies at the heart of the Deming philosophy and his principles of Profound Knowledge. In his four-day management seminars, Deming used two simple yet powerful experiments to educate his audience about statistical thinking. The first is the **Red Bead experiment**, which proceeds as follows. A Foreman (usually Deming) selects several volunteers from the audience: Six Willing Workers, a Recorder, two Inspectors, and a Chief Inspector. The materials for the experiment include 4,000 wooden beads—800 red and 3,200 white—and two Tupperware boxes, one slightly smaller than the other. Also, a paddle with 50 holes or depressions is used to scoop up 50 beads, which is the prescribed workload. In this experiment, the company is "producing" beads for a new customer who needs only white beads and will not take red beads. The Foreman explains that everyone will be an apprentice for three days to learn the job. During apprenticeship, the workers may ask questions. Once production starts, however, no questions are allowed. The procedures are rigid; no departures from procedures are permitted so that no variation in performance will occur. The Foreman explains to the Willing Workers that their jobs depend on their performance and if they are dismissed, many others are willing to replace them. Furthermore, no resignations are allowed.

> ***Deming has been credited with keeping statistics in the forefront of the worldwide quality improvement movement: "The triumph of statistics is the triumph of Dr. Deming. When others have wavered or been lukewarm in their support for statistics, Dr. Deming has stood firm in his conviction that statistics is the heart of quality control. Indeed, he goes further and makes statistical principles central to the whole production process."[23]***

The company's work standard, the Foreman explains, is 50 beads per day. The production process is simple: Mix the raw material and pour it into the smaller box. Repeat this procedure, returning the beads from the smaller box to the larger one. Grasp the paddle and insert it into the bead mixture. Raise the paddle at a 44-degree angle so that every depression will hold a bead. The two Inspectors count the beads independently and record the counts. The Chief Inspector checks the counts and announces the results, which are

FIGURE 2.5 First Day's Production (The paddle shows the result of the last Willing Worker, Ann)



Source: Copyright PQ Systems, www.pqsystems.com

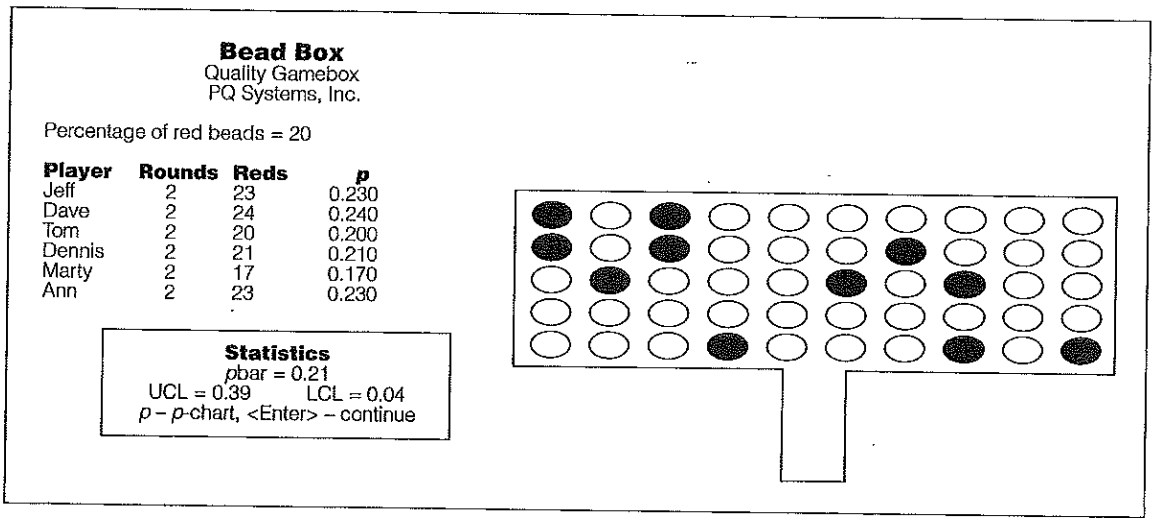
written down by the Recorder. The Chief Inspector then dismisses the worker. When all six Willing Workers have produced the day's quota, the Foreman evaluates the results.

Figure 2.5 shows the results of the first day's production generated with the Quality Gamebox computer simulation software. The Foreman is disappointed. He reminds the Willing Workers that their job is to make white beads, not red ones. The company is on a merit system, and it rewards only good performance. Marty only made 7 red beads and deserves a pay increase. The data do not lie; he is the best worker. Dennis made 14 red beads. Everyone likes him, but he must be placed on probation. The Foreman announces that management has set a goal of no more than 7 red beads per day per worker, and sees no reason why everyone cannot be as good as Marty.

Figure 2.6 shows the cumulative results for the second day. We see that after two days, Jeff had produced 23 red beads, Dave 24, Tom 20, Dennis 21, Marty 17, and Ann 23. (The second day's results can be found by subtraction: Jeff produces 13 beads, Dave 13, Tom 9, Dennis 7, Marty 10, and Ann 12.) The overall performance was not good. Management is watching carefully. The Foreman reminds them again that their jobs depend on performance. Marty is a big disappointment. The merit increase obviously went to his head. The Foreman chastises him in front of the other workers. Dennis, on the other hand, showed remarkable improvement; probation and the threat of losing his job made him a better worker—only 7 red beads—a 50 percent reduction in defects! He met the goal; if he can do it, anyone can. Dennis gets a special commendation from the plant manager.

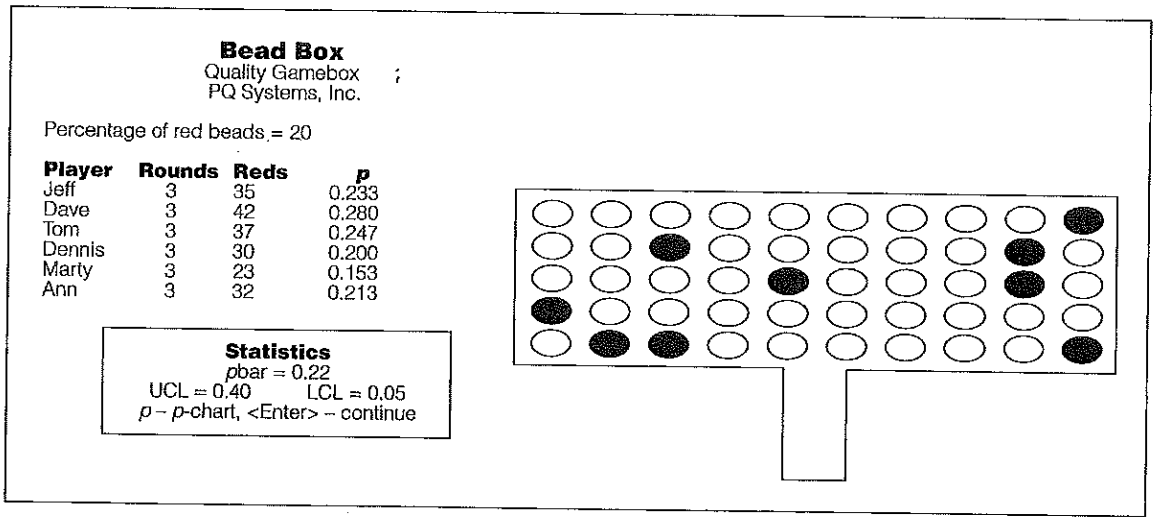
At the beginning of the third day, management announces a Zero Defects Day. Everyone will do their best on this last day of the apprenticeship program. The Foreman is desperate and he tells the Willing Workers again that their jobs are their own responsibility. From Figure 2.7, production figures can be determined (by computing the difference between the cumulative output of day 3 and day 2), and show that Jeff produces 12 red beads, Dave 18, Tom 17, Dennis 9, Marty 6, and Ann 11. Clearly, Marty learned a lesson the day before, but the group's overall performance is not good. Management is

FIGURE 2.6 Second Day's Cumulative Results



Source: Copyright PQ Systems, www.pqsystems.com

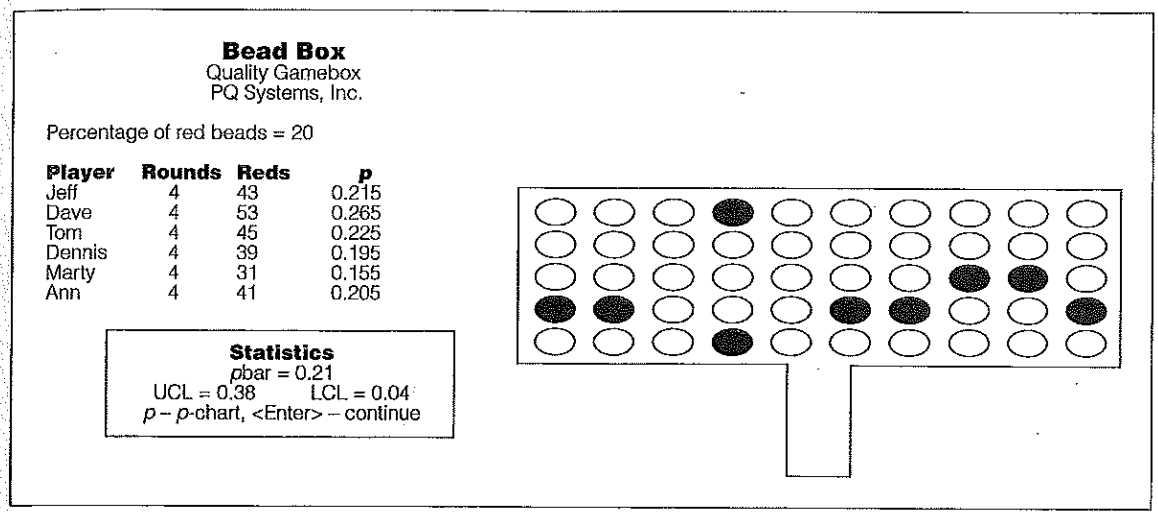
FIGURE 2.7 Third Day's Cumulative Results



Source: Copyright PQ Systems, www.pqsystems.com

bitterly disappointed at the results. The Zero Defect Day program did not improve quality substantially; in fact, more red beads were produced today than ever before. Costs are getting out of control, and there is talk of shutting down the entire plant. Dave and Tom receive pink slips informing them that tomorrow will be their last day; their work is clearly much worse than the others. But the Foreman is optimistic. He puts up a poster saying "Be a Quality Worker!" to encourage the others to reach the goal.

FIGURE 2.8 Fourth Day's Cumulative Results



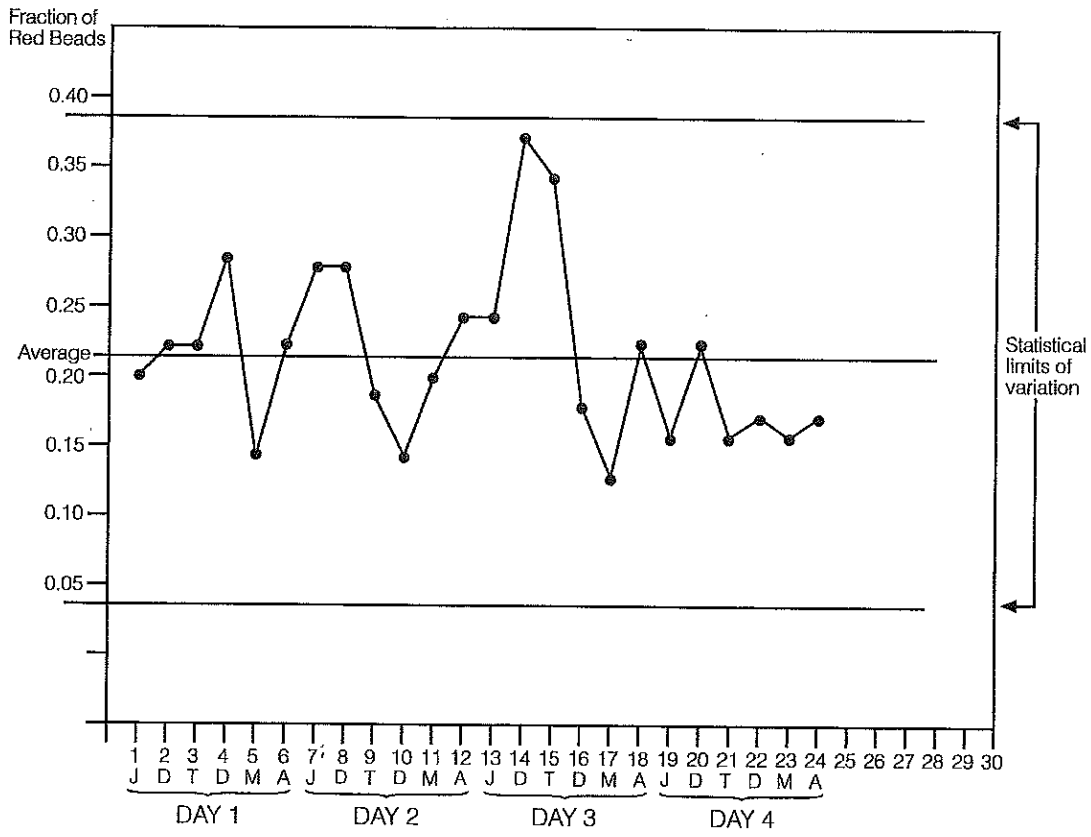
Source: Copyright PQ Systems, www.pqsystems.com

On the fourth day (see Figure 2.8), we find that the number of red beads produced by the six Willing Workers is 8, 11, 8, 9, 8, and 9. The production is still not good enough. The Foreman announces that management has decided to close the plant after all.

The Red Bead experiment offers several important lessons for managers:

- *Variation exists in systems and, if stable, can be predicted.* If we plot the fraction of red beads produced by each worker each day, we can observe this variation easily. Figure 2.9 is a plot of the fraction of red beads produced over time. All points fluctuate about the overall average, which is 0.21, falling roughly between 0.10 and 0.40. In Chapter 8, we will learn to calculate *statistical limits of variation* (0.04 and 0.38)—limits between which we would expect results from a stable system to fall. This variation shows that that the system of production is indeed stable; that is, the variation arises from common causes. Although the exact number of red beads in any particular paddle is not predictable, we can describe statistically what we expect from the system.
- *All the variation in the production of red beads, and the variation from day to day of any Willing Worker, came entirely from the process itself.* In this experiment, Deming deliberately eliminated the source of variability that managers usually believe is the most significant: people. Each worker was basically identical, and no evidence showed that any one of them was better than another. They could not control the number of red beads produced and could do no better than the system would allow. Neither motivation nor threats had any influence. Unfortunately, many managers believe that all variation is controllable and place blame on those who cannot do anything about it.
- *Numerical goals are often meaningless.* A Foreman who gives out merit pay and puts people on probation, supposedly as rewards and punishment of performance, actually rewards and punishes the performance of the process, not the Willing Workers. To rank or appraise people arbitrarily is demoralizing, especially when workers cannot influence the outcomes. No matter what the goal is, it has no effect on the actual number of red beads produced. Exhorting workers to "Do their best" only leads to

FIGURE 2.9 Run Chart of Fraction of Red Beads Produced

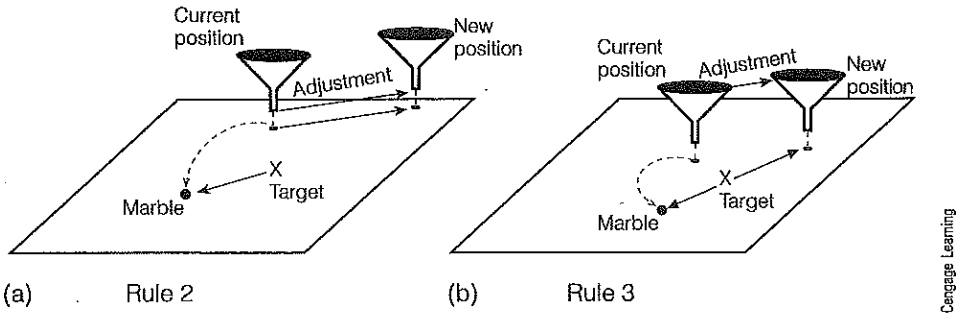


frustration. Management has no basis to assume that the best Willing Workers of the past will be the best in the future.

- *Management is responsible for the system.* The experiment shows bad management. Procedures are rigid. The Willing Workers have no say in improving the process. Management is responsible for the incoming material, but does not work with the supplier to improve the inputs to the system. Management designed the production system and decided to rely on inspection to control the process. These decisions have far more influence on the outcomes than the efforts of the workers. Three inspectors are probably as costly as the six workers and add practically no value to the output.

Deming's second experiment is the **Funnel Experiment**. Its purpose is to show that people can and do affect the outcomes of many processes and create unwanted variation by "tampering" with the process, or indiscriminately trying to remove common causes of variation. In this experiment, a funnel is suspended above a table with a target drawn on a tablecloth. The goal is to hit the target. Participants drop a marble through the funnel and mark the place where the marble eventually lands. Rarely will the marble rest on the target. This variation is due to common causes in the process. One strategy is to simply leave the funnel alone, which creates some variation of points around the target. This

FIGURE 2.10
Two Rules for Adjusting the Funnel



may be called *Rule 1*. However, many people believe they can improve the results by adjusting the location of the funnel. Three possible rules for adjusting the funnel are:

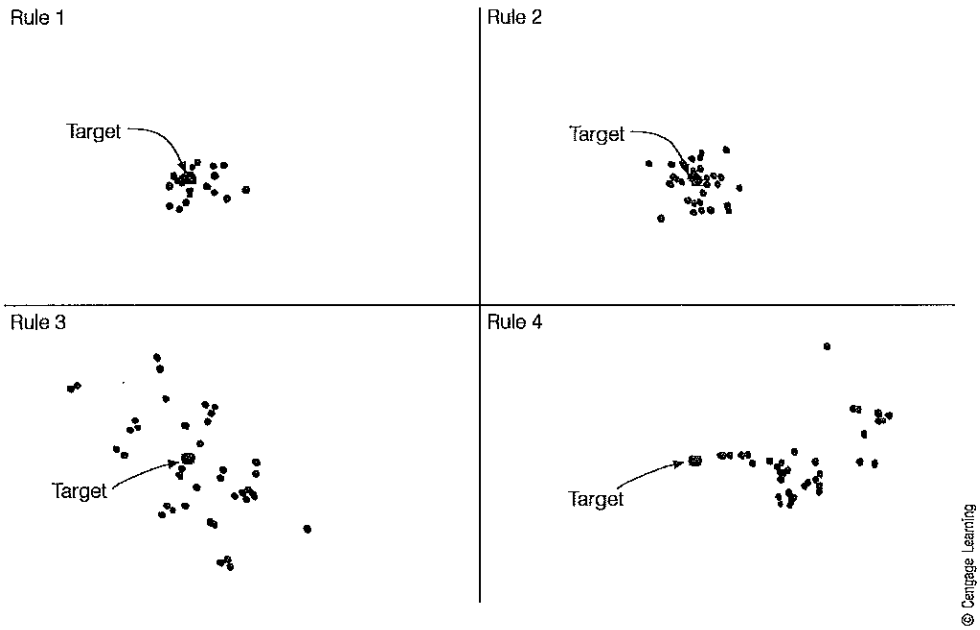
Rule 2. Measure the deviation from the point at which the marble comes to rest and the target. Move the funnel an equal distance in the opposite direction from its current position [Figure 2.10(a)].

Rule 3. Measure the deviation from the point at which the marble comes to rest and the target. Set the funnel an equal distance in the opposite direction of the error from the target [Figure 2.10(b)].

Rule 4. Place the funnel over the spot where the marble last came to rest.

Figure 2.11 shows a computer simulation of these strategies using the Quality Gamebox. Clearly the first rule—leave the funnel alone—results in the least variation.

FIGURE 2.11
Results of the Funnel Experiment



Formal statistical methods are vital to modern quality management; we will review important statistical concepts and methods in Chapter 6, and use them in various applications of quality in other chapters.

People use these rules inappropriately all the time, causir more variation than would normally occur. An amateur golf who hits a bad shot tends to make an immediate adjustment. the last manufactured part is off-specification, adjust the machin If a schedule was not met last month, change the process. If tl last quarter's earnings report was less than expected, dump tl stock. If an employee's performance last week was subpar ((exceptional), punish (or reward) the employee. In all of the cases, the error is usually compounded by an inappropriate rea tion. All of these policies stem from a lack of understanding variation, which originates from not understanding the process

QUALITY MANAGEMENT SYSTEMS

Quality can be managed in different ways. Many organizations use a centralized quali department; others have quality leaders who work in different business units or parts the organization (common to larger organizations); some have centralized committees leaders from multiple functions; still others rely on the senior leadership team to guic the quality process (more predominant in smaller organizations).[24]

No matter how quality is managed, organizations need a structured and systemat approach to implement the principles, practices, and techniques of total quality.[25] Accor ing to the ASQ online glossary, a **quality management system (QMS)** can be considered mechanism for managing and continuously improving core processes to "achieve maximu customer satisfaction at the lowest overall cost to the organization." It applies and synth sizes standards, methods, and tools to achieve quality-related goals. Thus a quality manag ment system represents a specific implementation of quality concepts, standards, method and tools, and is unique to an organization. Creating an effective QMS requires top ma agement commitment, resources availability, communication, integrated training across tl organization, integrated audits, technical guidelines, customers, employees, and the suppo of certification entities.[26] A QMS provides a basis for documenting processes used to co trol and improve operations, drive innovation, and achieve the following objectives:

- Higher product conformity and less variation.
- Fewer defects, waste, rework, and human error.
- Improved productivity, efficiency, and effectiveness.

One of the first things to do is to establish a **quality policy**—a formal document th demonstrates a commitment to achieving high quality and meeting customer expect tions. Next, management must establish an organizational structure for its QMS th includes responsibilities, methods of communication, maintenance of essential recor and documentation, and procedures for reviewing performance. Management must al identify and provide appropriate resources to achieve the objectives set forth in the quality policy. These resources might include people with special skills, training, worl spaces, manufacturing equipment, inspection technology, computer software, and tl supporting work environment. Individuals must be given the responsibility to initia actions to prevent the occurrence of defects and errors, to identify and solve quality related problems, and to verify the implementation of solutions.

The core of a QMS is focused on creating the goods and services that custome want. Therefore, a QMS should include processes for identifying customer requirement product planning and design processes, purchasing procedures, methods and technolo

for controlling the production of goods and services throughout the supply chain, inspection and/or testing, disposition of nonconforming product, and maintenance and validation of measuring and test equipment.

Understanding performance requires measurement and data analysis processes to evaluate the conformity of goods and services, customer satisfaction, and the integrity of the QMS itself. Such measurement should provide the basis for corrective action and continuous improvement, as well as prevention of future problems.

A **quality manual** serves as a permanent reference for implementing and maintaining the system. A quality manual need not be complex; a small company might need only a dozen pages while a large organization might need manuals for all key functions. Sufficient records should be maintained to demonstrate conformance to requirements and verify that the quality system is operating effectively. Typical records that might be maintained are inspection reports, test data, audit reports, and calibration data. They should be readily retrievable for analysis to identify trends and monitor the effectiveness of corrective actions. Other documents, such as drawings, specifications, inspection procedures and instructions, work instructions, and operation sheets are vital to achieving quality and should likewise be controlled.

Finally, the system needs to be maintained and kept up to date. This maintenance can be facilitated through **internal audits**, which focus on identifying whether documented procedures are being followed and are effective, and reporting the issues to management for corrective action. Internal audits generally include a review of process records, training records, complaints, corrective actions, and previous audit reports. A typical internal audit begins by asking those who perform a process regularly to explain how it works.[27] Their statements are compared to written procedures, and compliance and deviations are noted. Next, the trail of paperwork or other data are examined to determine whether the process is consistent with the intent of the written procedure and the worker's explanation. Internal auditors also need to analyze whether the process is meeting its intent and objectives, thus focusing on continuous improvement.

Although many ways exist to structure a QMS, many organizations start with the **ISO 9000 family of standards**, which are a set of standards and guidelines for quality management systems that represents an international consensus on good quality management practices.[28] They provide a comprehensive framework for designing and managing a quality management system and help organizations establish a process orientation and the discipline to document and control key processes.

ISO 9000 Family of Standards

As quality became a major focus of businesses throughout the world, various organizations developed standards and guidelines. Terms such as quality management, quality control, quality system, and quality assurance acquired different, sometimes conflicting meanings from country to country, within a country, and even within an industry.[29] To standardize quality requirements for European countries within the Common Market and those wishing to do business with those countries, a specialized agency for standardization, the International Organization for Standardization (IOS), founded in 1946 and composed of representatives from the national standards bodies of 91 nations, adopted a series of written quality standards in 1987. The IOS took a unique approach in adopting the "ISO" prefix in naming the standards. *ISO* is a scientific term for equal (as in isotherm lines on a weather map, which show equal temperatures). Thus, the intent was to ensure that organizations certified under the ISO 9000 standards have quality equal to their peers. The standards have been adopted in the United States by the American National Standards

Institute (ANSI) with the endorsement and cooperation of the American Society for Quality (ASQ). The standards are recognized throughout the world.

The standards required documentation for all processes affecting quality and suggest that compliance through auditing leads to continuous improvement. In some foreign markets, companies will not buy from suppliers who are not certified to the standards. For example, many products sold in Europe, such as telecommunication terminal equipment, medical devices, gas appliances, toys, and construction products require product certifications to assure safety. Often, ISO certification is necessary to obtain product certification. Thus, meeting these standards became a requirement for international business.

The standards became especially important when the Treaty on European Union was signed at Maastricht, the Netherlands in 1992, establishing free trade between member countries and making quality a key strategic objective. Consequently, the standards were revised in 1994. The ISO 9000:1994 series standards consisted of 20 fundamental elements of a basic quality system that included such things as management responsibility, design control, purchasing, product identification and traceability, process control, inspection and testing, corrective and preventive action, internal quality audits, training, and statistical techniques. The standards were intended to meet five objectives:

1. Achieve, maintain, and seek to continuously improve product quality (including services) in relationship to requirements.
2. Improve the quality of operations to continually meet customers' and stakeholders' stated and implied needs.
3. Provide confidence to internal management and other employees that quality requirements are being fulfilled and that improvement is taking place.
4. Provide confidence to customers and other stakeholders that quality requirements are being achieved in the delivered product.
5. Provide confidence that quality system requirements are fulfilled.

While these objectives were certainly in line with a TQ philosophy, the original standards and the 1994 revision met with considerable controversy.[30] The standards only required that the organization have a documented, verifiable process in place to ensure that it consistently produces what it says it will produce. A company could comply with the standards and still produce a poor-quality product—as long as it did so consistently! The European Union called for a deemphasis on ISO 9000 registration, citing the fact that companies were more concerned with "passing a test" than on focusing their energies on quality processes and improvement. In response, the IOS revised the standards in 2000. ISO 9000:2000 reflected a completely new structure, based on the eight quality management principles in Table 2.2. These eight principles were voted on and overwhelmingly approved at a conference in 1997 attended by 36 representatives of countries.[31]

In 2008, an amendment to the standards was released, designed to clarify some of the language and concepts, and improve compatibility with ISO 14001:2004, the popular environmental standard. It focused on clarifying legal standards, outsourcing, internal audits, the concept of competence, design and development processes, monitoring and measuring processes, and controlling non-conforming products.[32] However, the main focus of the standards were not substantially changed.

The ISO 9000 family standards focus on developing, documenting, and implementing procedures to ensure consistency of operations and performance in production and service delivery processes, with the aim of continual improvement, and supported by fundamental principles of total quality. The standards are generic and intended to apply to any organization, regardless of type, size, or products provided.

The standards consist of three documents:

1. *ISO 9000:2005—Fundamentals and vocabulary*: This document provides fundamental background information and establishes definitions of key terms used in the standards.
2. *ISO 9001:2008—Requirements*: This is the core document that provides the specific requirements for a quality management system to help organizations consistently provide products that meet customer and other regulatory requirements. The standard specifies the requirements that a quality system must meet, but does not dictate how they should be achieved, allowing them to be interpreted and applied to meet the unique needs of different types of businesses or national cultures. The standard does require that the organization audit its quality system to verify that it is managing its processes effectively. This standard can also be also used for customer audits or third-party certification. Many organizations pursue this to provide independent credibility and recognition of their quality management systems.
3. *ISO 9004:2009—Guidelines for Performance Improvements*: This document provides guidelines to assist organizations in improving and sustaining their quality management systems.

The ISO 9001:2008 requirements provide a structure for a basic quality assurance system. It consists of four major areas: Management Responsibility, Resource Management, Product Realization, and Measurement, Analysis, and Improvement.

- *Management Responsibility* addresses what top management must do to ensure an effective quality system, such as promoting the importance of quality throughout the organization, developing and implementing the quality management system, identifying and meeting customer requirements, defining an organizational quality policy and quality objectives, clearly defining responsibilities for quality, and controlling documents and records.
- *Resource Management* ensures that an organization provides sufficient people, facilities, and training resources.
- *Product Realization* refers to controlling the production/service process from receipt of an order or quote through design, materials procurement, manufacturing or service delivery, distribution, and subsequent field service.
- *Measurement, Analysis, and Improvement* focuses on control procedures for assuring quality in products and processes, analysis of quality-related data, and correction, prevention, and improvement planning activities.

The requirements are stated as a set of numbered "clauses" that state precisely what the organization should do. For example, clause 6.4, called "Work Environment," is: "The organization shall determine and manage the work environment needed to achieve conformity to product requirement. Note: The term 'work environment' relates to those conditions under which work is performed including physical, environmental, and other factors (such as noise, temperature, humidity, lighting, or weather)."[33] This clause requires the organization to identify aspects of the work environment that may impact the quality of the good or service produced, and have an approach for managing people-related factors such as work methods and ergonomics as well as the physical work environment. In addition, the standard requires 20 different types of documentation to be maintained. This provides the ability to audit conformance to the standards and can also provide due diligence and protect against liability. The standards can be rather difficult to understand, but numerous resources are available to help managers interpret and use them.[34]

ISO 9001:2015, released in late 2015, updates the standard to be more of a business management system. This revision strengthens its focus on leadership, planning, knowledge management, operations, performance evaluation, and improvement. For example, the standard requires organizations to determine external and internal issues that affect its strategic direction (see Chapter 11) and its ability to achieve outcomes from its quality management system. The standard is also more applicable to service industries. Another key change is a stronger focus on identifying and addressing risks. In many ways, these changes make the standards more similar to the Baldrige criteria, which we introduce in Chapter 10.

Although manufacturing is the largest adopter of ISO 9000, the standards are intended to apply to all types of businesses, including electronics and chemicals, and to services such as healthcare, banking, and transportation. The evolution of the standard has shed its manufacturing roots and made it easier for service companies to apply. For example, a software developer, Computer Associates of Islandia, New York, employs over 14,000 people in more than 40 countries. They used ISO 9001 to build a strong framework throughout all its sites (many of which were obtained through acquisitions of other software companies) to help standardize product development and support. Sears, Roebuck and Co. has registered almost 400 product repair centers and in-home services. As another example, in 1998, the Centers for Medicare and Medicaid Services began requiring ISO 9001 certification for all its new business contracts with claims processors.[35] Some professionals have argued that ISO 9000 can provide more effective management of public school systems.[36]

The ISO 9000 standards originally were intended to be advisory in nature and to be used for two-party contractual situations (between a customer and supplier) and for internal auditing. However, they quickly evolved into criteria for companies who wished to "certify" their quality management or achieve "registration" through a third-party auditor, usually a laboratory or some other accreditation agency (called a registrar). This process began in the United Kingdom. Rather than a supplier being audited for compliance to the standards by each customer, the registrar certifies the company, and this certification is accepted by all of the supplier's customers.

Implementing ISO 9000 is not an easy task.[37] Meeting the registration standards can be a painstaking and costly undertaking, often requiring organizations to develop and institute many new procedures and train many people. Individual sites—not entire companies—must achieve registration individually. All costs are borne by the applicant, so the process can be quite expensive. A registration audit may cost anywhere from $10,000 to more than $40,000, while the internal cost for documentation and training may exceed $100,000. Recertification is required every three years. Successful implementation of ISO 9000 requires the resources and support of top management, but the details fall mainly within the province of operating managers, supervisors, and employees to identify, develop, and document critical work processes.

ISO 9000 has three principal benefits:[38]

- *It provides discipline.* The ISO 9001 requirement for audits forces an organization to review its quality system on a routine basis. If it fails to maintain the quality system, audits should recognize this and call for corrective action.
- *It contains the basics of a good quality system.* ISO 9001 includes basic requirements for any sound quality system, such as understanding customer requirements, ensuring the ability to meet them, ensuring people resources capable of doing the work that affects quality, ensuring physical resources and support services needed to meet product requirements, and ensuring that problems are identified and corrected.
- *It offers a marketing program.* ISO certified organizations can use their status to differentiate themselves in the eyes of customers.

Diverse organizations have realized significant benefits from ISO 9000 that range from higher customer satisfaction and retention, better quality products, and improved productivity. At DuPont, for example, ISO 9000 has been credited with increasing on-time delivery from 70 percent to 90 percent, decreasing cycle time from 15 days to 1.5 days, increasing first-pass yields from 72 percent to 92 percent, and reducing the number of test procedures by one-third. Sun Microsystems' Milpitas plant was certified in 1992, and managers believe that it helped deliver improved quality and service to customers.[39] In Canada, Toronto Plastics, Ltd. reduced defects from 150,000 per million to 15,000 per million after one year of ISO implementation.[40] The first home builder to achieve registration, Michigan-based Delcor Homes, reduced its rate for correctable defects from 27.4 to 1.7 in two years and improved its building experience approval rating from the mid-60s to the mid-90s on a 100-point scale.[41] Thus, using ISO 9000 as a basis for a quality system can improve productivity, decrease costs, and increase customer satisfaction. In addition, organizations have found that using ISO 9000 resulted in increased use of data as a business management tool, increased management commitment, more efficient management reviews, and improved customer communication.[42]

Current information about ISO 9000 can be obtained from the ISO website (http://www.iso.org).

ISO standards are used around the world. A survey by ASQ and the American Productivity and Quality Center found that the majority of responding organizations use ISO as a quality framework. Countries in Europe, such as the Czech Republic and Germany, have the highest percentage (over 80 percent). In the United States, about 60 percent of organizations use it.

Building Effective Quality Management Systems

One practitioner has observed that many quality management systems focus more on compliance than on improving quality. This is an easy trap to fall into, particularly when applying ISO 9000 or other compliance processes such as those in life-science manufacturing, which are regulated by the Food and Drug Administration.[43] The goals of the quality department can easily become disconnected from the quality processes across the organization if the focus evolves toward simply maintaining data and documentation to display an ISO certificate or meet regulatory requirements. For example, studies in the life-sciences industry have shown that less than 40 percent of organizations have integrated their QMS with enterprise resource planning (ERP), less than 30 percent with manufacturing execution systems (MES), and only about 25 percent with supply chain management (SCM).[44]

An effective QMS needs to be integrated with enterprise systems such as ERP, MES, and SCM, and should focus on actionable decision making, seeking the root causes of problems, and improving processes and systems. It should drive the principles of quality management throughout the organization by fostering effective practices to implement the principles, as we described in Table 2.3. Again, as Deming, Juran, and Crosby so often pointed out, these responsibilities lie with an organization's leadership. In ISO 9000:2000, the entire section on Management Responsibility is concerned with the role of leadership in driving a quality system. For example, the standards require that "Top management shall provide evidence of its commitment to the development and implementation of the quality management system and continually improving its effectiveness by (a) communicating to the organization the importance of meeting customer as well as statutory and regulatory requirements, (b) establishing the quality policy, (c) ensuring that quality objectives are established, (d) conducting management reviews, and (e) ensuring the availability of resources." More specific responsibilities are spelled out in detail in other clauses of the standards.

SUMMARY OF KEY POINTS AND TERMINOLOGY

The Student Companion Site provides a summary of key concepts and terminology introduced in this chapter.

QUALITY *in* PRACTICE

Bringing Quality Principles to Life at KARLEE[45]

KARLEE is a contract manufacturer of precision sheet metal and machined components for telecommunications, semiconductor, and medical equipment industries, located in Garland, Texas. KARLEE provides a vertically integrated range of services that support customers from initial component design to a finished, assembled product. Their services include:

- Advanced design engineering support
- Prototype production
- Manufacture and assembly of precision machined and sheet metal fabricated products
- Product finishing (painting, silk screening, plating)
- Value-added assembly integration (cabling, power supply and back plane installation, and electrical testing)

Throughout its business, KARLEE exemplifies the principles of total quality in its business practices. Some of these are described below.

Customer Focus. KARLEE made a strategic decision to carefully select customers that support its values—particularly a systematic approach to business and performance management, desire for long-term partnerships, and global leadership. Management and Team Leaders work with each customer to establish current requirements and future needs, and each customer is assigned a three-person Customer Service team that is on call 24 hours a day for day-to-day production issues.

Leadership. Senior Executive Leaders (SELs) and the KARLEE Leadership Committee (KLC) set the strategic direction of the company, and communicate and reinforce values and expectations through performance reviews, participation in improvement or strategic projects, regular interactions with customers and team members, and recognition of team member achievements.

Involvement of People. Production and delivery processes are designed around cell manufacturing. Teams are responsible for knowing their customer's requirements and producing according to those requirements. Teams are empowered to change targets recommended during strategic planning if they believe it will help them achieve higher performance, as well as to schedule work, manage inventory, and design the layout of their work areas.

Process Approach. Processes such as prototype development, scheduling, production setup, fabrication, assembly, and delivery require process owners to be responsible for maintaining the process to customer requirements. A Quality Assurance team member works with manufacturing teams to create process documentation.

System Approach to Management. KARLEE'S strategic planning approach includes a strategic assessment of the entire company, and aligns corporate objectives and goals with its key business drivers. KARLEE uses information and data to set goals, align organizational directions and manage resource at the operating, process, and organizational levels.

Continual Improvement. Teams use a structured approach to evaluate and improve their processes, documenting them and presenting a status report of improvements to senior leaders and the KARLEE Steering Committee. Teams benchmark

competitors, "best practice" companies, and customers to learn from others.

Factual Approach to Decision Making. Teams analyze defect data, customer-reported problems, and control charts generated during production to identify problems and opportunities for improvement. Every business goal and project has defined methods for measurement, and senior leaders meet weekly to review company performance and ensure alignment with directions and plans.

Mutually Beneficial Supplier Relationships. KARLEE selects and develops suppliers that share their commitment to customer satisfaction to ensure they have the materials and services needed to support their customers. Supplier performance issues and expectations are discussed with individual suppliers and presented at the annual Supplier Symposium.

All this has contributed to an increased sales growth, and high levels of customer and employee satisfaction, and quality and operational performance, resulting in KARLEE receiving a Baldrige Award in 2000.

Key Issues for Discussion

1. From the information presented here, how would you say that KARLEE defines quality, drawing upon the definitions in Chapter 1?
2. Discuss how KARLEE's practices reflect the philosophies of Deming, Juran, and Crosby.

QUALITY *in* PRACTICE

ISO 9000 and Sears' Quality Management System[46]

Sears, Roebuck and Co., a wholly owned subsidiary of Sears Holdings Corp., is one of the largest retailers in North America. Sears offers a range of home merchandise, apparel, and automotive products and services through more than 2,400 Sears-branded and affiliated stores in the United States and Canada, which includes about 926 full-line and 1,100 specialty stores in the United States alone. Sears is the largest national provider of product repair services, with more than 14 million repairs performed annually.

After an eight-year effort, the company registered its product repair centers' and in-home service's quality management systems (QMS) to ISO 9001. Sears has always maintained a strong commitment to quality in its products and services. In keeping with this commitment, in 1998 the company decided to register all of its product repair centers to the ISO 9002:1994 quality management system standard (which was subsequently replaced by ISO 9001:2000). By the end of 2002, all of the 32 carry-in service centers were registered to ISO 9001. Once the repair centers were registered, Sears turned to the in-home service side of its business. About 10,000 Sears' technicians repair one of every five appliances in America. By the end of 2005, Sears had 383 locations under the scope of its ISO 9001 registration, including all six in-home regions. The company's 48 districts have their own certificates.

Recognizing that ISO 9001 provides a framework for large organizations to implement a consistent, cohesive program across geographic lines and throughout a multifaceted business, Sears sought registration to enhance its organizational process compliance. The company wanted a consistent process for improving customer satisfaction and enhancing service capabilities. ISO 9001 implementation played a large role in assisting with process standardization across the company. ISO 9001 is often associated with the manufacturing industry, and one major hurdle Sears had to overcome was communicating the value of a QMS within a retail and service environment.

ISO 9001 became a fundamental tool that provides the company a safe base for continued improvements. For example, Sears has made dramatic improvements in calibrating the tools used for repairs and service calls. Although the company had calibrated some of its tools prior to implementing ISO 9001, the standard requires 100-percent tool calibration for safety purposes. Not only does Sears have an

expansive program for calibrating its tools, but it has also opened and registered its own calibration lab to ISO/IEC 17025. This move minimizes calibration costs and expands third-party business opportunities.

Another significant benefit of ISO 9001 involves the company's handling of refrigerant. Sears works with Freon and other hazardous materials, which could pose a serious environmental violation if not handled properly. As part of its ISO 9001 efforts, Sears improved its existing hazardous-materials program by implementing a comprehensive program on refrigerant handling.

The standard also helped Sears' efficiency in completing repairs. For instance, in the Chattanooga, Tennessee, carry-in facility, the average daily completion rate for repairing lawn mowers or other items doubled from four or five to eight or nine per repairman as a result of ISO 9001 implementation.

Sears' district office in Houston has improved its technician recall rate because of the QMS. The recall rate is the percentage of times service technicians must return to customers' homes for a second time within 30 days. Before the SST, the recall rate in Houston was about 12 percent. In 2004, Houston service technicians made more than a quarter of a million service calls, with a 9.3-percent recall rate. In 2005, the rate dropped to 7.9 percent.

ISO 9001 has been instrumental in helping to standardize the manner in which technicians record field observations. This is important for solving certain types of problems, such as an appliance or part malfunction, customer abuse or an accident. To ensure consistency, technicians use a special tool kit for recording the event, including a disposable camera and standardized forms.

Key Issues for Discussion

1. What issues do you think that a large company such as Sears had to face in implementing ISO 9000 across its vast organization?
2. How are the ISO 9000:2000 Quality Management Principles reflected in this example? How might these principles have helped Sears address the issues you identified in the first question?

REVIEW QUESTIONS

1. How does Deming's definition of quality—"A product or a service possesses quality if it helps somebody and enjoys a good and sustainable market"—compare with the definitions discussed in Chapter 1?
2. Explain the Deming chain reaction.
3. Summarize Deming's 14 Points. How does each point relate to the four components of Profound Knowledge?
4. Summarize the four components of Profound Knowledge. How do they mutually support each other?
5. What is a system? Why is "systems thinking" important to quality management?
6. Why is it important to understand variation from a statistical perspective?
7. Explain the implications of not understanding the components of Profound Knowledge as suggested by Peter Scholtes.
8. Explain Juran's Quality Trilogy.
9. Summarize the breakthrough sequence that Juran advocated for quality improvement.
10. How is Juran's philosophy similar to or different from Deming's?
11. What are Crosby's Absolutes of Quality Management and Basic Elements of Improvement? How are they similar to or different from Deming's 14 Points?
12. Summarize the key contributions of Feigenbaum and Ishikawa to modern quality thinking.
13. Explain the differences among quality principles, practices, and techniques.
14. List and briefly explain the eight principles of quality management.
15. State two or three practices associated with each principle of quality management.
16. What is statistical thinking? Why is it important to managers and workers at all levels of an organization?
17. What are the operational problems created by excessive variation?
18. Explain the difference between common and special causes of variation.
19. Explain the two fundamental mistakes that managers make when attempting to improve a process. Can you cite any examples in your personal experience in which such mistakes were made?