40 Deming and Taguchi's Quality Engineering

40.1. Introduction

Many modern quality engineering and quality management philosophies originated in the United States throughout the twentieth century. Several people played key roles in the development and implementation of these revolutionary methods for managing organizations. Among the most influential of these people was William Edwards Deming. His philosophies on quality broadened the scope of quality engineering from a tactical nature to a strategic management way of life.

40.2. Brief Biography of William Edwards Deming

William Edwards Deming was born on October 14, 1900, to William Albert Deming and Pluma Irene Edwards in Sioux City, Iowa [1]. Seven years later, his family moved to Wyoming after receiving a land grant. The 40 acres of land given to the Deming family was useless for farming, making life very hard for Edwards and his two siblings. The family's first home was nothing more than a tarpaper shack.

Pluma Irene and William Albert Deming were well educated for the time. Pluma had studied music in San Francisco, and William Albert had studied mathematics and law. Both parents emphasized the importance of education and en-

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couraged their children to focus on their studies. Although Deming was going to school, he began picking up odd jobs to support the family when he was 12.

After graduating from high school in 1917, Deming enrolled in classes at the University of Wyoming in Laramie. Fortunately, the university did not have a tuition fee. Deming studied for four years, graduating with a bachelor of science degree in physics. He stayed at the university in Laramie for an additional year, teaching engineering and taking additional classes in mathematics. In 1918 he accepted a teaching position for two years at the Colorado School of Mines. He returned briefly to Wyoming in 1922 and married Agnes Bell.

Deming continued his formal education at the University of Colorado in Boulder, earning a master's degree in mathematics and physics in 1924. With the support and recommendation from one of his professors, he was accepted to Yale University as a doctoral candidate with a scholarship and part-time teaching position during the school year. During the summers, he traveled to Chicago to conduct research on telephone transmitters at the Western Electric Hawthorne Plant. While working at the Hawthorne Plant, Deming met and was mentored by Walter Shewhart, the pioneer of statistical process control. After completing his dissertation in 1928 on the packing of nucleons in helium atoms, Deming was awarded a Ph.D. degree in mathematical physics.

Although Deming found employment with the U.S. Department of Agriculture working in the Fixed Nitrogen Research Laboratory, times became difficult. In 1930, he was left a widower, raising his daughter alone. He remarried two years later. Lola Elizabeth Shupe remained his wife for 52 years until her death in 1984.

In 1933, Deming became head of the Mathematics and Statistics Department at the Graduate School of the U.S. Department of Agriculture. During his tenure, he developed basic research on sampling. Although his scientific papers focused on physics, his work involved the application of statistical methods, which extended into other disciplines.

During the 1930s, the U.S. Census Bureau began working on the implementation of statistical sampling as it related to demographics. Traditional full-count methods were tedious. In many cases, census figures were outdated before they were calculated. Improved methods were needed. The Census Bureau named Deming the head of mathematics and advisor on sampling in 1939. While in this position, Deming began applying Shewhart's statistical control methods to nonmanufacturing applications. He led the development of sampling procedures, which are now used throughout the world for current information on employment, housing, trade, and production.

After World War II, Deming established his private consulting practice and developed the 14 points for management, the seven deadly diseases, the Deming cycle for continuous improvement, and the system of profound knowledge. In 1946 Deming led the formation of the American Society for Quality Control. As a consultant to the War Department, he visited Japan for the first time in 1947 to aid in the 1951 census. He returned numerous times throughout the 1950s as a teacher and consultant to Japanese industry, through the Union of Japanese Scientists and Engineers. In 1960, the Emperor of Japan recognized Deming with the Second Order Medal of the Sacred Treasure for the improvement of the Japanese economy through the statistical control of quality.

Although Deming is best known for his work in Japan, he served as a consultant to many other countries, including Mexico, India, Greece, Turkey, Taiwan, Argentine, and France. He was also a member of the United Nations Subcommission on Statistical Sampling from 1947 to 1952.

Although Deming was awarded the Shewhart Medal in 1955 from the American Society for Quality Control, most businesses in the United States ignored his methods until the 1980s. On June 15, 1987, President Reagan presented Deming with the National Medal of Technology. After 40 years, his own country publicly acknowledged the significance of his work. Deming continued consulting until his death in 1993.

40.3. Deming's Key Quality Principles

While working as a consultant after World War II, Deming developed five key quality principles. Unlike those of his predecessor and mentor, Shewhart, these principles are strategic in nature, focusing on management. The principles include (1) the system of profound knowledge, (2) the 14 points for management, (3) the seven deadly diseases, (4) applications of common and special causes in management, and (5) the Deming cycle for continuous improvement. Each of these concepts is discussed in the following sections.

System of Profound Knowledge

Deming advocated a radical change in management philosophy based on his observations in applying statistical quality principles to common business practices. To make this transformation, people must understand four key elements of change, which he termed *profound knowledge*.

> The layout of profound knowledge appears here in four parts, all related to each other: appreciation for a system, knowledge about variation, theory of knowledge, and psychology.
>
> One need not be eminent in any part nor in all four parts in order to understand it and to apply it. The 14 points for management in industry, education, and government follow naturally as application of this outside knowledge, for transformation from the present style of Western management to one of optimization.
>
> The various segments of the system of profound knowledge proposed here cannot be separated. They interact with each other. Thus, knowledge of psychology is incomplete without knowledge of variation. [2, p. 93]

Deming realized that most scientific management philosophies did not take into account variation in people. To implement the changes he advocated, management needs to understand the psychology of its workers and the variation in psychology among them individually.

> A leader of transformation, and managers involved, need to learn the psychology of individuals, the psychology of a group, the psychology of society, and the psychology of change.
>
> Some understanding of variation, including appreciation of a stable system, and some understanding of special causes and common causes of variation are essential for management of a system, including management of people. [2, p. 95]

Deming's 14 Points for Management

To summarize what is needed to implement the profound system of knowledge within an organization, Deming developed the 14 points for management [3]. These key management guidelines can be applied to any organization, regardless of size or product produced.

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

> The 14 points are the basis for transformation of American industry. It will not suffice merely to solve problems, big or little. Adoption and action on the 14 points are a signal that the management intends to stay in business and aim to protect investors and jobs. Such a system formed the basis for lessons for top management in Japan in 1950 and in subsequent years. [3, p. 23]

Although the 14 points of management are numbered, they are not listed in any specific priority. Each of the points must be implemented within an organization to achieve the highest level of performance.

Deming's Seven Deadly Diseases

Just as the 14 points for management define what an organization must do to implement the system of profound knowledge, Deming identified seven points that inhibit its achievement [3]:

1. Lack of consistency of purpose to plan a product and service that will have a market, keep the company in business, and provide jobs
2. Emphasis on short-term profits: short-term thinking (just the opposite of consistency of purpose to stay in business), fed by fear of unfriendly takeover, and by push from bankers and owners of dividends
3. Evaluation of performance, merit rating, or annual review
4. Mobility of management; job hopping
5 Management by use only of visible figures, with little or no consideration of figures that are unknown and unknowable
6. Excessive medical costs
7. Excessive costs of liability, swelled by lawyers who work on contingency fees

Although some of these "diseases" can be avoided by following the 14 points for management, two sins in particular are currently unavoidable. Organizations currently exist in a culture in which litigation and medical costs are in many cases beyond their control.

Special Cause versus Common Cause

Shewhart developed the concepts of special cause (intermittent) and common (inherent) cause variation. In the late 1940s and throughout the 1950s, Deming showed that these principles can be applied not just to manufacturing, but to any system. With this in mind, management can make the following mistakes [2]: (1) to react to an outcome as if it came from special cause, when in reality it came from common causes of variation; and (2) to treat an outcome as if it came from common causes of variation, when in reality it came from a special cause.

Deming continually noted that management often punishes employees for errors and mistakes that are caused inherently by the system. The worker has no control but is responsible for the problem. No matter how much an employee is lectured or disciplined, improvement will not occur unless the system is improved. Improvement of the system is the responsibility of management.

Management must be able to distinguish between problems caused by common cause and special cause variation. Another destructive behavior in which management often engages is solving every problem as though it had a special cause. This approach to problem solving drains resources, leading down a path of frustration.

> So obvious, so fruitless. The vice president of a huge concern told me that he has a strict schedule of inspection of final product. To my question about how they use the data came the answer: “The data are in the computer. The computer provides a record and description of every defect found. Our engineers never stop until they find the cause of every defect.”
>
> Why was it, he wondered, that the level of defective tubes had stayed relatively stable, around 41/2 to 51/2 percent, for two years? My answer, The engineers were confusing common cause with special causes. Every fault was to them a special cause, to track down, discover, and eliminate. They were trying to find the causes of ups and downs in a stable system, making things worse, defeating their purpose. [2, pp. 181–182]

Deming’s Cycle for Continuous Improvement

Based on Shewhart’s steps in a dynamic scientific process for acquiring knowledge, the Deming cycle for continuous improvement was developed as a general problem-solving methodology for any product or process, regardless of level [2].

> *Step 1: Plan.* Somebody has the idea for improvement of a product or of a process. This is the 0-th stage, embedded in Step 1. It leads to a plan for a test, comparison, experiment. Step 1 is the foundation of the whole cycle. A hasty start may be ineffective, costly, and frustrating. People have a weakness to short-circuit this step. They do not wait to get into motion, to be active, to look busy, move into step 2.
>
> *Step 2: Do.* Carry out the test, comparison, or experiment, preferably on a small scale, according to the layout decided in Step 1.
>
> *Step 3: Study.* Study the results. Do they correspond with hopes and expectations? If not, what went wrong? Maybe we tricked ourselves in the first place, and should make a fresh start.
>
> *Step 4: Act.* Adopt the change. or abandon it. or run through the cycle again, possibly under different environmental conditions, different materials, different people, different rules. [2, pp. 131–133]

40.4. Complementing Philosophies

When comparing Taguchi methods to Deming’s teachings, one finds that the philosophies complement each other in several key areas. Deming stated relentlessly that management needed to change the system and reduce common cause variation in order to realize significant quality improvements. Moreover, he concurs with Taguchi’s teachings regarding quality loss and the deficient philosophy of quality by conformance, as presented in the following quote:

> The fallacy of zero defects. There is obviously something wrong when a measured characteristic barely inside a specification is declared to be conforming; outside it is declared to be non-conforming. The supposition that everything is all right inside the specification and all wrong outside does not correspond to this world.
>
> A better description of the world is the Taguchi Loss Function in which there is minimum loss at the nominal value, and an ever-increasing loss with departure either way from the nominal value. [3, p. 141]

Although Deming challenged management with improving the system, he never offered management a way to achieve reductions in a system's common cause variation, whether it be a product or process. Taguchi methods can be used to address this missing element of Deming's teachings by applying robust parameter design. The optimization of an ideal function maximizes its signal-to-noise ratio, reducing common cause variation of a given system. Furthermore, robust parameter design is consistent with Deming's cycle of continuous improvement.

Both Taguchi and Deming recognize that the largest gains in quality occur upstream in a product's life cycle. During the initial stages of product design and process development, the engineer has the most freedom, as no parameters have been specified. However, as a product or process is developed, the number of undetermined design parameters declines while noise factors begin to emerge. This concept was elegantly conveyed by Deming in *Out of the Crisis:* "A theme that appears over and over in this book is that quality must be built in at the design stage. It may be too late once plans on their way. There must be continual improvement in test methods, and ever better understanding of the customer's needs and of the way he uses and misuses the product" [3, p. 49].

By applying Taguchi methods as early as possible in the life cycle of a product or process, the effects of noise on a system can be curtailed. The result is a system with minimized common cause variation at launch.

References

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