HEROES AND MARTYRS OF QUALITY AND SAFETY

Walter A Shewhart, 1924, and the Hawthorne factory

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The year 1924—at a factory in Cicero, Illinois—saw the start of two of the most important developments ever in managerial thinking. In May that year Walter Shewhart described the first control chart which launched statistical process control and quality improvement. In November of that year there began a series of research projects which came to be known as the Hawthorne studies. This body of work was central to the creation of the fields of the sociology, social psychology, and anthropology of the work place. Although these events occurred at the same place and in the same year, there has been remarkably little cross fertilization of ideas between them.

WALTER ANDREW SHEWHART (1891–1967)

Walter Shewhart was born in New Canton, Illinois on 18 March 1891 to Anton and Esta Barney Shewhart. He received Bachelor's and Master's degrees from the University of Illinois, then attended the University of California at Berkeley from which he was awarded a Doctorate in physics in 1917. He taught at both universities and went on to head the department of physics at Wisconsin Normal School at LaCrosse for a short period of time.[1 2]

In 1918 Shewhart joined the Western Electric Company to assist their engineers in improving the quality of telephone hardware. Western Electric produced hardware for the Bell Telephone Company, which became the American Telephone and Telegraph Company (AT&T). The Western Electric Company manufactured telephone equipment for them and since 1905 its major plant was the Hawthorne Plant in Cicero, a suburb of Chicago. The company and its factory grew rapidly with the need for telephones. By 1913 there were 14 000 employees and by 1930 there were 43 000.[3] It was one of the largest manufacturing plants in the country. Shewart worked at Hawthorne until 1925 when he moved to the Bell Telephone Research Laboratories where he remained until his retirement in 1956.

While at Hawthorne, Shewhart met and influenced W Edwards Deming who went on to champion Shewhart's methods.[4 5] Joseph Juran also worked at Hawthorne from 1924 to 1941 and was influenced by Shewhart. Shewhart, Deming, and Juran are often considered to be the three founders of the quality improvement movement. Two of Shewhart's contributions continue to influence the daily work of quality—namely, control charts and the Plan–Do–Study–Act (PDSA) cycle.

Reducing variation: statistical process control

The focus on reducing variation as a way to improve quality is a non-obvious contribution of quality management. When the ancients built their temples they needed squared stones that would fit together. If the door of a new car is too big, it will not close. If it is too small, the rain will come in. In a high quality car the doors and the frame match with precision. Today all customers would expect such a fit. By way of contrast, one of the most widely observed phenomena in population health is regional and small area variation in care. Medicine has only started down the road of reducing variation.

Shewhart identified two categories of variation which he called ''assignable-cause'' and ''chance-cause'' variation. Others call the two categories ''special-cause'' and ''common-cause'' variation, respectively. He devised the control chart as a tool for distinguishing between the two. The various control charts that Shewhart proposed for variables and attributes include mean, range, *np*, *p*, *c*, and *u* charts.[6–8] Shewhart reported that bringing a process into a state of statistical control—where there is only chance-cause (common-cause) variation—and keeping it in control was needed to reduce waste and improve quality. Shewhart is referred to as the ''father of statistical quality control''.[2] Shewhart's historical memorandum of 16 May 1924 proposed the use of the statistical control chart to his supervisors.[2] In the preface to his book ''*Economic Control of Quality of Manufactured Product*''[9] Shewhart stated:

''*The object of industry is to set up economic ways of satisfying human wants and in so doing to reduce everything possible to routines requiring a minimum amount of human effort. Through the use of the scientific method, extended to take account of modern statistical concepts, it has been found possible to set up limits within which the results of routine efforts must lie if they are to be economical. Deviations in the results of a routine process outside such limits indicate that the routine has broken down and will no longer be economical until the cause of trouble is removed.*''

For over 50 years clinical laboratories have embraced Shewhart's ideas and incorporated statistical process control into standard operating procedures for clinical laboratory quality control[10–12] and proficiency testing.[13] More recently, other industries have re-discovered Shewhart's tools of statisical process control. Motorola developed the philosophy for quality improvement, based on statistical process control, which is called ''Six Sigma''. Sigma is the Greek letter used to denote the standard deviation of a population. In 1988 Motorola won the US Baldrige National Quality Award and this brought the six sigma concept to public attention. Several other organizations started using six sigma, and General Electric, under Jack Welch's leadership, popularized the six sigma method.

''*Sigma is a statistical unit of measurement that describes the distribution about the mean of any process or procedure. A process or procedure that can achieve plus or minus six-sigma capability can be expected to have a defect rate of no more than a few parts per million, even allowing for some shift in the mean. In statistical terms, this approaches zero defects*''.[7]

Shewhart cycle

The Shewhart cycle or Shewhart learning and improvement cycle combines management thinking with statistical analysis. The constant evaluation of management policy and procedures leads to continuous improvement. This cycle has also been called the Deming cycle, the Plan–Do–Check–Act (PDCA) cycle, or the Plan–Do–Study–Act (PDSA) cycle. While Deming marketed the cycle to the masses—a cycle which he called the Shewhart cycle—most people referred to it as the Deming cycle.

The Shewhart cycle has the following four stages:

- Plan: identify what can be improved and what change is needed
- Do: implement the design change
- Study: measure and analyse the process or outcome
- Act: if the results are not as hoped for

This cycle is used to make changes that lead to improvement in a manner of continuous quality improvement. This is a never ending process. After the easy low cost changes are made (the low hanging fruit harvested), the cycle process is repeated for another step, task, or process in the microsystem or system. After a period of time, other changes may result in the original process having an opportunity for improvement again.

Shewhart published numerous articles, many of which were in the *Bell System Technical Journal*, and two books: ''*Economic Control of Quality of Manufactured Product*''[9] in 1931 and ''*Statistical Method from the Viewpoint of Quality Control*''[14] in 1939 (reprinted in 1986). He was also the first editor of the John Wiley and Sons ''*Mathematical Statistics Series*'', and he continued to serve in this capacity for more than 20 years. Shewhart served as a consultant in the War Department during World War II and the resultant American War Standards helped in the productivity efforts. Other consultancy work included working with the United Nations and the government of India. Among the awards that Shewhart received was the Holley Medal from the American Society of Mechanical Engineers and he was the first recipient of the Shewhart Medal by the American Society for Quality Control. He died on 11 March 1967 in Troy Hills, New Jersey at the age of 75.

THE HAWTHORNE STUDIES

In 1923 the National Research Council's Division of Engineering and Industrial Research established the Committee on the Relation of Quality and Quantity of Illumination to Efficiency in the Industries. The chair was none other than Thomas Edison. Previous reports from several companies showed that better lighting increased productivity.[3] Western Electric was invited to carry out experiments to demonstrate this relationship. Starting in November 1924, the first study found no relationship between lighting and productivity. Later studies showed that productivity increased as lights were dimmed! This was followed by a series of experimental changes in working conditions for six women working in a separated assembly room. Thirteen sequential time periods were observed. Productivity rose over this time period apparently independently of the imposed changes. The conclusion was that the principal cause was that attention was paid to these workers. This unexpected result came to be known as the ''Hawthorne effect''. This can be seen as a form of social placebo effect. From 1928 to 1933 Elton Mayo, Fritz Roethlisberger and others continued this work. One of their conclusions was the importance of the ''informal organization'' created by the workers themselves in defining the level of worker productivity. This large body of work is best summarized in Roethlisberger and Dickson's ''*Management and the Worker*''.[15]

By 1933 the Great Depression had reduced the Hawthorne work force to 6000. Shewhart's work received worldwide attention but did not change the work at Hawthorne. ''*Shewhart was a skilled theoretician, but could not successfully convey quality ideas to the manufacturing work force*.'' By the time Juran left in 1941 ''*you could walk through this plant, the seed bed of the quality revolution, without seeing any control charts*.''[3] According to Juran: ''*The priorities assigned to the production departments were to meet schedules and achieve high productivity. Quality was left to the inspection department*.''[16]

Western Electric and AT&T jointly founded the Bell Laboratories in 1925. It became one of the world's great industry based research laboratories. In 1947 William Shockley and others there invented the transistor which made our computer age possible.[3] The first Western Electric plant to produce transistors was in Allentown, Pennsylvania. In the early 1950s quality control was a major problem there. Bonnie Small introduced Shewhart's methods and by the time she left Allentown there were 5000 control charts posted in the plant and performance had dramatically improved. She left the company effort to write ''*The Western Electric Statistical Quality Control Handbook*'' which first appeared in 1958. Building on these efforts, AT&T's power systems division became the first US manufacturer to win Japan's Deming prize. Today, except for a few buildings, the Hawthorne plant is gone and has been replaced by a shopping mall where, no doubt, one can buy cell phones made in China.

The events at Hawthorne in 1924 have changed the way managers see the world of work. Drawing on the Hawthorne studies and Shewart's statistical process control, the concepts of organizational behavior remain mostly unsynthesized, unmerged idea streams. The former have become the academic domain of social sciences and organizational behavior and the latter of engineering and production management. The former group of academics do not use mathematics with the enthusiasm that engineers do. These academic departmental boxes have delayed the synthesis of these ideas. This synthesis can happen in the work place by making the understanding of variation and its causes part of the common language of everyone. We pay attention to what we can and do measure. The choice of measures needs to be customer focused. Simply paying attention can create a Hawthorne effect. Creating a joyful transformation of the work environment may help align the goals of management in the formal organization with the informal organization of the workers. It is also worth remembering that technological change created Hawthorne and more such change did away with it.

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