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Sweating the Details

Painstaking application of the seven tools of experimental design can isolate a faulty link in the chain of production

The so-called "seven tools" identified by the Japanese quality-control expert Kaoru Ishikawa can seem commonsensical, even simplistic, to those who have never had to sort through a complex industrial process in search of the cause of a nagging defect in the end product. Indeed use of the seven tools is no guarantee that the key factor (or factors) will be easily identified and rectified. But they do help to focus the attention of the industrial sleuths assigned to track down the culprit, and (if applied with diligence) they can offer concrete clues on how to correct the problem.

All seven tools are simple statistical methods. Individually, they are used to gather, sort and present information about complex industrial processes, information that can then pinpoint probable causes of defects. In combination, they can weed out red herrings and separate key findings from distracting detail. And in concert with designed experiments, they can then isolate key variables and improve quality, productivity, efficiency and profits.

1. Check sheets: over any period of time, some products of any process are bound to be defective in some way. The observation of the total number of defective items is therefore not useful in itself in determining the source of trouble. Instead, check sheets (detailed data observation charts) are used to divide the faulty output by type of defect: those with cracks, for example, those that are the wrong size, those that are not hard enough, and so forth.

2. Pareto diagrams: the results gathered on the check sheets are then displayed as Pareto diagrams, simple bar charts used to display defect types in descending order of occurrence. Pareto charts help distinguish those defects that are important and ought to be studied from those that are trivial or random faults.

3. Cause-and-effect diagrams: once the most important defects are identified, the possible causes (and causes of causes) of those defects must be mapped out by those familiar with the production process – technicians, engineers, foremen. The resulting diagram is known as a fishbone chart because the lines of cause and effect converge like the bones of a fish. The fishbone chart can focus discussion on key steps in the process, but the fishbone chart is often only the first step toward further investigation, using Ishikawa's four other tools.

4. Histograms: bar charts showing the distribution of data within a population – summarizing, for example, the variation in the magnitude of the defect (what size of crack is most common, for example).

5. Stratification charts: histograms can themselves be further split into stratification charts, by plotting spreads evident in the histograms against other factors – by, say, production line (to see whether certain components have a tendency to produce more defects than others), or by raw material batch (to see if material provided by one supplier has a greater propensity to produce defective items).

6. Scatter diagrams: if there are important variations in the production process – such as oven temperature – then defects can be plotted against temperature to see if these (or perhaps even defects of a certain type) tend to cluster at higher or lower temperatures.

7. Control charts: the fluctuating factors examined in scatter diagrams can also be examined for their degree of variation over time, to determine if the control (or lack of control) of oven temperature, for example, is coincidental with greater or fewer defects.

Once investigators have applied the seven tools to key variables in the process, a "designed experiment" may then be conducted. Designed experiments are used to test key factors in controlled combinations to identify root causes of defects. It's an on-going process: the tools used above can be applied in various combinations, the results tested in controlled experiments, the outcome of the experiments sorted using the seven tools, the results then tested in further experiments.

The problem is, running such experiments can be costly and time consuming. The job of experts such as Jeff Wu is to carve the number of experiments down to a manageable number by painstaking and rigorous application of his statistical expertize.

Do these methods work? A quality-control industry magazine, *Quality Progress*, reported in June, 1987, the case of Matsushita Electric Corp. of America, which bought an American television plant near Chicage several years ago. At the time of the acquisition, the reject rate on the production line was an incredible 146% – meaning that most television sets were pulled off the line to be repaired at least once, and many were pulled twice. Five years later, by using the tools described here, the Japanese management had brought the reject rate down to just 2% – with simultaneous improvements in quality, productivity and morale.

REFERENCE: Ishikawa, K. *Guide to Quality Control*. Asian Productivity Organization, Minato-hu, Tokyo 107, Japan, 1982.

The article EM8904 reprinted above is used in Figure 11.19 of the STAT 221 Course Materials and in Statistical Highlight #97.