INDUSTRIAL TRAINING IN QUALITY IMPROVEMENT
PART I: OVERVIEW OF SESSION; THE ROLE OF STATISTICS

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In 1983, the top management at Portsmouth Naval Shipyard (PNS), a nuclear submarine overhaul facility employing about 9000 people, decided to embark on a course of action whose eventual goal was to change the organizational culture to one consistent with W. Edwards Deming's management philosophy. Consultants from the University of New Hampshire's Institute for Quality and Productivity (IQP) were invited to develop an instructional program at PNS. This first paper in a series of four will give background information on PNS, trace the role of elementary statistical tools in a quality improvement effort. The second paper will address the human relations skills necessary for effective teamwork and indicate why they were included in a course whose overt focus was these elementary statistical methods. In the third paper, this course is described in greater detail in terms of both its content and instructional approach. The final paper further analyzes instructional issues in connection with the course, and considers implications for the secondary and college statistics curricula.

In the summer of 1983, when IQP personnel were invited in, the Shipyard was under pressure to improve costs and schedules. A number of people in key top management positions had become familiar with Deming's management philosophy and saw it as a way to become more competitive. A "Deming Steering Committee" was formed. In order to focus the process improvement effort, four problem areas were targeted for initial attention and instruction: crane maintenance, ball valve overhaul, purchasing, and sandblasting. IQP was asked to design an instructional program in statistical problem-solving to be given to vertical slices of the organization involved in these four areas, with the intent that eventually the instruction would be given to everyone at PNS.

With substantial input from Shipyard employees who were familiar with statistical methods, we decided to develop two courses. The first, which would be a prerequisite to the second, would be called "Basic Charting," and would cover six of what have come to be called the "Seven Basic Charts": flowcharts, cause-and-effect diagrams, Pareto charts, histograms, run charts, and scatter diagrams. (The seventh basic chart is the control chart). This course included illustrations of flowcharts and cause-and-effect diagrams, and a discussion of how to construct them, but participants were exposed to their actual construction only through generic examples. Both the construction and the interpretation of the remaining four charts were heavily emphasized, as were the concepts behind them: the Pareto principle, centering and variability, normality, process variability, process stability, and linear relationships among variables. Data collection and the use of surveys were also covered. The second course, "Control Charting," focused on statistical process control. Sets of notes which contained examples and exercises using data from the Shipyard were developed for both courses.

We began teaching Basic Charting to groups of employees whom management had designated. But the course proved less than successful for reasons which will be detailed in the next paper. Basically they can be classified into two major categories: attitude problems stemming from a deep mistrust of management, and the inability of employees to work together, using in a group setting the statistical techniques they had learned in class.

And so we found that we had to revise our approach to teaching Basic Charting. We had to find a way to overcome, or at least neutralize, attitude problems, and we had to ensure that participants in the course would be able to use their knowledge effectively in a group setting. With input from several Shipyard employees and from Bill Conway, who was serving as a consultant to PNS, we designed a new course to precede Basic Charting. This new course was called "A Group Approach to Problem Solving" (GAPS). We required participants to come to the course already formed into project teams and having discussed problem areas. The project teams then went through the GAPS course as groups, working on their preselected problems throughout the course. The GAPS course intertwined statistical training with coaching and instruction in the group process and human relations. We found that by marrying statistics and team-building skills in this way a real synergy developed. Attitude problems which used to interfere with learning were often quickly overcome. The project teams were formed by management, and appropriate managers were often present when the course closed with group presentations. This provided visible management commitment. The new GAPS approach seemed successful: teams would leave the course with a good start on their problems and the enthusiasm to continue. They would usually continue so long as their management supported them.

The statistical methods covered in GAPS were the same as in Basic Charting; the difference were emphasis. An actual flowchart and cause-and-effect diagram were constructed in class by each project team for its designated process and problem. The other charts, and surveys, were covered in a way that emphasized interpretation rather than construction. The construction and a deeper understanding of these techniques were the focus of Basic Charting. However, the two courses were eventually merged into a single course where all the statistical methods were taught and practiced in the form of group exercises. This new GAPS course is the focus of this series of papers. In the remainder of this paper we will discuss the role in a company-wide quality improvement program of the statistical methods and concepts which were included in this course.

Viewing a production or administrative situation as a process is absolutely basic to making and holding quality improvement gains. By a process, we mean the blending together of inputs (or resources) to produce some result. These inputs might include people, materials, equipment, methods, and work environment. Only through an understanding of the process, can one control or improve the output. The ideal situation would be to understand the inputs and their blending so well that one would be able to <u>pre</u>-

dict the output characteristics. This would obviate the need to inspect the output, and would allow efforts at improvement or control to be focused on the process. One could then apply a strategy of prevention rather than detection.

A major tool in constructing an understanding of a process is the flowchart. The flowchart gives a schematic representation of the steps involved in a process. It is remarkable how often people who think they have a total understanding of a process have only incomplete or incorrect knowledge of how it operates. We find that flowcharting is an activity which is best done by a group, where the group includes individuals familiar with the day-to-day operation of the process. The construction of such a flowchart is almost always a very enlightening activity for the people involved. The flowchart of the actual process can be compared to a flowchart of the perfect process, or of an improved process, to highlight problem areas and opportunities for improvement.

Once a problem has been defined, the cause-and-effect diagram is almost always beneficial as a method of organizing, identifying, and interrelating causes of the problem. Again, this is an activity which benefits immensely from a group effort. Once completed, the cause-and-effect diagram points to which data needs to be gathered and analyzed to find and fix the actual causes of the problem. It may also result in insight on which causes might be common causes, and which might be special causes.

Often, when the causes of a problem can be classified into numerous categories, it is observed that only a few of these categories account for a significant proportion of the total occurrences of the problem. The Pareto chart helps focus attention on the "significant few" categories which account for this large proportion, rather than on the "trivial many" categories which account for only a small proportion of occurrences of the problem. Often, the "significant few" categories can be broken down further using Pareto analysis, giving additional focus to the process improvement effort. Pareto charts constructed over periodic intervals can be used to indicate whether the relative frequencies of the various categories remain stable over time, or to determine if efforts to reduce or eliminate occurrences in certain categories have been successful.

The histogram (as well as the tally sheet and stem-and-leaf plot) conveys information on the centering, spread, and shape of a data distribution. Various numerical measures (mean, median, range, standard deviation) give some of this information, but an actual picture of the data distribution is invaluable. Much information can be drawn from the shape of the distribution, and, if applicable, its relation to specification limits. This often emphasizes the value of being "on target" with a very narrow spread rather than being just "within spec". An understanding of the histogram and the concepts behind it is absolutely basic for anyone actively involved in a quality improvement effort. So often in industry data from a process is summarized by one single number: the mean. The variability of the process, as well as its shape, is totally overlooked. Yet precisely this knowledge can point the way to improvements!

The run (or trend) chart is another basic. The run chart gives information about the behavior of a process over time, allowing us to better understand it as a dynamic entity. It gives insight on process centering, and is a first step toward understanding common cause variation and special cause variation. Plotting data on a run chart together with specification limits can be enlightening.

Deming states that process improvement comes in two forms: action to eliminate special causes of variation; and action to reduce common cause variation. He goes on to state his 85%-15% rule: 85% of the problems originate from common causes, and hence are systemic problems and as such are the responsibility of management, while the remaining 15% stem from special causes which can usually be corrected by the local workforce. The run chart is of course only a precursor to the control chart, which is the proper tool to use in distinguishing between common and special causes of variation. However, we have found that the simple run chart can often provide extremely useful insights on the stability, centering, and variability of a process.

The scatter diagram, and its relative the correlation table, can provide useful information on the relationship between two variables. However, we feel that the scatter diagram, though valuable when it applies, is not as uniformly basic a tool as the other six of the "Seven Basic Charts."

Collection of meaningful data is crucial to statistical problem solving. One aspect of this is the use of surveys. Given the work environment at PNS, surveys of the appropriate employees were found to be extremely useful in identifying problems and their causes.

We feel that the value of the "Seven Basic Charts" and the concepts behind them goes far beyond their uses as problem-solving tools. Each of them, in its own way, helps focus attention on the process of interest. When interest centers on improving the process, individuals are less likely to feel threatened. To focus on the process is to "Stop fixing the blame and start fixing the problem." This also helps to open channels of honest communication between people who would otherwise find this very difficult, or who otherwise might not even see its value. Deming's 85%-15% rule is very useful here too: if the majority (85%) of the problems are systemic, these should receive priority in process improvement efforts. But improving the process is management's job. Those who work in the process can share their (data-based) knowledge of the process with management, but only management can make the necessary improvements. If it does so, workers at lower levels will see management committed to a new way of doing business. Trust and communication will ensue. In essence, the statistical methods described above support, facilitate, and reinforce the culture which is necessary if an organization is to make significant gains in quality improvement.