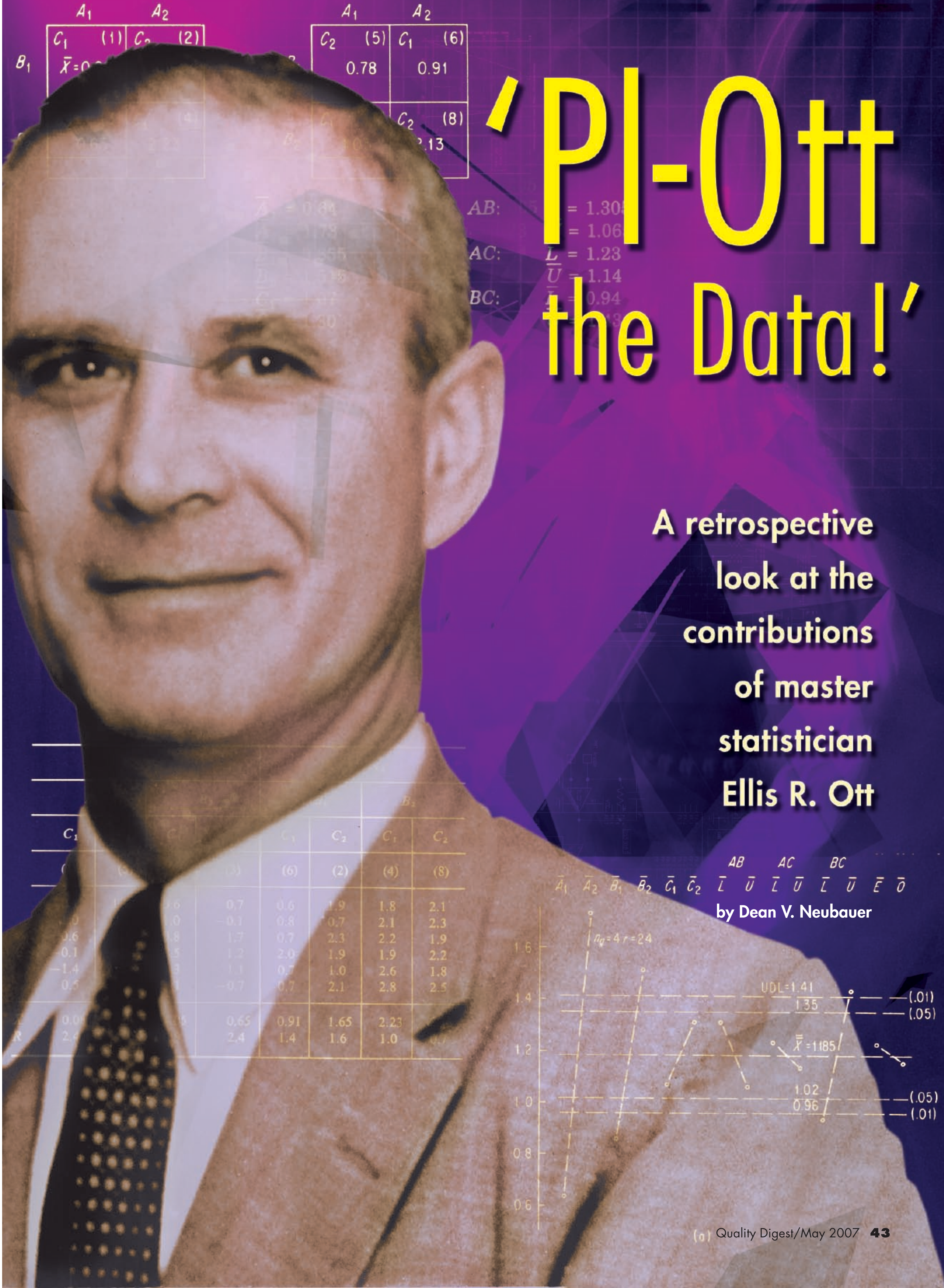
'Pl-Ott the Data!'



A retrospective look at the contributions of master statistician Ellis R. Ott

by Dean V. Neubauer

Know & Go

- Ellis Ott saw the bigger picture of how statistical methods could be applied in industrial settings.
- He was the guiding force behind the statistics program at Rutgers University.
- Ott outlined seven functions that should be performed by statistical quality control professionals.
- Long before DMAIC was thought of, Ott was promoting the use of applied statistics and troubleshooting strategies to characterize a process.
- He designed a graphical technique, analysis of means (ANOM), to communicate the results of an analysis of variance (ANOVA).

Long before Six Sigma, there was a leader who knew the value of sound, practical statistical methods in solving process problems. He didn't preach to statisticians so much as he spoke to practitioners. His name was Ellis R. Ott. An honorary member of the American Society for Quality, Ott was a pioneer in the use of graphical methods for applied statistical analysis. Many of his students have been—and still are—at the forefront of today's quality movement.

Ott's methods were published in his seminal book, *Process Quality Control* (McGraw Hill Higher Education, 1975), which is now in its fourth edition and available through ASQ Quality Press. These methods are gaining in popularity due to their applied statistical nature and ease of use.

"Plot the data!" was Ott's frequent rallying cry. It sounds simple enough. Surprisingly, some people, when faced with making a decision, will forego the effort to plot the data and merely glance at the numbers instead. If you think this is a rare event, think again.

Father of industrial statistics

Ott always saw the bigger picture of how statistical methods could be integrated into industrial settings. He realized that these methods should be easy to grasp and understand so that people could make data-based decisions. His analysis of means (ANOM) technique answered many of these needs, but perhaps more important, Ott knew that statistical quality control (SQC) professionals or industrial statisticians would be the catalysts for making this change to statistical thinking. He cared very much for his students and colleagues. His students in the graduate program in Applied and Mathematical Statistics at Rutgers University were his "seeds" whom he wished to plant in industrial settings to carry his message and philosophy forward.

In 1960 Ott received the prestigious Shewhart Medal for his outstanding contributions to the field of quality control. When accepting the award, Ott warned that "The American Society for Quality Control, and industry, can have an influence in an expanding and improving series of university programs… especially at the graduate level. The need for increased numbers of Ph.D.s is critical…. It isn't a question of whether industry can afford it—it is a question of whether it can afford not to." He went on to say that "theory and application must be coupled from the very beginning if we are to develop logical processes of reasoning and decision making."[1]

Ott's comments on the need for trained SQC professionals and a graphical technique such as ANOM are still sound advice today. Industry still needs trained SQC professionals. Although Six Sigma training of Green Belts and Black Belts works toward this end, subject matter experts are needed as well. These are people who possess a master's degree or doctorate in statistics but are capable of implementing applied statistical methods. In other words, they're also industrial applied statisticians. Ott's key message is that theory and practice are still fundamental ingredients in sound reasoning and decision making.

Lynne B. Hare, Ph.D., director of applied statistics with Kraft Foods Inc. and a graduate student during Ott's years at Rutgers, comments that Ott-type university seminars continue today with great frequency, but during the 1960s, they were unique to Ott and his program. Back then, Hare didn't think of the program as statistics. Later, he realized how important to the profession it really was. Years ahead of his time, Ott recognized the importance of balance among theory, applications and communications. Many universities now embrace his teaching principles and his model for departmental organization.

"There is no question that the guiding force behind the Rutgers statistics program was Ellis Ott."

Ott taught "Interpretation of Data," and many of his students say it was one of the most valuable courses they ever had. Although it wasn't mathematically sophisticated, the course did impart many practical lessons that students could use when they accepted their first industrial positions. Ott taught statistics by storytelling, and every lesson was a practical one in both statistical methods and the manner in which statistical consulting could be most effective. He surrounded himself with a versatile staff that spanned the full range from applications to theory so his students would receive a healthy statistical balance.

Ott helped transform the field of statistics by creating the realm of industrial statistics, which was more palatable to those who could use these methods to solve manufacturing problems. Although Walter A. Shewhart was clearly the "Father of Quality Control," it's Ellis Ott who should be remembered as the "Father of Industrial Statistics," someone whose strong passion for combining statistics with science and engineering created practical solutions for diverse industrial needs.

Ott as visionary

Ott's vision of what the Rutgers program should be and his use of applied statistics to solve problems were beyond that of many of his contemporaries.

"There is no question that the guiding force behind the Rutgers statistics program was Ellis Ott," says Dr. Ronald D. Snee, another Rutgers graduate student under Ott, who now serves as principal of process and organizational excellence at Tunnell Consulting in King of Prussia, Pennsylvania. "He was the man with the vision. He understood how statistics could be helpful to industry. He knew how to identify and educate students who would make useful contributions—both in their organizations and to society in general. He understood the theory and application of statistics, and quality technology.

"He was also a leader in the development of statistical methodology. He emphasized the importance of graphical analysis of data long before it became fashionable to do so.

"He promoted the ideas of statistical thinking, which he often discussed under the subject of process troubleshooting. He promoted a simple but elegant philosophy regarding improvement. It consisted of four steps: understand the technical background of the problem, collect some data, draw some plots of the data, and think about what you have learned and what action you should take. Many practicing statisticians will recognize this as the fundamental process that underlies many of their problem-solving and process improvement activities."

The practitioner hasn't succeeded in his or her task until the results of the study are understood by those in a position to make decisions and authorize action.

Achieving common ground in quality control

In August 1961, Ott shared his thoughts on what a trained SQC professional should be able to do as part of his or her job description. These ideas are just as applicable today as they were 45 years ago. In an *Industrial Quality Control* article, Ott outlines seven functions that should be performed by SQC professionals:

1. How to locate (i.e., identify) an opportunity with economic potential
2. How to plan an exploratory study—including the type of data to be collected and the manner of collecting them
3. How to collect these data or supervise their collection
4. How to analyze the data (this has received major attention from statisticians).
5. How to interpret the data and to check whether the interpretation agrees with the state of the science and of manufacturing, and whether the data even warrant an analysis and interpretation
6. How to convince appropriate personnel of the interpretation. The purpose of an industrial study is to provide a basis for action, and the practitioner hasn't succeeded in his or her task until the results of the study are understood by those in a position to make decisions and authorize action.
7. How to provide a pertinent continuing control. Many problems are solved in principle but recur because the continuing controls that are provided are inadequate.[2]

Ott added that the order of these seven functions wasn't vital. "In fact," he said, "subcycles of these functions will be frequent." He complained that although much had been written on statistical methods of analyzing data at hand, little attention had been paid to how to properly collect data, interpret it and convince the appropriate personnel of the interpretation.

Ott also recognized that the SQC professional can't do it alone. In May 1969, he wrote an article for *Quality Progress* in which he addressed the idea of achieving quality control of a process. He stressed that a quality control system isn't a "magic wand" that will fix all problems, although it can be when it works with people in all departments—including production, inspection and process improvement. He explained how people must work together to achieve the common goal of quality control:

"In your own plant or organization there are frustrations about where and how to keep control charts, where to apply acceptance sampling plans and where to start trouble-shooting expeditions. Simple systems of data collection presented on charts are always helpful. But all your time must not be spent fighting fires. You must improve your fire-prevention programs–your quality control systems of information—and you must establish effective feedback systems.

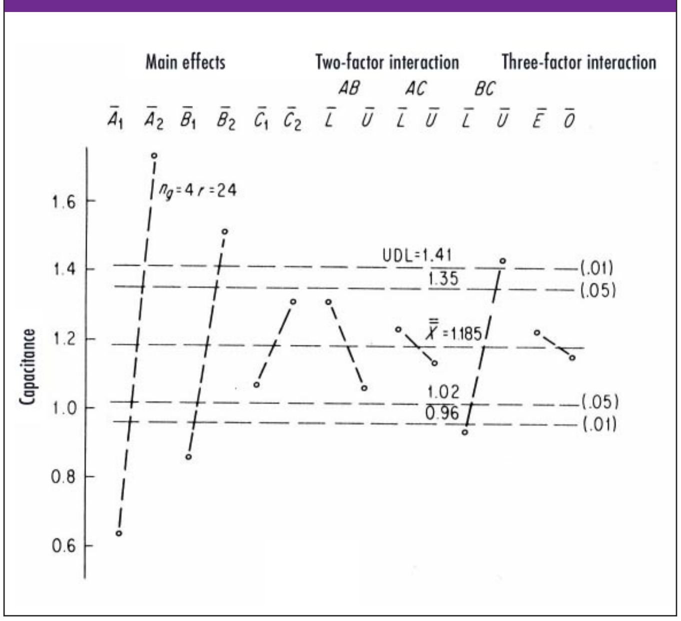
"It is vital to enlist the support and concern of many in improving quality methods. Get each foreman, supervisor and operator to understand the importance of his own position and function. They will need individual suggestions. Make them aware of the importance of reporting their process problems so that attention can be directed there. Such a program takes initiative, ingenuity, persuasiveness and knowledge of where quality control methods can make contributions.

"Each of us has the inclination at times to hope for the magic wand, to say, 'It's not my fault,' to explain why we can't organize and establish an effective quality control system. That's human nature."[3]

Analysis of means for graphical analysis

Long before Six Sigma's define, measure, analyze, improve and control (DMAIC) methodology, Ott was promoting the use of applied statistics and troubleshooting strategies to characterize and understand a process. His friendship with Shewhart, inventor of the control chart, led Ott to develop a graphical technique that communicated the results of an analysis of variance (ANOVA) from a designed experiment but that could be constructed in the manner of a control chart. This technique was called the analysis

Figure 1: Example of ANOM—Comparison of Electrical Capacitance of Nickel-Cadmium Batteries



of means. In August 1967, he published "Analysis of Means (ANOM)—A Graphical Procedure" in the Walter Shewhart memorial issue of *Industrial Quality Control*. (The article was reprinted in January 1983, in the Ellis Ott memorial issue of the *Journal of Quality Technology*). In 1986 ASQC acknowledged Ott with the Brumbaugh Award for this article.

In the article, Ott introduces ANOM by comparing a control chart and ANOVA, which helps put the technique into perspective for the reader:

"The Shewhart control chart is a common introduction to statistical analysis for many engineers, inspectors, chemists and other scientists. When these charts indicate the presence of an assignable cause (of nonrandom variability), an adjustment of the process is made if the remedy is known. When the nature of the assignable cause and the appropriate adjustment of the process are not known, there is a need and an opportunity to design production studies (or experiments). However, the majority of experimenters need professional guidance when they begin to analyze and interpret designed experiments using analysis of variance procedures; consequently, there might be a reluctance to plan and carry out a more sophisticated experimental program.

"The methods of analysis described in this article are an extension of Shewhart control chart techniques. They tend to encourage the design of experiments and are an effective method of presenting the findings. They involve dealing directly with means in contrast to the analysis of variance, in which means are compared by taking ratios of mean squares. The underlying concepts of these two procedures are basically the same; the conclusions are usually the same, but the nature of some differences is indicated in this article."[4]

Ott also lists several advantages of a graphical ANOM over the more conventional ANOVA, as follows:

- ANOM provides a direct study of possible effects of the factors by working with the means instead of the variances. Thus, ANOM gives a comparison of the relative importance and magnitude of the factors along with their measure of statistical significance.
- ANOM provides a graphical comparison of effects. Such a graphical presentation of the results is in a form that's comprehensible to appropriate technical and administrative personnel who aren't trained in statistical methods but who need the information as a basis for decision and action (seen as a critical advantage of ANOM).
- ANOM provides a pinpointing of sources of nonrandomness. Whereas ANOVA can identify a factor that significantly affects the response, it doesn't indicate which levels of the significant factor are responsible for its statistical significance unless a multiple comparison method is employed as a supplementary analysis. The amount of effort necessary to complete this degree of analysis has led many to use ANOM as their primary analysis tool.
- A graphical presentation of data is a necessity when interpreting the meaning of interactions that are deemed statistically significant by ANOVA.
- ANOM is more sensitive in detecting the nonrandomness of a single mean than ANOVA. On the other hand, ANOM is somewhat less sensitive in determining the overall variability of a group of k machines and others like them than ANOVA.
- ANOM frequently provides a bonus by suggesting the unsuspected presence of certain types of nonrandom variability; these suggestions can then be included in subsequent experiments for study.
- The graphical ANOM has often indicated errors in calculation in an ANOVA. These errors are usually apparent in a graphical presentation even to the untrained eye.
- ANOM can be programmed for graphical printout.

With ANOM, Ott found a connection between the world of statistics and that of industrial manufacturing. Traditionally, these worlds seldom mixed. Through Ott's efforts and teachings he was able to create a new generation of quality professional: the industrial applied statistician.

Epilogue

In 1970, the Metropolitan Section of ASQC (now the New York/New Jersey Metropolitan Section of ASQ) created the Ellis R. Ott Award to recognize his contributions and commitment to SQC. This award is presented annually to a recipient who exemplifies the same commitment.

In 1978, Ott was elevated to the status of honorary member of ASQC. At the time, only nine others had reached this level. Today, there are only 23 honorary members of ASQ.

After his death in 1981, the Ellis R. Ott Foundation was created by many of his colleagues, including former students Hare, Snee, Schilling, Lou Pasteelnick, Bill Frey and Ed Schecter. The latter three played a major role during the foundation's first few years when it accumulated the bulk of the resources that fund the scholarship. The foundation's purpose is to honor Ott's memory by advancing the goals to which he devoted decades of tireless effort: applying SQC to maximize industrial productivity and introducing SQC to a broad spectrum of people. Contributions to the foundation activities that focus on the techniques and principles Ott so dynamically expounded include technical seminars and conferences, specifically directed college courses, continuing education programs and publications in trade journals. The fund is presently administered by the ASQ Statistics Division.

The profile of Ott in the November 1986 issue of *Quality Progress* contained the following recollection of a classroom exchange between Ott and his students. It typifies the man and how he connected with his students:

Ott to class at the end of the semester: "I wonder if you've all gotten the point I've been trying to make this semester."

Voice from the back of the class: "Plot the data!"

Ott: "No, gentlemen, I've tried to teach you to think."

Second voice: "Think. Then plot the data."[7]

References

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2 Ott, Ellis R. "Professionalism and the University, *Industrial Quality Control*, August 1961, pp. 20–23

3 Ott, Ellis R., "Achieving Quality Control," *Quality Progress,* May 1969, pp. 12–14.

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5 Wescott, Mason E., "In Memoriam—Ellis Raymond Ott," *Journal of Quality Technology,* January 1983, pp. 5–7.

6 Snee, Ronald D., "A Tribute to Ellis R. Ott," *Journal of Quality Technology,* January 1983, pp. 1–2.

A Passion for Quality, Statistics and People

Ott had a profound effect on those who knew him. In researching this article, I contacted several of Ott's former students and colleagues from Rutgers University. The similarities among their stories define the character of a man who was greatly admired, and whose vision and guidance created a quality movement based on the use of applied statistics for process troubleshooting and improvement.

The late Mason E. Wescott, Ph.D., a former colleague of Ott who left Rutgers to form a graduate statistics program at Rochester Institute of Technology much like the program Ott created at Rutgers, wrote a tribute to Ott in the January 1983 Ellis Ott memorial issue of the *Journal of Quality Technology*. Wescott wrote that Ott, in his Rutgers classes and work as a consultant, was a superb salesman. He had a unique ability to teach and excite mixed groups, including foremen, engineers, factory employees and managers. Furthermore, Wescott noted that Ott was more than an effective teacher—he was a great leader and an innovative problem solver. His relentless search for assignable causes of excessive and/or erratic variation was dependent on graphical displays and the need to "plot the data." The effectiveness of this approach has been widely recognized by quality professionals.[5]

J. Stuart Hunter, Ph.D., an ASQ honorary member who is professor emeritus at Princeton University and a well-known statistician, consultant and lecturer in SQC methods, first met Ellis Ott as an North Carolina State graduate student in 1951. At the time, Hunter was working as a summer student at the Aberdeen Proving Grounds. Frank Grubbs suggested that he attend a conference at Rutgers run by Ott. Grubbs asked him to be sure to relay his personal regards to Ott, whom he deeply respected as a fellow applied statistician. The meeting, organized under the local ASQC, had more than a thousand attendees. When Hunter finally got to Ott to relay Grubbs' salutations, he was immediately swept up as part of his inner circle and passed around as a misled graduate student in statistics who should be going to Rutgers. It was as though he had known him for years. This was also his first opportunity to meet Harold Dodge and Mason Wescott and become acquainted with the Western Electric and Bell Labs crew of quality experts. Hunter became an immediate and fervent ASQC member from that day forward.

Ott's devotion to his students is also seen in comments made by Edward G. Schilling, Ph. D., another Rutgers graduate student under Ott, who is currently professor emeritus at Rochester Institute of Technology and co-author with Ott (and me) of subsequent editions of *Process Quality Control.*

As an instructor of statistics at the University of Buffalo, Schilling first met Ott when he drove to New Brunswick, New Jersey, on a cold April day for an interview. Schilling was there on the recommendation of two of Ott's former students at the University of Buffalo, both of whom were convinced of the potential of the Rutgers program in industrial statistics and the character and ability of its chair. At that time it was the only program of its kind in the world.

The interview that day was successful, but there were two problems: Schilling had no relevant industrial experience, and he planned to marry that year. Ott solved both problems at one blow. "Don't worry, my boy," he promised. "I'll get you a job."

The following September, Schilling and his new bride arrived in New Brunswick to a new apartment found by the department secretary, and a new job as a quality technician for the Radio Corporation of America. Ott did more than admit Schilling to the program; he changed his life forever.

Ott loved statistics and took a great interest in conveying that love to his carefully selected students. His faculty also was outstanding, and each of them had industrial experience. Ott believed that experience in analyzing real data on real problems was absolutely necessary for an appreciation of the power and universal applicability of statistical methods. Schilling summarized his description of Ott in this quote:

"Dr. Ott had the indefinable quality that every good applied statistician needs: insight and intuition. Without it, there would have been no analysis of means. He realized that statistical methods provide a form of communication in which the statistics act as a bridge between real-world phenomena and the analyst in the face of variation. Control charts are an obvious example. Ellis took the control chart concept and applied it to designed experiments through the analysis of means. Thus, he developed a tool to communicate the results to an experimenter in a less complicated but more insightful way."[6]

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7 "Profile: The ASQC Honorary Members, Ellis R. Ott—Educator of a Generation of QC Professionals," *Quality Progress*, November 1986, pp. 58–59.

Acknowledgements

The author is indebted to Lynne Hare, Ph. D.; J Stuart Hunter, Ph.D.; Truman Koehler; Thomas D. Murphy; Edward G. Schilling, Ph.D.; Ronald Snee Ph.D.; and Neil Ullman for sharing their first-hand experiences of Ellis Ott. Although there are certainly many others who knew him, the experiences of these individuals provide an excellent cross section of former colleagues and Rutgers graduate students who made this article better than it may have been otherwise.

About the author

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Comments

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