

BOOK REVIEWS

Evaluation and Control of Measurements

Reviewed by Milton J. Kowalewski, Jr., 221 Orchard St., Golden, CO 80401.

REFERENCE: Mandel, J., *Evaluation and Control of Measurements*, Marcel Dekker, Inc., New York, 1991, ISBN 0-8247-8531-2.

Mandel admits in the preface that unexpectedly, "the book is unorthodox." The author doesn't apologize because he believes that data analysis is in general not aided by applying established statistical techniques such as analysis of variance (ANOVA) and covariance. *Evaluation And Control of Measurement* should be useful to the experimental scientist and the statistical consultant. Each of the thirteen chapters begins with either a scope or an introduction to the concept and provides a summary, conclusions, or discussion of an example of the concept. The text should add a glossary of terms to assist the readers not familiar with statistical terms. The following is a synopsis of each chapter with reviewer comments:

Chapter 1, Measurement and Statistics starts with the universal truth that processes, especially for manufactured products, necessitates treating measurement as a process. Measurements require quality control, too. In fact, quality control of products is impossible without reliable measuring processes. Mandel leaps right into the mathematical treatise by introducing rectangular plots of desired properties, P and measured characteristics, M . In addition, Mandel alerts the reader that frequently calibration curves are nonlinear. Mandel refers immediately to concerns of reproducibility of calibration curves, both within laboratories and between laboratories that the author later expands in Chapter 10, Interlaboratory Studies.

Chapter 2, Basic Statistical Concepts as well as their interrelationships are discussed. Frequency distributions, the variate (the variable representing the value of the measurement), frequency density, weighted average or mean, variance, changes of scale, covariance, calculations of correlation coefficients, and combinations of random variables are introduced and explained to differentiate between population parameters and their sample estimates.

Chapter 3, Precision and Accuracy: The Central Limit Theorem, Weighting introduces the standard error of the mean that is gradually being accepted as the standard deviation of the mean, accuracy and its contradistinction bias. Contrary to Mandel's intent for the text, to develop concepts and relations necessary to carry out meaningful analysis of experimental data, he discusses the central limit theorem because of its great practical significance. Mandel also shows how weights can be used when measurements have different precisions.

Chapter 4, Sources of Variability describes the distinction between two common sources of random variability; within-group and between-group effects. Mandel discusses assumptions necessary for analysis of variance and an alternative method used when assumptions are not satisfied. The author presents a new

approach developed for the analysis of data classified within and between groups. In addition, the concept of accepting consensus values originating from various sources of data is offered.

Chapter 5, Linear Functions of a Single Variable covers three common cases of calculation of straight line parameters of calibration curves. They are: the classical (where x is without error, and the error variance of y is constant); the weighted case (where variance of the error of y varies in a known relative fashion); and the so-called "error-in-variable" case in which both x and y are subject to error, each with its own constant standard deviation of error. Formulas and illustrative examples are discussed.

Chapter 6, Linear Functions of Several Variables are used to provide interpretation of the outcomes of analyses. Regression, regressors, orthogonality, and a method intrinsically interesting and that can be carried out on a hand held calculator programmed for straight line fitting are presented. Mandel follows with collinearity and multicollinearity examples. Effective Prediction Domain or EDP construction is also explained in five distinct steps.

Chapter 7, Structured Two-Way Tables of Measurements uses design of experiment factorial combinations to discuss measuring y at all combinations of two factors x_1 and x_2 . Mandel offers good advice in opposition to a popular "two-way analysis of variance" technique and explains why after a sample traditional analysis. In addition, the author uses previously developed chapter sections to illustrate new concepts. He provides a very logical and thoroughly documented path to follow for each and every concept developed, especially additivity and concurrence.

Chapter 8, A Fit of High-Precision Two-Way Data continues Mandel's use of insights gained in previous chapters to repetitive table presentation, description, and mathematical explanations of the modified quadratic equation using the Box-Cox (1964) transformation to yield data of high precision.

Chapter 9, A General Treatment of Two-Way Structured Data tells the reader to test whether conditions for application of the linear model presented in Chapter 7 exist for all rows and columns of the linear function tables. Mandel proposes a basic singular value decomposition (SVD) model that leads to a complete representation of data by a finite number of terms, and very often to a good approximation by a rather small number of terms. However, while all steps presented are extremely simple they are time consuming and a computer is practically indispensable. The author discusses properties eigenvectors and eigenvalues presented earlier in Chapter 6 and his earlier 1982 work. This chapter adds a third component, multiplicative interactions to the analysis of variance additive rows and columns discussed in Chapter 7.

Chapter 10, Interlaboratory Studies and the importance of controlling the manufacturing process are discussed. Precision, accuracy, data analysis and the theoretical flaw of the level-by-level analysis are described as well as outliers, the k -Statistic, the h -Statistic, repeatability, and reproducibility as functions of level. Mandel applies the row-linear model developed in earlier chapters to study trends not most effectively detectable by the h - and k -plots. The author concludes from his presentation and

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experience that analysis of variance tables, which are generally considered "exact" statistical methods, can be shown to be deficient. In addition, *Evaluation And Control of Measurements* concludes that it is useful to look at data using different statistical techniques, that real data seldom follows a single theoretical pattern, and mathematical models may be aesthetically satisfactory, but rarely represent real data sets.

Chapter 11, Control Charts are included to show that they are very effective tools for the control of measuring processes. Mandel discusses time interval criteria of control charts as well as randomization criteria. To judge whether processes are not changing discrete data control charts are presented.

Chapter 12, Comparison of Alternative Methods elucidates the need to compare methods expressed in different units to select the best method of measurement. Mandel illustrates mathematically the experimental determination of sensitivity as a basic measure of uncertainty in conjunction with considerations based on economic factors of sampling and testing.

Chapter 13, Data Analysis: Past, Present, and Future challenges the reader to accept the facts that we live in a world of unknowns, and can only make reasonable assumptions about truth. Mandel propounds that in the future, "data analysis will be concerned more and more with useful approximations to the truth, with emphasis on the usefulness of inferences rather than on their probability values."

Appendices on Critical Values of h and k at the 1.0% level, 0.5% level, 0.1% level; Factors for Control Charts; Areas of the Standard Normal Distribution, and Degrees of Freedom Corresponding to the First Three Eigenvalues for an $r \times s$ Table, assist the reader in following the author's treatise and using the content for personal applications.

Bibliography

- Box, G. E. P. and Cox, D. R. (1964), "An Analysis of Transformations." *Journal of Royal Statistical Society, Series B*, 26, pp. 211-252.
- Mandel, J., "Use of the Singular Value Decomposition in Regression Analysis." *American Statistician*, 1982, Vol. 36, pp. 15-24.
- Mandel, J. and Paule, R. C. "Interlaboratory Evaluation of a Material with Unequal Number of Replicates." *Analytical Chemistry*, Vol. 42, 1970, pp. 1194-1197.

A Sourcebook of Standards Information Education, Access and Development

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REFERENCE: Spivak, S. M. and Winsell, K. A., Eds., *A Sourcebook of Standards Information: Education, Access and Development*, G. K. Hall and Company, Boston, MA, 1991, 451 pp., ISBN 0-8161-1948-1.

If this book were to be rated on a scale of 1 to 10, in terms of filling a long-felt need by persons who have a desire to learn

the "what, when, where, why, who, and how of standards," it surely would deserve at least a 9.5.

Following a well-written Introduction by the authors, in which they set forth their *raison d'être* for the book, to provide a wide range of concepts directed toward standards information and education, the volume is subdivided into six major sections. The captions of each section and the titles of each article that they encompass clearly advertise the breadth and scope of each work.

In *Part 1: Standardization, Technology and Society* there are three excellent papers on Democratic Forms: The Place of Scientific Societies in Advanced Societies; Standards and Library Goals; and Standardization and Technology—The Impact on Libraries and Archives.

In *Part 2: Education for Technical Standards and Standards Information*, a collection of articles under the following five headings treat the historical and philosophical aspects of standards education: Standards Education Today; Standards Engineering Education; Toward the Development of a Model Standards Curriculum for Library and Information Sciences; Education in Information Systems Standards; and Educating Archivists for Automation.

Part 3: Accessing Standards and Technical Information in North America is treated in four papers starting with Accessing Standards Information in Canada; Accessing Standards Information in the United States: Verification, Identification, Acquisition, and Technical Assistance; and going on to Documentation and Information Exchange in the World of Standards; and Electronic Access to Standards and Technical Documents.

Part 4: Developing Standards for Accessibility is devoted to A Case Study in the Development of a Research-Based Building Accessibility Standard: ANSI-117.1 (1980).

Under *Part 5: Information Exchange and the Utility of Standards*, seven papers present a comprehensive picture of that subject under the headings: An Introduction to Library and Information Services Technical Standards Literature; Libraries and Access to Information in an Open Systems Environment; Archival Administration, Records Management and Computer Data; Archival Information Exchange and the Role of Bibliographic Networks; Data and Document Interchange Standards: A View from the National Archives of Canada; The Use of Standards in the Application of the AMC Format; and Museum Information Standards: Progress and Prospects.

Last, but certainly not least, is *Part 6: Problems and Promises: Present and Future Trends* in which three contributors pose some provocative ideas about the Future Directions in Standardization; Problems and Dangers of Standards; and The Future of Standards.

As if the foregoing topics and their treatments were not enough to satisfy the reader/user of this splendid reference work, there are provided some outstanding supplementary materials, as follows:

Appendix A: Recommendations of the Working Group on Standards for Archival Description (1989) is a compendium of

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17 recommendations ranging from "the role archivists should play in the development and implementation of standards" to an identification of "at least six areas in which significantly more research and development must take place in order to fully develop the potential of archival description."

Appendix B: Standards Information Centers in which the names, addresses, telephone numbers and other relevant information of practically every organization in North America which either publishes or distributes standards is identified. This is an exceedingly valuable and handy reference for anyone wishing to access standards produced in the United States, Canada, or with the assistance of organizations in those countries, just about any other country in the world.

Glossary of Standards-Related Terminology, which contains 126 definitions and identifications of terms and organizations that are every day words known to people active in the world of standards. The source of each of the definitions is given, an extremely valuable piece of information as some people will rely on the acceptability of definitions published by certain organizations more than by others.

And, finally, the authors have provided an exceptionally comprehensive *Annotated Standards Bibliography for North America*, followed by brief resumes of the backgrounds of each of the contributors to the book. Even the Index appears to have been well designed to make finding of topics, organizations, and authors quite facile.

If anyone should wonder why this reviewer has lauded the book so highly and yet held his numerical rating of it to be 9.5 instead of a maximum of 10, there are two reasons. One is partly because of the acknowledgment by the authors (p. 337) in their

discussion of the bibliography, where they express regret that they "have undoubtedly missed some publications that are worthy of inclusion here," and that they "welcome information on citations or major works that should be included in a later edition of this book."

This reviewer readily calls to mind at least two references that could have been included in this text and certainly should deserve to be included in that next edition. One is *International Standardization, Tests, Certification and Related Matters, and Their Implication Under Trade Agreements Act of 1979*, the proceedings of the first major public conference of the United States Department of Commerce on the titled subjects, which was held in Washington on 15-16 Oct. 1980. It covered the general concept and a number of much broader proposals than the formation of a United States Standards Council, which was the subject of hearings conducted by the National Institute for Standards and Technology in 1990 and all too briefly described by Albert L. Batik in "The Future of Standards," p. 291 at 293. The other reference that might usefully be included is the story behind the formation of International Laboratory Accreditation Conferences (ILAC), which is only mentioned briefly in the bibliography. That story can be found in a series of three articles that appeared in the Jan./Feb., March/April, and May/June 1989 issues of *Standards Engineering*. The teachings of ILAC are the foundation of the mutual recognition of testing results based on nationally or internationally recognized standards that have become the basis of conformity acceptance and other basic infrastructures, such as factory registrations and other arrangements, which are becoming more and more essential for international trade today.