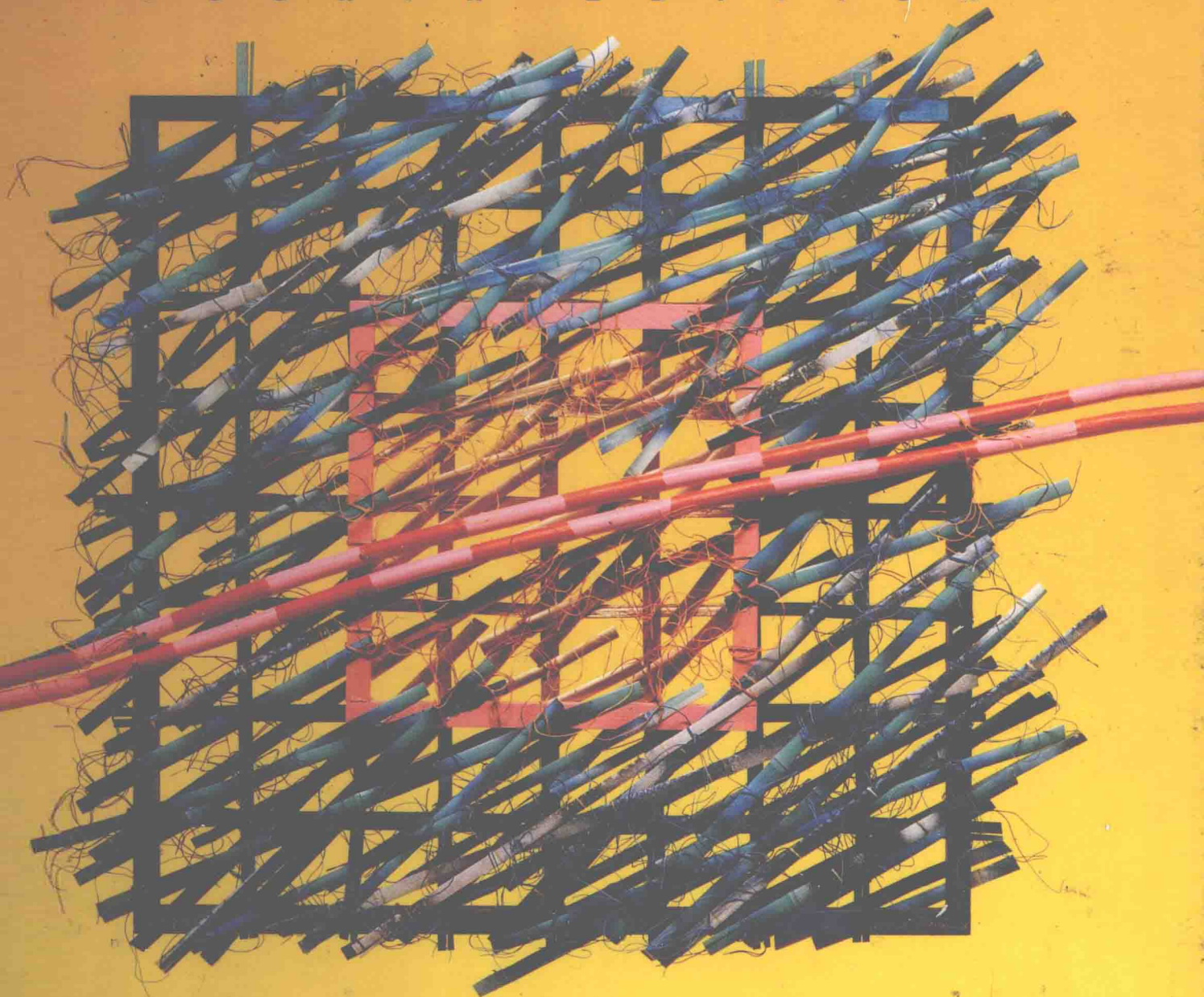


# STATISTICS BY EXAMPLE

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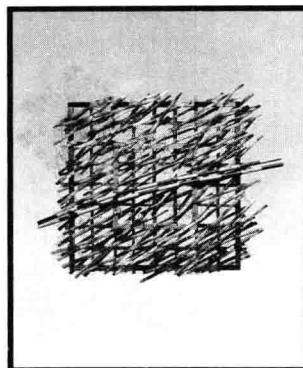
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FOURTH EDITION

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# Statistics by Example



Terry Sincich  
University of South Florida

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On the Cover: The cover features California artist Nance O'Banion's *Magic Square*, a painted bamboo and wire wall-construction measuring 28" high  $\times$  37" wide  $\times$  2" diameter. Part of a series O'Banion terms "three-dimensional drawings," the piece plays with the notions of change, speed, and duality. O'Banion has exhibited her art work internationally and is represented in the United States by The Allrich Gallery, San Francisco, California. Her work may be found in numerous public collections including The Oakland Museum, Oakland, CA; the American Craft Museum, New York, NY; the Seattle Art Museum, Seattle, WA; and the Monterey Peninsula Museum of Art, Monterey, CA. She also has a large-scale permanent installation at the San Francisco International Airport.

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# Preface

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This introductory college statistics text is designed for students who have only a high school background in mathematics as a prerequisite. It differs from most other texts in two ways:

1. **Real data sets.** Explanations of basic statistical concepts and methodology are based on and motivated by the use of real data sets.
2. **Teaching by example.** Concepts and statistical methods are explained in examples. Many of these examples arise as questions posed about the data sets.

We believe this practical orientation helps the student to relate statistics to real-life problems and, hopefully, will develop a pattern of thought that will persist after the student enters the business world. And we are not alone. At an American Statistical Association (ASA) workshop on “Making Statistics More Effective in Schools of Business,” held at the University of Chicago in June 1986, there was a substantial consensus among the participants on the following point: Students are most effectively motivated by seeing statistics at work in real applications, problems, cases, and projects. In much of the current teaching of statistics, there is a limited opportunity for students to work with real data or to make serious use of statistical computing.

The text contains four real data sets to help motivate students; the first two are heavily used as instructional vehicles. These data sets are:

**Appendix A** The set of actual starting salaries, majors, and colleges of 2,768 University of Florida graduates during the period from May 1987 to August 1988.

**Appendix B** The starting salaries (extracted from Appendix A) of bachelor’s degree graduates of the Colleges of Business Administration, Engineering, Liberal Arts and Sciences, Journalism, and Nursing.

**Appendix C** Supermarket customer checkout times for mechanical and automated checkers.

**Appendix D** Length, weight, and DDT measurements for various species of fish collected from the Tennessee River, Alabama, and its creek tributaries.

Although all of the data sets are used to develop the notion of a population and a sample, the starting salaries of college graduates (Appendices A and B) are used to demonstrate the need for data description, to develop the notion of a sampling distribution, and to motivate the inferential methods commonly studied in an introductory statistics course.

In addition to teaching via data sets and by example, the fourth edition retains the following features of the earlier editions:

1. **Case studies** Four case studies that detail specific and interesting current events are used in each chapter to pose questions for the student. These case studies are extracted from journals, newspapers, and magazines. The first case study, presented as a section in the text, demonstrates how to apply the statistical techniques learned in the chapter to solve the problem. The student is left to answer the questions posed by the three case studies given at the end of the chapter. (Refer to the Table of Contents for a list of the case studies.)
2. **Examples** The text, as its name implies, employs the “teaching by example” method. Each section contains several worked examples to demonstrate how to solve various types of statistical problems encountered in the real world.
3. **Key concepts highlighted** Throughout the text, key concepts are highlighted through the use of boxes.
  - a. **Definitions** are boxed.
  - b. **Steps** for constructing bar graphs, performing statistical calculations, and conducting statistical tests are listed and boxed for each procedure.
  - c. **Key words**, which must be added to a student’s vocabulary, are listed at the end of each chapter.
  - d. **Key formulas** are listed at the end of each chapter.
  - e. **Warnings**, indicating situations where a student might misuse a statistical technique, are presented in boxed form. The student is directed to specific alternative methods.
4. **Many exercises** Since most students learn best by doing, the text contains a large number (over 1,000) of exercises. The answers for odd-numbered exercises are provided at the end of the text. Each chapter contains exercises at the end of each section and a set of Supplementary Exercises at the chapter’s end. The exercises are of two types:
  - a. **Learning the Mechanics** These exercises are intended to be straightforward applications of the new concepts presented in the section. They are introduced in a few words and are unhampered by a barrage of background information designed to make them “practical,” but which often detracts from instructional objectives. Thus, with a minimum of labor, the student can recheck his or her ability to comprehend a concept or definition.
  - b. **Applying the Concepts** The mechanical exercises are followed by realistic exercises that allow the student to see applications of statistics to the solutions of a variety of real-world problems. Many of these exercises contain data extracted from newspaper articles, magazines, and journals. Once the mechanics are mastered, these exercises develop students’ skills at comprehending realistic problems that describe situations to which the techniques may be applied.
5. **Computer printouts** The use of statistical computer software packages is introduced in the presentation of graphical descriptive methods (Chapter 2), numerical descriptive methods (Chapter 3), sampling and sampling distribu-

tions (Chapter 7), the analysis of variance (Chapter 11), simple linear regression analysis (Chapter 12), multiple regression analysis (Chapter 13), and analysis of categorical data (Chapter 14). The computer printouts for three popular software packages — Minitab, SAS, and SPSS — are presented.

6. **Integrating the data sets and the computer** The data sets can be entered into computer storage and can be accessed by students for sampling and statistical inference. The student (or instructor) can then access the data sets for the demonstration of statistical concepts and for realistic statistical exercises. For example, the data sets can be used by the instructor to illustrate the concept of a sampling distribution and the concepts of estimation and tests of hypotheses.

The fourth edition contains several substantial changes, additions, and enhancements.

1. **Using the Computer (relevant chapters)** The text is now accompanied by DellenStat, a user-friendly, totally menu-driven statistical software package designed to run on IBM-compatible PCs. DellenStat is unique in that it (1) does the “number crunching” that one expects from a computer package, (2) provides interpretations of the results of the analysis to match the interpretations given in the text, and (3) lists any assumptions that are necessary for the analysis to be valid. (More details on DellenStat are provided below.) To encourage the use of computers in the statistical analysis of data, the student is asked to analyze a particular data set with DellenStat at the end of the relevant chapters.
2. **Interpreting the standard deviation (Chapter 3)** A new section (Section 3.6) on interpreting the standard deviation has been added to Chapter 3, Numerical Methods for Describing Quantitative Data. Tchebysheff’s theorem is now presented in addition to the Empirical Rule.
3. **Reduced emphasis on probability formulas (Chapter 4)** Based on the recommendations of the ASA workshop (see above), we have attempted to reduce the emphasis on probability formulas in this introductory text. For example, the material on the Combinations Rule has been moved to Case Study Section 4.4 for those instructors who wish to cover it. Chapter 4 now presents only the essential probability concepts (e.g., mutually exclusive events, conditional probability, and independent events) needed to apply the statistical inferential techniques in later chapters. Problem solving for the sake of problem solving is avoided.
4. **Normal approximation to binomial (Chapter 6)** The chapter now includes a new section (Section 6.4) on the normal approximation to the binomial distribution.
5. **Reorganization of chapters on estimation and tests of hypothesis (Chapters 8 and 10)** Chapter 8 (Estimation) and Chapter 10 (Hypothesis Testing: Applications) have been shortened considerably by combining the large- and small-sample cases for a population parameter into a single section. Chapter 10 now begins, more logically, with the section on determining the parameter of interest.

6. **New optional section on calculating  $\beta$  (Chapter 9)** An optional section (Section 9.6) on calculating  $\beta$ , the probability of a Type II error, has been added to Chapter 9, General Concepts of Hypothesis Testing.
7. **New optional sections on inferences about population variances (Chapters 8 and 10)** Three new optional sections on estimating and testing population variances have been added: confidence intervals for a population variance (Section 8.10), the  $\chi^2$  test for a single variance (Section 10.9), and the  $F$  test for comparing two population variances (Section 10.10).
8. **Less emphasis on analysis of variance formulas (Chapter 11)** The fourth edition adopts a computerized rather than a “cookbook” approach to ANOVA. All calculation formulas are relegated to optional Section 11.9, and the emphasis is changed to the understanding and interpretation of designed experiments. Computer printouts are presented for each type of analysis covered, with space that was formerly occupied by tedious calculations now devoted to interpretation of the results produced by the statistical software.
9. **New section on multiple comparisons of means in ANOVA (Chapter 11)** As a follow-up to an ANOVA, the Bonferroni multiple comparisons procedure is presented in Section 11.7.
10. **Multiple regression chapter expanded (Chapter 13)** The fourth edition now includes four new sections on model building in multiple regression: Interaction Models (Section 13.9), Second-Order Models (Section 13.10), Qualitative Variables (Section 13.11), and Testing Portions of a Model (Section 13.12). The material on residual analysis (Section 13.13) has also been expanded and now covers the problems of model misspecification, nonnormality, unequal variances, and outliers.
11. **Goodness-of-fit test (Chapter 14)** A  $\chi^2$  goodness-of-fit test for categorical data with one direction of classification (Section 14.1) has been added to Chapter 14.
12. **Nonparametric sign test and Wilcoxon rank sum test (Chapter 15)** The chapter on nonparametric statistics has been expanded to cover the sign test for making inferences about the median of a single population (Section 15.2). Also, we have replaced the Mann – Whitney  $U$  test for comparing two populations with the equivalent (and easier to use) Wilcoxon rank sum test (Section 15.3).
13. **Case studies updated** The case studies are updated, where necessary, in the fourth edition and several new case studies are included.
14. **More exercises with “real” data** Many new “real-world” exercises have been added to each chapter. These exercises, like the case studies, are extracted from news articles, magazines, and professional journals to give students the opportunity to apply their knowledge of statistics to current practical problems.

Numerous less obvious changes in details have been made throughout the text in response to suggestions by current users of the earlier editions.

The text is also accompanied by the following supplementary material:

1. **Student's solutions manual** (by Nancy Shafer) A student's exercise solutions manual presents the full solutions for half (the odd) exercises and case studies contained in the text.
2. **Instructor's solutions manual** (by Mark Dummeldinger) The instructor's exercise solutions manual presents the solutions to the other half (the even) exercises and case studies contained in the text.
3. **Appendix data sets on diskette or tape** The data in the appendices are available on either an IBM PC diskette or a 7-track, nonlabelled magnetic computer tape.
4. **Minitab Supplement** (by David D. Krueger and Ruth K. Meyer) The Minitab computer supplement was developed to be used with Minitab Release 5.1, as general-purpose statistical computing system. The supplement, which was written especially for the student with no previous experience with computers, provides step-by-step descriptions of how to use Minitab effectively as an aid in data analysis. Each chapter begins with a list of new commands introduced in the chapter. Brief examples are then given to explain new commands, followed by examples from the text illustrating the new and previously learned commands. Where appropriate, simulation examples are included. Exercises, many of which are drawn from the text, conclude each chapter.

A special feature of the supplement is a chapter describing a survey sampling project. The objectives of the project are to illustrate the evaluation of a questionnaire, provide a review of statistical techniques, and illustrate the use of Minitab for questionnaire evaluation.

5. **DellenStat** (by Michael Conlon) DellenStat is an integrated statistics package consisting of a workbook and an IBM PC floppy diskette with software and example sets of data. The system contains a file creation and management facility, a statistics facility, and a presentation facility. The software is menu-driven and has an extensive help facility. It is completely compatible with the text.

The DellenStat workbook describes the operation of the software and uses examples from the text. After an introductory chapter for new computer users, the remaining chapters follow the outline of the text. Additional chapters show how to create new sets of data. Technical appendices cover material for advanced users and programmers.

DellenStat runs on any IBM PC or close compatible with at least 256K of memory and at least one floppy disk drive.

6. **DellenTest** This unique computer-generated random test system is available to instructors without cost. Utilizing an IBM PC computer and a number of commonly used dot-matrix printers, the system will generate an almost unlimited number of quizzes, chapter tests, final examinations, and drill exercises. At the same time, the system produces an answer key and student worksheet with an answer column that exactly matches the column on the answer key.

I wish to acknowledge the many individuals who provided their invaluable assistance during the preparation of the original text and subsequent revisions. Their efforts are much appreciated. In particular, I thank the following reviewers of this latest edition, who suggested many of the changes listed above: Maurice L. Monahan (South Dakota State University), Elaine Bohanon (Bemidji State University), Bill Redmond (Bismarck State College), Larry J. Ringer (Texas A&M University), LaVern J. Meyer (Millikin University), Carolyn Likins (Millikin University), and William Mendenhall (University of Florida). Susan Reiland deserves special recognition for her excellent line-by-line reviews during the writing of the original manuscript and for managing the production of all three revisions. I am very grateful to the following for providing the data sets and accompanying background information: Maurice Mayberry (Director, Career Resources Center, University of Florida), Jim Sullivan (Water and Air Research), Info Tech, and Venus Wong (who patiently spent long hours at the supermarket recording customer checkout times).

Finally, I owe very special thanks to my wife, Faith Sincich, who not only provided the necessary moral support one needs when undertaking a project like this, but also did an excellent job of typing, cutting, pasting, proofing, editing, and solving exercises. Without her, the fourth edition of this text could not have been completed.

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