ELEMENTARY STATISTICS

WITH MULTIMEDIA STUDY GUIDE

TENTH EDITION

MARIO F. TRIOLA

Elementary
STATISTICS

with Multimedia Study Guide

Tenth Edition

Mario F. Triola

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About the cover: Dandelion seeds being scattered in the wind. This cover is symbolic of basic statistical methodology. A variety of random variables affect the dispersion of the seeds, and analysis of those variables can result in predicted locations of next year's flowers. Finding order and predictability in seemingly random events is a hallmark activity of statistics.

Symbol Table

$\overline{A}$ — complement of event A

H_0 — null hypothesis

H_1 — alternative hypothesis

α — alpha; probability of a type I error or the area of the critical region

β — beta; probability of a type II error

r — sample linear correlation coefficient

ρ — rho; population linear correlation coefficient

r^2 — coefficient of determination

R^2 — multiple coefficient of determination

r_s — Spearman's rank correlation coefficient

b_1 — point estimate of the slope of the regression line

b_0 — point estimate of the y-intercept of the regression line

$\hat{y}$ — predicted value of y

d — difference between two matched values

$\overline{d}$ — mean of the differences d found from matched sample data

s_d — standard deviation of the differences d found from matched sample data

s_e — standard error of estimate

T — rank sum; used in the Wilcoxon signed-ranks test

H — Kruskal-Wallis test statistic

R — sum of the ranks for a sample; used in the Wilcoxon rank-sum test

μ_R — expected mean rank; used in the Wilcoxon rank-sum test

σ_R — expected standard deviation of ranks; used in the Wilcoxon rank-sum test

G — number of runs in runs test for randomness

μ_G — expected mean number of runs; used in runs test for randomness

σ_G — expected standard deviation for the number of runs; used in runs test for randomness

μ_x — mean of the population of all possible sample means $\overline{x}$

σ_x — standard deviation of the population of all possible sample means $\overline{x}$

E — margin of error of the estimate of a population parameter, or expected value

Q_1, Q_2, Q_3 — quartiles

$D_1, D_2, \ldots, D_9$ — deciles

$P_1, P_2, \ldots, P_{99}$ — percentiles

x — data value

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To Marc and Scott
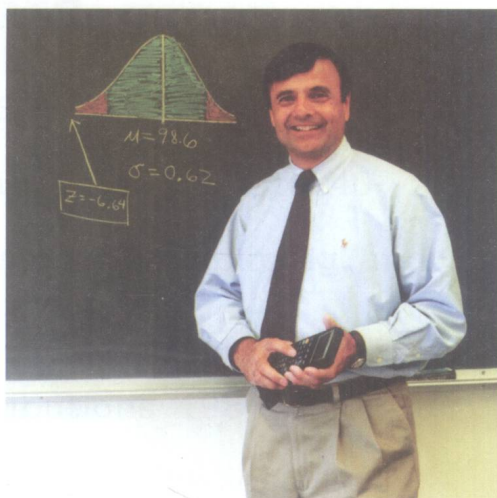
About the Author

Mario F. Triola is a Professor Emeritus of Mathematics at Dutchess Community College, where he has taught statistics for over 30 years. Marty is the author of *Essentials of Statistics, Elementary Statistics Using Excel, Elementary Statistics Using the Graphing Calculator,* and he is a co-author of *Biostatistics for the Biological and Health Sciences, Statistical Reasoning for Everyday Life* and *Business Statistics.* He has written several manuals and workbooks for technology supporting statistics education. Outside of the classroom, Marty has been a speaker at many conferences and colleges. His consulting work includes the design of casino slot machines and fishing rods, and he has worked with attorneys in determining probabilities in paternity lawsuits, identifying salary inequities based on gender, analyzing disputed election results, analyzing medical data, and analyzing medical school surveys. Marty has testified as an expert witness in New York State Supreme Court. The Text and Academic Authors Association has awarded Mario F. Triola a "Texty" for Excellence for his work on *Elementary Statistics.*

Preface

Philosophy

Elementary Statistics, Tenth Edition, is the result of over 30 years of teaching, research, and innovation in statistics education. The goal of this book is to be an engaging and thorough introduction to statistics for students. Although formulas and formal procedures can be found throughout the text, it emphasizes the development of statistical literacy and critical thinking. This book encourages thinking over the blind use of mechanical procedures.

Elementary Statistics has been the leading introductory statistics textbook in the United States for many years. By reaching millions of students, it has become the single best-selling statistics textbook of all time. Here are some important features that have contributed to its consistent success:

- Emphasis on statistical literacy and critical thinking
- Emphasis on understanding concepts instead of cookbook calculations
- Abundant use of *real* data
- Writing style that is clear, friendly, and occasionally humorous
- Diverse and abundant pedagogical features
- An array of helpful supplements for students and professors
- Addison-Wesley sales, technical, support, and editorial professionals who are exceptional in their commitment and expertise

Apart from learning about statistics, another important objective of *Elementary Statistics,* Tenth Edition is to provide a framework that fosters personal growth through the use of technology, work with peers, critical thinking, and the development of communication skills. *Elementary Statistics* allows students to apply their learned skills beyond the classroom in a real-world context.

This text reflects recommendations from the American Statistical Association and its *Guidelines for Assessment and Instruction in Statistics Education* (GAISE), the Mathematical Association of America, the American Mathematical Association of Two-Year Colleges, and the National Council of Teachers of Mathematics.

Audience/Prerequisites

Elementary Statistics is written for students majoring in any subject. Although the use of algebra is minimal, students should have completed at least a high school or college elementary algebra course. In many cases, underlying theory behind topics is included, but this book does not require the mathematical rigor more suitable for mathematics majors. Because the many examples and exercises cover a

wide variety of statistical applications, *Elementary Statistics* will be interesting and appropriate for students studying disciplines ranging from the social sciences of psychology and sociology to areas such as education, the allied health fields, business, economics, engineering, the humanities, the physical sciences, journalism, communications, and liberal arts.

Technology

Elementary Statistics, Tenth Edition, can be used easily without reference to any specific technology. Many instructors teach this course with their students using nothing more than a scientific calculator. However, for those who choose to supplement the course with specific technology, both in-text and supplemental materials are available.

Changes in this Edition

- Multimedia Study Guide CD-ROM: Contains review Exercises, Videos, animated flow-charts, and selected exercise solutions.
- The section on Visualizing Data has been divided into two sections, with increased emphasis on statistical graphics:

   Section 2-3: Histograms

   Section 2-4: Statistical Graphics

- The former chapter on Describing, Exploring, and Comparing Data has been divided into two chapters:

   Chapter 2: Summarizing and Graphing Data

   Chapter 3: Statistics for Describing, Exploring, and Comparing Data

- New section: **McNemar's Test for Matched Pairs** (Section 11-4)
- New section on the enclosed CD-ROM: **Bayes' Theorem**
- The text in some sections has been partitioned into Part 1 (Basics) and Part 2 (Beyond the Basics) so that it is easier to focus on core concepts.
- Discussions on certain topics have been expanded: Power (Section 8-2); residual plots (Section 10-3); logistic regression (Section 10-5); and interaction plots (Section 12-3).
- **Requirement check**: Where appropriate, solutions begin with a formal check of the requirements that must be verified before a particular method should be used.
- **Statistical Literacy and Critical Thinking:** Each exercise section begins with four exercises that specifically involve statistical literacy and critical thinking. Also, the end of each chapter has another four exercises of this type.
- **Answers from technology:** The answers in Appendix E are based on the use of tables, but answers from technology are also included when there are discrepancies. For example, one answer is given as "*P*-value: 0.2743 (Tech: 0.2739)," where "Tech" indicates the answer that would be obtained by using a technology, such as STATDISK, Minitab, Excel, or a TI-83/84 Plus calculator. Also, when applicable, *P*-values are now provided for almost all answers.

- **Small data sets:** This edition has many more exercises that involve smaller data sets.

- **New exercises and examples:** 68% of the exercises are new, and 53% of the exercises use real data. 66% of the examples are new.

- **Top 20 Topics:** In this edition, we have identified the **Top 20 Topics** that are especially important in any introductory statistics course. These topics are marked with a [top 20] in the text. Students using MyStatLab have access to additional resources for learning these topics with definitions, animations, and video lessons.

Flexible Syllabus

The organization of this book reflects the preferences of most statistics instructors, but there are two common variations that can be easily used with this Tenth Edition:

- **Early coverage of correlation/regression:** Some instructors prefer to cover the basics of correlation and regression early in the course, such as immediately following the topics of Chapter 3. *Sections 10-2 (Correlation) and 10-3 (Regression) can be covered early in the course.* Simply limit coverage to Part 1 (Basic Concepts) in each of those two sections.

- **Minimum probability:** Some instructors feel strongly that coverage of probability should be extensive, while others feel just as strongly that coverage should be kept to a minimum. Instructors preferring minimum coverage can include Section 4-2 while skipping the remaining sections of Chapter 4, as they are not essential for the chapters that follow. Many instructors prefer to cover the fundamentals of probability along with the basics of the addition rule and multiplication rule, and those topics can be covered with Sections 4-1 through 4-4. Section 4-5 includes conditional probability, and the subsequent sections cover simulation methods and counting (including permutations and combinations).

Exercises

There are over 1750 exercises—*68 percent of them are new!* More exercises use smaller data sets, and many require the *interpretation* of results. Because exercises are of such critical importance to any statistics book, great care has been taken to ensure their usefulness, relevance, and accuracy. Three statisticians have read carefully through the final stages of the book to verify accuracy of the text material and exercise answers. Exercises are arranged in order of increasing difficulty by dividing them into two groups: (1) Basic Skills and Concepts and (2) Beyond the Basics. The Beyond the Basics exercises address more difficult concepts or require a somewhat stronger mathematical background. In a few cases, these exercises also introduce a new concept.

   Real data: *53% of the exercises use real data.* (Because this edition has many more exercises in the category of Statistical Literacy and Critical Thinking, the percentage of exercises using real data is less than in the ninth edition, but the

number of exercises using real data is approximately the same.) Because the use of real data is such an important consideration for students, hundreds of hours have been devoted to finding real, meaningful, and interesting data. In addition to the real data included throughout the book, some exercises refer to the 18 large data sets listed in Appendix B.

Hallmark Features

Great care has been taken to ensure that each chapter of *Elementary Statistics* will help students understand the concepts presented. The following features are designed to help meet that objective:

- **Chapter-opening features:** A list of chapter sections previews the chapter for the student; a chapter-opening problem, using real data, then motivates the chapter material; and the first section is a chapter overview that provides a statement of the chapter's objectives.

- **End-of-chapter features:** A Chapter Review summarizes the key concepts and topics of the chapter; Statistical Literacy and Critical Thinking exercises address chapter concepts; Review Exercises offer practice on the chapter concepts and procedures—plus new videos show how to work through these exercises.

- **Cumulative Review Exercises** reinforce earlier material; Videos to accompany the Review Exercises can be found on the Multimedia Study Guide CD-ROM that accompanies this text.

- **From Data to Decision: Critical Thinking** is a capstone problem that requires critical thinking and writing;
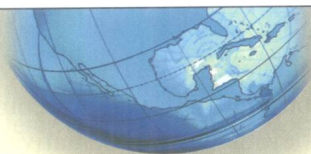
From Data to Decision

- **Cooperative Group Activities** encourage active learning in groups;
- **Technology Projects** are for use with STATDISK, Minitab, Excel, or a TI-83>84 Plus calculator;

Using Technology

STATDISK
MINITAB
EXCEL
T1-83/84 PLUS

- **Internet Projects** provide students an opportunity to work with Internet data sets and, in some cases, applets;

Internet Project

- **Margin Essays:** The text includes 122 margin essays, which illustrate uses and abuses of statistics in real, practical, and interesting applications. Topics include *Do Boys or Girls Run in the Family, Lefties Die Sooner?, and Picking Lottery Numbers.*

- **Flowcharts:** These appear throughout the text to simplify and clarify more complex concepts and procedures. New for this edition, the flowcharts have been animated and can be accessed at this text's MyStatLab (www.mystatlab.com) site and on the accompanying Multimedia Study Guide CD-ROM.

- **Statistical Software:** STATDISK, Minitab, Excel and TI-83/84 PLUS instructions and output appear throughout the text.

- **Real Data Sets:** These are used extensively throughout the entire book. Appendix B lists 18 data sets, including 4 that are new and 3 others with new data. These data sets are provided in printed form in Appendix B, and in electronic form on the Web site and the CD bound in the back of new copies of the book. The data sets include such diverse topics as alcohol and tobacco use in animated children's movies, eruptions of the Old Faithful geyser, and measurements related to second-hand smoke.

- **Interviews:** Every chapter of the text includes interviews with professional men and women in a variety of fields who use statistics in their day-to-day work.

- **Quick-Reference Endpapers:** Tables A-2 and A-3 (the normal and *t* distributions) are reproduced on inside cover pages. A symbol table is included at the back of the book for quick and easy reference to key symbols.

- **Detachable Formula / Table Card:** This insert, organized by chapter, gives students a quick reference for studying, or for use when taking tests (if allowed by the instructor).

- **Book Companion CD-ROM:** The CD-ROM was prepared by Mario F. Triola and is packaged with every new copy of the text. It includes the data sets from Appendix B, which are stored as text files, Minitab worksheets, SPSS files, SAS files, Excel workbooks, and a TI-83/84 Plus application. The CD also includes a section on Bayes' Theorem, programs for the TI-83/84 Plus® graphing calculator, STATDISK Statistical Software (Version 10.1), and the Excel add-in DDXL, which is designed to enhance the capabilities of Excel's statistics programs.

- **Multimedia Study Guide CD-ROM:** Contains review exercise videos, animated flowcharts, and exercise solutions.

Supplements

The student and instructor supplements packages are intended to be the most complete and helpful learning system available for the introductory statistics course. Instructors should contact their local Addison-Wesley sales representative, or e-mail the company directly at exam@aw.com for examination copies.

For the Instructor

- *Annotated Instructor's Edition,* by Mario F. Triola, contains answers to all exercises in the margin, plus recommended assignments, and teaching suggestions. ISBN: 0-321-33182-6.

- *Instructor's Solutions Manual,* by Milton Loyer (Penn State University), contains solutions to all the exercises and sample course syllabi. ISBN: 0-321-36916-5.

- *Insider's Guide to Teaching with the Triola Statistics Series,* by Mario F. Triola, contains sample syllabi, and tips for incorporating projects, as well as lesson overviews, extra examples, minimum outcome objectives, and recommended assignments for each chapter. ISBN 0-321-40964-7.

- **MyStatLab** (part of the MyMathLab and MathXL product family) is a text-specific, easily customizable online course that integrates interactive multimedia instruction with the textbook content. MyStatLab is powered by CourseCompass™—Pearson Education's online teaching and learning environment— and by MathXL®—our online homework, tutorial, and assessment system. MyStatLab gives you the tools needed to deliver all or a portion of your course online, whether your students are in a lab setting or working from home. MyStatLab provides a rich and flexible set of course materials, featuring free-response tutorial exercises for unlimited practice and mastery. Students can also use online tools, such as video lectures, animations, and a multimedia textbook, to independently improve their understanding and performance. Instructors can use MyStatLab's homework and test managers to select and assign online exercises correlated directly to the textbook, and you can also create and assign your own online exercises and import TestGen tests for added flexibility. MyStatLab's online gradebook—designed specifically for mathematics and statistics—automatically tracks students' homework and test results and gives the instructor control over how to calculate final grades. Instructors can also add offline (paper-and-pencil) grades to the gradebook. MyStatLab is available to qualified adopters.

  For more information, visit www.mystatlab.com or contact your Addison-Wesley sales representative for a demonstration.

- **Testing System:** Great care has been taken to create the most comprehensive testing system possible for the new edition of *Elementary Statistics.* Not only is there a printed test bank, there is also a computerized test generator, **TestGen,** that allows instructors to view and edit testbank questions, transfer them to tests, and print in a variety of formats. The program also offers many options for sorting, organizing and displaying testbanks and tests. A built-in random number and test generator makes **TestGen** ideal for creating multiple

versions of tests and provides more possible test items than printed testbank questions. Users can export tests to be compatible with a variety of course management systems, or even just to display in a web browser. Additionally, tests created with TestGen can be used with **QuizMaster,** which enables students to take exams on a computer network. **Printed Testbank** ISBN: 0-321-36914-9; **TestGen** for Mac and Windows ISBN: 0-321-36904-1.

- **PowerPoint® Lecture Presentation CD:** Free to qualified adopters, this classroom lecture presentation software is geared specifically to the sequence and philosophy of *Elementary Statistics.* Key graphics from the book are included to help bring the statistical concepts alive in the classroom. These slides are also available on the Triola Web site at www.aw-bc.com/triola. Mac and Windows ISBN: 0-321-36905-X.

For the Student

- **MathXL® for Statistics** is a powerful online homework, tutorial, and assessment system that accompanies Addison Wesley textbooks in statistics and mathematics. With MathXL for Statistics, instructors can create, edit, and assign online homework created specifically for the Triola textbook and tests using algorithmically generated exercises correlated at the objective level to this book. All student work is tracked in MathXL's online gradebook. Students can take chapter tests in MathXL for Statistics and receive personalized study plans based on their test results. The study plan diagnoses weaknesses and links students directly to tutorial exercises for the objectives they need to study and retest. Students can also access animations and Triola video clips directly from selected exercises. MathXL for Statistics is available to qualified adopters. For more information, visit our Web site at www.mathxl.com, or contact your Addison-Wesley sales representative.

- **Videos** have been expanded and now supplement most sections in the book, with many topics presented by the author. The videos feature technologies found in the book and the worked-out Chapter Review exercises. This is an excellent resource for students who have missed class or wish to review a topic. It is also an excellent resource for instructors involved with distance learning, individual study, or self-paced learning programs. **Videotape Series** ISBN: 0-321-36913-0. **Digital Video Tutor** (CD-ROM version). ISBN: 0-321-41268-0.

- **Triola** *Elementary Statistics* **Web Site:** This Web site may be accessed at http://www.aw-bc.com/triola, and provides Internet projects keyed to every chapter of the text, plus the book's data sets as they appear on the CD.

- *Student's Solutions Manual,* by Milton Loyer (Penn State University), provides detailed, worked-out solutions to all odd-numbered text exercises. ISBN: 0-321-36918-1.

The following technology manuals include instructions on and examples of the technology's use. Each one has been written to correspond with the text.

- *Excel® Student Laboratory Manual and Workbook,* written by Johanna Halsey and Ellena Reda (Dutchess Community College), ISBN: 0-321-36909-2.

- *MINITAB® Student Laboratory Manual and Workbook,* written by Mario F. Triola. ISBN: 0-321-36919-X.

- *SAS Student Laboratory Manual and Workbook,* written by Joseph Morgan ISBN 0-321-36910-6.

- *SPSS® Student Laboratory Manual and Workbook,* ISBN 0-321-36911-4.

- *STATDISK Student Laboratory Manual and Workbook,* written by Mario F. Triola. ISBN: 0-321-36912-2.

- *Graphing Calculator Manual for the TI-83 Plus, TI-84 Plus, and TI-89,* by Patricia Humphrey (Georgia Southern University) ISBN: 0-321-36920-3.

- *ActivStats®,* developed by Paul Velleman and Data Description, Inc., provides complete coverage of introductory statistics topics on CD-ROM, using a full range of multimedia. *ActivStats* integrates video, simulation, animation, narration, text, interactive experiments, World Wide Web access, and Data Desk®, a statistical software package. Homework problems and data sets from the Triola text are included on the CD-ROM. ActivStats for Windows and Macintosh ISBN: 0-321-30364-4. **Also available in versions for Excel, JMP, Minitab, and SPSS.** See your Addison-Wesley sales representative for details or check the Web site at www.aw.com/activstats.

- *Addison-Wesley Tutor Center:* Free tutoring is available to students who purchase a new copy of the 10th Edition of *Elementary Statistics* when bundled with an access code. The Addison-Wesley Tutor Center is staffed by qualified statistics and mathematics instructors who provide students with tutoring on text examples and any exercise with an answer in the back of the book. Tutoring assistance is provided by toll-free telephone, fax, e-mail and whiteboard technology—which allows tutors and students to actually see the problems worked while they "talk" in real time over the Internet. This service is available five days a week, seven hours a day. For more information, please contact your Addison-Wesley sales representative.

- *The Student Edition of MINITAB* is a condensed version of the professional release of MINITAB Statistical Software. It offers students the full range of MINITAB's statistical methods and graphical capabilities, along with worksheets that can include up to 10,000 data points. It comes with a user's manual that includes case studies and hands-on tutorials, and is perfect for use in any introductory statistics course, including those in the life and social sciences. The currently available Student Edition is *The Student Guide to Minitab Release 14.* ISBN 0-201-77469-0. MINITAB Student Release 14 statistical software is available for bundling with the Triola textbook. ISBN 0-321-11313-6 (CD only).

Any of these products can be purchased separately, or bundled with Addison-Wesley texts. Instructors can contact local sales representatives for details on purchasing and bundling supplements with the textbook or contact the company at exam@aw.com for examination copies of any of these items.

Acknowledgments

This Tenth Edition of *Elementary Statistics* is particularly special. I am so grateful to the thousands of statistics professors who have contributed to the success of this book. I am particularly grateful to my students who were so instrumental in shaping an approach to effective teaching that could be translated into a textbook, and the numerous students who have studied from this book and graciously provided many helpful comments.

The success of *Elementary Statistics* is attributable to the commitment and dedication of the entire Addison-Wesley team, and I extend my most sincere thanks to Deirdre Lynch, Christine O'Brien, Greg Tobin, Peggy McMahon, Barbara Atkinson, Phyllis Hubbard, Ceci Fleming, Celena Carr, Sara Oliver, Joe Vetere, Beth Anderson, and Dana Weightman. I also thank Janet Nuciforo of Nesbitt Graphics for her superb production work.

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