Dedication

To my parents and family, my friends, and my colleagues who are also friends. Without their patience and support, this would not have been possible.

—Rob

To my teachers and students, and to my family who have helped me in many different ways.

—Colleen

To my family, parents, my “Edmonton-Fam,” dearest friends, and trusted colleagues. Thank you for your patience and unwavering support.

—Jim

To my mother, for her inspiring example.

—Michelle
About the Authors

Robert Gould

Robert L. Gould (Ph.D., University of California, San Diego) is a leader in the statistics education community. He has served as chair of the American Statistical Association’s Committee on Teacher Enhancement, has served as chair of the ASA’s Statistics Education Section, and served on a panel of co-authors for the Guidelines for Assessment in Instruction on Statistics Education (GAISE) College Report. As the associate director of professional development for CAUSE (Consortium for the Advancement of Undergraduate Statistics Education), Rob has worked closely with the American Mathematical Association of Two-Year Colleges (AMATYC) to provide travelling workshops and summer institutes in statistics. For over 10 years, he has served as Vice-Chair of Undergraduate Studies at the UCLA Department of Statistics, and he is Director of the UCLA Center for the Teaching of Statistics. In 2009, Rob was elected president of the Southern California Chapter of the American Statistical Association.

In his free time, Rob plays the cello, runs, and is an ardent reader of fiction.

Colleen Ryan

Colleen N. Ryan has taught statistics, chemistry, and physics to diverse community college students for decades. She taught at Oxnard College from 1975 to 2006, where she earned the Teacher of the Year Award. Colleen currently teaches statistics part-time at California Lutheran University. She often designs her own lab activities. Her passion is to discover new ways to make statistical theory practical, easy to understand, and sometimes even fun.

Colleen earned a B.A. in physics from Wellesley College, an M.A.T. in physics from Harvard University, and an M.A. in chemistry from Wellesley College. Her first exposure to statistics was with Frederick Mosteller at Harvard.

In her spare time, Colleen sings with the Oaks Camerata, has been an avid skier, and enjoys time with her family.
Jim Stallard

James B. Stallard has been teaching statistics and probability at the University of Calgary since 1996, where he currently serves as Associate Head, Teaching and Learning of the Department of Mathematics and Statistics. He has served as chair of the Statistical Education Committee of the SSC (Statistical Society of Canada) and as the President of the Statistical Education Section of the SSC. He earned a B.Sc. in statistics and economics from the University of Alberta, and a M.Sc. from the University of Calgary.

In his spare time, Jim likes to spend time with his family, play hockey, and fish the beautiful rivers that carve their way through the foothills of Southwestern Alberta.

Michelle Boué

Michelle Boué holds M.Sc. and Ph.D. degrees in Applied Mathematics from Brown University. She has over 20 years of experience teaching mathematics and statistics at different colleges and universities in Canada, the United States and Mexico, including Trent University, St. Francis Xavier University, the University of Massachusetts (Amherst), Newbury College, and the ITAM (Instituto Tecnológico Autónomo de México). In recent years, she has turned her attention to the promotion of science and mathematics education in elementary and secondary schools. She is currently a presenter for the Scientists in School organization in Ontario.
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Preface

About This Book

The primary focus of this text is data. We live in a data-driven economy and, more and more, in a data-centred culture. We don’t choose whether we interact with data; the choice is made for us by websites that track our browsing patterns, membership cards that trace our spending habits, cars that register our driving patterns, and smartphones that record our most personal moments.

The silver lining of what some have called the Data Deluge is that we all have access to rich and valuable data relevant in many important fields: environment, civics, social sciences, economics, health care, and entertainment. This text teaches students to learn from such data and, we hope, to become cognizant of the role of the data that appear all around them. We want students to develop a data habit of mind in which, when faced with decisions, claims, or just plain curiosity, they know to reach for an appropriate data set to answer their questions. More importantly, our goal is for students to have the ability to process and objectively, as well as critically, analyze such data using the statistical tools they will acquire from their study of this text. Clearly, we’ve come a long way from the “mean median mode” days of rote calculation. The modern economy requires much more than knowing how to plug numbers into a formula. Today’s students must know which questions can be answered by applying which statistic and how to use technology to compute such statistics from within complex data sets.

What’s New in the Canadian Edition

The Canadian Edition remains true to the goals of the U.S. text: to provide students with the tools they need to make sense of the world by teaching them to collect, visualize, analyze, and interpret data. However, we have introduced a substantial number of changes that will enable us to better achieve this vision inside the Canadian classroom:

• Canadian and global data of interest to Canadian students have been incorporated throughout the text to demonstrate practical and relevant applications. The new, updated, or revised material includes over 400 exercises, nearly 100 chapter examples, and 11 completely new case studies. New content can be found involving climate change, health care, languages, Aboriginal issues, multiculturalism, sports, vaccinations, and lottery scandals, to name but a few.

• A list of Learning Objectives appears on the introductory page of each chapter. The Learning Objectives are revisited at the end of the chapter, with specific questions answered in the Chapter Summary. This new learning tool reflects the current emphasis on learning objectives and gives the student a quick way of reviewing the key concepts of the chapter.

• Chapter 5 has been substantially revised, with more examples covering conditional probability.

• Chapter 11 has been restructured and expanded, with a new section discussing the calculations required to complete an ANOVA table.

• A new section dedicated to the Kruskal-Wallis test has been added to the non-parametric tests of Chapter 13.

• Material on special topics from several chapters has been moved to MyStatLab so as to make room for new content. All online sections are indicated by an online icon in the book’s table of contents.
• IBM SPSS Statistics software ("SPSS") has been added to the list of calculation tools covered by the text. The steps for performing calculations using SPSS have been added to the end of each chapter when appropriate, and some examples within the text discuss the analysis of SPSS output.

• Snapshot boxes break down key statistical concepts, quickly summarizing each concept or procedure. In this edition we have explicitly included a “When is it used?” summary in each Snapshot.

• The SI metric system of units is used throughout the text.

Approach

Our text is concept-based, as opposed to method-based. We do teach useful statistical methods, but we emphasize that applying the method is secondary to understanding the concept.

In the real world, computers do most of the heavy lifting for statisticians. We therefore adopt an approach that frees the instructor from having to teach tedious procedures and leaves more time for teaching a deeper understanding of concepts. Accordingly, we present formulas as an aid to understanding the concepts rather than as the focus of study.

We believe students need to learn how to

• determine which statistical procedures are appropriate,

• instruct the software to carry out the procedures, and

• interpret the output.

We understand that students will probably see only one type of statistical software in class. But we believe it is useful for students to compare output from several different sources, so in some examples we ask them to read output from two or more software packages.

One of the authors (Rob Gould) served on a panel of co-authors for the collegiate version of the Guidelines and Instruction in Statistics Education (GAISE). One of the Canadian authors (Jim Stallard) has served as both chair and president of various statistical education branches of the Statistical Society of Canada. In the preparation of this book, we have adopted up-to-date approaches to teaching and learning statistics endorsed by the American Statistical Association and the Statistical Society of Canada.

• We emphasize understanding over rote performance of procedures.

• We use real data whenever possible.

• We encourage the use of technology both to develop conceptual understanding and to analyze data.

• We believe strongly that students learn by doing. For this reason, the homework problems offer students both practice in basic procedures and challenges to build conceptual understanding.

Coverage

The first two-thirds of this book are concept-driven and cover exploratory data analysis and inferential statistics—fundamental concepts that every introductory statistics student should learn. The final third of the book builds on that strong conceptual foundation and is more methods-based. It presents several popular statistical methods and more fully explores methods presented earlier, such as regression and data collection.

Our ordering of topics is guided by the Cycle of Data.

Chapters 1–4: Exploratory Data Analysis. The first four chapters cover data collection and summary. Chapter 1 introduces the important topic of data collection and compares

\(^{5}\)SPSS Inc. was acquired by IBM in October, 2009.
and contrasts observational studies with controlled experiments. This chapter also teaches students how to handle raw data so that the data can be uploaded to their statistical software. Chapters 2 and 3 discuss graphical and numerical summaries of single variables based on samples. We emphasize that the purpose is not just to produce a graph or a number but, instead, to explain what those graphs and numbers say about the world. Chapter 4 introduces simple linear regression and presents it as a technique for providing graphical and numerical summaries of relationships between two numerical variables. We feel strongly that introducing regression early in the text is beneficial in building student understanding of the applicability of statistics to real-world scenarios. After completing the chapters covering data collection and summary, students have acquired the skills and sophistication they need to describe two-variable relationships and to generate informal hypotheses. Two-variable relationships provide a rich context for class discussion and allow the course to move from fabricated problems (because one-variable analyses are relatively rare in the real world) to real problems that appear frequently in everyday life. We return to regression in Chapter 14, when we discuss statistical inference in the context of regression, which requires quite a bit of machinery. We feel that it would be a shame to delay until the end of the course all the insights that regression without inference can provide.

Chapters 5–8: Inference. These chapters teach the fundamental concepts of statistical inference. The main idea is that our data mirror the real world, but imperfectly; although our estimates are uncertain, under the right conditions we can quantify our uncertainty. Verifying that these conditions exist and understanding what happens if they are not satisfied are important themes of these chapters.

Chapters 9–11: Methods. Here we return to the themes covered earlier in the text and present them in a new context by introducing additional statistical methods, such as estimating population means, analyzing categorical variables, and analyzing relations between a numerical and a categorical variable. We also introduce ANOVA as a technique for comparing means of several populations.

Chapters 12–14: Special Topics. Students who have covered all topics up to this point will have a solid foundation in statistics. These final chapters build on that foundation and offer more details, as we explore the topics of designing controlled experiments, survey sampling, additional contexts for hypothesis testing, and using regression to make inferences about a population.

In Chapter 12 we provide guidance for reading scientific literature. Even if your schedule does not allow you to cover Chapter 12, we recommend using online Section 12.3 to offer students the experience of critically examining real scientific papers.

Organization

Our preferred order of progressing through the text is reflected in the Contents, but there are some alternative pathways as well.

12- to 14-Week Semester. The first 10 chapters would provide a full, one-semester course in introductory statistics. If time remains, cover Chapter 11 as well, so that students can solidify their understanding of confidence intervals and hypothesis tests by revisiting the topics with several groups.

Proportions First. Ask two statisticians, and you will get three opinions on whether it is best to teach means or proportions first. We have come down on the side of proportions for a variety of reasons. Proportions are much easier to find in popular news media (particularly around election time), so they can be more readily tied to students’ everyday lives. Also, the mathematics and statistical theory is simpler; because there’s no need to provide a separate estimate for the population standard deviation, inference is based on the Normal distribution, and no further approximations (that is, the t-distribution) are required. Hence, we can quickly get to the heart of the matter with fewer technical diversions.
The basic problem here is how to quantify the uncertainty involved in estimating a parameter and how to quantify the probability of making incorrect decisions when posing hypotheses. We cover these ideas in detail in the context of proportions. Students can then more easily learn how these same concepts are applied in the new context of means (and any other parameter they may need to estimate).

Means First. Conversely, many people feel that there is time for only one parameter and that this parameter should be the mean. For this alternative presentation, cover Chapters 6, 7, and 9, in that order. On this path, students learn about survey sampling and the terminology of inference (population vs. sample, parameter vs. statistic) and then tackle inference for the mean, including hypothesis testing.

To minimize the coverage of proportions, you might choose to cover Chapter 6, Section 7.1 (which covers in detail the language and framework of statistical inference), and then Chapter 9. Chapters 7 and 8 develop the concepts of statistical inference more slowly than in Chapter 9, but essentially, Chapter 9 develops the same ideas in the context of the mean.

If you present Chapter 9 before Chapters 7 and 8, we recommend that you devote roughly twice as much time to Chapter 9 as you have devoted to previous chapters, because many challenging ideas are explored in this chapter. If you have already covered Chapters 7 and 8 thoroughly, Chapter 9 can be covered more quickly.

Features
We’ve incorporated into this book a variety of features to aid student learning and to facilitate the use of this text in any classroom.

Integrating Technology
Modern statistics is inseparable from technology. We have worked to make this textbook accessible for any classroom, regardless of the level of in-class exposure to technology, while still remaining true to the demands of the analysis. We know that students sometimes do not have access to technology when doing homework, so many exercises provide output from software and ask students to interpret and critically evaluate that given output.

Using technology is important because it enables students to handle real data, and real data sets are often large and messy. The following features are designed to guide students.

• Tech Tips outline steps for performing calculations using TI-83/84 graphing calculators, Excel, Minitab, StatCrunch, and SPSS. We do not want students to get stuck because they don’t know how to reproduce the results we show in the book, so whenever a new method or procedure is introduced, an icon, , refers students to the TechTips section at the end of the chapter. Each set of TechTips contains at least one mini-example, so that students are not only learning to use the technology but also practising data analysis and reinforcing ideas discussed in the text.

MyStatLab, which accompanies this text, includes some sections on special topics, as well as all data sets needed for examples and exercises.

Guiding Students

• After a short introduction and a list of Learning Objectives, each chapter begins by posing a real-world Case Study. At the end of the chapter, we show how techniques covered in the chapter helped solve the problem presented in the Case Study.

• Margin Notes draw attention to details that enhance student learning and reading comprehension.

  • Caution notes provide warnings about common mistakes or misconceptions.
  • Looking Back reminders refer students to earlier coverage of a topic.
  • Details clarify or expand on a concept.
Key Points highlight essential concepts to draw special attention to them. Understanding these concepts is essential for progress.

Snapshots break down key statistical concepts introduced in the chapter, quickly summarizing each concept or procedure and indicating when and how it should be used.

An abundance of worked-out examples model solutions to real-world problems relevant to students’ lives. Each example is tied to an end-of-chapter exercise so that students can practise solving a similar problem and test their understanding. Within the exercise sets, the icon TRY indicates which problems are tied to worked-out examples in that chapter, and the numbers of those examples are indicated.

A Chapter Review concludes each chapter. In it students can find a list of important new terms, a series of specific questions and answers related to the chapter’s Learning Objectives (including all important formulas), and sources for data, articles, and graphics referred to in the chapter.

Active Learning

For each chapter we’ve included an activity, Exploring Statistics, that students are intended to do in class as a group. We have used these activities ourselves, and we have found that they greatly increase student understanding and keep students engaged in class. Detailed instructions are available for instructors in the Instructor’s Edition of the text.

All exercises are located at the end of the chapter. Section Exercises are designed to begin with a few basic problems that strengthen recall and assess basic knowledge, followed by mid-level exercises that ask more complex, open-ended questions. Chapter Review Exercises provide a comprehensive review of material covered throughout the chapter.

The exercises emphasize good statistical practice by requiring students to verify conditions, make suitable use of graphics, find numerical values, and interpret their findings in writing. Most exercises are paired so that students can check their work on the odd-numbered exercise and then tackle the corresponding even-numbered exercise.

Challenging exercises, identified with an asterisk (*), ask open-ended questions and sometimes require students to perform a complete statistical analysis. For exercises marked with a $\square$, accompanying data sets are available online at MyStatLab. The answers to all odd-numbered exercises appear in the back of the book. All solutions have been thoroughly revised and updated by Jim Stallard and Michelle Boué for this edition.

Most chapters include select exercises, marked with a $\square$ within the exercise set, to indicate that problem-solving help is available in the Guided Exercises section. If students need support while doing homework they can turn to the Guided Exercises to see a step-by-step approach to solving the problem.
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Supplements

Student Resources

Companion Website for this text can be accessed at www.pearsoncanada.ca/canadianstats. From there, you can download the Student Solutions Manual and Data Sets for use with this text.

Student Solutions Manual provides detailed, worked-out solutions to all odd-numbered text exercises. These downloadable PDF files are available at the textbook’s Companion Website and on MyStatLab.

Data Sets, used in the textbook, have been provided in various formats for use in different applications, including Excel, Minitab, SPSS, and more. These can be accessed at the textbook’s Companion Website and MyStatLab.

Study Cards for Statistics Software This series of study cards, available for Excel, Minitab, JMP, SPSS, R, StatCrunch, and the TI-83/84 graphing calculators, provides students with easy, step-by-step guides to the most common statistics software. These will be available free of charge through MyStatLab. You can also visit www.myPearsonStore.com for more information.

Instructor Resources

Instructor’s Solutions Manual contains worked-out solutions to all the text exercises.

Online Test Bank (download only), by Mike Kowalski, University of Alberta, includes three sets of tests for each chapter. The Test Bank is available for download at http://catalogue.pearsoned.ca.


PowerPoint® Lecture Slides, by author Michelle Boué, provide an outline to use in a lecture setting, presenting definitions, figures, Guided Exercises, Case Studies, and Snapshots from the text. These slides are available within MyStatLab or at http://catalogue.pearsoned.ca.

Learning Catalytics is a web-based platform for managing the interactive classroom. Learning Catalytics will generate classroom discussion and promote peer-to-peer learning with real-time analytics and can be accessed through MyStatLab.

MyStatLab™ Online Course (access code required)

MyStatLab is a course management system that delivers proven results in helping individual students succeed.

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MyStatLab provides engaging experiences that personalize, stimulate, and measure learning for each student.

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- Getting Ready for Statistics: A library of questions now appears within each MyStatLab course to offer the developmental math topics students need for the course. These can be assigned as a prerequisite to other assignments, if desired.
- Data sets from the book are provided in multiple formats.
- Technology Tutorial Videos. These brief video clips walk students through common statistical procedures for Minitab, Excel, and the TI-83/84 graphing calculator.
- Conceptual Question Library: In addition to algorithmically regenerated questions that are aligned with your textbook, there is a library of 1000 Conceptual Questions available in the assessment manager that require students to apply their statistical understanding.
- StatCrunch: MyStatLab includes a web-based statistical software, StatCrunch, within the online assessment platform so that students can easily analyze data sets.
from exercises and the text. In addition, MyStatLab includes access to www.StatCrunch.com, a website where users can access more than 13,000 shared data sets, conduct online surveys, perform complex analyses using the powerful statistical software, and generate compelling reports.

• Integration of Statistical Software: Knowing that students often use external statistical software, we make it easy to copy our data sets, both from the ebook and the MyStatLab questions, into software such as StatCrunch, Minitab, Excel, and more. Students have access to a variety of support tools—Technology Instruction Videos, Technology Study Cards, and Manuals for select titles—to learn how to effectively use statistical software.

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• Create and assign their own online exercises and import TestGen tests for added flexibility.
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With MathXL for Statistics, students can:

• Take chapter tests in MathXL and receive personalized study plans and/or personalized homework assignments based on their test results.
• Use the study plan and/or the homework to link directly to tutorial exercises for the objectives they need to study.
• Access supplemental animations and video clips directly from selected exercises.
• Copy our data sets, both from the ebook and the MyStatLab questions, into software like StatCrunch, Minitab, Excel, SPSS, and more.

MathXL for Statistics is available to qualified adopters. For more information, visit www.mathxl.com or contact your Pearson representative.

StatCrunch™

Powerful web-based statistical software that allows users to perform complex analyses, share data sets, and generate compelling reports of their data. The vibrant online community offers more than 13,000 data sets for students to analyze.

• Collect. Users can upload their own data to StatCrunch or search a large library of publicly shared data sets, spanning almost any topic of interest. Also, an online survey tool allows users to quickly collect data via web-based surveys.
• Crunch. A full range of numerical and graphical methods allows users to analyze and gain insights from any data set. Interactive graphics help users understand statistical concepts, and are available for export to enrich reports with visual representations of data.
• Communicate. Reporting options help users create a wide variety of visually appealing representations of their data.

Full access to StatCrunch is available with a MyStatLab kit, and StatCrunch is available by itself to qualified adopters. For more information, visit www.statcrunch.com or contact your Pearson representative.

TestGen (www.pearsoned.com/testgen)

Enables instructors to build, edit, print, and administer tests using a computerized bank of questions developed to cover all the student learning objectives of the text. TestGen is algorithmically based, and instructors can create multiple but equivalent versions of the same question or test with the click of a button. Instructors can also modify Test Bank questions or add new questions. The software and Test Bank are available for download from Pearson Education’s online catalogue.