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Book Review

Workshop Statistics: Discovery with Data

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Dickinson College, Pennsylvania
$25, 1995, 452pp., 0-387-94497-4,
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Over the past few years I have written articles and given conference presentations describing ways statistics courses should be redesigned to better facilitate student learning. I have encouraged the use of active learning strategies, problem solving using real data sets of interest to students, small group discussions, writing assignments, and appropriate technology. Allan Rossman's new introductory text, *Workshop Statistics*, appears to have incorporated all of these important components in a low-cost softcover textbook.

This book is distinguished from other introductory textbooks in several important ways. There is a focus on "big ideas" rather than a large collection of skills, definitions, explanations, and techniques. Instead of presenting students with methods of analyzing data and descriptions of concepts, *Workshop Statistics* is designed to provoke students to discover concepts themselves. When skills are presented it is because there is a reason to use them: to carry out the next step in solving a problem by analyzing data. Rossman explains that pages of expository material or solved examples are omitted to emphasize "the idea that students construct their own knowledge of statistical ideas as they work through the activities." While most textbooks contain problem sets at the end of the chapter, each focusing on a different (and often contrived) set of data, the homework activities in this text extend the types of activities conducted in class, examining a few real data sets in more detail. An emphasis on "writing to learn" is also embedded in the activities by continually asking students to write about different aspects of data analysis and to summarize what they have learned about a particular topic.

Workshop Statistics is divided into six units, each consisting from three to five topics. Over 100 data sets are either generated by students or included in tables (soon to be available on a data disk). Students combine data explorations by hand with use of a computer or calculator to generate graphs and statistics.

The first unit, Topic 1: "Exploring Data: Distributions," illustrates the hands-on data exploration approach. This unit is divided into five topics, each appropriate for one class session. On the first day of class students make predictions and gather data about themselves (gender, political views, opinions of statistics). They are guided through activities where they learn how to generate and analyze data to describe the number of states and countries they have visited. By the end of this first activity students have learned to distinguish different types of variables and data and how to construct and describe dotplots and histograms. In the next section students are asked to compare and examine dotplots, allowing ideas to emerge of center, spread, shape, and outliers as distinguishing features of these plots. Topics 3 and 4

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introduce more details on measures of center and spread, and the fifth topic challenges students to integrate and use these techniques in comparing distributions.

The next unit of the text explores relationships between two variables with topics on graphing bivariate data, correlation and regression, and tables of categorical data. Students are first shown scatterplots of data where they develop their own ideas of association between variables. Later they analyze data on space shuttle o-ring failures, peanut butter cost and quality, and cars' fuel efficiency. By examining and manipulating different scatterplots while viewing correlation coefficients, students construct ideas of how different factors influence the correlation between variables. In an activity comparing the average number of television sets per person and life expectancy for 22 countries, students discover that correlation does not imply causation.

The third unit, "Randomness," is quite a departure from the typical chapter on probability in most introductory textbooks. Instead, this unit introduces sampling distributions and then focuses on the normal distribution and the central limit theorem. As Rossman explains in the introduction, there is no formal treatment of probability. Instead, ideas of probability are introduced in the context of simulation and random variation and as they apply to methods of statistical inference.

Topic 4 introduces statistical inference first through confidence intervals for proportions and then through significance tests. Topic 5 includes important aspects of designing experiments and extends inference to comparisons of two proportions. In the last unit, "Inference From Data: Measurements," students learn to make inferences involving one or two population means.

This textbook not only looks exciting, it also works well with students. I know because I used an earlier version of *Workshop Statistics* in a class and have also observed Allan Rossman teaching a class at Dickinson College. Students typically work in pairs or groups on the data exploration activities after a whole-class orientation to the day's topic. While Allan teaches his class in a room equipped with Macintosh computers, allowing students to easily analyze data using Minitab, the format of the book allows students to use any type of computer or graphing calculator either during or outside of class. I have found students to enjoy the activities and appreciate the varied and interesting data sets. Although students initially resist writing long verbal descriptions, they eventually learn how to do this and appear to value the process.

I encourage all statistics educators to seriously consider using this innovative text. I believe that it provides an exemplary instructional approach that should enable more students to overcome their fears about learning statistics and to become statistically literate.

Reviewed by Joan Garfield
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Book Review

Statistics and Data Analysis: An Introduction (2nd ed.)

Andrew F. Siegel and Charles J. Morgan

Wiley, 1995, $68, ISBN 0471574244

This book is the second edition of an underground classic first published in 1988. The first edition (by Siegel alone) was reviewed for Volume 26 of STN (December 1990) by Joan Garfield. She used it for many years at the University of Minnesota, and colleagues and I used it at Plymouth State College until last summer. It recently showed up as one of the seven textbooks the College Board is recommending for the new Advanced Placement Test in Statistics. Even so, it is no secret that the book was not a great success. The second edition attempts to broaden the book's appeal. I think it succeeds, but sometimes at the expense of muting a few of the virtues that made the first edition so outstanding.

One of those virtues is the writing. The first edition was by far the most readable introductory statistics text I have ever used. It was also written in a warm and friendly tone that remains unusual in statistics textbooks. The second edition maintains a high level of readability. The warmth is somewhat diluted.

Another thing that set the book apart was its content. Although the NCTM Standards suggest big changes in how mathematics is taught, and smaller changes in what mathematics is taught, the underlying mathematics has not changed much. One and one still is two, and has been for quite some time. Statistics, on the other hand, underwent a great revolution in the 1960's, a revolution often linked with the name of John Tukey. One of the first things I look for in a statistics textbook is whether there is any sign that the author has heard about this revolution yet.

Because so many statistics textbooks are written by non-statisticians, the news has spread very slowly. Andrew Siegel was part of the Tukey revolution, and I think that is one reason why the first edition was ahead of its time. All the good K-12 statistics materials from NCTM and QLP are definitely post-Tukey, but many college textbooks still are not. Caveat emptor.

One sign of Tukey's influence is the use of stem (and leaf) plots and box (and whisker) plots. These are a necessary condition for textbook adoption these days, but alas not a sufficient one.

A few of you may remember the "new math" era, when set ideas were supposed to unify all of mathematics. We then saw textbooks that sprouted an obligatory "Chapter 0" where set notation (not ideas) was introduced, and then forgotten, and certainly never used to unify the rest of the content. Similarly, we have reached the point where most textbooks now mention the stem and leaf or boxplot, but many really don't know what they are for, and so never use them for anything.

Another way people characterize the Tukey revolution is in terms of the "three R's" of post-Tukey statistics

- residuals
- reexpression
- robustness

Residuals are usually first encountered in the context of fitting lines to data. There they are the (signed) distances between the points and the fitted line. Analyzing them helps us to evaluate how well our straight line model fits the data. Siegel and Morgan introduce residuals very early—the deviations from the mean that figure in the computation of variance and standard deviation are presented as residuals. Toward the end of the book there is a masterful example of the use of residuals in regression analysis. Data is presented on the average heights of girls for ages 2-11. Height versus age looks like a nearly perfect straight line, and the correlation is 0.997. Yet a graph of the residuals shows pronounced curvature in the relationship, something you would never see without examining the residuals! (Although the book does not mention it, fitting a quadratic to the data gives a residual plot that clearly indicates a cubic component!) This is an example of one of the great strengths of this book—it not only shows you the latest techniques, it shows them to you in examples that indicate what the technique does for you and why it is important, rather than with examples that merely show you the mechanics of carrying out the technique. Without the "why," the "how" is useless.

Reexpression is more often called "transformation." Perhaps the most traditional example of that is the fact that some relationships are better plotted on logarithmic or semilogarithmic graph paper. The TI-82 calculator uses such transformations (taking logs of x or y or both) to fit a variety of models to two-variable data. The first edition of Siegel contains the best elementary introduction to the use of transformations in statistics. They are introduced early in the book and used in both the analysis of variance and regression chapters. The second edition contains the second-best elementary introduction to the use of transformations in statistics. The initial coverage is cut about in half, and the applications to regression have disappeared. This is especially unfortunate for use in the high schools, where the logarithmic and exponential curve fitting features have found many uses in mathematics and science classes, and raised a lot of questions and confusion among teachers about what is going on there. In this instance, I think Wiley has stepped backward too far. While the first edition may have been (too far?) ahead of its time, much has changed since 1988, and in this area the second edition is behind the times—though still ahead of most other textbooks!

The third R, robustness, refers to the ability of a statistical measure or technique to resist the effects of errors and outliers in the data, or violations of the assumptions underlying the technique. The traditional mean and standard deviation are not very robust to outliers, and so the more robust median and interquartile range are preferred in many situations. (Note that the boxplot is based on them.) Siegel and Morgan introduce these robust measures first, and present them as the standard tools. The mean and standard deviation are then introduced as specialized tools particularly appropriate to normally distributed data. This makes it clear that the Tukey revolution really was a revolution—it not only introduced additional techniques, but changed the way statisticians regard the older techniques. Siegel and Morgan understand this, but many other textbook authors do not.

One serious flaw in the first edition was the very small number of problems for students. I would estimate that the new edition has three to five times as many. There are answers to about half of these, and the answers contain more words than numbers. The words deal with interpretation of the data, which, after all, is what statistics is all about. There is also an Instructor's Solution Manual in the works with more detailed solutions. (I put it on reserve in the library for student use.)

Another criticism of the first edition was that it contained hardly any formulas. Calculations were explained in a manner resembling instructions for filling out your income tax forms. Personally, I saw this as an asset. I teach a general education statistics course to first and second year students at a small former state teachers' college. For most of these students, formulas would be a barrier to understanding rather than a path to understanding. However, if you are a high school teacher trying to show students the use of algebra in statistics, you will want to see formulas. If you are a high school teacher doing an AP Statistics course, you will want to keep your students' algebra skills reasonably fresh for when they take the SAT and go on to college. Indeed, the sample questions distributed for AP Statistics require much more algebraic facility than most of my college students have. For those who like a little algebra in their statistics, the second edition of this book is now bilingual.

Indeed, the second edition is trilingual. The steps of carrying out a procedure are given in words, in formulas, and in commands for the Minitab statistical software. The computer examples do not replace a manual for the software; often you see just the final steps of an analysis, without any explanation of how they set up the database or how they got to the last step. At least the examples get you started and provide some experience in interpreting computer printout in situations where no computer is available. I think the choice of the Minitab software package is a good one. There are versions of Minitab for DOS, Windows, and the Macintosh. The software was originally designed for educational purposes, and is probably the most widely used software in college statistics courses, yet it is also used by a majority of the Fortune Top 50 companies in the US. It was also one of the first packages to reflect the Tukey revolution. A disk containing most of the data sets from the book is promised. The draft disk I examined had some bugs in it but there were about 100 data sets, some of them definitely too large to ask students to type in.

There is no mention of calculators in either edition of the book. That does not bother me, since a computer is a much more appropriate tool for statistics, but it may bother some high school teachers for whom graphing calculators are more familiar and accessible to both themselves and their students. While we all have to do the best we can with what we have, I hope prior comfort levels with calculators will not divert teachers from pressing for more appropriate technology.

One of the limitations of calculators in statistics is their limited data storage capacity. This book "recycles" many of its data sets over and over, using them to illustrate a number of different points. Sometimes a question raised in one chapter is not fully answered until a later chapter when the same data is examined again. I think this is a good technique, but I would hate to have to constantly be retyping or reloading the data into a calculator.

My biggest disappointment with this text is that it does not do a very good job of convincing the student that statistics is important. There are many real data sets, and they are often extremely well chosen to illustrate the techniques, but the techniques are not often used to answer any real question of interest. For example, the areas of important islands in the Atlantic Ocean are used as an example of transforming data. It is a wonderful example for that purpose. If you plot the data on a linear scale you get Greenland at one end of the graph and a big smudge including all the other islands at the other end. You can not even get a legible graph without transforming this data. However, no reason is ever given as to why we might want to study the areas of these islands. We come away from the example knowing more about statistics, but we do not know any more about islands. This is sad, because statistics is primarily a tool to answer real questions in areas outside of statistics. I should make it clear that the present book is not outstandingly bad in this regard. It is actually somewhat above average. However, it is a failing of most textbooks that has come to bother me more and more each year. You will need to supplement this one (and most others) with some more motivating and realistic examples.

One potential supplement would be *Statistics by Example* by Sincich (Dellen). This book contains a huge number of problems based on real studies. Often the background is too sketchy or too technical, and sometimes we get only summary statistics rather than raw data, but there are so many problems that it is still a worthwhile resource. (The book is pretty ordinary otherwise, with only slight signs of Tukey-awareness.)

My colleague Bill Roberts and I are currently half way through an introductory statistics course using the Siegel and Morgan text, and we are quite happy with it. I urge anyone looking for a textbook to adopt to look at it. Those wanting to learn more about statistics themselves might want to try to dig up a copy of the first edition.

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Software Review

Graphers
Sunburst Communications, 1996, 1-800-321-7511
$99 for one computer; $198 for 5
Teacher's Guide-Macintosh, by Lois Edwards.

Hardware requirements: Macintosh 68020 processor or higher; color display screen. 512x384 pixels or larger, with 256 colors; System 6.0.7 or higher; 2 MB of RAM; hard drive with at least 5 MB of free space. (Also available for Windows 3.1.)

This state-of-the-art graphing software for elementary school children was created by the designer of Data Insights, Lois Edwards. It supports many of the principles for teaching statistics, enumerated in Guidelines for the Teaching of Statistics: K-12 Mathematics Curriculum (Burrill 1991). In particular, *Graphers* supports three distinctive objectives of a data graphing curriculum—learning about [traditional, standard] graphs, using graphs to solve problems and using graphs to communicate" (Edwards 1996, p. 15). This review focuses on the features of the software and the support documentation.

The Software—When the program opens, a delightful, catchy melody and colorful animation capture children's attention. Like opening the cover to an inviting book, this initial experience engages children. After exploring with the software and becoming familiar with the features that are available, the data collection and graphing may begin by establishing a purpose presented in the form of an interesting question to which the children may respond by clicking on data items (e.g., a particular color or season). The graphs that children create are generated by the data they "make" or enter as they click on various types of data that may be used to answer such questions as "Which is your favorite color?" "Which is your favorite season?" "During which season is your birthday?."

General features—The graphs that the children create are dynamic; that is, as children enter more data or delete data, the graph is modified corresponding to the change in the data. Students are able to insert titles and labels.

The software treats all data as whole numbers, although "[i]n several places, *Graphers* offers a choice of whole numbers, fractions, decimals and percents" (Edwards 1996, p. 99) "as labels for the count axis, circle graph and table, but not as data" (p. 78). A "tool bar" allows for modifying the graph by inserting or deleting grid lines, changing the scale, inserting icons or word labels, inserting numerical labels, and orienting the graph vertically or horizontally. After a graph is completed, it can be "cut" from the main screen and placed on a "tack board" at the bottom of the screen for future reference and comparison with other graph forms. Two graphs can be viewed on the screen simultaneously. Once data or graphs are created, a printing feature allows the children to print their graphs and their "notebook," which is a screen where children can write about their graph. A "Tell me" button is available for help.

A "preference" feature allows the teacher to make adjustments in the way the software is executed (e.g., sound off/on; various graphs off/on; graph speed). Two font sizes (i.e., 12 point and 18 point) are available depending on the sophistication of the students. Nonreaders can benefit from the "speech" capability. A trash-can icon is visible so that children can "discard" data items they feel are inappropriate. The graph changes accordingly. The software has two parts—Warm-up, and Work-out.

Warm-up—A tutorial is available to introduce the user to the features in this part of the software. In the Warm-up part of the program, children can "make" categorical data by clicking on a topic (e.g., colors) and clicking on data categories (e.g., a palette of colors) to represent individual pieces of data. Once the data are randomly stamped on the work screen, a graph type may be selected and a graph is constructed using the data items. Depending on the level of the children, a total of 40 pieces of simple counting data may be entered. By using this software, children get the message that graphs are dynamic; that is, graphs change as data are entered or deleted. Data or graphs created using the Warm-up part of the software cannot be saved. Also, there is no access to other data files in this part of the software. Saving and accessing files are available in the Work-out part of the program.

Work-out—In Work-out, children can enter or "make" counting data, multiple-variable sorting data, and time data. The data may be organized in a frequency table and then converted to one of six types of graphs or plots (i.e., pictograph, bar graph, circle graph, line graph, grid plot, loop). Depending on children's readiness for large quantities of data, a maximum of 100 pieces of data may be used to create a graph. Children may compare two types of graphs by showing two graphs on the same screen.

Graph types that are available are dependent on the kinds of data used. For example, discrete data may be graphed in pictographs and bar graphs. The line graph is available for "time data." This is a desirable feature for children learning about the nature and representation of different types of data.

Support Documentation—*The Teacher's Guide* is very comprehensive and well written. There is an extensive Table of Contents. "How to Use This Guide" is very helpful in getting started.

Prior to using the software with children, the guide describes the importance of designing instruction to reflect children's development. Constructing graphs with objects and pictures, building on children's concrete experiences, and making graphs by hand, is advice that supports the principles for teaching statistics (Burrill 1991) and developing graph comprehension skills (Curcio 1989).

The guide contains 16 lessons, each of which has an "Overview," "Objectives," "Preparation," "Steps" (i.e., survey, management, introduction), "At the computer," and "Next." Other support documentation in the Guide includes 23 pages of blackline masters, and an annotated bibliography.

Reviewer's Comments—*Graphers* is a wonderful tool for providing children with opportunities to explore the relationship between data ,and traditional/standard graphs. Some of the reactions of this reviewer follow.

1. Having the capability to display two graphs on the screen using the half-page feature facilitates a comparison of the data displayed in two different forms. However, if the word label feature is used, the words overlap making it difficult to read the word labels. Using the icon label may be more appropriate when using the half-page feature.

2. Once 12 data items are entered on a pictograph or bar graph, the maximum number of entries permitted for the category is reached. There is no message or warning that no more data items can be graphed for the particular category. Novice graphers may not be aware of this limitation during the execution of their graphs.

3. Although the *Teacher's Guide* lists field-test sites, the grade level of the children involved in the field-testing is not indicated. As suggested in the guide, it is critical for primary grade children to be involved in hands-on experiences in collecting, organizing, and representing data before they work on the computer. Based on the features and capabilities of this software, it is not limited for use with children in grades K-4, as the support documentation suggests. Some of the features (e.g., modifying scale, data distortion, comparing graphs, interpreting a circle graph) are more appropriate for use with children in the upper elementary grades (i.e., grades 4-6), as indicated in the Sunburst catalogue. As suggested in the guide, depending on children's ability, it may be more appropriate for children to have experience interpreting, analyzing, and discussing circle graphs created by a computer before they are involved in the complex task of constructing them by hand (Edwards 1996, p. 84).

4. Although the guide reminds teachers about the importance of framing questions that are meaningful and of interest to children based on their experiences (Edwards 1996, pp. 15-16), the suggestion seems to be to have teachers "impose" the questions rather than to have the children pose the questions. Some recent reports indicate that as early as kindergarten, children are capable of formulating questions to guide their own data collection and recording (Curcio and Folkson 1996; Folkson in press).

5. Lesson 11 suggests collecting data to plan for "an imaginary school party" (Edwards 1996, p. 47). Young children could become involved, and often they do, in planning for a "real" party. Whether the children are involved in planning for a real party or for planning for snack (a common daily event in the primary grades), posing questions, collecting and recording data, and communicating their findings to the class become very meaningful, relevant tasks for them.

6. Although "discrete" and "continuous" data are mentioned on page 55 of the guide, it is not until page 76 that the terms are explained. Primary and elementary grade teachers who are new to incorporating data collection and analysis into their curriculum may need to have an explanation with examples when the terms are first introduced.

7. For the most part, the suggestions for data collection include a reason or a purpose for collecting data (e.g., Edwards 1996, pp. 69, 71). However, in some cases, it is not clear why a child would want to go through the motions of collecting the required data. For example, why would a child want to know the number of chairs and the number of desks at home and in the classroom? (p. 62)

The software reflects high expectations in data interpretation for young children. Communicating such expectations is desirable at a time when functioning in our highly technological society is becoming more and more dependent on citizens' ability to deal with and to understand data. As budget restraints continue to present difficulties for the upgrading of hardware in our public schools ("Connecting" 1995), it is hoped that the resources do become available for schools to obtain the equipment and such state-of-the-art software as *Graphers* to challenge the youngest of our data consumers.

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Statistics in the Classroom

Hats Off to Least Squares

Two of my students, Katherine Brady and Kari Cornelius, recently investigated the way hats are sized. They discovered that only men's hats are sized in a numerically and they collected a sample of measurements on 26 hats made in the U.S. and Italy. The hat sizes in their sample ranged from 6 5/8 to 7 5/8, hat sizes being given in eighths, and they measured circumference, and the length of the major and minor axes, all to the nearest 1/4 inch. They found it especially difficult to accurately measure circumference. Circumference of an ellipse is, in fact, a function of the major and minor axes and a look into the CRC Standard Math Tables shows that circumference is an elliptic integral whose integrand depends upon the major and minor axes length.

At any rate, an exercise that you may wish to have your students try is to fit hat size by circumference or by major axes or by minor axes using least squares. A least squares model of any of these through the origin works quite well. For example, trying

hat size = c * circumference

with the below data gives a c of about .3285 with a standard error (the typical residual size) being about .10. From *Sizes: The Illustrated Encyclo-pedia* by John Lord (1995), p. 117, it is known that men's hat size is, in fact, circumference divided by pi (and then rounded to the nearest eighth). For sake of comparison, note that the reciprocal of pi is about .3183. If you try fitting hat size to a constant times the length of the major axes you will find a somewhat better standard error of about .08. The model using circumference faring somewhat worse, perhaps, because the difficulty in measuring circumference. Fitting hat size to a constant times the length of the minor axes gives a standard error of about .13.

More complicated models, of course, can be tried. Fitting hat size to a linear combination of the major and minor axis length very nearly gives the rather appealing least squares model

hat size = (2/3)*major axis + (1/3)*minor axis

with an improved standard error of less than .07.

An interesting rule of thumb that my students heard from a salesperson is that one can estimate one's hat size by measuring the hand from the base of the palm to the tip of the middle finger, in inches.

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From the Editor

For those who are interested in joining the AP-STATS network, subscribe by sending the message: subscribe apstat-L <your email address> to: majordomo@etc.bc.ca. Leave subject line blank and do not sign the message.

Email request to me for a list of some AP Statistics workshops for summer 1996.

Received a note from Lyle Sparrowgrove in Sitka, Alaska indicating that a group of Middle School teachers there are doing activities in cooperation with the local Alaska Fish and Game Department and Sitka Sac-Roe Herring fishery that are very similar to those described in last issue's "Tag and Recapture with Live Prey" article. Terrific!

Rather than browsing aimlessly over the web this summer, if you are looking for data sets and activities, there is more than enough to keep you busy at the following two sites for starters: www.uvm.edu/~dhowell/StatPages/StatHomePage.html , and www.stat.ucla.edu. Send me your favorite web sites to include in STN.

Also, the American Statistical Association's homepage is at www.amstat.org. In particular, click on Cleveland under the Chapters link, and learn about us at the Cleveland Chapter as well as our fine city.

Be sure to put at the top of your summer priority list, "send an article to Jerry about the great stats activity I did last year!" or, "I must write Jerry about wanting certain software or textbook reviewed." THANKS! Have an intellectually inspiring summer. See you in the fall.

Keep Us Informed...

The Statistics Teacher Network is a newsletter published three times a year by the American Statistical Association–National Council of Teachers of Mathematics Joint Committee on the Curriculum in Statistics and Probability.

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