conclusion to the Fermat story. This was fitting, for Wiles' great proof is a true milestone in the history of mathematics: it exhibits how so many of the abstract developments of mathematics influence the simplest of all serious questions, and perhaps let us believe that so much of the work that has been done, in so many diverse areas, is really worthwhile!

How can any other question reflect so well the mathematical culture from which it springs, and in which it is finally laid to rest?

Finally, let me repeat that Van der Poorten's monograph is a wonderful mathematics book, which dares to breach the stylistic barriers that usually impede understanding. It encompasses a lot of material, from most elementary to very deep, but remains accessible. I expect it will turn a lot of people on to number theory and arithmetic geometry, and indeed the beauty of mathematics as a whole. At the very least, if you have a clever undergraduate student who is bored by upper division calculus and ready for something a little more poignant, get her to read this book, and let her first experience of research-level mathematics be provoking, inspiring, and fun.

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University of Georgia, Athens, GA 30602-7403
andrew@math.uga.edu

The Basic Practice of Statistics. By David S. Moore. W. H. Freeman and Company, New York, 1995, 680 pp., $59.95.

Reviewed by **Frederick Leysieffer**

It finally happened. Your colleague who has been teaching the statistics courses all these years is going on leave. Your chair looked at the transcripts of everyone in your department and discovered that you once took a course in statistics. Now you are responsible for the departmental statistics teaching next year. Your first step is to select a text. What do you look for?

The first thing to remember is that statistics is a discipline in and of itself. Sure, lots of mathematics departments teach statistics, but so do departments of psychology, education, economics, industrial engineering, and so on. And, of course, so do departments of statistics. Statistics as a discipline derives its reason for existence and its methodological impetus from measurement problems in the many and varied areas of application, and it relies on rigorous mathematics for its theoretical foundation.

To one accustomed to the beauties of mathematical rigor, books for a first course in statistics appear to have too much of a cookbook flavor. Often they follow the lines of: "Here is a data set. Analyze it this way." No reasons are given. All statistics books that seek to describe various methods of data analysis to non-mathematical students have to invoke this approach to some extent. To do otherwise would require students to have a more extensive mathematical background in order to understand the derivations of formulas. This approach is consistent with the background that many users of statistics have. In fact, many very effective users of statistical techniques take the mathematical derivations on faith along with the statement of assumptions that must be satisfied before a procedure can be used validly. They then apply statistical techniques to problems in the social and natural sciences.

There is, however, a type of rigor one absolutely must have in elementary texts. One must demand clarity and precision in the presentation of definitions of statistical concepts. Notions such as the laws of large numbers, the central limit theorem, sampling distributions, p-values, and the meaning of confidence intervals are examples of concepts that require careful definition to facilitate clear thinking and comprehension by students. These concepts all have precise meanings harking back to their mathematical origins. They are not easy for students to grasp. Muddy definitions are useless. Carefully crafted qualitative definitions are necessary and possible in a text at this level.

Furthermore, as each statistical procedure is introduced, the assumptions that one must make about the data to validate the use of the procedure must be clearly and unambiguously stated. The exposition of these points must not be muddy.

Teaching statistics should be and certainly can be fun. I prefer texts from which I can learn, texts in which the author's examples come from actual situations. Examples or exercises that begin: "A certain manufacturer produces widgets..." are dull and really deadly if you want to keep the interest of your students. Avoid texts with cutesy examples and go for the texts with real data. There are many fascinating data sets out there—after all, statistics is about data analysis. Don't settle for the ersatz. Make sure there are lots of examples and lots of exercises to work.

The order of presentation of material makes a difference in orienting your students, and indeed in how you can teach your course. The standard formula, used in many well-regarded texts, is to begin with a review of set theory, to introduce elementary probability theory, and gradually to work up to some inference problems, usually testing hypotheses and estimation through confidence intervals.

The problem with that progression of topics for the less mathematically prepared student is that although the order is mathematically logical, you really do not get around to studying statistics until it is too late. There are simply not that many interesting real-life examples illustrating the addition rule for probabilities. Students who thought they signed up to learn about data analysis lose interest. The old standard ordering of material does not really drive home the point that statistics is a separate discipline. It provides a bit of mathematical rigor, but only through some really elementary mathematics, after which it reverts to the cookbook style again.

A better way is to begin with statistical ideas. There is much one can do to give students a feeling for statistics before introducing probabilities and doing formal inference. One can consider data displays and examine relationships between variables without probabilities. It makes sense to consider sampling and the collection of data as a valid component of a statistics course. With engaging examples, students stay interested.

These are all reasons why *The Basic Practice of Statistics* by David S. Moore is well worth considering if your course introduces statistical ideas to students having minimal mathematical preparation. Moore was president of the American Statistical Association in 1998, and he has served on a joint committee of that organization and the Mathematical Association of America that studied the teaching of introductory statistics. His objective, as stated in the book's introduction, is to emphasize statistical thinking with more data, more concepts, less theory, and fewer recipes. His recent MONTHLY paper with Cobb [**2**] gives a comprehensive exposition of this approach. As evidence of his dedication to this methodology, the first three chapters of the text—225 pages—assume no probability theory.

The material on graphical displays in the first chapter is the tip of the iceberg of exploratory data analysis. The second chapter gives examples of the difficult problem of finding relationships in large data sets of the sort that scientists (meteorologists, for example) routinely generate in their research. Effective visual displays can help in examining data sets: they reveal relationships that otherwise may be obscured by the wealth of data collected. For ancillary reading, students can refer to Tufte [**8**] for a beautiful exposition of visual displays of data.

The chapter on sampling is welcome in an introductory text. Careful data collection is an art. It is full of pitfalls, some predictable and others unexpected. Students become better consumers of statistics if they realize this and understand basic criteria for effective data collection, notions of randomness, principles of experimental design, and ethical considerations in the collection process—goals that one might hope to achieve in an introductory course in statistics.

Group projects provide an excellent vehicle to introduce students to the processes of effective and useful data collection. There is a difference between reading about data collection and actually doing it. Projects give a statistics course the added dimension of practical experience. The ordering of topics in this text lends itself extremely well to doing class projects. Early on, students who have mastered the first three chapters can decide on a project, determine what they want to measure, design a data collection procedure, display their results, and begin to look for relationships in the data. With careful coaching by the instructor, students can collect data that can then be analyzed with the inference techniques to be learned later in the course.

In the fourth chapter, Moore introduces sampling distributions in an intuitive way, motivating the subsequent discussion of probability distributions by appealing to empirical considerations. This is a key chapter since all that follows depends upon one's accepting, at this level, the various sampling distributions that go with the variety of data analysis procedures. We do not see set theory, nor is there an emphasis on rules for probabilities.

With the fifth chapter and beyond, the text settles into a more formula-based mode that requires students to accept the validity of the various sampling distributions. At this point, mathematically prepared students who know about multiple integrals and change of variables and who are curious about the origins of the t- or F-distributions or similar concepts could consult a mathematical statistics text for derivations. The classic text by Hogg and Craig [**4**] is a good place to start.

Subject coverage is certainly appropriate for a text at this level. The essential concepts of statistical inference are treated, though nonparametric statistics are not covered.

The instructor may want to supplement the course by showing parts of the video series *Against All Odds* [**1**]. Moore was the content developer for the series, and it meshes nicely with the material in the text. See Moore's article on the place of video materials in the classroom [**5**]. Also, a recently issued CD-ROM and workbook, *An Electronic Companion to Statistics* [**3**], features short parts of the series.

In considering this text, one could also look at two other books by Moore that bracket this one in the amount of mathematical preparation required. *Statistics: Concepts and Controversies* [**6**] takes a more qualitative approach and emphasizes statistical concepts over techniques. Moore's book with McCabe, *Introduction to the Practice of Statistics* [**7**], emphasizes a bit more of the formal development and is intended for a more advanced student. Either book could be helpful ancillary reading for students.

Numerous fine examples throughout the text keep up the interest of both the instructor and the student. Some examples can surprise the reader, and some can reinforce previous beliefs. A scatter plot shows the inverse relationship between the median SAT score in a state and the percentage of high school seniors in the state who took the test (p. 103). There is an example of a lurking variable related to public housing in Hull, England (p. 144). The notes and data sources sections at the ends of chapters exhibit the wide variety of disciplines from which real data were chosen for illustrative purposes.

The text is pleasantly laid out. The exposition is excellent and precise. Moore includes nice ancillary features in his text. Warnings illustrate when statistical inference is not valid for all sets of data, e.g., the discussion of the Hawthorne effect on p. 383. The biographical sketches of famous statisticians inject welcome human interest.

However one structures a first course in statistics, if the student audience is minimally prepared mathematically, then David Moore's carefully crafted text deserves attention.

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Office of the Provost, The Florida State University, Tallahassee, FL 32306
leysieff@stat.fsu.edu