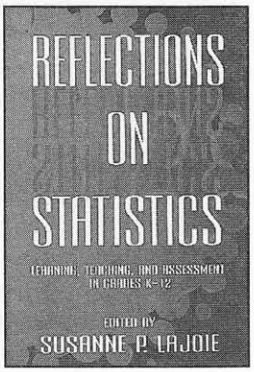
Statistics Goes to School



Reflections on Statistics: Learning, Teaching, and Assessment in Grades K–12
by Susanne P. Lajoie

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Review by Clifford Konold

You were probably in college when you took your first course in statistics. If your experience was anything like mine, you shook your head after handing in the final exam, wondering what that had been all about. Nothing, certainly, that would be appropriate for children. It may therefore surprise you to learn that if you have kids or grandkids in this year's crop of first graders, they will likely be learning something about statistics.

The contributing authors of this volume were members of a cross-disciplinary working group, hosted by the University of Wisconsin's National Center for Research in Mathematical Science Education. The purpose of this working group was to "help teachers and researchers make informed decisions about how to introduce statistics in grades K–12" (p. vii). Chapters of the book are divided into four sections focused on content, teaching, learning, and assessment. The word "Reflections" in the book's title and the editor's acknowledgment that the effort is "still in its infancy" (p. xi), signal the fact that this volume is not a set of simple directives. Rather, it offers a variety of perspectives on the state of the art in K–12 statistics education. It will be of special interest not only to educators directly involved in the effect to teach statistics in the schools, but also to those psychologists exploring the nature of reasoning under uncertainty. Indeed, as is evident in the chapter by Metz, much of the current classroom-based research on learning probability and statistics is an outgrowth of earlier psychological research of Piaget and of Kahneman and Tversky.

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The first chapter by Scheaffer, Watkins, and Landwehr (all statisticians by training) provides a good overview of the conceptual terrain. After laying out the major statistical ideas they believe students should confront by Grade 12, they remind us that attempts to infuse statistics into the precollege curricula go back at least to the mid-1920s. I might add that such an effort was part of the agenda of the "new math" movement of the 1960s, and its importance was signaled by the decision of the National Council of Teachers of Mathematics (NCTM) to devote their 1981 yearbook to the teaching of probability and statistics (Shulte, 1981).

What's different now? For one thing, in nearly every mathematics curricula of every grade level you will now find prime-time space devoted to probability and statistics. This achievement can be credited in large part to the impact of the 1989 NCTM *Standards,* and the fact that the NCTM *Standards* granted probability and statistics a status equal to that of geometry and algebra. Therefore, the problems are no longer those that inspired the authors of the 1981 NCTM yearbook—justifying why these topics deserve instructional time and providing teachers with materials, tools, and activities they might use to shoehorn probability and statistics into an already overcrowded curriculum. Questions raised here include what we ought to be teaching as part of a comprehensive curriculum at various grades; how we ought to be teaching it; what we know about intuitive thinking and learning of key probabilistic and statistical concepts and the role of assessment in teaching; and how to deal with the fact that most of the teachers we are counting on to teach these topics have never taken, let alone taught, a course in probability or statistics.

One of the features that sets this volume apart from related works is its breadth. Typically a book on teaching statistics will focus on particular aspects of the problem, such as teacher development (Hawkins, 1990), use of technology (Garfield & Burrill, 1997), or at least deal with only half of the puzzle (e.g., probability, Kapadia & Borovcnik, 1991). Of course, the primary danger of not limiting the scope is producing a superficial piece with glaring gaps. Although not superficial, there are noticeable lacunae. There is virtually no discussion of data analysis in the early elementary grades; although technology gets mentioned here and there, the instructional use of the computer as a tool for data analysis and probability simulation remains largely unexamined. The major advantage of taking on a range of issues across the whole of the K–12 curriculum is that it allows authors and readers to consider the complex interrelations among various programmatic components (e.g., between curriculum goals and assessment methods), the conceptual fields common to probability and statistics and, perhaps most important, how instruction over the years might ultimately help students build from undifferentiated intuitions to formalized and integrated concepts. A Preface and Epilogue written by Lajoie, and an introductory chapter by Lajoie and Romberg, offer helpful overarching observations, but it is unfortunate that there is little or no cross-referencing of chapters within the book nor any systematic attempt to address themes or problems across the chapters. Despite this, the book does deliver more than the sum of its parts, especially for those interested in looking across the middle school grades where many of the chapters happen to focus.

There are two recent developments whose influences are evident throughout the volume. First, due largely to the wide-spread availability of cheap computing, statistics is moving away from the narrow road of hypothesis testing toward a vision of data analysis John Tukey began advocating in the 1960s. Tukey (1977) conceives of data analysis more broadly as techniques for exploring data and for generating and clarifying insights about underlying structure. One finds in these chapters not only discussion of various exploratory graphical techniques introduced by Tukey, such as box plots and stem-and-leaf plots, but also a perspective on data analysis that is no longer tied to and driven by statistical inference. We encounter examples throughout the volume of students investigating covariate data and comparing two groups (e.g., the jawbone lengths of modern vs. ancient pike) without being asked to worry yet about sampling assumptions or effect size. The concern, rather, is getting students to deal with questions about real data, to engage their theories about why groups

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might differ, to flexibly explore data for interesting and telling trends, and communicate their findings to others. One result of this approach is that rather than being sandwiched between descriptive and inferential acts, probability gets its own staging in the curriculum. Thus, the book is really more about data analysis and probability than about statistics as it is traditionally understood.

The other permeating influence is the ongoing effort to "reform" mathematics and science education, a movement that is currently under attack by advocates of "back to basics." Romberg, who convened this working group on statistics, played a prominent role in the creation of the NCTM *Standards,* which to a large extent has served to legitimize and organize the reform movement. In addition to numerous citings of the NCTM *Standards,* there are references throughout the volume hearkening to the works of Piaget, Dewey, von Glasersfeld, and Vygotsky to argue that instruction in statistics should strive for meaning making and understanding rather than for simply memorizing and applying rules and formulae. You will not find students in any of the classrooms described sitting alone at their seats computing means of arbitrary numbers. What they will be doing, according to Lajoie, Lavigne, Munsie, and Wilkie, is carrying out rather ambitious projects "designed to engage students in complex investigations of realistic problems that integrate concepts from a number of disciplines and extend over a long period of time" (p. 204). In Chapter 9 by Schwartz, Goldman, Vye, and Barron, sixth graders design sampling methods to estimate how many students might visit a particular booth at an upcoming fun fair and use this information to determine the number of prizes the booth operators should have on hand. In Chapter 7 by Derry, Levin, Osana, and Jones, middle-school students conduct a mock legislative hearing in which they present and debate statistical evidence from real cases to decide whether the government should regulate the production and sale of dietary supplements and vitamins.

Having tagged the authors as educational reformers, I should quickly add that this is not a collection of apologies. Nearly every chapter is research oriented and struggles with the tough questions that arise when one undertakes to educate students by engaging them in complex tasks. This introspective tendency is supported in part by the significant role that student intuitive reasoning has played in the reform effort. One of the tenets of constructivist theory, which most reform educators embrace in some form, is that people learn by trying to apply what they already know. The work of Kahneman and Tversky has thus served to inform these statistics educators of the kinds of intuitive thinking on which to build effective instruction. Unfortunately, developers of the new mathematics curricula (one of which is described by Burrill and Romberg in Chapter 2) did not have years of experience teaching probability and statistics at the precollege level to draw on in designing their materials. And the research literature available at the time was not quite appropriate for their purposes either, in that it focused mostly on college-level statistics, on ideas central to statistical inference, and typically involved short laboratory studies using subjects rather than extended investigations in classrooms. To complicate matters, at most every grade level, curriculum developers had to assume that students had little prior experience with statistics. Thus, the curriculum currently in place, if effective, will probably need overhauling in a few years.

Several of the chapters present and review more recent research that focuses not only on how people with no prior statistical training reason, but on how reasoning develops over instruction. The character of the research is thus not of the "my-method-works-better-than-yours" variety, but includes fine-grained analysis of the evolution of student thinking over instruction. Schwartz et al., for example, look at various schemes fifth and sixth graders initially apply to problems that call for statistical sampling. These "prototheories" include the idea of sampling as an election in which everyone should be given a chance to vote. As one student suggested, "Put up a sign, and whoever wants to come to the booth can fill [the survey] out" (p. 243). Figuring out how to help students come to an understanding of statistical sampling is not easy.

> On the one hand, it is necessary to make contact with the students' prior knowledge, and hence we do not believe that one should avoid the contexts that bring these prototheories to mind. On the other hand, because the children's prototheories overlap with the structure of a statistical inference, it may be difficult for children and teachers to assess how a prototheory differs from more normative conceptions of statistics. (p. 270)

They document how, with instructional support, students are able to develop a prototheory of fairness that allows them to view sampling of people more as they do sampling marbles from an urn, getting them somewhat closer to a normative theory of random sampling.

Similarly, many of the chapters include both generalizations about what concepts students seem to understand after some instruction and those that elude them still, with ideas about how instruction might proceed. Thus, when the authors do resort to preaching, their tone is one of preaching to a choir that has some hard work ahead. ❑

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