Teaching Beginners as a Mirror of the Discipline

David S. Moore
Purdue University
West Lafayette, IN, USA

Australian and New Zealand Journal of Statistics **41** (1999), 135–137. Invited discussion of the Presidential Address by Professor Des Nichols.

Professor Nicholls' address is, as fits the occasion, broad in scope. Brief comments must be selective if they are to be useful. I will ask a quite specific question: How should our teaching of beginners change in response to the changing environment that Professor Nicholls describes? I speak not of training neophyte statisticians, but of instructing the large numbers of students from many disciplines who crowd our first tertiary courses.

Professor Nicholls offers some key phrases that begin to answer this question. He speaks of moving "beyond the boundaries defined by the traditionally mathematically-based probabilistic inference;" of "emphasizing the collection and presentation of data, considerations of data quality, and the importance of communication;" and he emphasizes that "we must be prepared to be flexible." I take it for granted that up-to-date instruction for beginners now devotes substantial time to exploratory analysis of data (aided by software that automates graphs and calculations) and to the design of samples and experiments as well as to formal inference. That is, I assume we agree that the traditional emphasis on inference alone was too narrow. This broadening of beginning instruction is a mirror in which we see the reflection of a discipline being reshaped by technology and by closer interaction with other fields.

This is real progress. Yet my summary comment on the contemporary situation is that *we are still too narrow*. In a world where procedures are automated, thinking broadly becomes more important. We must attempt to persuade students by repeated examples that *data beat anecdotes*. We must encourage them to ask of any statistical study "Does this answer the right question?" and "Does the answer make sense?" In so doing, we are equipping them with filters for numerical nonsense, with tools to perform triage on the information flood. There is no technical shortcut to statistical common sense. We will have to devote valuable time to discussion of examples that largely lack traditional technical content but are by no means intellectually trivial. Here are two examples:

> Standard measures of unemployment require that a person be actively seeking work in order to count as unemployed. These measures reflect our values concerning work. Do they in all cases answer the right question?

> I have seen repeated citations of the statement (Johnston and Packer 1987) that "Only 15 percent of the new entrants into the labor force over the next 13 years [the years 1987 to 2000] will be native white males." It requires only minimal knowledge of the demographics of the United States to see that this statement makes no sense. It appears on the first page of the Executive Summary of a report. On page 95, we discover that the 15% actually refers to new entrants *net of those leaving the work force.* This latter group is dominated by native white males who die or retire. I can see no reason why anyone would be interested in net new entrants, but "only 15% white males" does make a catchy headline.

Moving to somewhat more conventional content, there are several clusters of "big ideas" that deserve emphasis. Here are two:

> Almost all observed associations between two variables are influenced by other variables lurking in the background. Therefore association does not imply causation. In assessing evidence for causation, the key question is "How were the data produced?" and the gold standard is the randomized comparative experiment.

> Variation is everywhere: individuals vary, repeated measurements on the same individual vary. Therefore conclusions are uncertain. Our intuition about uncertainty is weak—for example, we tend to draw unwarranted conclusions from short-term irregularity. Statistical methods take account of uncertainty and correct our intuition.

Statisticians can easily expand these brief synopses and add others. I am persuaded that in our rush to convey important technical content we often pass over broad ways of thinking and clusters of big ideas, assuming that they follow obviously from technical material. They do not. And for almost all beginning students, broad thinking and big ideas are in the long run incomparably more valuable than any technique.

I will add one more principle: we should accustom students to using automated tools gracefully. A final example:

> Density estimation is a menu item in the software I most commonly use. Why do we constrain students to using histograms when density estimators are often a more useful tool for describing the distribution of a single quantitative variable?

Is it because it is possible (though painful for non-trivial data) to make a histogram by hand? Is it because we don't want to explain how kernel density estimation works? We professors are far too ready to declare useful tools off-limits because "students won't understand what is really going on" unless we have driven them through theory, hand calculations, or both. In fact, students are equipped to understand the input (Is a density function a valid summary for these data?) and the output (This is a density function. Is it unimodal, skewed, and so on?). This level of understanding enables them to use the tool. How the the density function on the screen was produced from the data is a specialist issue.

Introductory instruction that devotes more time to "statistical thinking" at the expense of specific statistical theory or methods is in part simply the result of honest appraisal of the needs of students in the new environment. Almost all will have to make sense of data. All will have ever-better technology immediately available. Few, once they leave their schooling behind, will ever want to conduct ANOVA.

There is, however, another reason to broaden our teaching. Basic instruction in any discipline is a mirror in which the masses see reflected the discipline's self-image. We are right, as Professor Nicholls says, "to contemplate the thought that we may lose our identity." We are most likely to lose our identity if we consider ourselves providers of specialized technical expertise rather than as the people best equipped to think broadly about data and chance. What we offer beginners should reflect the conviction that statistical ideas are the keys to sound thinking about data, variation, and uncertainty in all areas of life and work. The intellectual stimulation and manifest importance of what we offer beginners is also our best long-run hope of reforming how doctors, engineers, executives and politicians view statistics and statisticians, for it is they who sit before us in a still-unformed state.

Reference

W. B. Johnston and A. E. Packer (1987), *Workforce 2000*, Indianapolis, Indiana: Hudson Institute.