Session A6
Psychological Factors Affecting the Teaching of Probability and Statistics

Session A9
Classroom Research Issues

Organisers: Joan Garfield (Minneapolis, Minnesota, USA)
Susan Jo Russell (Cambridge, Massachusetts, USA)

Research on Elementary and Secondary Students

Introduction: Susan Jo Russell (Cambridge, Massachusetts, USA)

Invited Speakers: David Green (Leicestershire, England)
Andee Rubin, Bertram Bruce and Yvette Tenney (Cambridge, Massachusetts, USA)
Susan Jo Russell and Janice Mokros (Cambridge, Massachusetts, USA)
Heinz Steinbring (Bielefeld, Germany)

Contributed Paper: Marjorie Roth Leon and Judith Zawojewski (Evanston, Illinois, USA)

Research on University Students

Introduction: Joan Garfield (Minneapolis, Minnesota, USA)

Invited Speakers: Manfred Borovcnik (Klagenfurt, Austria)
Joan Garfield and Robert delMas (Minneapolis, Minnesota, USA)
Clifford Konold, Alexander Pollatsek, Arnold Well and Jill Hendrickson (Amherst, Massachusetts, USA) and Abigail Lipson (Cambridge, Massachusetts, USA)

Contributed Paper: Flavia Jolliffe (Surrey, England)

Abstract: Fay Sharples (Hamilton, New Zealand) and Flavia Jolliffe (Surrey, England)

Introduction to Research Papers on Elementary and Secondary Students

Increased attention to the study of statistics at the pre-college level in recent years has led to a greater research effort to investigate students' understanding of critical statistical ideas. Like cognitive studies in other areas in mathematics or science, these investigations tend to complicate our view of the teaching and learning of what at first may appear to be straightforward notions. By looking carefully at the varieties of informal thinking people bring to the study of statistics, not only do we find out about the nature of students' thinking about specific concepts, but we also understand more fully the difficulties involved for students in grasping the underlying nature of statistics as a discipline.

While the arithmetic involved in early experiences with statistics and probability is relatively trivial, the nature of statistics is new and strange territory for most pre-college students. The very idea of using mathematics to model and predict, rather than for calculating precise results, is one with which most students, and many teachers, are uncomfortable and unfamiliar (Russell, 1990). Rather, they learn statistics as a set of procedures, they view error as "mistakes", and they expect any calculated value to be demonstrably "right" or "wrong". This set of papers illuminates the difficulties students encounter as they attempt to come to terms with key statistical concepts and with how statistics are used to model reality.

For the pre-college student, understanding representativeness is at the heart of grasping the nature of statistics. For elementary school students, averages are one of the first classes of values they encounter which *model* a mathematical relationship rather than indicate a directly measurable value. The ease with which an average may be computed obscures the complex way in which this value represents a set of data. Two of the papers in this group deal with this central idea in the study of descriptive statistics. Marjorie Leon and Judith Zawojewski continue the investigation of the properties of the mean begun by Strauss and Bichler. In their large-scale study, they attempt to distinguish between easier and more difficult aspects of understanding the mean as well as the effect of different problem formats on students' ability to correctly determine an average. Susan Jo Russell and Janice Mokros use clinical interviews to explore in depth how students view the relationship between an average and the data it represents. They identify the variety of intuitive notions which students bring to their use of descriptive statistics and examine the interaction between these strong informal understandings and the learning of formal procedures.

Representativeness continues to be a primary focus as students move into inferential statistics, as the paper by Andee Rubin, Bertram Bruce and Yvette Tenney indicates. Just as an average is a sort of model, providing some, but not all, information about the data set, so a sample models a population. As Rubin et al. point out, this model involves an apparent contradiction: sample representativeness implies that the sample has characteristics similar to the population, while sample variability implies that the sample may not match the population. As students learn about sampling, over-reliance on sample representativeness in some instances and sample variability in others results in the development of inconsistent models of the relationship between the sample and the population from which it was drawn.

In the Rubin et al. paper, it is noted that in some contexts randomness may appear to students as "mistakes" rather than as a naturally occurring phenomenon that we use statistics to capture and describe. David Green's study of students' understanding of probability provides evidence that students make probabilities in coin tossing come out "right". According to his comparison of 7-10 year olds with 11-14 year olds, this view of randomness appears not to change much with age. Green also investigates students' performance on problems dealing with comparison of odds, where he finds that school experience with ratios appears to improve students' ability to deal with this problem type.

Throughout these studies, we see students who conform their knowledge to classroom expectations in order to be "right", disregarding experience and intuitions which might actually increase their mathematical power. Heinz Steinbring's paper deals directly with the ways in which classroom discourse "tunnels" students' views so that complex stochastic ideas are reduced to mere convention. His microanalysis of a classroom episode describes how the contrast between a theoretical model of a probabilistic situation and an instance which appears to contradict the model is explained away rather than used as an opportunity for deepening mathematical understanding.

By taking seriously the complexity of students' thinking as well as the complexity of apparently simple statistical ideas, research such as that reported in these five papers can support educators to appropriately complicate their views of what is involved in the teaching and learning of basic statistical ideas at the pre-college level. Without this deeper view, we run the risk that our students will build their early foundation in statistics on sand, which appears solid for long enough for them to pass their examinations, but soon shifts, blurs, and finally disappears with time.

Note

Because papers were shortened for these Proceedings, text has been reduced and, in some cases, references have been eliminated.

An introduction to the second group of papers appears on p.338.

Reference

Russell, S J (1990) Issues in training teachers to teach statistics in the elementary school : a world of uncertainty. In: A Hawkins (ed) *Training Teachers to Teach Statistics*. Proceedings of the International Statistical Institute Round Table Conference, Budapest, Hungary, 23-27 July 1988. ISI, Voorburg, The Netherlands.