NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Statistics for All—the Flip Side of Quantitative Reasoning

by NCTM President J. Michael Shaughnessy
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Recently I had the opportunity to participate in the 8th International Conference on Teaching Statistics (ICOTS). Once every four years, hundreds of teachers (elementary through tertiary levels), statisticians, and researchers gather from all over the world for a week to share the latest innovations on the teaching and learning of statistics. Over the years I've had the opportunity to attend five ICOTS meetings, and each time I've been increasingly impressed by how important statistical literacy has become for all of us around the globe. And statistics will only continue to become more critical in the future. Statistical literacy has risen to the top of my advocacy list, right alongside numeracy, and perhaps even ahead of "algebra for all." By statistical literacy, I mean much more than just the ability to read graphs or compute means as representatives for data sets. I mean developing the ability to reason in the presence of, or under conditions of uncertainty. It may be that the most important quantitative reasoning ability of all is the facility to read and interpret statistical information and make informed inferences based on statistical and probabilistic information.

Mathematical arguments are based on proof and certainty. There is beauty—and perhaps even comfort—in convincing mathematical arguments such as the proof that demonstrates that the amazing Pythagorean relationship holds among the sides of *every* right triangle, or that for *any* circle the ratio of the circumference to the diameter is equal to the same number, every time, no matter the size of the circle. This is beautiful stuff, and we clearly want all our students to understand and to bask in these elegant mathematical truths. However, unlike the reasoning behind this mathematics, statistical reasoning and sense making, by their very nature, occur under conditions of uncertainty. The twin sister of the "certainty" in mathematics is the "uncertainty" in statistics. We must prepare our students to deal with *both* types of quantitative reasoning as they grow in the mathematical sciences.

Statistical arguments are based on how likely—or unlikely—a result, or a sample, or a measurement difference among groups is to occur with no other explanation than chance alone. For example, suppose that 24 boys and 24 girls try out for 35 slots in a student orchestra. After the tryouts are over it turns out that 21 girls and 14 boys were selected for the orchestra. Does that outcome seem reasonable, or might it indicate discrimination against boys in the selection process? One way to test for possible discrimination is to find out how likely it would be for that 21–14 split to occur just by chance, if boys and girls were randomly selected for those 35 orchestra slots. The legal system often must make decisions similar to this, usually based solely on probabilistic information rather than on certain information. Judges, prosecutors, and defense lawyers all have to make arguments based on reasoning under conditions of uncertainty. Citizens need to be aware of how such decisions can be defended or critiqued on the basis of quantitative reasoning using probability and statistics.

We as citizens are constantly deluged by statistical information—from the news media, from medical associations, and from the business and investment communities, to name just a few. Often the information is presented in a form that can easily be misleading or confusing—sometimes even purposely so. For example, what does the pharmaceutical industry mean by the term "five-year survival rate?" Are you impressed or suspicious when you hear that one medical treatment showed a 20% increase in the five-year survival rate as compared to another treatment? You should be wary, because if this information were framed in terms of absolute numbers rather than percentages, it might mean, for example, that when given treatment A, five patients for every 1000 died prior to five years, while for treatment B only four patients in 1000 passed away prior to five years. The results for treatment B are just one patient in 1000 better, but also "20% better," than the results for treatment A. Are those data robust enough to convince you to go with treatment B, especially if treatment B also showed increased side effects or other health risks? Quantitative reasoning in the presence of uncertainty is a critical ability for all of us to develop because it will continue to have an impact on our lives and our decisions.

More than 20 years ago, with the publication of *Curriculum and Evaluation Standards for School Mathematics* (1989), NCTM took a strong stance on the importance of including statistics and probability throughout the K–12 school years. Subsequently, the Council reaffirmed the importance of statistics for all students in *Principles and Standards for School Mathematics* (2000). And the Council will continue to advocate for the inclusion of statistics and the importance of statistical reasoning throughout the K–12 years as the Common Core State Standards (CCSS) are introduced, adopted, and implemented. These standards do devote substantial attention to statistics, but only starting in grade 6. This learning trajectory differs substantially from the recommendations in NCTM's Standards documents. It also differs from the statistics standards that are currently implemented in many other nations that were represented at the ICOTS meeting. For example, New Zealand and Australia have decided to include statistics throughout all grade levels in their new national curricular documents. The CCSS position also differs from the American Statistical Association's *Guidelines for Assessment and Instruction in Statistics Education* (GAISE), which includes recommendations for statistics education for each of the K–4, 5–8, and 9–12 school grade bands.

As our states decide to adopt the CCSS, and as they begin to think about how to interpret and implement them in their local settings, let us not forget the importance of including and promoting statistical reasoning for all our students—at *all* grade levels. We have taken so many positive steps in promoting statistics education for our K–12 mathematics students that this is not the time to step backward as we reach out to help our students develop their facility for the flip side of quantitative reasoning—reasoning in the presence of uncertainty.