

**STATISTICS AND PROBABILITY IN
THE SCHOOL MATHEMATICS CURRICULUM:
A REVIEW OF THE ASA – NCTM QUANTITATIVE LITERACY PROJECT**

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We live in an information society. We are confronted, in fact, inundated, with quantitative information at all levels of endeavor. Charts, graphs, figures, rates, percentages, probabilities, averages, forecasts, and trend lines are inescapable parts of our everyday lives that affect our decisions on health, citizenship, parenthood, jobs, financial concerns and many other important matters. In order to be called "educated" today a person must have some facility for dealing with data and making intelligent decisions based on quantitative arguments.

We live in a scientific age. We are confronted with arguments that demand logical, scientific reasoning even if we aren't trained scientists. We must be able to clearly see our way through a maze of reported "facts" in order to separate credible conclusions from specious ones. We must be able to intelligently weigh the evidence on the causes of cancer, the effects of pollutants on the environment, or the results of a limited nuclear war. Teachers, and then students, must be trained to make intelligent decisions based on numerical information if our society is to grow and prosper.

Such training is the goal of the Quantitative Literacy Project, which is directed by a joint committee of the American Statistical Association and the National Council of Teachers of Mathematics. It is the intent of this three-year project to complete the following activities:

1. Provide guidelines on the teaching of statistics and probability within the mathematics curriculum;
2. Develop a model inservice program for training teachers in modern statistical concepts and in methods for teaching these concepts;
3. Produce curriculum materials to assist teachers in the proper presentation of statistical and probabilistic concepts, and encourage further development in natural and social sciences; and
4. Develop a mechanism to evaluate the effectiveness of the materials and the techniques for teaching statistics.

During the course of the project, teaching guidelines are being developed after careful study of both historical and current views of needs for statistical training, and subsequent to evaluation of methods for delivering appropriate training to both teachers and students. The major focus of the

project will be the development and delivery of a program of continuing education for elementary teachers and secondary teachers of mathematics and science that will prepare them to teach statistical and probabilistic skills and concepts effectively. Development and production of teaching materials, an integral part of the project, will result in more effective teacher training and better tools for use in the classroom than are now available. Development of both the inservice aspect and the teaching materials will be tied to past and present views of what is important in statistics, and will be influenced heavily by those topics that are likely to be needed by industry and government.

Since 1968, the Joint ASA/NCTM Committee has directed its efforts toward the development of innovating curriculum materials and methods to promote the teaching of statistical concepts. Recent work has focused on preparing a series of four unified booklets to introduce basic skills of statistics and probability. These are directed for use by middle school (upper elementary and junior high school) teachers and students, although they will be valuable at the high school level as well. Topics covered include ways to collect, display, and interpret small sets of data; elementary probability; using simulation to understand topics in probability and to solve probability problems that cannot be solved theoretically at this level; and using the ideas of random sample and confidence interval to learn about a population.

The titles of the booklets are:

- "Exploring Data"
- "Exploring Probability"
- "The Art and Techniques of Simulation"
- "Exploring Surveys: Information from Samples"

The booklets will be published by the Fall of 1986. Taken together, the four booklets will provide an introduction to the ideas of statistics and probability that educated citizens should possess. They will help teach students how to deal with the type of data and questions that they will meet more and more frequently. The usefulness of statistics and probability in dealing with practical problems is shown through many examples. The emphasis is not on watering down advanced mathematical statistics and probability for younger students, but rather on experiencing real examples and hands-on applications.

All of the booklets follow the same basic style. For each of the several topics in a booklet, there is first some brief explanatory material and questions for discussion; the teacher can present this to the class. Then there are worksheets (exercises) that can be duplicated for use by students. Students perform their own probability experiments and simulations, and analyze data given to them. They also collect their own data and analyze the results. Throughout all the activities, they learn skills that have many applications and solutions to problems that are interesting and important.

"Exploring Data" uses data sets concerning the nutrition in fast foods, sales of the most popular children's books, accident rates for different automobiles, television ratings, baseball home run records, life expectancy values, and many others. Examples are presented and studied that will be interesting to students. The statistical analyses concentrate on constructing and interpreting certain simple graphical displays. Numerical summaries are the median, maximum and minimum, quartiles, inter-quartile range, and mean. Graphs used are the stem-and-leaf plot and box plot for displaying a single variable, and the scatter plot for displaying two variables. A simple method for fitting a straight line to a scatter plot is used, and scatter plots against time are smoothed and interpreted. The focus is on data sets that represent the kinds of issues that citizens must deal with; then simple graphical methods are used to extract, summarize, and display information in the data. The interdisciplinary nature of statistics allows illustrations from many areas of science and everyday activities.

"Probability" develops the basic notions through experiments that the students perform themselves. These involve simple spinners, dice, coins, and cards. The ideas of equally likely events, probability of an event, and independent events are arrived at through many examples. Then, tree diagrams are used to present outcomes of compound events. Neither "Exploring Probability" nor "Exploring Data" has the other as a prerequisite. Either could be taught first, or they could be studied simultaneously.

The next booklet, "Simulation," builds on ideas introduced in both of the first two booklets. This shows how practical problems, some fairly complex, can be solved, at least approximately, by using simple simulation techniques. The examples also introduce and develop the idea of a mathematical model. Many of the problems can be solved using small hand-done simulations using coins, dice and random number tables. For larger or more complicated problems, simulations are usually done using microcomputers that are now becoming widely available. Example problems include simulating the probability of guessing five or more correct answers in a 25 question multiple-choice test; simulating the spread of an infectious disease; and simulating a simplified version of the airline overbooking and no-show problem. The examples show that realistic and interesting problems can be stated and then solved using simulation ideas; however, the mathematics required for exact solutions is well beyond the level of the students. The booklet also takes advantage of the capabilities of microcomputers.

"Exploring Surveys" makes use of material developed in the earlier booklets to deal with basic problems of statistical inference such as: if we have a sample proportion from a population, as in a common opinion poll, what can we conclude about the true (unknown) proportion in the entire population? Techniques from the second and third booklets are used to simulate this situation, and the results are displayed using plots from the first booklet. The notion of random sample from a population is important. From the simulations, the idea of a sampling distribution of the sample proportion is developed. By doing this for populations with different true proportions, and by comparing the results, the student is led to the idea of a confidence interval for the population proportion based on the proportion in the sample. Through experience with examples and simulations, the stu-

dent learns the underlying ideas; there is no recourse to mathematical formulas that would not be understood.

Another effort of this project is to develop guidelines for teaching statistics and probability in the precollege curriculum. This document will indicate recommended components for teaching statistics and probability to this population, and will reflect those aspects that have been demonstrated as possible to teach effectively at these levels. The guidelines will serve as a framework for developing other aspects of the project. Finally, the guidelines will be published separately and distributed so that others interested in the application of statistical education may use them.

The microcomputer is becoming more readily available in elementary and secondary classrooms throughout the country. Large, real data sets can be managed efficiently with the use of a computer. Likewise, simulations of probabilities of complex events can be completed satisfactorily only with such assistance. Alternative guidelines for computer uses will be developed by this project, and suggestions will be incorporated into the curriculum materials. Computer software will accompany most instructional units to be developed, although the basic units will not require a computer to be used by either teachers or students.

A model inservice training program to prepare forty teachers to use the materials in the classroom was developed for presentation in December of 1984. The model program was three days in duration: two days for the initial training, one day as an evaluation session during which teachers assisted with revisions for subsequent inservice programs and provided feedback on the training materials. In the Spring of 1985, teachers trained in the model inservice training program began to conduct workshops in their own areas, thus providing the multiplier effect of the project.

Further, in the Spring of 1985, four regional two-day inservice training sessions were conducted. The regional workshops were based on the model inservice program. The implementation of these sessions provide the basis for producing a videotape on the QL Project. The videotape will be disseminated to help prepare teachers who cannot participate in any of the regional inservices or any of the replication workshops. This tape will be available by Fall, 1986.

By the Fall of 1986, a large number of teachers will have participated in the inservice aspect of the project, tested the teaching materials, and received training in the QL methods. Each aspect will be evaluated thoroughly prior to implementing procedures for widespread dissemination.