THE STATISTICS TEACHER NETWORK

No. 22 OCTOBER 1989

A newsletter published three times a year
by the American Statistical Association - National Council of Teachers of Mathematics
Joint Committee on the Curriculum in Statistics and Probability.

ICOTS 3

The third in the series of International Conferences on the Teaching of Statistics will be held August 19-24, 1990 at the University of Otago, Dunedin, New Zealand. Sessions will be devoted to the teaching of statistics at all levels; the program promises to be interesting and exciting.

If you wish to contribute a paper regarding statistics instruction in grades 6 - 12, contact Dr. James Landwehr, AT&T Bell Laboratories, Room 2C-257, Murray Hill, New Jersey, 07974.

Against All Odds

Against All Odds, the television series highlighted in our last two issues, is now being broadcast. Thanks to WTIU in Bloomington, IN, we can give the following partial list of stations carrying this series: KQEC and KQED(San Francisco), KRMA(Denver), WLVT(Bethlehem, PA), WTCI(Chattanooga), WMHT(Schenectady), WBGU(Bowling Green, OH), WGBH(Boston), WMVT(Milwaukee), KOZK and KOZJ (Springfield and Joplin, MO), KOCE(Huntington Beach, CA), the stations of New Hampshire Public Television and the Oregon Community College Telecommunications Consortium. Some stations, such as WFYI(Indianapolis), will air the series later this year or early in 1990. Contact your local PBS stations for this series which you'll not want to miss!

-- John Kinney

Quantitative Literacy – A Status Report

Topeka, Towson, Corvallis, Richmond and Cleveland: five successful quantitative literacy workshops were held in these cities during June and July for approximately 200 secondary teachers. The participants explored data, created simulations, estimated probabilities, studied sampling and worked on projects. In Towson one team broke eggs and in Topeka they watched TV. On Friday each group used the techniques they had learned throughout the week and reported on their project. At the conclusion of the workshops, the teachers made plans for using the materials and ideas with their classes. During the 1989-90 school year each group will meet at scheduled times for follow-up sessions to discuss what happened to these plans, to share experiences and to continue planning for further implementation. Teachers from the workshop are also willing to share with others. If you are from a region near one of the QL sites and are interested in an in-service session or in hearing from one of the participants about the workshop experiences and how quantitative literacy works in the classroom, contact either Gail Burrill or Kathryn Rowe, American Statistical Association, 1429 Duke St., Alexandria, VA 22314-3402, who will put you in touch with someone from your area.

Quantitative Literacy Workshops

The National Council of Teachers of Mathematics recently published Standards for Teaching Mathematics contains strands on statistics and probability at all levels and for all students. To introduce teachers to appropriate content and techniques for teaching this content the Center for Statistical Education will organize and coordinate in-service sessions or workshops for schools, districts or regions who are interested in such services. The QL staff, classroom teachers, university professors and professional statisticians work with teachers on materials and activities designed to introduce simple statistical concepts emphasizing hands-on work and actual classroom experiences. The programs can be structured to accommodate different school environments and can vary in length from one day to several weeks. This can be an effective use of funding programs such as the Eisenhower funds to make a real change in a district's mathematics program. For more information, contact Kathryn Rowe, American Statistical Association, 1429 Duke Street, Alexandria, VA 22314; 703-684-1221.

Statistics Camp at University of Puerto Rico

Thirty students from all over the western region of Puerto Rico participated in the first summer statistics camp sponsored by the National Science Foundation's Young Scholars Program and the University of Puerto Rico at Mayaguez. The summer program, officially entitled "Career Orientation and Training in the Field of Statistics for Secondary School Students in Puerto Rico," took place from June 5 to July 16, 1989. It was headed by two professors at the University's College of Business, Dr. Jorge I. Vélez Arocho, Dean of the College, and Dr. Bodapati V.R. Gandhi, Professor of Management.

The six week summer camp was divided into two major parts. The first four weeks were spent primarily on an introduction to statistics. Students spent four to six hours a day in classes and laboratories learning separate modules on descriptive statistics, probability and statistical inference, research methodology, and computers and statistical packages. The 30 students, nearly all of whom had finished their junior year in high school, had at least finished Algebra I and were among the best students in their high schools. None of them had significant prior experience with statistics.

The class and laboratory hours focused on the use of statistics in practical application. Lecture-based learning was de-emphasized; much time was spent on in-class exercises and laboratories where students worked on real-world situations and attempted to find solutions using statistical techniques. Students also visited local industries and research centers in the university to understand applications and uses of statistics in the real world.

These four weeks culminated in the two "Mentor Weeks," in which professionals from industry, education, and public service came to discuss the use of statistics in their professions and to suggest potential projects that students might wish to work on during the following year. Most mentors accepted two students to work with on separate projects. Each individual project is to be presented in a Statistics Fair, to be held towards the end of the 1989-90 school year.

The projects the students are working on reflect the extraordinary range of potential applications and the students' and mentors' diverse interests. Topics include: the effect of mouthwash on microorganisms that cause tooth decay; genetic comparisons between native and imported cattle; the effect of the Eastern Airlines strike on the movement of passengers in Puerto Rican airports; an analysis of temperature patterns in the Mayagüez region and the relationship between pavement characteristics and accident rates.

The general objective of the Young Scholars Program is to interest young students in the sciences in order to have them pursue doctoral degrees when they grow older. This statistics project originated from the belief and experience that statistical analyses and inference can be made very meaningful to the student if the data are collected by him. It is hoped that their research experiences will inspire them to continue their scientific and statistical educations.

– B.V.R. Gandhi

Statistics and Probability in K-12 School Mathematics Receives a Big Push from the NCTM *Standards for Curriculum and Evaluation in School Mathematics*

Henry S. Kepner, Jr.
University of Wisconsin-Milwaukee

In March, the National Council of Teachers of Mathematics released a set of standards on the teaching of mathematics, *Standards for Curriculum and Evaluation in School Mathematics.* This document of 272 pages represents a three-year effort by the professional organization of 78,000 members to present a vision of mathematics education, grades K-12, as it should be in the 1990's. The publication presents a set of 54 standards against which school mathematics programs and evaluation procedures should be examined. The *Standards* presents these valued statements in grade level clusters Kindergarten- Grade 4, Grades 5-8, and Grades 9-12, as well as a fourth cluster of standards for the evaluation of school mathematics. The project and initial dissemination was at a cost of over one million dollars of NCTM membership dues. This document followed a January release of *Everybody Counts A Report to the Nation on the Future of Mathematics Education*, a national call to action on revising mathematics education from kindergarten through graduate school.

A New Vision of Mathematics Education

The *Standards* presents a common vision of changes in direction and expectations for school mathematics. This vision has several key elements: 1) It is time to redefine the goals for learning mathematics - that is describing what it means to be mathematically powerful. 2) The curriculum should be *conceptually* driven. 3) Close links between mathematics and the physical world must be demonstrated. 4) Mathematics instruction must focus on the interrelatedness of mathematical ideas - mathematics as an integrated whole. 5) Students should be actively involved in doing mathematics. 6) There is a redefined role for mathematical procedures and what it means to compute. 7) Regular use of calculators and computers as powerful tools in the study of mathematics. 8) A new emphasis for content which is currently being taught as well as the inclusion of some mathematics which has not commonly been taught or emphasized.

Statistics and Probability: Key Element in This Vision

The *Standards* calls for student involvement in statistical activities at all grade levels. Statistical thinking starts in the primary grades with the creation of student data from class activities and surveys on topics of student interest. The subject should be pursued at higher levels throughout the curriculum with special emphasis on collecting, organizing, summarizing, and interpreting data from other school disciplines such as science and the social sciences as well as outside interests of the students.

In contrast to the traditional view of statistics, the *Standards* reflects the position that statistics, or more correctly, data analysis *precedes* probability in the educational setting. Students can learn to investigate interesting questions from many areas of personal experience and study through the gathering, exploring, and interpreting of data. Statistical inferences can be initiated in a qualitative manner. At various levels of study, the need for probabilistic concepts appear. That is the appropriate time for the more formal study of such concepts.

Before examining a detailed listing and examination of the statistics and probability standards, a study of the vision of school mathematics is appropriate. A core set of standards starts each of the four sections of the document. These address: problem solving as the focus of all mathematics, the need for extensive efforts at student communication of mathematics in many forms, increasing student abilities to reason mathematically in many ways, and the calling attention to the connections within mathematics and to uses in other disciplines and applications.

Problem Solving as the Focus of Mathematics

The *Standards* presents the vision that problem solving is the prime goal of mathematics instruction at all levels. This first standard in each section states that students are to use problem solving processes in their learning of mathematics content - not just in isolated "word problem" sections. Students should learn strategies that are useful in solving a wide variety of problems from many contexts, both within mathematics and its use in other disciplines. Students should discuss alternative strategies individuals have used in solving problems as well as the relationships between the strategies. This level of involvement leads to student formulation of problems, student planning of a strategy and execution of that strategy, and student verification and interpretation of the results.

The new vision calls for students dealing with mathematical problems where there is not a unique answer and definitely not a single way to solve the problem. Students must be involved in problems that take time to solve and that may require several trials to complete. In contrast to the artificial and uninteresting age, coin, and work problems; statistics projects based on questions from student interests provide ideal settings for student problem solving experiences. Often such problems will be tackled by groups or teams of students - not an isolated individual.

Mathematics as Communication and Reasoning

A major change in the mathematics program recommends that "the study of mathematics include numerous opportunities for communication so that students can: * relate physical materials, pictures, and diagrams to mathematical ideas; * reflect on and clarify their thinking about mathematical ideas and situations; relate their everyday language to mathematical language and symbolism; and * realize that representing, discussing, reading, writing, and listening to mathematics are a vital part of learning and using mathematics." (p 26) This vision challenges the widely held belief that school mathematics always leads to computation with a single answer placed in a box on a worksheet. Students and teachers must gain facility in talking and writing about the subject and its applications in every form of communication. Everyday, the question, "Why?" should be pursued by students and teachers. The level of justification or reasoning will differ greatly with the maturity of the students, but students should learn that they have the power to create and solve mathematical problems around them. In so doing, they must read and listen to others in considering mathematical solutions. In turn, they must be able to communicate in oral and written form about mathematics - in common language, in prose with appropriate use of mathematical terminology, and finally through highly abstract symbolism.

Again, the statistics parts of the document exemplify opportunities for experience and practice in communicating and reasoning. Once a survey or probability experiment has been completed, the student faces a major communication task: How to best present the information and results to others. The communication goal is identical to writing and reading expectations in the language curriculum. Students need the same level of expertise in receiving information from charts, graphs and tables as they do from common language narratives. Also, they need practice presenting their information and interpretations that way, as well as in their native language.

Mathematical Connections and a Core Curriculum

Throughout the curriculum, students must see mathematics as a connected whole. Arithmetic concepts typically have geometric representations, e.g., multiplication shown as an array of rows and columns. Conversely, geometric concepts frequently can be represented algebraically such as seen through analytic geometry. Statistical data may be appropriately represented by a line of best fit which represents the trends in the data. Such a representation may be expressed geometrically or algebraically. Likewise, students must learn and use mathematics as a way of representing ideas and experiments from other disciplines.

The move to an overt demonstration of the connections within mathematics and between mathematics and other subjects is an important change. The curriculum of today is often viewed by students as a set of isolated facts and procedures to be memorized. The *Standards* calls for a strong interconnectedness of topics carried out through student discussion as well as through presented examples.

At the high school level, the *Standards* call for a core of mathematics for all students. This vision develops the rationale that all students should have experience with the major components of mathematics and their applications. All students should have basic concepts and and relationships, as well as applications in algebra, geometry and measurement, statistics and probability, as well as discrete mathematics. While some students will go further in some areas, all students must have skills and experiences in each area. The traditional sequencing of arithmetic, algebra and geometry is not justifiable. Students who are not experts in algebra can learn a great deal about statistical concepts and relations. The use of the mathematics curriculum as a filter to discard future citizens' access to all mathematical areas must be eliminated as a matter of national concern.

The statements on *connections* recommend a move to an integrated curriculum in which separate, year-long courses in algebra and geometry are abandoned in favor of a spiral curriculum which integrates arithmetic, algebra, geometry, and statistics every year. While this will go against a long tradition of separation of topics in the US, such an integration already exists in the mathematics curricula of most other countries in the world.

Statistics is one key part of mathematics that allows students to see and experience the use mathematics in many areas of study. The field of science is often presented as the collection of patterns, called theories, that are relatively consistent with experimental data. Students need experience seeking such patterns through examining tables of data, or later, trying to construct lines of best fit through data in graphical form. Social science educator, Hartoonian (Laughlin, 1989) states, "social mathematics includes abilities that are used when we measure or quantify social phenomena in any way to communicate these measures to others, plus those related abilities that we need when judging the information presented to us as we decide whom to vote for, what car to purchase, or what personal economic course to follow. Part of this definition includes methods of observation and data collection." (p. 51)

From the discussion so far, you should have the feeling that statistics and probability provide an excellent tool for having students do mathematics - not just memorize facts and formulas in isolation. Statistical activities allow students to experience the action of mathematics as well as present a piece of content. With a view that statistics and probability are two critical mathematical components of this new vision, let's start an examination of the specific items.

The K-4 Standard in Statistics and Probability

NCTM calls for several student outcomes in the K-4 curriculum, for students of age 5-8:

In grades K-4, the mathematics curriculum should include experiences with data analysis and probability so that students can -

* **collect, organize, and describe data;**
* **construct, read, and interpret displays of data;**
* **formulate and solve problems that involve collecting and analyzing data;**
* **explore concepts of chance.** (p. 54)

In the early grades, data representation starts with a very concrete form, e.g, use of actual objects or cubes to represent objects or characteristics. E.g., in considering the favorite ice cream flavor of students in class, each student could place one cube in the stack representing each flavor. Such a concrete bar graph allows students to determine the most (tallest stack) or least favorite flavors - even without counting. Later, such graphs can be constructed in various pictorial forms. This growth parallels student abilities to let spoken words, pictures, and finally groups of symbols (letters) on a page represent complex ideas or collections of data. Our challenge is to help students comfortably collect, represent, and interpret data from a wide range of personal and school experiences. Teacher modeling of each component is necessary over time. Students must be encouraged to use this form of representation frequently and to learn from information presented in this format. Examination of charts in newspapers and books is an important part of the learning process - for effective information gathering beyond the mathematics lesson each day.

To keep students from viewing the collection, organization, and description of data as mere busy work, such action must be done on topics of interest to the students. There are plenty to use after class brainstorming on interests and fantasies. In at least some of the projects performed, students must have the opportunity to make decisions based on the results of their data collection. While not inferential statistics in a real sense, students could decide what might be best to sell for a fund-raising project based on a survey of what parents and neighbors would prefer to buy under child pressure - nuts, fruit, pizzas, raffle tickets. A frequency graph could help decide what items to eliminate and maybe even assist in the choice of a final item for sale.

While extensive psychology research indicates that probabilistic concepts are not well-formed in this age range, students can carry out tasks which are based on probability , record the results, and discuss them. In playing board games which use dice, students can tally the numbers derived, either from a single die or from the sum from a pair of dice. From such tallies, students can discuss which numbers occur most often, least often, and so on. This experimentation, collection of data, and conjectures are sound forerunners of the concept of chance.

This early exploration of chance creates student awareness of probability settings as they contrast with the deterministic characteristics of the remaining mathematics curriculum. Patterns in geometry and number often yield identical conclusions or results every time! Students and teachers value the pattern that 4 + 5 is always 9. In the dice experiment, every student will likely have a different tally table. Students must struggle with the acceptance of such a result - in contrast to the unique "answers" in most of their mathematics.

Statistics in Grades 5-8

For grades 5-8, typically students of age 9-12, there is one standard on probability and one on statistics. The statistics one reads:

In grades 5-8, the mathematics curriculum should include exploration of statistics in real-world situations so that students can -

* **systematically collect, organize, and describe data;**

* **construct, read, and interpret tables, charts, and graphs;**
* **make inferences and convincing arguments that are based on data analysis;**
* **evaluate arguments that are based on data analysis;**
* **develop an appreciation for statistical methods as powerful means for decision making.** (p. 105)

In this age range, the emphasis in reading instruction shifts from techniques of deciphering letter-sound relationships to one of gaining information and following arguments in context. This transition to reading in content areas must include the reception of information through statistical representation as well as the printed word. More and more, our presentation format is the graph, chart, or table. The mathematical expectations of reading and interpreting such formats, evaluating arguments based on data analysis, and developing an appreciation of statistical methods for decision making should come through work in science, social science, health topics, and student gathering of information on topics young adolescents are curious about. This is a challenge to middle school teachers to integrate the teaching of statistics with the multitude of subjects in the school day - and beyond.

The position of the *Standards* document is that students will better read, interpret, and evaluate data analysis presented to them after they have extensive experience preparing their own analysis. Thus, student experiments in collecting, organizing, and describing data in a context they know well or have a high level of interest will pay large dividends in their ability to constructively evaluate information presented by others on topics where they are less familiar. The opportunity to practice the statistical process - from gathering information to communicating results - within a controlled setting where peers, teachers, and parents can participate and question is a valuable learning setting in preparation for evaluating arguments from others.

In grades 5-8, there is a major emphasis on building some of the basic representation techniques. In addition to the traditional charts, graphs (bar, circle, and line) and tables, the *Standards* recommends building student skills in presenting data with the more recently developed exploratory analysis plots: stem-and-leaf, box-and-whiskers, and scatter. In learning to represent data in these various forms, a communication challenge is made to students and teachers. Students should represent the same data in several forms with the intent of evaluating which form best presents the visual message they intend. When this task is undertaken with a set of information interesting to the students, and in a context where they are communicating to someone on a matter of importance, this concern about a best presentation takes on great meaning to the students. This communication task is a powerful problem solving situation which seldom has a unique or "correct" answer!

At this level, students should be challenged to interpret data once it is presented. Such practice is critical in helping students comprehend and evaluate messages conveyed to us in the media. Students will learn that the presentation of statistical data leads to the asking of additional questions, usually of a more sophisticated nature, and we see the need to carry out a further study on more refined questions that need answers or clarification. That is the world of applied statistics!

The NCTM *Standards* present the strongest, most unified call for the inclusion of statistics and probability concepts and applications in the entire K-12 mathematics curriculum. The time is right and we have some good initial instructional materials to serve as models in meeting these expectations. In the next issue, the statistics standards for high school, grades 9-12, and the probability standards for grades 5-12 will be presented and explored in detail as well as commentary on the role of computation - more commonly called number crunching.

Resources for your deliberation:

Standards for Curriculum and Evaluation in School Mathematics. National Council of Teachers of Mathematics, 1906 Association Drive, Reston, VA 22091. $25 (Member price for additional copies, $20). 1989.

Everybody Counts A Report to the Nation on the Future of Mathematics Education. National Academy Press, 2101 Constitution Avenue, NW, Washington, DC 20418. $7.95 single copy. (2-9 copies $6.50 each, 10 or more copies at $4.95 each.) 1989.

Hartoonian, M. Social Mathematics. In Laughlin, et. al. (eds.) *From Information to Decision Making: New Challenges for Effective Citizenship*. Washington, D.C.: The National Council for the Social Studies, 1989.

REVIEW

MYSTAT^{TM}: A Personal Version of SYSTAT

Systat, Inc., 1800 Sherman Ave., Evanston, IL 60201, [(312) 864-5670]

Macintosh or IBM PC Hardware (Macintosh version is reviewed here.)

Cost: Free with S.A.S.E. and a request on institutional letterhead.

MYSTAT^{TM} Version 1.0 (1988), an interactive statistical package with graphic capabilities, has most of the basic descriptive statistical routines (measures of central tendency, variability, relationship, crosstabulations) available in other microcomputer packages. Although the program requires a megabyte of memory (the standard of a Macintosh Plus and grades above), it is contained on a single disk and has the capability of storing a relatively large quantity of data on a single disk. Either a hard disk drive or two 800K floppy disk drives are also needed. Of course, a printer (e.g. Imagewriter II or LaserWriter) is needed for a hard copy of the output.

As indicated by its name, **MYSTAT: A Personal Version of SYSTAT** can trace its developmental history to that of SYSTAT, which has been under development (and continues to be) since the mid-1970's. Initially programmed for MS-DOS machines, later versions in 1986 and 1987 were written for other microcomputers, including the Macintosh.

A clearly-written 34-page manual accompanies the program. Numerous 'screen dumps' show what you should see on the screen at various stages. Using a data set included with the program, examples of analyses are demonstrated. The manual is well-designed, with bold-faced or italicized headings making it easy to find the relevant material.

There is an eight-screen tutorial program provided on the disk. This tutorial can be customized by the teacher for instructional use with a class. In addition there is a data file called USSTATS with 48 subjects and 20 variables on the disk. Examples of analyses using this data file are illustrated at many points in the documentation. A 'help' screen for the editor menu is available. Help is also available by selecting the question mark (?) in a dialog box for any analysis or graphical procedure. A help screen will appear explaining the various options available with the chosen procedure.

One of the strengths of this program is that the researcher can perform interactive analysis with menus and dialog boxes or macro commands can be written to perform the analysis. Actually, these two modes of operation can be interchanged. This macro command mode is useful for extensive or repetitious analysis. The macro command mode provides a written log of transformations and analysis.

Error diagnostics, as most of us know them, consist of an error number, followed by a cryptic explanation. Often the error message is misleading: Something in the program (instructions) before the offending statement caused the error, (e.g. a syntax error). Since MYSTAT runs primarily interactively, the term 'error' is seldom, if ever, found. If something in appropriate is specified, a 'beep' informs the user immediately. If something possible is specified, but later turns out to be inappropriate (for example trying to perform a t-test with more than two groups), a conversation box appears with a message describing the problem. This saves the researcher from experiencing the humiliation of committing an 'error'.

Data can be entered into the program in one of three ways: MYSTAT contains a data editor that allows direct input from the keyboard. In addition, data can be entered from a text file or from clipboard-captured material from word processing or spreadsheet programs. Text file input can be rather time consuming for rather large data sets, but is quite handy for examples that might be done as part of a class exercise or assignment.

Several methods of statistical analysis are available: descriptive statistics (e.g., means, standard deviations, kurtosis, standard error of mean, frequency tables, etc.), correlational regression analysis, analysis of variance, nonparametric analysis (sign test, Wilcoxon signed-rank, Friedman 2-way ANOVA).

There are three methods of output of results: Results can be sent to screen, printer, or a file, which can be incorporated into a word processing document. Several graphical output options are available: scatterplots, correlational influence plots, line plots, box and whisker plots, histograms, time series plots, and stem-and-leaf diagrams. Graphics can be overlaid on previous graph-