The Statistics Teacher Network

Number 30 ASA/NCTM Joint Committee on the Curriculum in Statistics and Probability May 1992

Hands-on Training

"Finally! A Reason for Algebra...Statistics! (I'm Serious!)"

This title is a quote from a college student who worked with some of the materials used in an eighth grade statistics class at Campobello-Gramling School in the fall of 1991. The project, involving all of the eighth grade algebra students at the small school, was a pilot for materials developed at the University of South Carolina at Spartanburg for teaching inferential statistics to those with only a prealgebra prerequisite.

The course began with a healthy review of arithmetic topics needed for beginning descriptive statistics and developed the necessary topics in algebra as they were needed for progressing to inference. The order of algebra topics covered closely paralleled that of the Addison-Wesley *Algebra* used simultaneously by the students in their traditional algebra class, and the natural coordination was enhanced by the presence of the algebra teacher in the statistics classroom each day. Linear equations and inequalities, absolute value, and the equation of a line were covered in both classes, but through statistics, the participants could see clearly why they were being asked to do this work.

The project was motivated by the belief that statistics is seen by students, teachers, and the general public as one of the most applicable of all quantitative disciplines. As such it can be used to motivate the algebra and other mathematics it requires. And although ultimate success of the project can only be determined by subsequent performance of the participants, first indications are extremely positive. At the time of this writing, near the end of the 18-week course, eighth grade participants have submitted small projects and passed tests requiring knowledge of descriptive statistics, including mean, median, mode, standard deviation, range, difference between means, and the population proportion; graphical techniques including histograms, ogives, box-and-whisker plots, stem-and-leaf plots, dot plots and narrative graphics; regression techniques including "eyeball" fitting, median fit lines, and least squares (using a calculator); and confidence intervals for the mean and population proportion. Hypothesis testing will be the subject of the last two weeks, but, although the materials are ready for presentation, we do not anticipate that much additional progress can be made before the end of the term. We do hope to have sufficient time to expose the students to the contrapositive reasoning needed for understanding hypothesis testing.

A major contributing factor to the success of the project has been the motivation derived from using real data. Over half of the participants are actively involved in school athletics, and these especially delight in applying their new knowledge to data sets gathered in their own gym or sent from the office of the NFL. Field trips to take statistics at college varsity basketball and soccer games have given a first hand look at what goes on behind the statistician's table and have provided additional interesting data sets. In-class

Features in This Issue

projects analyzing heart rate data collected before and after dancing, error data collected from tossing paper wads at a vertical line, and a "voting box" exercise have shown the power of stem-and-leaf plots, the central limit theorem, and sampling for prediction of the population proportion, respectively.

The approach taken here is comprehensive—not the piecemeal strand approach used at some schools. The course materials are innovative, using humor and mirth in discussing topics of interest to young people. We think it is more efficient in that it integrates topics in an effective and repeatable way. It is more in keeping with the spirit of the *Standards*, not only in its content, but also in the way it requires the student to make connections among various mathematical disciplines and to the world around us.

—M.B. Ulmer

Book Review

UCSMP: Functions, Statistics, and Trigonometry

Usiskin, et al; Scott, Foresman

The one adjective that could be used to describe this text is "rich." It is filled with interesting questions as well as interesting problems. For this book to be successful, the students must be able to read a mathematics book and learn from the reading. If the teacher must do all the teaching, the text will not be finished in a school year and the book should be finished since it contains so many worthwhile topics. A graphing calculator or a computer lab with software that includes graphing utilities is a must.

The title describes the use of the book—it is for a senior year functions, statistics, trigonometry class. The statistical material appears throughout the chapters. Functions are developed as a way to explain the distribution of data. This means that the quadratic function is a model rather than an abstract form. Logarithmic and exponential functions are developed with data. The trigonometric functions are developed using the right triangle and many of the problems use real world situations.

Probability is developed in a typical textbook fashion but simulations are utilized to solve practical probability problems such as the airline overbooking question. Mathematical problems such as the area beneath a curve are solved using simulations. The chapter on sequences includes a discussion of sampling for quality control. Polynomials, which dominate many texts but not the real world, are delayed until chapter nine. To demonstrate what functions are important, probability functions have their own complete chapter.

In keeping with the NCTM *Standards* there is a reduced emphasis on conic sections. The chapter on this material is entitled "Quadratic Relations." The ancillary material included with the text offers outstanding supplementary materials. With the right teacher (one familiar with the practical use of statistics) and the right group of high school students, this text would lead to a wonderful year of enjoyable and practical mathematics. The student who successfully completed a course using this text would be well prepared for college mathematics.

—Murray H. Siegel

Regional Programs in Action

Statistical Education in North Carolina

There are three current or recently completed statistical education projects in the Department of Mathematical Sciences at Appalachian State University. The goals of these three projects are to affect change in the secondary mathematics curriculum and the styles and methods of instruction. The projects have been built on three fundamental assumptions:

(1) The prevailing style of presentation in the secondary mathematics curriculum is too narrow and formalized. We must broaden the curriculum and encourage active learning styles which stress experimental and exploratory approaches to learning. Mathematics instruction needs to get out of the textbook and into the laboratory.

(2) The role of the teacher is absolutely crucial to affect change in the curriculum and styles of instruction. The teacher's attitude about what is important and how it should be taught is the most important factor in the change equation.

(3) Statistics should be presented in a coherent fashion and must be considered as a "whole" problem solving process consisting of question formulation, data collection, analysis, interpretation and inference. Statistics should be approached through problems, not just techniques. The role of statistics in society and statistics across the curriculum are important objectives of statistical education.

SIM-PAC, "Simulations in Mathematics Probability and Computing," was supported by the National Science Foundation's Materials Development & Research program during 1987-1991. SIM-PAC developed instructional strategies for learning probability concepts through the study of computer simulation models. The materials produced include simulation models implemented for both the IBM-PC and the Macintosh microcomputers, student activities for each model and a teacher manual. The materials are designed for the secondary student in grades 9-12.

The SIM-PAC models are 1) DICE, 2) BINOMIAL, 3) GEOMETRIC, 4) SPINNER, 5) TOKENS, 6) RUNS, 7) RANDOM WALK, 8) ESTIMATE. Each SIM-PAC program provides simulations of a random experiment and statistical summaries of at least one random variable. Summaries of simulated trials include bar graphs, serial mean plots, and box plots; frequency, relative frequency, and cumulative relative frequency tables. Each model contains a unique graphic which visualizes a single trial of the random experiment. Each program has a standard format which provides for four active simulations, changing parameters in the model, comparisons of graphs, and a summary table for results from more than four simulations.

Todd Platt and Tom Fix were the programmers for SIM-PAC; Mark Harris was the software design consultant. Peter Holmes of the Centre for Statistical Education, University of Sheffield, England, was the instructional design consultant.

STAT-LINC, "Statistics Leaders in North Carolina," is supported by the National Science Foundation's Teacher Preparation & Enhancement program 1990-1993. STAT-LINC is a teacher education project which is developing a model for teacher preparation in statistics. The project is built around 24 Lead Teachers (secondary mathematics) who were selected during the spring of 1990. The Lead Teachers attended an intensive four week institute during each of the summers of 1990 and 1991. The institutes emphasized statistical concepts and problem solving, teaching statistics, curriculum, and the role of the Lead Teacher. Participants practiced learning through problem solving activities; less than fifteen percent of institute sessions were in a lecture format. STAT-LINC held two conferences for the Lead Teachers and biology teachers from their respective schools in the fall of 1992 to consider the role of statistics in the biological sciences and ways that the statistics teacher and the biology teacher can collaborate. STAT-LINC will conduct five day workshops for middle school teachers at three sites in the summer of 1992 in which Lead Teachers will serve as workshop staff. This will be repeated for secondary teachers in the summer of 1993. STAT-LINC will also host a conference on statistical education and the curriculum for administrators and coordinators during 1992-93.

Peter Holmes is a special consultant and institute staff member. John Wasik, Professor of Statistics at N.C. State University, is a project associate.

We are seeking collaborators in several other states who would like to participate in a project to replicate successful aspects of the STAT-LINC project.

STAT-MAPS, "Statistics-Materials and Activities for Problem Solving," is supported by the National Science Foundation's Materials Development /& Research program 1991-94. STAT-MAPS is developing and testing a comprehensive secondary curriculum in statistical education and developing the supporting materials. The curriculum will address the needs of students in grades 9-12 who do not intend to go to college as well as the college-intending students.

The curriculum is based on active learning through applications of statistics, stresses exploratory and experimental approaches to learning, and will emphasize statistics in society. STAT-MAPS is developing categories of statistical problem solving based on eight types of statistical interpretations and inference: (1) Fundamentals—Interpreting Tables and Graphs; (2) Interpreting Univariate Data; (3) Interpreting Bivariate Data; (4) Interpreting Designed Experiments; (5) Interpreting Time Series; (6) Estimating Population Values from Samples; (7) Model Fitting; (8) Statistical Decision Making/Assessing Statistical Significance. STAT-MAPS intends to produce a student text, an activities manual, and a teacher's manual.

Peter Holmes and Dick Scheaffer are project consultants for curriculum and materials. John Wasik is a project associate for evaluation.

STAT-MAPS is seeking additional teachers who are interested in class testing materials during 1992-94.

If you wish to obtain further information about SIM-PAC materials, have an interest in the new project to use STAT-LINC ideas, wish to class test STAT-MAPS materials, or have other questions concerning these projects contact:

STATISTICAL EDUCATION PROJECTS
Mike Perry, *Director of Projects*
Gary Kader, *Associate Director of Projects*
Department of Mathematical Sciences
Appalachian State University
Boone, NC 28608
phone: (704) 262-3050
e-mail: PERRYLM@CONRAD.APPSTATE.EDU

Your Assistance Requested!

Revision of *Exploring Data*

We have received the message that the data sets in *Exploring Data* are out of date, so we will be revising it early this summer. We would appreciate new data sets, comments, corrections, and suggestions from teachers who have used the book.

Many of you teach your students how to gather data as well as analyze it and we would like to include some interesting data sets that have been collected by students. Please send us anything that you think other teachers could use with their students. Include the student's name (with teacher's name and school) so that he or she can be given credit in *Exploring Data*.

Thanks to all of you for your support of the Quantitative Literacy Project.

Ann Watkins
Department of Mathematics
California State University, Northridge
Northridge CA 91330

Jim Landwehr
AT&T Bell Laboratories, Room 2C-257
600 Mountain Avenue
Murray Hill NJ 07974

Book Review

Introductory Statistics

Jay Devore and Roxy Peck, West Publishing, St. Paul, MN; 1990

Introductory Statistics is in the traditional mold of textbooks which, as the title states, are designed to introduce students to statistics. Written for college undergraduates or advanced high school students, *Introductory Statistics* covers descriptive statistics, probability, sampling, hypothesis testing, bivariate data analysis, and other topics usually found in introductory statistics texts.

However, the book has two notable advantages over many other texts in this genre. The authors extensively use realistic examples and real data sets culled from the media and other sources throughout the text. Reading about and analyzing the data for actual high school dropout rates in the Los Angeles area or the percentage of females in the workforce in various nations is not only more interesting than doing the same for "XYZ tire company," but it clearly illustrates to students the techniques being studied can be applied to familiar everyday situations. Such problems also provide students with information regarding the world around them. furthermore, real data problems can often serve as springboards for discussing non-mathematical but critical aspects of statistics such as the underlying causes of results and the validity of conclusions.

Secondly, as had been the trend in recently published introductory statistics texts, *Introductory Statistics* is easy to read. This book can be used by its intended audience not merely as a bank of problems but as a learning tool and a resource as well.

Exploratory data analysis techniques such as stem-and-leaf plots and box plots are introduced but only very cursorily. There is no attempt to interrelate the exploratory techniques and the more advanced techniques such as chi-square as is done in recent articles and books such as *Using Statistics* by Travers, *et al.* Indeed, the one-page treatment of box plots is labelled "optional."

In summary, *Introductory Statistics* has a wealth of data sets, realistic examples, and a clear easy-to-read style. Whether a teacher chooses to use a traditional text as the primary text in a course or simply as a resource, *Introductory Statistics* would fulfill that role very well.

—Peter Barbella

One Good Book Deserves Another

Fifth Unit of the QL Series Now in Production

A unit entitled *Exploring Measurements*, by Peter Barbella, James Kepner, and Richard Scheaffer, is now in the production stage at Dale Seymour Publications. Building on the other four units of this popular series, the new unit combines data exploration and simulation to develop an empirical approach to confidence intervals for means and medians, much in the spirit of the work with proportions in the unit on *Exploring Surveys*. Along the way, the standard deviation is introduced as a measure of variation that is sometimes a useful supplement to the measures in *Exploring Data*. (This provides a good opportunity to actually use the statistical functions on a calculator.) The normal curve (not in functional form) is introduced as a useful model both for measurements and for sampling distributions, and the two-standard-deviation 95% rule forms the basis of confidence interval construction. Many activities for students involving compiled data as well as data they are asked to collect illustrate ideas such as measurement error, weighted means, randomization, decision-making under uncertainty, quality control, and standardization of measurements. The unit is probably most useful at grades 10 and higher, after students have had some experience with exploring data.

—**Richard Scheaffer**

Teaching Tools

The TI-81—A Second-Generation Graphing Calculator

Graphing calculators are quickly becoming the most significant tool for teaching and learning mathematics at both the secondary and college level. These hand-held computers provide students and teachers with powerful mathematical utilities for a wide variety of tasks. The first generation of graphing calculators was introduced in 1985 with the Casio *fx-7000* G series. These machines, although originally designed for scientists and engineers, were widely accepted in the educational market because of their unique features for teaching mathematics. (See a review of the Casio products in the *Statistics Teacher Network Newsletter*, May 1990.) In 1990 a second generation graphing calculator was introduced, the Texas Instruments *TI-81*. This machine is a significant improvement over the first generation machines because it was designed specifically as a tool for teaching and learning mathematics. Engineers and designers from Texas Instruments consulted with hundreds of mathematics teachers from across the country who were using graphing calculators in their classrooms. The result of this collaboration is a machine which is powerful, affordable, and easy for students to operate.

The most distinguishing feature of the *TI-81*'s keyboard is that it seems clean and uncluttered. Many of the mathematical functions usually placed on shifted key positions are found on pull-down menus, much like computer menus. The most commonly used commands are found on the three-level keys ("2nd" function and "alpha" shift keys are used). Graphing function keys are grouped in one place, directly under the screen. All of the menu keys are grouped in one row. The cursor control keys are out in the open and oriented so they make sense to novice users. Selecting items from the menus can be done by moving the cursor to the appropriate position with the arrow keys, or by typing the number of the selection. Learning the location of the various menu options may take a little time, however most of these options are related to more advanced functions and do not hinder operation of the machine for the first time user. The keyboard is covered with a hard shell case with rubber friction strips (on the cover and the case). These welcomed improvements will help with the problem of rough handling by students and accidental dropping caused by slippery, smooth outer cases.

The most distinguishing operational feature of the *TI-81* is the constant memory of data and mathematical functions entered in the machine. Many students (and teachers!) were frustrated with previous graphing calculators because the current function graphed was easily lost by inadvertently pressing the wrong key or by doing some other operation on the calculator. The TI-81 has a function menu that allows the user to enter up to four functions at the same time. These functions may be graphed, evaluated numerically, or used in composition with other functions. Once entered on the menu, these functions stay in the memory even if the calculator is turned off. The function menu also provides the user with a new level of variable; in Figure 1, the functions defined in Y_1 and Y_2 are used as variables in Y_3 and Y_4.

The statistical features of the *TI-81* are similar to other graphing calculators with two notable exceptions—data storage and regression formula handling. The *TI-81* will perform single variable analysis and four types of regression analysis on dual variable data sets. Histograms, scatterplots, and xy-line graphs can be drawn automatically. One significant new feature of this machine is the data entry and storage capability. Dual variable data is entered in a menu which maintains each individual datum entry without lumping it into a summation. This means that individual datum values may be viewed edited, inserted, or deleted from the list. Data may be sorted based on the x or y list or

:$Y_1 = .5X + 4$
:$Y_2 = X^2 - 2X - 3$
:$Y_3 = Y_1 + Y_2$
:$Y_4 = Y_1^2$

Figure 1: *Functions defined on the function menu*

```
:Y1 ■ .6077636153 +
.8406720742 X
:Y2 ■ - 6.737846031 +
7.096154847 ln X
:Y3 = 2.906879862 *
1.107330171 ^ X
:Y4 = 1.21060946 X ^
```

Figure 2: *Four regression models on the function menu; only Y_1 and Y_2 selected*

mathematically manipulated from a program written for the calculator. Up to 150 dual data values may be entered. The statistical memories are shared with the programming memory so data entry may be limited by a large number of bytes of memory used in programs.

The data storage memories are like arrays; each statistical memory location is addressed by a subscript number. These data memories can be used to store any numerical information. One flaw in the *TI-81*'s operations is that the user cannot create a specific number of data memory storage locations with a single command. This becomes necessary when the memories are used out of order to store values, as in a dice rolling simulation. To overcome this problem, a loop in a program must be used to create the locations by entering zeros or some other constant as a memory place holder.

Once any of the four types of regression analysis are performed on a dual data set, the regression formula is stored in a wild card command "RegEq." Selecting this command writes the complete regression equation on the function menu or on the home screen for graphing purposes. Once entered on the function menu, the regression formula is saved. In this way, all four types of regression can be performed and the resulting equations stored on the function

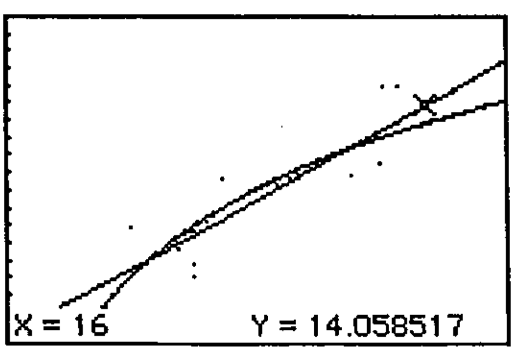

Figure 3: *Trace cursor on the linear model*

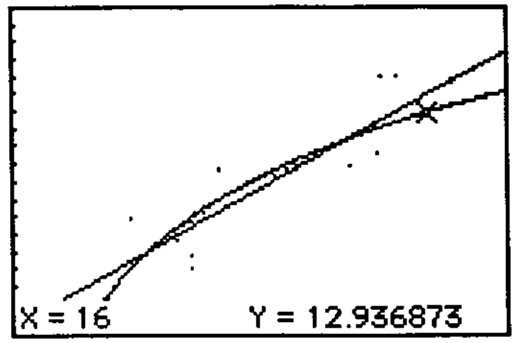

Figure 4: *Trace cursor on the log model*

menu. All, or any combination of these graphs may be drawn sequentially or simultaneously by selecting the equations from the list which you want to see. Figure 2 shows the function menu with four regression equations entered; only Y_1 (linear regression) and Y_2 (logarithmic regression) are selected for viewing.

The Casio *fx-7000G* series introduced the idea of tracing along the graph of a function. The *TI-81* has made the trace function much more powerful by allowing the trace cursor to continue to follow the graph of the function even if the cursor's position is off the screen. Numerical values for x and $f(x)$ of the cursor's current position (on or off the screen) are both given at the bottom of the screen at the same time. This important feature is like a spreadsheet in that the user can see as many lines of a table as desired, one at a time. Numerical exploration of a function can continue even when the graphical representation is not seen. For example, when analyzing regression curves, the trace cursor can continue along the regression line to investigate values outside the visible data set.

A new feature of the *TI-81*'s trace cursor is that it can "jump" to any of the four graphs drawn on the screen. This means that function values for four different regression models can be compared on the screen both visually and numerically. Figures 3 and 4 show the trace cursor on two different regression models at the same x-value. The graphics window scrolls left and right as the trace cursor moves through the domain of the function, but it will not scroll up or down. The trace cursor is a flashing "spider" that is easy to see and appears in the middle of the specified domain of the viewing screen.

Like other computers, the *TI-81* only reaches its full potential when programs are added to the operating memory. Programming allows the user to customize and expand the applications of the machine to suit the particular classroom situation. The programming language built into

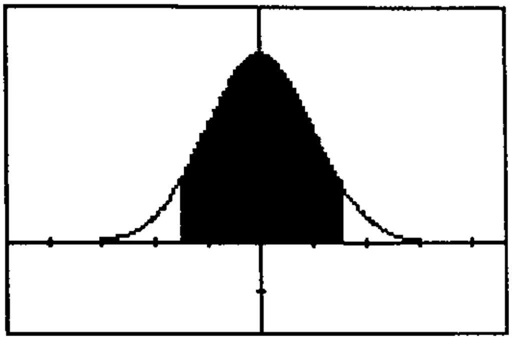

Figure 5: *Graph shaded to show area*

the *TI-81* is relatively simple to learn because it has a limited number of commands. The limited language means that there are certain operations that this machine cannot perform, like screen formatting. However, many interactions between numerical, graphical, and statistical output are easily accomplished by built-in utilities. For example, drawing a histogram of a data set or shading under a curve is done with a single command.

Figure 5 shows the graphical output and Figure 6 shows the numerical input and output of a program which calculates the one-tail or two-tail probability for a standard normal Z-score. The graphical output shades under the normal curve to show the area being calculated. The numerical calculation of the probability is a polynomial approximation, correct to four decimal places. Figure 7 shows the graphical output for a dice rolling experiment. The random generator built into the *TI-81* returns 10-digit pseudorandom numbers. Figure 8 shows the output from a program that selects five Lotto tickets at once (using any set of numbers the user chooses). The output is displayed in a matrix with each column being a single ticket. The values are chosen without order and without replacement. The final display is sorted in numerical order for easy reading.

```
NORMAL CURVE
1-TAIL = 1
2-TAIL = 2
? 2
Z-SCORE =
? 1.5
P(Z) =
                .8664
```

Figure 6: *Numerical input and output*

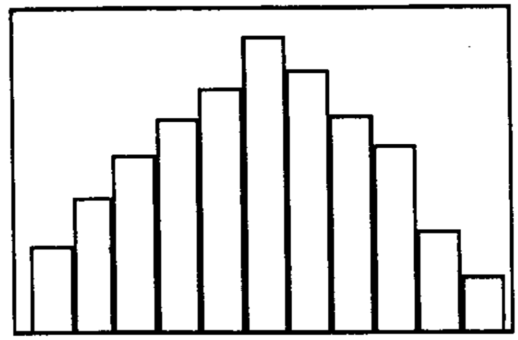

Figure 7: *Histogram of a dice rolling experiment*

Conclusion

The TI-81 has taken the best of the first generation machines and turned the graphing calculator into an indispensable tool for the mathematics classroom. Even the owner's manual is readable and understandable. This truly personal computer has the potential to change mathematics and statistics teaching techniques forever. No longer will we merely ask our students to regurgitate simple facts or answers, but we will ask them to probe, analyze extend, conjecture, explore, and generalize. The query "What would happen if..." will become the most used phrase in our teaching repertoire. We have all read recommendations from NCTM, NCSM, and other professional organizations about the importance of integrating computer technology into mathematics teaching at all levels. The *TI-81* is the most powerful, affordable, and sensible solution for students from grades 7 to 16.

—Charles Vonder Embse

Note

Normal curve, dice rolling, and Lotto programs from C. Vonder Embse, *Exploring Programming on the TI-81*. Reading, MA: Addison-Wesley Publishing Co., in press.

```
[A]
...3    1    13   14   6 ]
...15   9    17   16   7 ]
...30   20   29   17   16]
...32   35   32   18   30]
...39   36   49   23   43]
...45   41   50   36   53]
```

Figure 8: *Five Lotto tickets displayed in a matrix*