This paper discusses different ways of using statistics more creatively. One method begins with two conflicting headlines from newspapers and analyzes them statistically by using a graphing calculator. Other activities using graphing calculators are also presented. (ASK)
This is a presentation done at the AMATYC Conference in Atlanta, Georgia. Presenters were Peggy Tibbs, Susan Jordan, and Donna Sherrill. We are all instructors in the Mathematics Department at Arkansas Tech University, Russellville, Arkansas. We all teach Math 1103, a course that satisfies General Education requirements for those students who are not planning to take calculus. The text we are currently using is Explorations in College Algebra, (Wiley, 1998), written by Linda Kime and Judith Clark. The presentation is an adaptation of an Exploration in Chapter 3 of this book.

The presentation modeled cooperative grouping. The parts of the presentation were:

1) Introduction.
2) Review of concepts needed to do the activity.
   a) Three Ways to Describe Change.
   b) Creating and Manipulating a Connected Scatter Plot
3) Group Activity.
4) Presentations by groups.
INTRODUCTION

These two headlines appeared in the Arkansas Democrat-Gazette on November 6, 1997:

TRAFFIC DEATHS ROSE ON HIGHER-SPEED ROUTES

SPEED LIMITS UP, SAFETY TOO

How can both these headlines be true? Both authors were referring to a study released by the Arkansas Highway and Transportation Department. The first author says: "Traffic fatalities along routes where speed limits were raised a year ago have climbed 15%." The second author says: "After 1987, the higher speed limit reduced statewide fatality rates by 3.4% to 5.1%, compared to the rates in the states that did not raise limits. True, the actual number of fatalities continued to increase after 1987, but the volume of traffic increased even faster."

Each writer chose the part of the report that supported his opinion.

Now, refer to these graphs:(See I, II, and III) Is violent crime increasing or decreasing? It depends on what part of the data you use!
Traffic deaths rose on higher-speed routes

Fatalities climbed 15 percent, study shows

BY NOEL E. OMAN
ARKANSAS DEMOCRAT-GAZETTE

Traffic fatalities along routes where speed limits were raised a year ago have climbed 15 percent, a state Highway and Transportation Department study showed.

But the study does not show how much, if at all, the increased speed limits contributed to the increased deaths.

"It's informational only," said department spokesman Randy Ort. "I don't think we're trying to draw any conclusions at this point in time."

While suburban freeways saw the death toll climb from 11 to 27 with the higher speed limits, or a 145 percent increase, deaths fell by 1 percent on rural highways where speeds were increased.

The study also noted that more vehicles were using the highways than a year ago. When the 7.4 percent increase in traffic was factored in, the adjusted fatality rate increase dropped from 15 percent to 6.7 percent.

"With more vehicles traveling these routes, there are more chances for crash occurrences," the report said.

The State Highway Commission heard a summary of the report Wednesday but took no action. The department is waiting for a more detailed federal study of the effect of increased speed limits nationwide. The federal study has been drafted but is under review.

See FATALITIES, Page 11A
Statistics and probabilities can be puzzling, even paradoxical, as the man who wrote:

Very, very, very few
People die at ninety-two.
I suppose that I shall be
Safer still at ninety-three.

Another example: In the movie "Father's Day," Billy Crystal wants Robin Williams to facilitate a deception by pretending to cry. Crystal suggests that Williams imagine that he is a tragic hero like Lou Gehrig. Williams asks, "Who's that?"

Crystal, dumbfounded, says, "Everybody knows Lou Gehrig—the baseball player, he died of Lou Gehrig's disease."

Williams, flabbergasted that someone named Lou Gehrig died of something named Lou Gehrig's disease, exclaims: "Wow! What are the odds on that?"

Which is prologue to today's subject: What were the odds in 1987 that the increases in states' speed limits would result in decreasing statewide fatality rates? Here with a story about the vagaries of statistical analyses and social policies, a story with a happy ending.

Two scholars who can explain the counterintuitive results of increased speed limits are Charles Lave and Patrick Elias of the Department of Economics at the University of California at Irvine. The story they tell begins with the 1973 Yom Kippur War, the oil embargo, and the federal law coercing states to enforce 55 mph limits. Federal highway funding would be reduced for states not meeting compliance requirements, which included speed monitoring programs and reports of the proportion of drivers violating the new limit.

The primary reason for the 55 mph limit was fuel conservation, and when the energy crisis passed, Americans grew restless. In 1987, states were allowed to raise their limits on rural interstates and 40 adopted 65 mph limits. Opponents stressed not conservation but safety, predicting carnage. Their mantra was, "Speed kills."

Concerning developments immediately after 1987, Lave and Elias note that constraining the evidence is a more complex task than some analysts realize. Their conclusion is that, up to a point, higher speed limits save lives.

After 1987, the higher speed limit reduced statewide fatality rates by 3.4 percent to 5.1 percent, compared to the rates in states that did not raise limits. True, the actual number of fatalities continued to increase after 1987, but the volume of traffic increased even faster. The critical measurement is fatality per vehicle mile traveled in the entire state. Some studies found that raising speed limits on particular highways increased, or did not decrease, fatalities on those particular highways. However, such studies failed to gauge the ways in which all of a state's highways comprise a single interdependent system, and that highway systems and safety systems also are interdependent.

Lave and Elias say the 55 mph limit caused the misallocation of traffic and of police resources. The federal government had demanded strict compliance with the 55 mph limit, which forced state highway patrols to concentrate on speed enforcement on the interstate highways, which have the densest concentration of high-speed traffic. But these are also the safest highways.

And state police patrol resources were then decreasingly available for such safety programs as truck inspections and drunk driving checkpoints. Furthermore, many drivers who wanted to speed switched to less traveled, less patrolled but less safe roads.

The 55 mph limit might have decreased fatalities on some roads by increasing patrolling and decreasing traffic volume from what it would have been without that limit. However, the effect on a state's total highways system was apt to be a net subtraction from safety.

Raising speed limits lured some drivers back to safer, more heavily patrolled roads, and allowed highway patrols to shift resources back to the programs they thought most effective. And it decreased a real killer—speed variance among vehicles.

Many collisions occur when cars are overtaking and passing one another. Speed variance among drivers increases when speed limits are set so low that there is a high rate of noncompliance. Raising speed limits reduced turbulence in the traffic stream, leading Lave to say, "Variance kills, not speed."

When in November 1995 Congress empowered states to set such limits as they chose, fatalities did not increase the 10 percent to 14 percent predicted by the Casandras who foresaw 4,400-6,000 extra deaths per year. Neither did fatalities increase even the 2 percent to 3 percent that would have been expected, extrapolating from recent trends. Instead, Lave concludes that fatalities have declined slightly (0.14 percent) even as total vehicle miles increased 2 percent.

This is a cautionary tale about the complexity of discerning reality in a welter of statistics. It also is an encouraging tale. Sometimes the unintended consequences of a policy—in this case, increased safety from speed limits that were increased for reasons other than safety—are good.

George Will has won the Pulitzer Prize for commentary.
I. Violent crime in Arkansas is increasing at a tremendous rate. For the last 9 years, beginning in 1985, there has been an average increase of 710 cases per year. This is an increase of 78%.

Yearly Violent Crime Trend

II. Violent crime in Arkansas is decreasing rapidly. Since 1994, there has been a record-setting 10% decline in murder, rape, robbery, and aggravated assault. This is a drop of 1422 cases.
III. COMPLETE GRAPH

Yearly Violent Crime Trend

Thousands


VIOLENT CRIME:
Murder
Rape
Robbery
Aggravated Assault

BEST COPY AVAILABLE
Three Ways to Describe Change:

1. **Average Rate of Change** is one of the most useful measures of describing change.

\[
\text{Average Rate of Change} = \frac{\text{change in vertical variable}}{\text{change in horizontal variable}}
\]

**Units of Average Rate of Change** = \( \frac{\text{units of vertical variable}}{\text{units of horizontal variable}} \)

Below to the left is data of life expectancy at birth during selected years from 1940 to 1994 for all races in the United States taken from the National Center of Health Statistics found on the internet in the Data Warehouse. Below to the right is a connected scatter plot of the data with year on the horizontal axis and life expectancy on the vertical axis.

<table>
<thead>
<tr>
<th>Year</th>
<th>Life Expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>62.9</td>
</tr>
<tr>
<td>1950</td>
<td>68.2</td>
</tr>
<tr>
<td>1960</td>
<td>69.7</td>
</tr>
<tr>
<td>1970</td>
<td>70.8</td>
</tr>
<tr>
<td>1980</td>
<td>73.7</td>
</tr>
<tr>
<td>1990</td>
<td>75.4</td>
</tr>
<tr>
<td>1994</td>
<td>75.7</td>
</tr>
</tbody>
</table>

**Example 1:** Find the average rate of change in life expectancy from 1940 to 1970 and give the correct units.

\[
\text{Average rate of change} = \frac{70.8 - 62.9}{1970 - 1940} = \frac{7.9}{30} = 0.263 \text{ years per year}
\]

**Example 2:** Find the average rate of change in life expectancy from 1950 to 1994 and give the correct units.

\[
\text{Average rate of change} = \frac{75.7 - 68.2}{1994 - 1950} = \frac{7.5}{44} = 0.170 \text{ years per year}
\]
The average rate of change depends entirely on the endpoints you use to calculate the rate.

Below is a graph of the average rate of change versus the year. As you can see the average rate of change is changing.

2. Absolute Change = The change in the vertical variable.

Example 1: Find the absolute change from 1960 to 1980.

Absolute change = 73.7 - 69.7 = 4 years

Example 2: Find the absolute change from 1940 to 1994.

Absolute change = 75.7 - 62.9 = 12.8 years

3. Percent Change = \( \frac{\text{change in vertical variable}}{\text{original value of vertical variable}} \)

Example 1: Find the percent change from 1970 to 1990.

Percent change = \( \frac{75.4 - 70.8}{70.8} = \frac{4.6}{70.8} = 0.065 = 6.5\% \)

Example 2: Find the percent change from 1940 to 1994.

Percent change = \( \frac{75.7 - 62.9}{62.9} = \frac{12.8}{62.9} = 0.203 = 20.3\% \)
Creating and manipulating a connected scatter plot (xyLine)

Before we begin, so that we are all starting at the same point, let's reset our calculators. We do this by pushing 2nd +, #5 (Reset). Now push ENTER to select All Memory. Finally push #2 to reset, and all memory will be cleared. This sets the calculator up just as it would be straight from the factory. You may find at this point that your screen is either lighter or darker than you would like. If this is the case, push 2nd up arrow to darken, or 2nd down arrow to lighten.

In order to generate a scatter plot, we must first input some data for the calculator to graph. We will use the following data set, in which \( x \) represents the year and \( y \) represents the birth rate (number of live births per 1000 population) for all races combined in the U.S.\(^1\)

<table>
<thead>
<tr>
<th>Year</th>
<th>Birth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>16</td>
</tr>
<tr>
<td>1989</td>
<td>16.4</td>
</tr>
<tr>
<td>1990</td>
<td>16.7</td>
</tr>
<tr>
<td>1991</td>
<td>16.3</td>
</tr>
<tr>
<td>1992</td>
<td>15.9</td>
</tr>
<tr>
<td>1993</td>
<td>15.5</td>
</tr>
<tr>
<td>1994</td>
<td>15.2</td>
</tr>
</tbody>
</table>

We enter data into our lists in the following manner. First push the STAT key, which gives the screen shown in fig. 1.

Then push ENTER, which will select the Edit feature and will give the screen shown in fig. 2.

Starting with List 1, we input each piece of data by entering the appropriate number and then pushing ENTER. This automatically moves the cursor on to the next entry position. When List 1 is filled in, push the right arrow key to begin filling in List 2. Your lists should now appear as in fig. 3.

\(^1\)Data Warehouse
Now we are ready to graph our data. We access the statistical plots by pushing 2nd y=, which will give the screen shown in fig. 4.

To access Plot 1, push ENTER, which will yield the screen shown in fig. 5. This is how your screen should appear when everything is set as it should be.

Push ENTER again (with the cursor on On) to turn the plot on. Use your down arrow key to move to the second line, where we select the type of graph we want. The type we're doing is the connected scatter plot (or xyLine), which is the second option. Put your cursor on this type and push ENTER to select it. Now use your down arrow key to move to the third line. The Xlist should be L1 (2nd 1) and the Ylist should be L2 (2nd 2). Finally, the Mark can be whatever you choose.

Once the plot is set up the way we want it, we push ZOOM 9, (ZoomStat), which automatically sets our window optimally for the data we're graphing. You should now have the graph which is shown in fig. 6.

This graph shows how the birth rate has changed over time.

Now we can alter the appearance of this or any connected scatter plot (or xyLine) simply by manipulating the axes. To make a graph appear steeper (more dramatic), we stretch out the y-axis and/or condense the x-axis. Push WINDOW to see that the window is set up as shown in fig. 7.
Condensing the x-axis means putting a wider range of x-values in the same horizontal space, so if we change the window so that the x-axis goes from a minimum of 1980 to a maximum of 2000, as shown in fig. 8, we can see this result by pushing GRAPH. (fig. 9)

<table>
<thead>
<tr>
<th>WINDOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xmin=1980</td>
</tr>
<tr>
<td>Xmax=2000</td>
</tr>
<tr>
<td>Xscl=1</td>
</tr>
<tr>
<td>Ymin=14.945</td>
</tr>
<tr>
<td>Ymax=16.955</td>
</tr>
<tr>
<td>Yscl=1</td>
</tr>
<tr>
<td>Xres=1</td>
</tr>
</tbody>
</table>

To get back to our original graph, push ZOOM 9.

To make a graph appear less steep (hence less dramatic), we stretch out the x-axis and/or condense the y-axis. Condensing the y-axis means putting a wider range of y-values in the same vertical space, so if we change the window so that the y-axis goes from a minimum of 12 to a maximum of 20, as shown in fig. 10, we can see this result by pushing GRAPH. (fig. 11)

<table>
<thead>
<tr>
<th>WINDOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xmin=1987.4</td>
</tr>
<tr>
<td>Xmax=1994.6</td>
</tr>
<tr>
<td>Xscl=1</td>
</tr>
<tr>
<td>Ymin=12</td>
</tr>
<tr>
<td>Ymax=20</td>
</tr>
<tr>
<td>Yscl=1</td>
</tr>
<tr>
<td>Xres=1</td>
</tr>
</tbody>
</table>
Consider the following four graphs. Although they appear very different, they are all graphs of the same linear function, \( y = 0.25x + 30 \). Their appearances have been altered simply by changing the viewing rectangle on the calculator. This effect could also be achieved with paper and pencil by altering the scaling on the two axes.
$Y = 0.25x + 30$
HAVING IT YOUR WAY: HOW TO USE STATISTICS CREATIVELY

GROUP ACTIVITY

Objectives:
1) To see how statistics can be slanted, so that you will be a more sophisticated consumer of statistics you will encounter.
2) To teach the principles of good statistical graphing by negative examples.
2) To reinforce the concepts of slope, rate of change, and scaling graphs.

Materials required:
For each group, 2 transparencies, pens, graph paper, data set, and calculator.

Procedure:
Your task is to construct the strongest possible case for two opposing points of view, using the same set of data. You must not "lie", but you may slant or misrepresent your data. You must construct a graph to support each point of view. You may use only numbers that are actually in the data set, but you are free to pick and choose the ones that best support your case.
Prepare a short argument to support your case. Use rate of change between two appropriate endpoints as part of your discussion. Use "loaded" vocabulary. You may be outrageously biased, and you may commit sins of omission.

Prepare two transparencies showing your graphs. Choose two group members to make short presentations to the large group. The audience will decide who was most convincing.
BURGLARY TREND IN ARKANSAS

Source: Arkansas Crime Information Center
http://www.acic.org/

Using the information about burglaries in Arkansas over the last eleven years, your group must show:
1) Burglaries are increasing.
2) Burglaries are decreasing.

Burglary Trend

[Graph showing the trend of burglaries from 1985 to 1996]
PUBLIC DEBT

Source: The Bureau of the Public Debt
http://www.public.debt.treas.gov/opd/opd/.htm

<table>
<thead>
<tr>
<th>Year</th>
<th>Debt in billions of dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>358</td>
</tr>
<tr>
<td>1970</td>
<td>389</td>
</tr>
<tr>
<td>1972</td>
<td>449</td>
</tr>
<tr>
<td>1974</td>
<td>492</td>
</tr>
<tr>
<td>1976</td>
<td>654</td>
</tr>
<tr>
<td>1978</td>
<td>789</td>
</tr>
<tr>
<td>1980</td>
<td>930</td>
</tr>
<tr>
<td>1982</td>
<td>1,197</td>
</tr>
<tr>
<td>1984</td>
<td>1,663</td>
</tr>
<tr>
<td>1986</td>
<td>2,125</td>
</tr>
<tr>
<td>1988</td>
<td>2,602</td>
</tr>
<tr>
<td>1990</td>
<td>3,233</td>
</tr>
<tr>
<td>1992</td>
<td>4,065</td>
</tr>
<tr>
<td>1994</td>
<td>4,693</td>
</tr>
<tr>
<td>1996</td>
<td>5,225</td>
</tr>
<tr>
<td>1997 (so far)</td>
<td>5,427</td>
</tr>
</tbody>
</table>

Your group must show convincingly:
1) The public debt is rising **catastrophically**!
2) The public debt is rising very slowly.
DEATHS OF PERSONS WITH AIDS

Source: HIV/AIDS SURVEILLANCE REPORT, VOL. 9, NO. 1
Centers for Disease Control and Prevention, Atlanta Georgia
(Free copies available: 1-800-458-5231)

<table>
<thead>
<tr>
<th>Year</th>
<th>Pediatric</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>390</td>
<td>31,900</td>
<td>4,250</td>
<td>36,600</td>
</tr>
<tr>
<td>1992</td>
<td>420</td>
<td>35,600</td>
<td>5,100</td>
<td>41,100</td>
</tr>
<tr>
<td>1993</td>
<td>530</td>
<td>38,100</td>
<td>6,000</td>
<td>44,600</td>
</tr>
<tr>
<td>1994</td>
<td>560</td>
<td>41,400</td>
<td>7,400</td>
<td>49,400</td>
</tr>
<tr>
<td>1995</td>
<td>530</td>
<td>42,000</td>
<td>8,100</td>
<td>50,700</td>
</tr>
<tr>
<td>1996</td>
<td>440</td>
<td>31,400</td>
<td>7,300</td>
<td>39,200</td>
</tr>
</tbody>
</table>

Note: "Pediatric" refers to children less than 13 years old. "Male" and "Female" refer to those 13 years old and older.

In your group, you must show:
1. AIDS deaths are falling dramatically.
2. AIDS deaths are increasing steadily.

FIREARM RELATED DEATHS IN GEORGIA

Source: Georgia Injury Mortality Statistics
http://www.cdc.gov/ncipc/osp/states

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>1,299</td>
</tr>
<tr>
<td>1990</td>
<td>1,284</td>
</tr>
<tr>
<td>1991</td>
<td>1,377</td>
</tr>
<tr>
<td>1992</td>
<td>1,242</td>
</tr>
<tr>
<td>1993</td>
<td>1,338</td>
</tr>
<tr>
<td>1994</td>
<td>1,271</td>
</tr>
<tr>
<td>1995</td>
<td>1,182</td>
</tr>
</tbody>
</table>

In your group, you must show:
1) Firearm related deaths are down.
2) Firearm related deaths are almost constant.
FERTILITY RATES FROM 1980 TO 1994


Internet: Data Warehouse

Use this table to show:
1. The number of registered births of all races in the United States is decreasing dramatically.
2. The number of registered births of all races in the United States is increasing significantly.

Live births, birth rates, and fertility rates, by race: United States, specified years 1940-55 and each year, 1960-94

[Birth rates are live births per 1,000 population in specified group. Fertility rates per 1,000 women aged 15-44 years in specified group. Population enumerated as of April 1 for census years and estimated as of July 1 for all other years. Beginning with 1970, excludes births to nonresidents of the United States]

<table>
<thead>
<tr>
<th>Year</th>
<th>Registered births</th>
<th>Race of mother:</th>
<th>Number</th>
<th>Birth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>All races¹</td>
<td>American Indian ²</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>1994</td>
<td>3,952,767</td>
<td>121,004</td>
<td>636,391</td>
<td>37,740</td>
</tr>
<tr>
<td>1993</td>
<td>4,000,240</td>
<td>149,833</td>
<td>658,875</td>
<td>38,732</td>
</tr>
<tr>
<td>1992</td>
<td>4,065,013</td>
<td>201,678</td>
<td>673,633</td>
<td>39,453</td>
</tr>
<tr>
<td>1991</td>
<td>4,110,907</td>
<td>241,273</td>
<td>682,602</td>
<td>38,841</td>
</tr>
<tr>
<td>1990</td>
<td>4,158,212</td>
<td>290,273</td>
<td>684,336</td>
<td>39,051</td>
</tr>
<tr>
<td>1989</td>
<td>4,040,958</td>
<td>192,355</td>
<td>673,124</td>
<td>39,478</td>
</tr>
<tr>
<td>1988</td>
<td>3,909,510</td>
<td>102,083</td>
<td>638,562</td>
<td>37,088</td>
</tr>
<tr>
<td>1987</td>
<td>3,809,394</td>
<td>103,828</td>
<td>611,173</td>
<td>35,322</td>
</tr>
<tr>
<td>1986</td>
<td>3,756,547</td>
<td>101,175</td>
<td>592,910</td>
<td>34,169</td>
</tr>
<tr>
<td>1985</td>
<td>3,760,561</td>
<td>103,713</td>
<td>581,824</td>
<td>34,037</td>
</tr>
<tr>
<td>1984³</td>
<td>3,669,141</td>
<td>100,579</td>
<td>568,138</td>
<td>32,256</td>
</tr>
<tr>
<td>1983³</td>
<td>3,638,933</td>
<td>102,468</td>
<td>562,624</td>
<td>32,881</td>
</tr>
<tr>
<td>1982³</td>
<td>3,680,537</td>
<td>101,817</td>
<td>568,506</td>
<td>32,436</td>
</tr>
<tr>
<td>1981³</td>
<td>3,629,238</td>
<td>947,679</td>
<td>564,955</td>
<td>29,688</td>
</tr>
<tr>
<td>1980³</td>
<td>3,612,258</td>
<td>936,351</td>
<td>568,808</td>
<td>29,389</td>
</tr>
</tbody>
</table>
INTERNET SOURCES FOR DATA SETS:

Public Debt:  
http://www.publicdebt.treas.gov/bpd/bpdhome.htm

Arkansas Crime Information Center:  
http://www.acic.org/

State Injury Mortality Rates:  
http://www.cdc.gov/ncipc/osp/states

Statistics and Research:  

Data Warehouse:  
http://www.cdc.gov/nchswww/datawh/datawh.htm

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Signature:

Peggy Tibbs

Printed Name/Position/Title:

Peggy Tibbs - Instructor

Organization/Address:

Arkansas Tech University
RussoUO, AR 72801

Telephone:

501-964-0257

FAX:

E-Mail Address:

mart@atuvm.atu.edu

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