Beyond Show and Tell

Using Spreadsheets to Solve Problems

By Mary Burns

Subject: Spreadsheets, social studies

Audience: Teachers, teacher educators, technology coordinators

Grade Level: 9–12 (Ages 14–18)

Technology: Spreadsheets, Internet/Web

Standards: *NETS•S* 3, 6; *NETS•T* I (http://www.iste.org/standards)

I've read a good deal in the past year or so about the "second wave," or "second generation" of educational technology—how schools have moved beyond the use of office tools (word processing, presentation, spreadsheet, and database tools) to more robust applications, such as advanced multimedia software, geographic information system (GIS), and even computer-aided design (CAD) applications.

Such declarations stand in contrast to the majority of classrooms in which I spend time. Though I certainly have seen abundant use of such "first generation" tools as PowerPoint, Word, and Web editing software, far less common is use of the remaining tools—spreadsheets and databases. On the rare occasions I have seen spreadsheet use, in math and science classes, the software is employed, not as an analytical, modeling, or problem-solving tool, but as a display tool, with students creating charts and graphs of pre-generated data. Though the visual display of quantitative data is certainly an important attribute of spreadsheets, their use appears to be limited to this function.

Consequently, I wonder if we really have moved beyond "show and tell." Has mainstream instructional technology use stalled at mere knowledge presentation and bypassed knowledge generation? Are spreadsheets and databases the orphans of this first generation—largely ignored or underused?

Those of us who work in technology integration may need to make more of an effort to help teachers understand the analytical, inter-disciplinary, creative, and visual capabilities of spreadsheet software.

Why the Reluctance?

Why the reluctance among many teachers to use spreadsheets for anything other than making tables and creating graphs? Admittedly, spreadsheets aren't the sexiest software tool. A blank screen of rows and columns can be intimidating and visually daunting. Spreadsheets presuppose, indeed demand, a basic familiarity with arithmetical functions and logical reasoning. They are powerful, generative, and therefore complex. In intensive work with math and science teachers, I have experienced a real reluctance, even resistance, to using spreadsheets for anything other than creating tables or presenting data. (See Active Learning with Technology, right.)

Yet spreadsheets offer great potential for many students to attain a level of higher-order and critical thinking skills and problem-solving abilities. Though a PowerPoint presentation allows students to organize and present information, the tool itself does not *create* this information. In contrast, spreadsheets, because of their ability to generate *and* display information, allow students to learn *with* and *from* the tool. In their chapter in S. P. Lajoie's book *Computers as Cognitive Tools II*, Jonassen and Carr said spreadsheets "demand both abstract and concrete reasoning by the learner, modeling the mathematical logic implied by calculations." Perhaps more important, through the use of variables, spreadsheets enable learners to model complex and rich real-world phenomena that can be manipulated, analyzed, evaluated, and displayed both quantitatively and visually.

Aren't Spreadsheets Just for Math?

Spreadsheets most easily lend themselves to quantitative analysis, and for that reason, are more common in analytical types of subjects such as math and science. However, spreadsheets can generate and elucidate conceptual understanding in subject areas normally not considered conducive to their use. As an illustration, I'd like to discuss a social studies activity the Southwest Educational Development Laboratory created and conducted with several U.S. government, U.S. history, and social studies teachers. The information generated by spreadsheets clarified, and indeed made explicit, the functioning of U.S. representative government in a way that would have been otherwise impossible with any other first-generation office tool.

What's the Answer?

Reapportioning Congress is a problem-based, interdisciplinary project in which teams of three teachers each reallocate the 435 members of the 2002 U.S. House of Representatives based on 2000 census data. Teachers create a method for apportionment, ensure that it is mathemati-

Active Learning with Technology

In SouthCentral RTEC's most recent professional development project, Active Learning with Technology, we promoted spreadsheet use with teachers that went beyond the simple creation of lists and charts. Five of the six staff development sessions focused on advanced spreadsheet use, such as how to perform more complex calculations, extrapolate data, create trend lines, and use Excel's logical and statistical functions.

Uses

Though teachers still rely heavily on the chart-making ability of Excel, their spreadsheet use has become more complex. In one math class, teachers had students use a trend extrapolation method to determine when the student population of the school would exceed its available classroom space. In another joint math and science project, called "Old Moldy," students used a mold sample to derive an exponential function that modeled mold growth. They learned the concept of exponential growth and used Excel to create a model of it.

Finally, in a third math class, pairs of students researched a career of their choice and used various spreadsheet formulas to determine how much money they would earn in a given year. Using statistical functions, each pair determined at what point both persons would be earning the same amount (i.e., the point of intersection).

Results

The results of this emphasis on more advanced spreadsheet use speak for themselves. Before this project, only 6% of project teachers reported some sort of spreadsheet use, and math teachers reported no use. By project end in May 2003, 12% of the project teachers reported spreadsheet use. And, all 15 of the project's math teachers reported regular use.

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cally fair and logical, and display in chart form the 5–10 states gaining the greatest number of representatives and the 5–10 losing the greatest number of representatives based on their reapportionment method. They also provide a written and tabular explanation of their reapportionment method.

Using a variety of spreadsheet functions and formulas, teachers set about solving the problem. Some groups discovered how to use Excel's If-Then analysis (a logic function) to assign new representation to each state that experienced an increase in population of a certain number. Others used the statistical functions to assign a mean number of representatives to all states. One group took the historical data on representation and did a trend extrapolation to predict the new number of representatives. Most used formulas to create a weighted average of the 435 representatives across the 50 states. No matter what formula or functions groups used, almost all groups have employed one of the three historical methods of reapportionment (the Jefferson, Hamilton, and Webster Methods), and almost every group arrived at the current distribution of representations across all states.

Additionally, we asked teachers to use spreadsheets to answer the following two questions:

1. Are the votes of all U.S. residents, in all states, weighted equally? For example, does a Californian have the same share of one vote as someone in Maine?
2. The U.S. Constitution in Article I, Section 2 dictates that each state should have representation that is approximately equal. Is this the case? Are all U.S. residents provided with the same equality of representation? (The U.S. Constitution Article I, Section 2, originally mandated that the ratio of representatives to population be 1 to 30,000: "The actual Enumeration shall be made…within every subsequent term of ten years…(t)he number of Representatives shall not exceed one for every thirty thousand…" This "apportionment ratio" was modified in 1865 by the XIV Amendment, Section 2, to in part adjust for the nation's approximately eightfold increase in population from 1790: "Representatives shall be apportioned among the several states according to their respective numbers, counting the whole number of persons in each state, excluding Indians not taxed.")

Teachers answered the first question by dividing the number of senators and representatives for each state by the state's total population. They sorted the results from highest to lowest (i.e., states' whose residents' vote is weighted more) and created a bar chart illustrating their results (Figure 1).

They immediately recognized that residents of states with smaller populations (such as Wyoming, Vermont, and North Dakota) have a larger share of the vote than residents in more populous states (California, Texas, and New York, for instance). Though all voters have an equal vote, not all voters have an equal *share* of a vote. "Wow!" said Wattine Rac, a U.S. government teacher at Texas City High School, "I must have known this, but I've never seen this before. This is really dramatic!" What would the data look like if participants removed the number of senators and looked only at representatives? Figure 2 provides an illustration.

This favorable weighting toward states with smaller populations is the result of the Connecticut Compromise of 1787. The issue of representation had threatened to derail the Constitutional Convention of 1787—indeed the Constitution itself. Delegates from populous states, such as Virginia, believed they should enjoy proportionally greater representation in the Senate as well as in the House. Small-state delegates demanded that all states be equally represented in both houses. Roger Sherman, one of Connecticut's delegates to the Constitutional Convention, proposed the "Great Compromise" to this stalemate. As a result of this "Connecticut Compromise," members in the House of Representatives would be apportioned among the states according to population and elected by the people. In the Senate, all states would have an equal number of representatives (two each). The granting of two senators per state tilts the relative balance of power toward small states, but, as Figure 2 illustrates, that weighting toward small states changes if senators are removed from the formula.

Similarly, in spite of the Constitution's original requirement of equality of representation (the 1:30,000 ratio), not all House members represent the same number of constituents. As Figure 3 demonstrates, the number ranges from approximately 495,000 to 905,000.

Teachers immediately saw the real-world implications of these two exercises. Though the differential in the "share of the vote" is miniscule—

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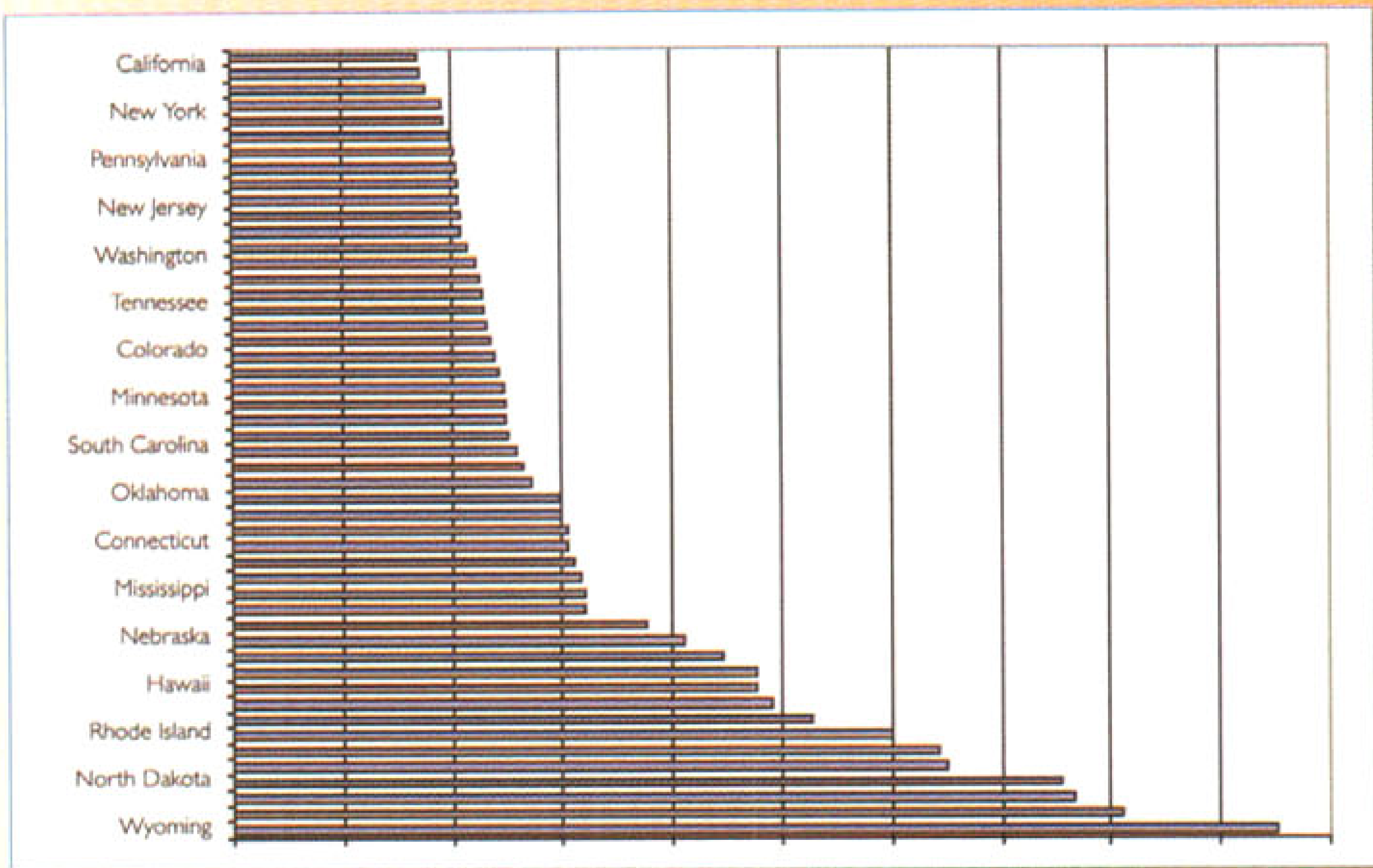

Figure 1. Residents' "share of the vote" by selected states is information created by dividing each state's total representation by its population. Data are then sorted from lowest to highest and graphed. (***Editor's note:*** All states aren't shown because of space limitations.)

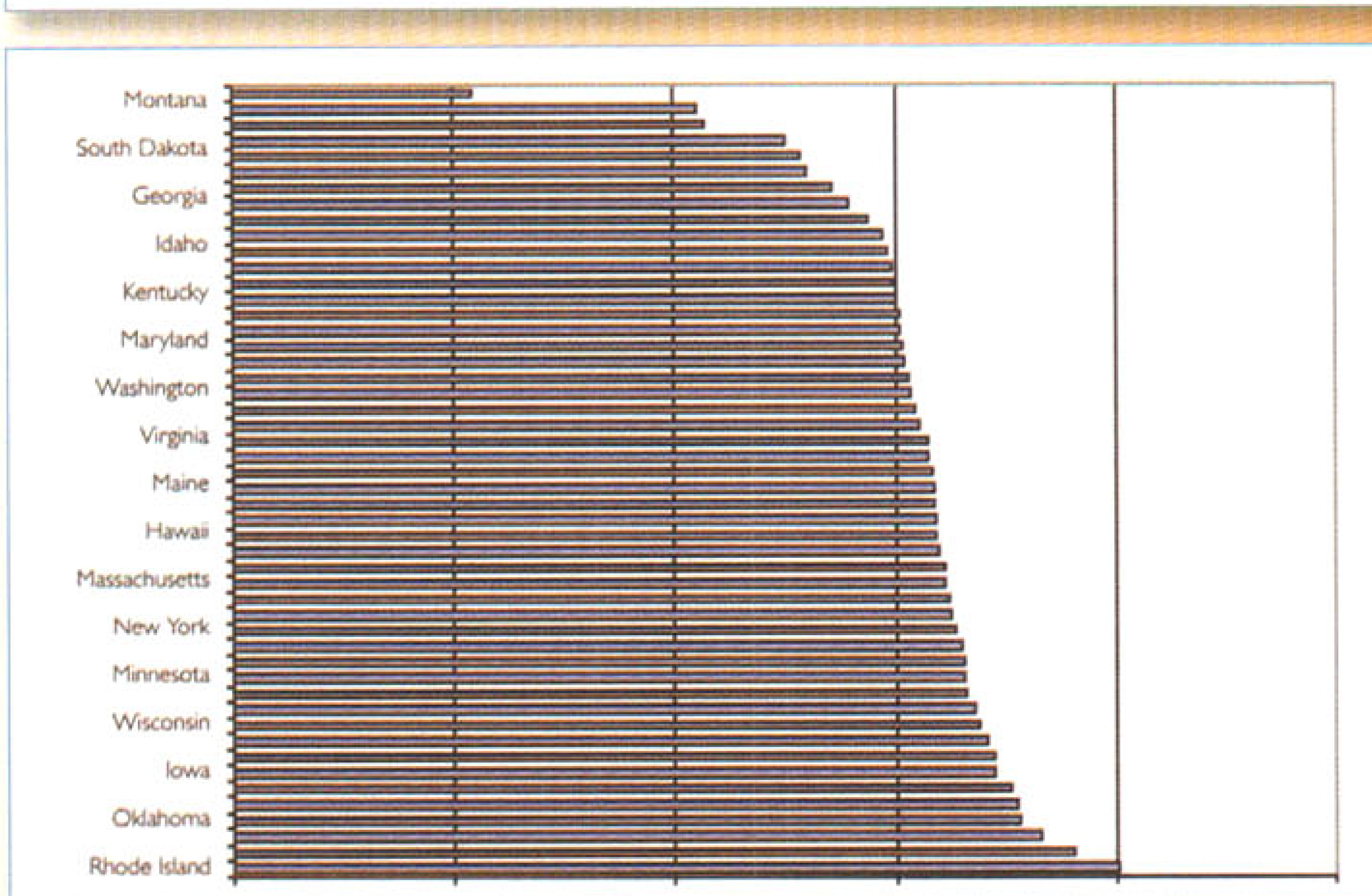

Figure 2. Residents' share of the vote across a sampling of states if senators are removed. When senators are removed from the calculation, the weighting toward sparsely populated states is affected as the ratio of representatives to residents becomes much higher. Notice the effect on Montana, for example, which has a population of 905,000 (2000 Census) and one representative. Its ratio of representatives to population is thus 1:905,000.

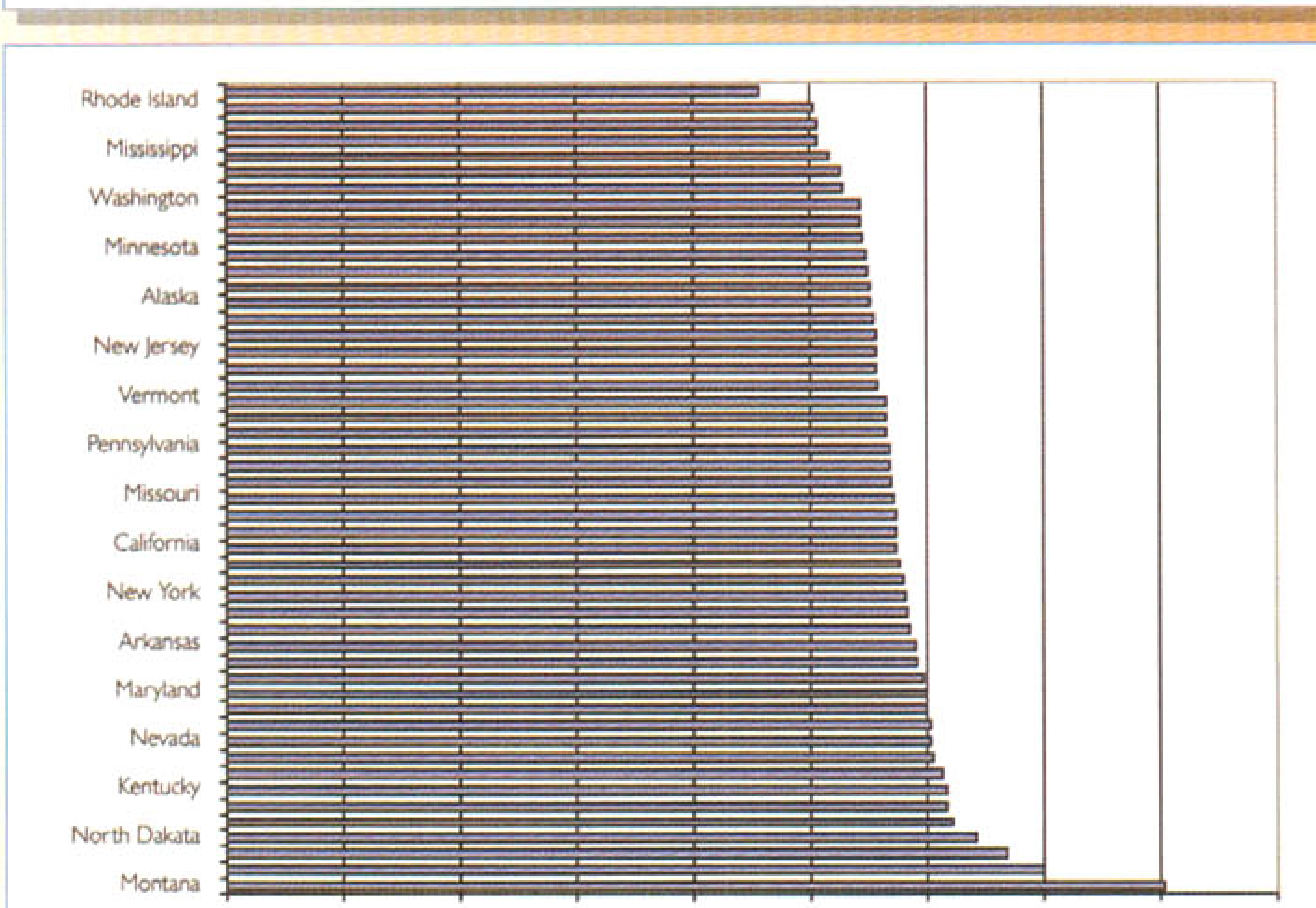

Figure 3. Ratio from smallest to largest of House members to constituents by selected states. Data are derived by dividing the population of each state by its total number of representatives.

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a matter of a few decimal places—the difference becomes apparent in presidential elections. Each state's number of electoral votes matches its total representation (House and Senate). A candidate can lose the popular vote but cobble together enough electoral votes to win the overall election. The ratio of representatives to voters matters, because a smaller ratio theoretically means that representative should be more responsive to members of his or her constituency.

The greatest benefit of this activity, and indeed the greatest benefit of spreadsheet software, I believe, is that the spreadsheet's power to both generate and display data in a visual format enriches the study of another subject area in a way that most likely would not be possible without the tool. For example, reapportionment is an undertaking that is fundamental to representative democracy: it determines the number of representatives a state has and thus how much of a voice—and funding—a state or district receives. By engaging in a process in which they had to reallocate all 435 members of the House of Representatives, *reapportionment* moves from an abstract government term to an authentic mathematical process with real implications for voting and funding. Similarly, the Connecticut Compromise is one of those events pivotal to the ratification of the Constitution, but how many understand the present implications of such an event? By actually calculating how the Connecticut Compromise created a system that unevenly weights voting in favor of less populous states and then displaying results graphically, rather abstract elements of our representational system, such as the electoral college, become more concrete.

I have conducted this activity on numerous occasions with teachers and have witnessed some extremely rich discussions, and heard teachers propose projects based on this activity. Here are some examples:

- Is the United States a democracy or a republic? What are the similarities and differences and pros and cons of each?
- Should the size of the House of Representatives be increased? (The number of representatives has been 435 since 1910, when the U.S. population was 91 million. As of June 2003, the U.S. population was 291,264,820.)
- Is the U.S. majority system of government more, less, or equally fair as that of other representative democracies? (Presently, in our "winner take all" system, a candidate in a three person race can win with less than 50 percent of the vote, while the majority have their vote in essence nullified.)
- Given that reapportionment affects the number of electoral votes a state receives, students might want to examine the tension between the electoral college and popular vote systems.
- Should the United States move toward a proportional system of representation? Presently the representative with 905,000 people in his or her constituency has the same voting weight as one that represents 450,000 constituents. Would such a proportional system mitigate the "big money" effect in political campaigns? How?

Conclusion

This article has focused on using spreadsheets with teachers, as opposed to with students, because teacher exposure to and confidence with spreadsheets' cross-curricular possibilities is the key to more rigorous use in the classroom. Perhaps the dearth of spreadsheet use in the classrooms I have visited is more a failure of imagination than expertise: teachers still see spreadsheets as tools used exclusively for math activities, the most desirable attribute of which is an ability to make colorful charts and graphs. But before we move on to the next generation of software tools, those of us who work in technology integration may need to make more of an effort to help teachers understand the analytical, interdisciplinary, creative, and visual capabilities of spreadsheet software.

Resources

Classrooms that Excel: http://www.sabine.k12.la.us/class/

Jonassen, D. H., & Carr, C. S. (2000). Mindtools: Affording multiple knowledge representations for learning. In S. P. Lajoie (Ed.), *Computers as cognitive tools II: No more walls: Theory change, paradigm shifts and their influence on the use of computers for instructional purposes* (pp. 165–196).

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Mahwah, NJ: Lawrence Erlbaum Associates. Available: http://www.ed.psu.edu/insys/400/ssdb.htm.

Lab Write at North Carolina State University: http://www.ncsu.edu/labwrite

LT Technologies: Spreadsheets: http://lttechno.com/links/spreadsheets.html

Reapportioning Congress (select the Reapportioning Congress link): http://www.southcentralrtec.org/alt/alt.html

Roland, L. (1997). Distributing representatives: Using spreadsheets to study apportionment. *Learning & Leading with Technology, 24*(8), 26–29.

Simon, J. L. (2000). *Excel 2000 in a nutshell: A power user's quick reference.* Sebastopol, CA: O'Reilly & Associates.

TAP into Learning: Using What Learners Know: http://www.southcentralrtec.org/tap.html (scroll to Using What Learners Know/Spreadsheets: They're Not Just for Math Anymore)

U.S. Census: http://www.census.gov

U.S. Constitution Article 1, Section 2: http://memory.loc.gov/const/const.html or http://www.law.cornell.edu/constitution/constitution.table.html

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