

*“Research & Practice,” established early in 2001, features educational research that is directly relevant to the work of classroom teachers. Here, I invited geographer Sarah Bednarz and her colleagues to summarize the research on teaching and learning with maps in the social studies curriculum.*

—Walter C. Parker, “Research and Practice” Editor, University of Washington, Seattle

# Maps and Map Learning in Social Studies

Sarah Witham Bednarz, Gillian Acheson, and Robert S. Bednarz

**Maps are not the whole** of geography, but there can be no geography without them. In fact, well-known geographers have often defined their subject around maps and map use. In 1939, Richard Hartshorne stated, “So important is the use of maps in geographic work that ... it seems fair to suggest to the geographer if the problem cannot be studied fundamentally by maps ... then it is questionable whether or not it is within the field of geography.”<sup>1</sup> Fifty years later Peter Haggett expressed the same sentiment even more directly and succinctly: “Geography is the art of the mappable.”<sup>2</sup>

Since 1990, the importance of maps and other graphic representations has become even more important to geography and geographers. This is due, to a large extent, to the development and widespread diffusion of geographic (spatial) technologies. As computers and silicon chips have become more capable and less expensive, geographic information systems (GIS), global positioning satellite (GPS) receivers, and remotely sensed images of Earth from airplanes and satellites have become accessible to geography students and faculty at all levels. These technologies are key research and communication tools for geographers and have significantly increased interest in geography as evidenced by rising enrollments in university undergraduate and graduate programs.<sup>3</sup> Another indication of the growing importance of maps is a rising interest among geographers, psychologists, and cognitive scientists in

spatial thinking, the kind of thinking that underpins map reading and interpretation. Spatial thinking is the knowledge, skills, and habits of mind to use spatial concepts, maps and graphs, and processes of reasoning in order to organize and solve problems.<sup>4</sup>

Of course geospatial technologies and their products are available to students and faculty in all disciplines, and they have become ever more common in the daily lives of more and more people. In fact, one can argue that the ability to use maps, images, and spatial technologies intelligently and critically is becoming a requirement to participate effectively as a citizen in modern society. Consider these four developments:

1. Travelers, hikers, hunters, and fishers frequently use GPS systems to find their locations and to assist them in getting to their destination. These systems are

also becoming more common in automobiles.

2. Google, the most popular internet search utility, now offers users maps at virtually any scale desired and, recently, through Google Earth, remotely sensed images that users can view from any direction or angle.

3. Governments and non-governmental organizations (NGOs) typically make information available via printed and, increasingly, online maps. For example, the federal government lets online users map census data; cities and towns post their planning and land-use maps on the internet; and property tax districts post maps of tax rates and assessed values on their websites. NGOs are using “participatory GIS” or web-based GIS mapping tools to allow stakeholders to interactively explore spatial aspects of a wide range of issues, from urban neighborhood revitalization efforts to cleanup decisions at a plutonium production facility.<sup>5</sup>

4. Static and animated maps are much more common in today’s newspapers, magazines, and electronic media than

they were 20 years ago. As the cost of producing and reproducing maps and images has declined, the media have increased both the amount and the sophistication of the materials they publish. These maps play an important role in both representing and reproducing space.<sup>6</sup> The well-known 2004 election map showing the red (Republican) and blue (Democrat) states (Figure 1) illustrates this. The map has taken on iconic status and reinforces the erroneous view that President Bush's victory was a landslide. The population-based cartogram constructed by Michael Gastner and colleagues at the University of Michigan (Figure 2) offers a more accurate representation of the vote.<sup>7</sup> In this way, maps and graphics may play a role in legitimating or disputing specific ideologies, beliefs, and practices.

These developments, and more, both allow and require modern citizens to understand spatial information presented on electronic and printed maps and images. For this reason, helping students become competent users and creators of these technologies should be an important element of all of the social studies—maps are not just for geography anymore. This places a new—but welcomed—burden on geography educators to ensure that map learning and spatial thinking are taught and taught well in the social studies.<sup>8</sup> But are they?

### Assessing Students' Knowledge

Assessments indicate that students are not competent map users. An analysis of the 2001 National Assessment of Educational Progress (NAEP) geography exam revealed that at every level (grades 4, 8, and 12) test items that required students to use and interpret maps were the most challenging (see Table 1). At grade 4, nine of the ten most difficult items required map interpretation, construction, or use. For grades 8 and 12, five and seven of the ten most frequently missed questions involved maps.<sup>9</sup>

### Teachers' Goals

One explanation for these low scores is that few social studies teachers are aware of the growing importance of maps, or are

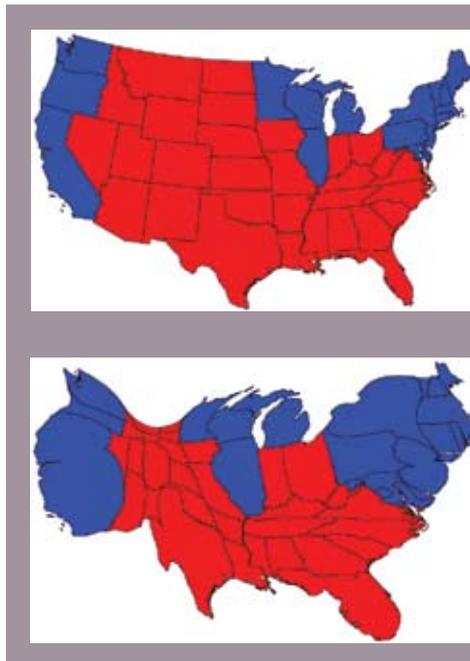


Figure 1. Election Results by State.

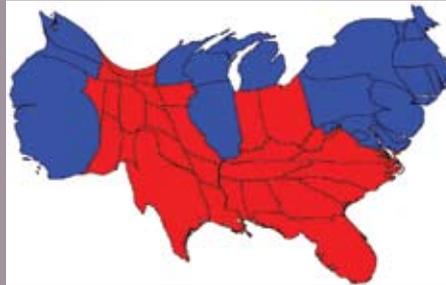


Figure 2. Election Results by State in a Population Cartogram.

Source: M. Gastner, C. Shalizi, and M. Newman. Maps and Cartograms of the 2004 U.S. Presidential Election Results, [www-personal.umich.edu/~mejn/election/](http://www-personal.umich.edu/~mejn/election/).

prepared and motivated to teach about and with maps. Teaching *about* maps means providing students with the skills and understandings required to read, interpret, and produce maps. Teaching *with* maps means using maps to help students learn key social studies concepts and relationships. Teaching with maps enables students to learn *through* maps—that is, to think spatially—in various reasoning and problem-solving contexts in the classroom and real world.<sup>10</sup>

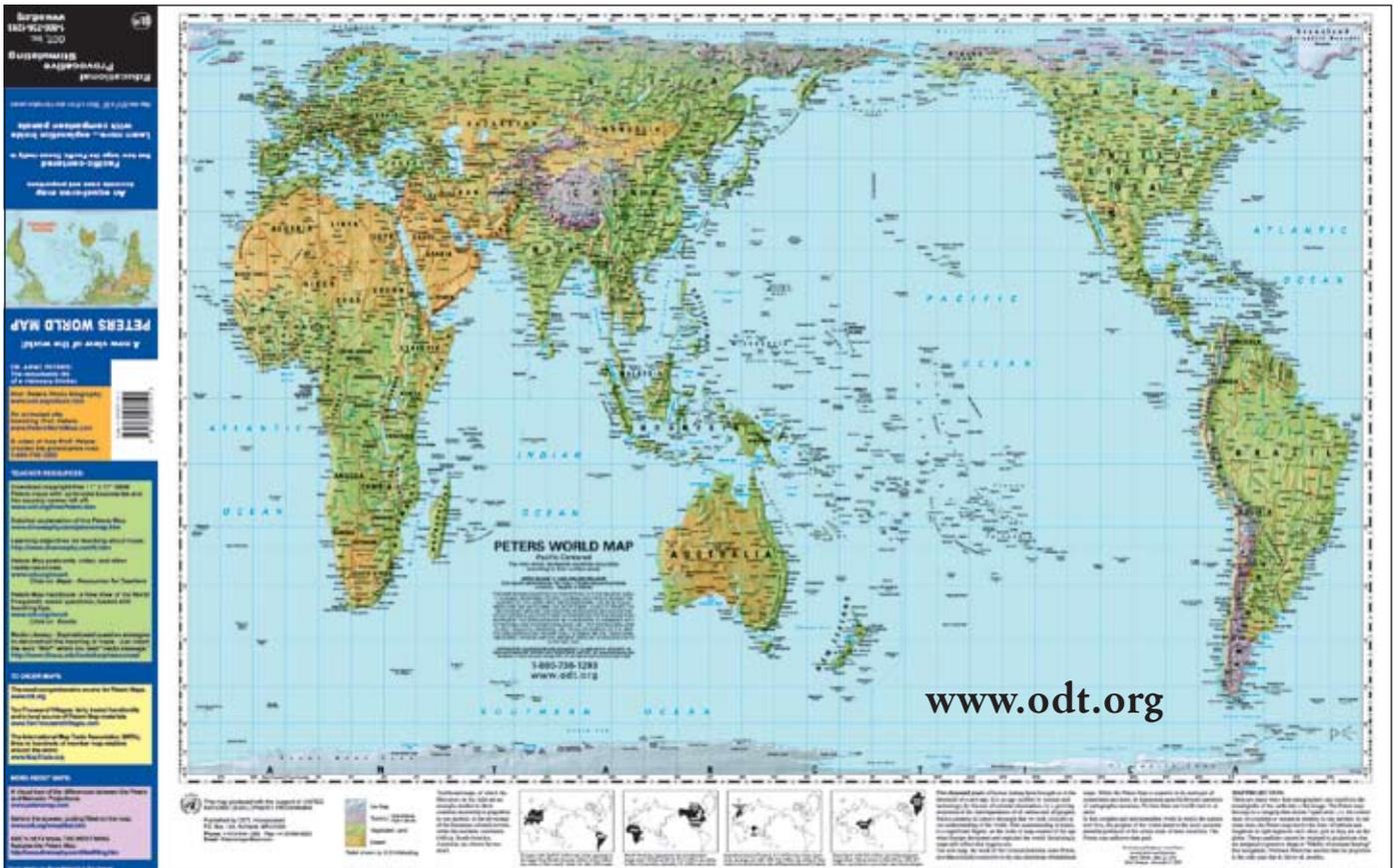
A recent survey completed by members of the Texas Alliance for Geographic Education provides information about teachers' attitudes towards maps, how they use maps, and how they teach map skills.<sup>11</sup> These teachers taught elementary (K-5), middle (6-8), and high (9-12) school, and they ranged in classroom experience from one to 38 years with an average of almost 14 years. All were expected to teach map skills as a component of the state-mandated social studies curriculum, which includes geography as a strand from kindergarten to grade 12.

The survey revealed that these teachers' methods were highly individualized. They used a variety of approaches and materials, including the textbook, workbooks, and self-made worksheets. Three broad approaches to teaching map lessons were identified: employing hands-

on activities, repeating lessons periodically, and making the content relevant to students. Teachers described hands-on activities, especially "making" (labeling blank outline maps) maps, as a way for students both to learn about maps and to learn with maps.

When teachers were asked the most important thing students learned from their map lessons, about one-third identified reading, interpreting, and analyzing maps. They expected their students to evaluate the information provided by the maps, to make inferences and decisions based on that information, to gain what one teacher called an "appreciation of spatial perspectives and understanding of spatial dimensions through scale," and, in the words of another teacher, "to understand the geographic impacts illustrated by the map." Thus, about one-third of teachers claimed to focus their map lessons on higher-order thinking involving the analysis and interpretation of the information presented on maps.

However, when they were asked to describe the content of their lessons, their responses indicated that they were mainly teaching students to read maps. That is, they taught about latitude and longitude (or teaching students about grids), the five components of maps (title, date, direction, legend, and scale), the different



Peters Pacific-Centered World Map.

types of maps (e.g., political, economic, physical, or topographic), and locating places. Teachers went on to report the most important skills for their students to learn included way-finding; locating cities, countries, and physical features; and understanding latitude and longitude, scale, direction, and map symbols. Generally speaking, then, their stated higher-order goals were not supported by their lower-order practices.

### Map Learning

Researchers from a variety of fields have explored map learning. Geographers, social studies educators, and psychologists have studied how people use maps to organize information and find their way. They have also studied how people create and use mental images, termed “mental maps,” to understand their environments and to organize their knowledge of places. The results of this research should be integrated into curricula and textbooks and understood by teachers in order to improve students’ map learning and spatial thinking.

Three findings are especially important concerning students’ ability to use maps, their ability to understand maps, and the cognitive complexity of map use.

First, even the youngest students possess significant spatial skills, and they can be taught to read and interpret maps and images. Although many parents and teachers are skeptical about the ability of young children to understand and use maps, even elementary school students can use maps effectively. Research shows that young children are surprisingly adept at using maps (and remotely sensed images) to find locations and trace their paths to and from familiar destinations.<sup>12</sup>

Second, children can use maps for more than way-finding. They are able to understand and use symbols and patterns represented by color or shading.<sup>13</sup> A few studies suggest that simple maps can be understood by children even without formal instruction. Some have interpreted these results to mean that certain spatial abilities are innate and that we need not wait until children

progress to later developmental stages to introduce them to maps and other spatial representations.<sup>14</sup>

Third, this ‘intuitive’ map learning seems to level off; that is, without formal instruction, students’ map learning plateaus. After all, map interpretation is a complex, multi-stepped cognitive process. One problem is that children and adults cling to a variety of misconceptions about maps and map use.<sup>15</sup> For example, people often misinterpret symbols on maps. Understanding symbols requires abstract thinking and the ability to make generalizations. Point symbols, such as a dot to indicate the location of a city, are frequently assumed by novice map users to indicate size. They understand that a point is a distinct, small, and finite area when, in fact, the boundaries of the city might be much larger than the point on the map. Other map readers interpret point symbols as circles surrounding the location of a city or an area where something is taking place. Graduated symbols that portray the magnitude of a phenomena (i.e., a

town's population) by using symbols of different sizes further confuse map readers. Even adults often interpret the symbol's size as a representation of the town's area, not its population. Thus, the symbol denoting New York City's population, which is very dense, is misunderstood to indicate that the city covers a large area.

Pictorial symbols, such as the use of a single cow to indicate a region of cattle raising or a derrick to represent an area of oil production, are often used to simplify map interpretation in elementary social studies texts and atlases, yet they frequently confuse young students. For example, the single cow symbol has been interpreted by young learners to represent the presence of one giant cow in an area rather than a cattle-raising region.

A car symbol positioned in an area of automobile production was interpreted variously by young British students as showing the location of a parking lot, the site of a traffic jam, a place where people liked red cars, and as the location of a broken car.<sup>16</sup> The triangle symbol often used to represent mountains can mislead students to think that all mountains have distinct, pointed peaks similar to the symbol.

Color, an important component of maps, is regularly interpreted naïvely as well. The green shading typically used to indicate a region with low elevation is often misunderstood by map readers to represent grassland or forest. Colors on political maps indicating the area of a country can lead to confusion as well; some students associate the color of the

country with other assumed attributes of that place when, in fact, the mapmaker selected the color only for cartographic or artistic purposes. Researchers report that individuals react subjectively to color. "Red, for instance is associated with fire, warning, heat, blood, anger, courage, power, love, material force, and Communism."<sup>17</sup> When Tom Sawyer and Huck Finn are traveling down the Mississippi, Huck thinks he knows where they are by the color of the landscape. Tom asks, "You know by the *color*?" Huck answers, "It's got everything to do with it. Illinois is green, Indiana is pink." Incredulously, Tom replies, "Did you reckon the states was the same color out-of-doors as they are on the map?"<sup>18</sup>

In addition to the misconceptions about symbols and color, many map read-

Ten Most Difficult Test Items, NAEP 2002. (Items in italics involve map skills.)		
Grade 4 Top Ten Most Difficult Test Questions	Grade 8 Top Ten Most Difficult Test Questions	Grade 12 Top Ten Most Difficult Test Questions
<ul style="list-style-type: none"> <li>• <i>Interpret resource map to determine likely location for large city to develop</i></li> <li>• <i>Draw map based on written description of its features</i></li> <li>• Identify the mountain range in which Switzerland is located</li> <li>• <i>Use multiple maps to locate states where crops grow year round</i></li> <li>• <i>Use map to determine which countries might have a conflict over resources</i></li> <li>• <i>Use multiple maps to compare conditions for farming in two countries</i></li> <li>• <i>Interpret information given on transit map</i></li> <li>• <i>Find and draw specified route on a transit system map</i></li> <li>• <i>Identify a megalopolis on a population map</i></li> <li>• <i>Determine elevation of a region on a physical map</i></li> </ul>	<ul style="list-style-type: none"> <li>• Describe and explain differences in population pyramids</li> <li>• <i>Use a time zone map</i></li> <li>• <i>Use map to explain international trade in oil</i></li> <li>• Explain two reasons for high rate of tropical deforestation</li> <li>• <i>Use multiple maps to explain land use in Canada region</i></li> <li>• Recognize the natural forces that cause erosion</li> <li>• <i>Use map to explain historical shift in center of U.S. population</i></li> <li>• Identify purpose of OPEC</li> <li>• Understand and compare different views on land ownership</li> <li>• <i>Interpret resource map to determine likely location for large city to develop</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Use data and maps to explain Mongolia's economic development</i></li> <li>• Explain reasons for international trade in oil</li> <li>• Explain differences between two countries using population pyramids</li> <li>• <i>Use atlas to explain regional variations in land use</i></li> <li>• <i>Use map to explain historical shift in center of U.S. population</i></li> <li>• <i>Use map to explain economic impact of Mid-East War</i></li> <li>• <i>Use multiple maps to describe regions where most Australians live</i></li> <li>• Explain high rate of tropical deforestation</li> <li>• <i>Use map and charts to compare urbanization in two European countries</i></li> <li>• <i>Use a time zone map</i></li> </ul>

ers find it difficult to identify relationships from maps, particularly thematic maps. For example, the relationship between high literacy rates and low infant mortality rates often goes undetected by students because they do not recognize the negative or inverse relationships between variables.<sup>19</sup> Relationships can occur when high values are associated with other high values or when high values are associated with low values, as in this case.

Instruction does make a difference. Several studies confirm that the understanding of maps and how to use them can be improved.<sup>20</sup> Children as young as four or five can be successfully taught about the shape of Earth, directions, Earth-sun relations, and the concept of scale.<sup>21</sup> Instruction using maps as a primary tool can improve the mental maps of seventh-grade students and increase their understanding of the characteristics of places on a worldwide basis.<sup>22</sup> A short, 20-minute session that taught a

group of college students basic map terminology and how to read a topographic map improved their performance significantly compared to a group that received no instruction.<sup>23</sup>

As this brief review suggests, research does not provide teachers with a tested method they can adopt to ensure their students' success. Nevertheless, research strongly implies that students can use maps effectively, that appropriate instruction can help them improve their skills, and that instruction should be developed with a full understanding of the difficulties learners experience in map learning and spatial thinking.

### A Map Curriculum

*The National Geography Standards: Geography for Life* (1994), written more than a decade ago under the auspices of the United States Department of Education, specifies the essential subject matter, skills, and perspectives that all people should have to be geographically

literate. The standards-setting process gave geography educators an opportunity to reflect on map learning, spatial thinking, and other key aspects of school geography. One goal of *Geography for Life* was for educators to see maps as a means of communication and to give students opportunities to become fluent in the language of maps.

Maps play a central role in the first three (of 18) standards summarized under the heading *Seeing the World in Spatial Terms*. Standard 1—*how to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective*—is about maps, mapping, and using maps (and other geographic representations such as globes, graphs, diagrams, and aerial- and satellite-produced images) to learn geography. Standard 2—*how to use mental maps to organize information about people, places, and environments*—is about developing a personal understanding of

## STRATFORD, MONTICELLO, AND THE UNIVERSITY OF VIRGINIA

### *An Invitation to "Live and Learn in Historic Virginia"*

Monticello, Stratford, and the University of Virginia invite you to apply for their annual seminar for teachers, "Leadership and Life in Revolutionary America." Dates for 2007 will be June 24-July 13. Principal "classrooms" are Jefferson's Monticello and the Lees' Stratford. However, participants also visit many other Virginia historic sites and stay a week at the historic Jeffersonian area of the University of Virginia known as "the Lawn."

Six semester hours of graduate credit in history from the University of Virginia will be awarded upon successful completion of the seminar. Tuition includes graduate course fees, room and board, and textbooks.

Now in its 27th year, the seminar is an Award of Merit recipient from the American Association for State and Local History. Applications are available online at [www.stratfordhall.org](http://www.stratfordhall.org). Application materials must be received by March 1, 2007.



For details, call **(804) 493-8038, ext. 1558**

email [kmcfarland@stratfordhall.org](mailto:kmcfarland@stratfordhall.org),

fax (804) 493-8006, or write:

Education Office, Stratford,

Stratford, VA 22558.





The Mercator map, because it was designed to preserve on the flat map characteristics of the round earth useful to Earth navigators, exaggerates the sizes of places farther from the equator. Europe, for example, looks larger than South America but is actually only half its size, while Greenland appears as large as Africa, but is less than 10 percent as large. By ignoring the needs of navigators, The Peters Map is able to show true size relationships, though at the cost of distorting shapes.

—Denis Wood

the locations and characteristics of places (a student's mental map). Standard 3—*how to analyze the spatial organization of people, places, and environments on Earth's surface*—focuses on the ability to describe and analyze patterns of people, places, and environments on Earth using both visual and mental maps.

The National Geography Standards were built on a foundation of traditional map components and skills such as reading maps, using scale to determine distance, and understanding map symbols. But the document also made recommendations based on the research already reviewed here that, while not practiced widely, are essential to our vision of map learning.

One suggestion was that students should be able to *make* maps as well as read them. For example, the standards recommended that by the end of fourth grade, a student should be able to represent information geographically by reading a story and creating a sketch map to illustrate it. An example of this skill would be showing the movement of the family of ducks through the city of Boston, as

described in the classic children's book *Make Way for Ducklings*.<sup>24</sup>

A second recommendation of the National Geography Standards was that students should use maps produced with new technologies such as GIS and remote sensing. Maps displaying satellite imagery (e.g., Google Earth) are widely available now and becoming very popular; it was considered important, even in 1994, that students expand their map interpretation skills to include digital maps and images. Although the standards did not suggest integration of GIS into K-12 education, its growing importance was highlighted in an appendix. A more recent National Academy of Science study explores the role of GIS in supporting spatial thinking.<sup>25</sup>

A third suggestion addresses social studies learning in general. Research suggests that when students read, they remember information as both word statements and visual images. This "dual encoding" can be enhanced when teachers encourage their students to link what they read to maps and other geographic representations. For example, every

American fifth-grade student reads about Paul Revere's ride, but what is understood and remembered is questionable.<sup>26</sup> If students are asked to make a map of this momentous event showing the starting point, the opposite shore, the route of the two riders, and the eventual destination, Revere's ride becomes vivid. Linking *what* with *where*, and reading and thinking *with* and *through* maps, makes content more memorable.<sup>27</sup>

### Talking Back to Maps

"Both in the selectivity of their content and in their signs and styles of representation, maps are a way of conceiving, articulating, and structuring the human world which is biased towards, promoted by, and exerts influence upon particular sets of social relations."<sup>28</sup> Just as the quotes at the beginning of this article represent the traditional importance of maps to the discipline of geography, so this quote from J.B. Harley represents a postmodern appreciation. Postmodern geographic thought has had little impact on geography education in the elementary and secondary schools of the United States,

but we believe two perspectives of critical cartography are essential components of a revitalized pedagogy of maps and map learning: students and teachers should understand how geographic knowledge is created, and they should understand the purposes of such knowledge.

In the context of maps and map learning, it is important that students and teachers understand that maps are social constructions. Just as texts are written by individuals with varying points of view,

and can be read and interpreted in different ways and for different purposes, maps, too, are not objective representations of reality but social productions that can be subjected to critical analysis. Part of any revitalization of map learning, or to use Harley's phrase, "an increase in levels of carto-literacy," must include explicit instruction about how to interrogate a map—to consider the conditions under which it was produced, whether it may portray a particular point of view, and

what, if any, messages it conveys about power and perspective.<sup>29</sup> We believe it is essential for students to develop a critical awareness and skepticism about maps as well as other graphics and images. We close with two examples.

During the Cold War, those who wished to emphasize the danger faced by the United States from communism often portrayed global spheres of influence using a Mercator projection. The size of countries on this type of map is exaggerated as one moves toward the poles. Thus, using this map to depict Eastern Europe, China, and the USSR (often in a bright symbolic red color) made this northerly region seem larger and more menacing than it would have on a map that represented areas more realistically.<sup>30</sup>

Choosing where to center a map also conveys the point of view of the map-maker. Harley points out that centering this same Mercator projection on Europe strongly supported Europeans' view of their global hegemony. This view makes it appear that "two-thirds of the Earth's surface lie in high latitudes," the location of Europe. At the same time "the colonies inhabited by coloured peoples are shown too small."<sup>31</sup> The practice of putting oneself at the center of the map is still common. Most American textbook maps in use today show the world with the North American-European core at the center, dividing the Pacific Rim in half and assigning it to the edges of the map. Not surprisingly, Japanese textbook maps frequently center on the Pacific basin splitting the Atlantic Ocean in half and assigning it to the map's edges.

**Here are three strategies to help students become more critically "carto-literate":**

1. Have students take a problem solving approach by asking them to map a phenomenon, such as murders in the United States, in two ways. First, have them (inappropriately) plot the total number of murders by state. Then after dividing the number of murders by the states' populations, ask students to map the per

*continues on page 432*

**RESOURCES FROM  
RETHINKING SCHOOLS**



**4 easy ways to order!**

ORDER ONLINE:  
www.rethinkingschools.org

CALL TOLL-FREE:  
800-669-4192

FAX ORDER TO:  
802-864-7626

MAIL ORDER TO:  
Rethinking Schools  
P.O. Box 2222  
Williston, VT 05495

**VISIT US AT  
BOOTH 216  
AT NCSS 2006  
IN WASHINGTON, D.C.  
FREE BOOK TO FIRST  
500 VISITORS!**

\*Plus shipping and handling.  
U.S. shipping and handling costs are 15% of the total (minimum charge \$4.00). Canadian shipping and handling costs are 25% of the total (minimum charge \$5.00).

**RETHINKING SCHOOLS MAGAZINE**

The leading grassroots education magazine. Every issue is packed with innovative teaching ideas, analyses of important policy issues, and listings of valuable resources. Two years: \$29.95 (Save \$9 off the cover price!) One year: \$17.95 Subscriptions to Canada and Mexico add \$5 per year.

**THE LINE BETWEEN US  
Teaching About the Border and Mexican Immigration**

Using stories, historical narrative, role plays, poetry, and video, veteran teacher Bill Bigelow shows how he approaches immigration and border issues in his classroom. ISBN 0-942961-31-5 • 160 pages • Only \$16.95!\*

**RETHINKING GLOBALIZATION  
Teaching for Justice in an Unjust World**

"A treasury of ideas and information," according to historian Howard Zinn. Includes role plays, interviews, poetry, stories, background readings, and hands-on teaching tools. ISBN 0-942961-28-5 • 400 pages • Only \$18.95!\*

**OPEN MINDS TO EQUALITY  
A Sourcebook of Learning Activities to Affirm Diversity and Promote Equity**

Activities to help students understand and change inequalities based on race, gender, class, age, language, sexual orientation, physical/mental ability, and religion. ISBN: 0-942961-32-3 • 408 pages • Only \$24.95!\*

capita murder rate. Ask why the latter is more appropriate if one is interested in comparing the murder rate between states. By linking how a map is created to its purpose, students should gain a better sense of ways maps can distort relationships.

2. Have students take an inquiry approach to understand the characteristics of map projections. The objective is to comprehend how projections affect the information maps convey and the conclusions that can or cannot be reached from maps with various projections. Ask students to compare the size of northern regions (e.g., Canada, Russia, Greenland) on world maps with different projections such as the Mercator, the Robinson, and the Peters (See Peters Pacific-Centered map on page 400). Which maps show (relative) sizes most accurately? Which show shape or distance more accurately? Ask students how map readers might be confused or misled if an inappropriate map projection is chosen.<sup>32</sup>

3. Combine problem solving with inquiry by requiring students to collect examples of maps from a range of local, national, and international sources, including newspapers and magazines. Display the maps, and guide students' evaluation of them, questioning the maps' social and political purpose(s), perspectives, biases, and possible distortions. By reflecting on the assumptions made in producing each map, students may develop the habit of mind to view maps critically.<sup>33</sup> 

**Notes**

1. Richard Hartshorne, *The Nature of Geography* (Washington, D.C.: Association of American Geographers, 1939).
2. Peter Haggett, *The Geographer's Art* (Cambridge, Mass.: Blackwell, 1990).
3. Douglas Richardson and Patricia Solis, "Confronted by Insurmountable Opportunities: Geography in Society at the AAG's Centennial," *Professional Geographer* 56, no.1: 4-11.
4. Committee on the Support for Thinking Spatially: The Incorporation of Geographic Information Science across the K-12 Curriculum, Committee on Geography, National Research Council, *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum* (Washington D.C.: National Academy Press, 2005).

5. Sarah Elwood, "Negotiating Knowledge Production: The Everyday Inclusions, Exclusions, and Contradictions of Participatory GIS Research," *Professional Geographer* 58, no. 2 (2006): 197-208; Christina H. Drew, Timothy L. Nyerges, Kevin McCarthy, and J.A. Moore "Using Decision Paths to Explore Three Environmental Cleanup Decisions: A Cross Case Analysis" *International Journal of Environment and Pollution* 17, no. 3 (2002): 171-201.
6. Henri Lefebvre, *The Production of Space* (Oxford, UK: Basil Blackwell, 1991).
7. Michael Gastner, Cosma Shalizi, and Mark Newman, "Maps and Cartograms of the 2004 US Presidential Election Results" (Ann Arbor, Michigan: University of Michigan, Accessed January 3, 2006), [www-personal.umich.edu/~mejn/election](http://www-personal.umich.edu/~mejn/election).
8. Gillian Acheson and Sarah W. Bednarz, "Maps," *The Social Studies Review* 42, no. 2 (2004): 77-84.
9. Andrew R Weiss, Anthony D. Lutkus, Barbara S. Hildebrandt, and Mathew S. Johnson, *NAEP: The Nation's Report Card: Geography 2001* (Washington D.C.: National Center for Education Statistics, 2002).
10. Lynn Liben, "Thinking Through Maps," in *Spatial Schemas and Abstract Thought*, ed. Meredith Gattis (Cambridge, Mass.: MIT Press, 2001).
11. Gillian Acheson, *Teaching the Tool of the Trade: An Exploration of Teachers' Beliefs, Knowledge, and Practices about Maps* (Ph.D. dissertation, Texas A&M University, 2005).
12. Mark Blades and Christopher Spencer, "The Use of Maps by 4-6 Year-Old-Children in a Large-scale Maze," *British Journal of Developmental Psychology* 5, no. 1 (1987): 19-24; Blades and Spencer, "The Development of 3- to 6-Year-Olds' Map Using Ability: The Relative Importance of Landmarks and Map Alignment," *The Journal of Genetic Psychology* 151, no. 2 (1990): 181-194; Neil Bluestone and Linda Acredolo, "Developmental Changes in Map-reading Skills," *Child Development* 50 (1979): 691-697; Joseph M. Kirman and M. Unsworth, "Digital Data in the Grade 6 Classroom," *Journal of Geography* 91, no. 6 (1992): 241; Clark C. Presson, "The Development of Map-Reading Skills," *Child Development* 53, no. 1 (1982): 196-199; David H. Uttal and Henry M. Wellman, "Young Children's Representation of Spatial Information Acquired From Maps," *Developmental Psychology* 25, no. 1 (1989): 128-138.
13. David Boardman, "The Development of Graphicacy: Children's Understanding of Maps," *Geography* 74, no. 2 (1989): 321-331; Karen M. Trifonoff, "Going Beyond Location: Thematic Maps in the Early Elementary Grades," *Journal of Geography* 94, no. 6 (March/April 1995): 368-374; Patrick Wiegand and Bernadette Stiell (1996).
14. James M. Blaut, "The Mapping Abilities of Young Children: Children Can," *Annals of the Association of American Geographers* 87, no. 1 (1997): 152-158; James M. Blaut, and David Stea, "Studies of Geographic Learning," *Annals of Association of American Geographers* 61, no. 2 (1971): 387-393.
15. Arline L. Bronzaft, Stephen B. Dobrow, and T. J. O'Hanlon, "Spatial Orientation in a Subway System," *Environment and Behavior* 8, no. 4 (1976): 575-594; Roger M. Downs and Lynn S. Liben, "The Development of Expertise in Geography: A Cognitive-Development Approach to Geographic Education," *Annals of the Association of American Geographers* 81, no. 2 (1991): 304-327; Jeannine B. Mealey, Malcolm M. Cohen, and Kevin Jordan, "Effects of Map Orientation during Learning on Airport Identification," *Aviation, Space, and Environmental Medicine* 69, no. 2 (1998): 104-110; Phillip Muehrcke, "Beyond Abstract Map Symbols," *The Journal of Geography* 73, no. 8 (1974): 35-52.
16. Patrick Wiegand and Bernadette Stiell, "Communication in Children's Picture Atlases," *The Cartographic Journal* 33, no. 1 (1996): 17-25.
17. Mark Monmonier, *How To Lie with Maps*, 2nd Ed. (Chicago: University of Chicago Press, 1996), 170.
18. Mark Twain, *Tom Sawyer Abroad: Tom Sawyer, Detective, and Other Stories* (New York: Harper 1910): 29.
19. Patrick Wiegand, "Cartography and Geoinformation Science in the Curriculum," (Keynote address, Commission on Geographical Education, International Geographical Union, Glasgow, UK, August 11-15, 2005).
20. Roger M. Downs and Lynn S. Liben (1991); Madeline Gregg and Gaea Leinhardt, "Mapping Out Geography: An Example of Epistemology and Education," *Review of Educational Research* 64, no. 2 (1994): 311-361; M. H. Matthews, *Making Sense of Place: Children's Understanding of Large-Scale Environments* (London: Harvester Wheatsheaf, 1992).
21. Cammie L. Atkins, "Introducing Basic Map and Globe Concepts to Young Children," *Journal of Geography* 80 (1981): 228-233.
22. John J. Chiodo, "Improving the Cognitive Development of Students' Mental Maps of the World," *Journal of Geography* 96, no. 3 (1997): 153-163.
23. James Saku "Map Use, Teaching, and Experience," *Cartographica* 49, no. 3-4 (1992): 38-45.
24. Robert McCloskey, *Make Way for Ducklings* (New York: The Viking Press, 1941).
25. *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum*.
26. Jere Brophy and Bruce VanSledright, *Teaching and Learning History in Elementary Schools* (New York: Teachers College Press, 1997).
27. Reginald G. Golledge and Robert J. Stimson, *Spatial Behavior: A Geographic Perspective* (New York: Guilford Press, 1997).
28. J.B. Harley, "Maps, Knowledge, and Power," in *The Iconography of Landscape*, eds. Denis Cosgrove and Stephen Daniels (Cambridge: Cambridge University Press, 1994).
29. *Ibid.*, 278.
30. Monmonier, 95
31. Harley, 290
32. Judy M. Olson, "Map Projections and the Visual Detective: How to Tell if a Map is Equal Area, Conformal, or Neither," *Journal of Geography* 105, no. 1 (2006): 13-32; and Avner Segall, "Maps as Stories about the World," *Social Studies and the Young Learner* 16, no. 1 (2003), 21-25.
33. John Morgan and David Lambert, *Geography: Teaching School Subjects 11-19* (London: Routledge, 2005), 114.

SARAH WITHAM BEDNARZ is associate professor of geography in the College of Geosciences at Texas A&M University. ROBERT S. BEDNARZ is a professor of geography at Texas A&M University. GILLIAN ACHESON is assistant professor of geography at Southern Illinois University-Edwardsville. Correspondence regarding this article may be sent to [s-bednarz@tamu.edu](mailto:s-bednarz@tamu.edu).