Spatial Concepts in GIS Design

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My current part-time position as co-Director of the New York Center for Geographic Learning has brought an unexpected bonus—standing, for a dozen 18-minute blocks of time every week, on a crowded subway, where writing, telephoning, or even reading a book or newspaper is not feasible. Rather than simply stare at the advertisements, ceiling, or other riders, I got into the habit of taking a couple of densely-worded journal articles on each trip. The selection of articles followed the trails of author citation and keyword searches wherever they led. The result, after several years of "conscientious subterranean inquiry," is a rather sizeable bibliography of thoughtfully digested articles from more than 130 journals in a wide range of related disciplines, including architecture, developmental psychology, linguistics, logic, neurobiology, robot engineering, and vision science, as well as geography and geographic information systems.

The focus of this inquiry is the burgeoning volume of research on human spatial cognition, a field that has expanded even more rapidly since the development of reliable brain-scanning technologies such as fMRI, PET, and TCMS. I think is reasonable to say that these technologies, and the inferences made from them, will prove to be as important in psychology as the theory of Plate Tectonics was in geology. For us in geography and related disciplines, the primary message is that we can no longer accept the simple but in their own way revolutionary ideas of the late 20th century (as encapsulated in Howard Gardner's justly famous book, Frames of Mind: The Theory of Multiple Intelligences). Where he posited "a" spatial intelligence, we must now acknowledge that the human brain appears to have several, perhaps as many as a dozen, at least partially independent structures that seem to be dedicated to doing analytically distinct forms of spatial thinking—e.g., comparing numerosities in different places and the sizes of different areas, preserving memories in spatial sequence, viewing areas or landmarks as part of spatial hierarchies, drawing analogies involving places that are spatially similar in some way, recognizing and describing spatial patterns, and so forth.

The astounding (but, in retrospect, quite predictable) fact is that scores of studies in dozens of journals have independently verified a rather simple statement: different individuals may preferentially employ different modes of spatial thinking to examine the same landscape, map, or other geographic representation, with measurably different degrees of proficiency according to different kinds of assessment. Teasing out any kind of explanatory theory at this time is undoubtedly premature; my own recent effort has been to ignore the nuances and potential conflicts and simply to focus on designing educational materials that might trigger (or at least provide practice in) specific modes of spatial thinking. In the grand scheme of things, these materials and teacher instructions are best viewed as hypothesis generators, not hypothesis provers, although in revised form they could serve as raw materials for controlled studies at some future date (a task that they might serve far better than the imaginary and often patently unrealistic maps that are the focus of a deplorably large number of published studies).

In any case, our maps and supporting materials have been used in a number of New York City public schools that have produced dramatic increases in standardized-test scores in very challenging demographic and socio-economic environments. Scientific integrity precludes any claim of a strong causal relationship between our materials and these test scores—the sample size is far too small and the "experiment" has no controls, in the accepted sense of the word. But we can sleep comfortably at night, knowing that we have honored the doctor's Hippocratic Oath—"Above all, do no harm." In short, there is no credible evidence that devoting significant amounts of time to these specific kinds of geography lessons in kindergarten, first grade, third grade, middle school, and high school have had any adverse effect on standardized reading or math scores.

Partly as a result of these pilot studies, we now have some evidence to use in debates with people who think that studying geography will harm students because it will decrease the class time spent on reading and math, and therefore will result in lower scores on the standardized tests that are such an important part of the educational environment in 2008. Our results hint at the exact opposite: they suggest that if you want to improve scores on reading and math tests, you should at least consider teaching more and better geography!

It is from this perspective that I can now return to my initial research interest on the origin and propagation of error in GIS and its applications in resource management. One tentative but potentially disturbing pair of conclusions (both solidly supported by dozens of research studies) is that different people may preferentially perceive different things in a geographic representation, and that modern GIS software does not support all modes of spatial thinking equally well. As a result, the knowledge gained from a geospatial analysis may not be equally approachable by all the stakeholders who may have an interest in its application.

And that is probably a topic for another decade of research!