Design and/or Default: Assaying Cartography in the 21st Century

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Abstract

"Visualization … an act of cognition, a human ability to develop mental representations … the use of concrete visual representations – on paper or … other media – to make spatial contexts and problems visible." [MacEachren *et al.*, 1992]

While CAD, employed in the production of infrastructure maps, revolutionized the monitoring and maintenance of utilities and transportation and communication networks, GIS has made it possible to analyze and present information for a wider sphere of environmental management situations.

Experts routinely base important, far-reaching decisions upon maps made using geographical information systems. On the other hand, almost everyone interacts regularly with maps in print and electronic media. Less skilled at map use, the general user may not understand even these simple maps and be baffled by the informational complexity of even the most carefully contrived simplifications of the environment. Even familiar environments may look foreign when a map depicts abstract attributes (such as the ratio of family income to poverty level). Maps of such non-experiential phenomena may make spatial contexts visible, but they probably do not provide an adequate base for appropriate environmental understanding.

It is time to address some difficult questions. How conceptually and operationally dependable are software **default** options? How realistically and understandably can experiential and abstract **landscapes** be portrayed? What is the foundation of map **design** … what are its fundamentals, limits, and obligations? What is the role of design in assuring optimal visualization?

1 Maps, Geographical Information Systems, and Their Users

The premise is relatively simple: maps are the critical components of any geographical information system, and they must do their jobs efficiently in the input stage, the processing stage, and the output stage. Considering the last stage, what job is the map (the principal product of any venture into geographical analysis) supposed to do? Considering the user, a key element at this point in the operation of the GIS, what behavior should result from the use of the map? Performance (of the map, and by the user) becomes the key issue … and the manner in which the map has been produced, the critical stage in the operation of the GIS, is of extreme importance.

It is this last part of the process that is the focus of this paper. We must assume that the input in the first stage of the GIS, the data that are the substance of the overall analytical process, have been gathered and organized by professionals, by experts, by power users … not by novices [Bailey 1996, 242]. Given the purpose and goals of a GIS, one has to be assured that the original data are more than appropriate … they must be accurate, unbiased, and more.

Similarly, the processing stage must be carried out by equally qualified people and appropriate software. It would also be comforting to know that these first two stages have been carried out with the "end user" in mind … that the final product has been organized so that the person(s) who must use the output of the GIS to obtain and manage the environmental information can handle the information accession and analysis tasks efficiently.

2 Map Use: The Extremes: Cartometrics and Visualization

There are two extremes in user activities with mapped information. Computer-assisted design, computer-mapping, and geographical information systems have made it possible to produce with great ease many different types of maps. The role of CAD in the production of infrastructure maps has, in a quarter of a century, revolutionized the monitoring and the maintenance of public utilities and transportation and communication networks.

In these cases the map (GIS) is created for what can be called "cartometric" activities. In this type of situation, the map is used as an "instrument" … measurements are made, and data are plotted [McCleary *et al.* 1993]. There are many types of maps (and charts) made with this purpose in mind: nautical and aeronautical charts, architectural and highway plans, and geological and soil maps. In these cases, the situation is clear: detailed data are necessary to carry out the navigation (wayfinding) or the "environmental management" tasks. These "concrete visual representations … make spatial contexts and problems visible" [MacEachren *et al.* 1992]. The course can be set and followed, the site surveyed and the construction undertaken, and the field work and laboratory analysis expedited.

Cartometric activities generally lie in the realm of the expert and the professional, and effective use of the map happens only as a result of considerable education and training. At the opposite end of the spectrum are those maps that are created purely as "displays" … the environmental portrayal is created for visual examination, for the eye-brain (the front end of the human cognitive or information processing) system to perceive and then, as necessary, cognize the information [Lindsey and Norman 1972, Wickens *et al.* 2004]. No measurements are made, save those carried out in a purely visual way. This "visualization" activity happens all of the time, to everybody, expert or novice. In using maps to make some of these visualizations, there are SWAG and guesstimates. The media abounds with opportunities to see great variety in these types of map uses … as do many environmentally focused activities.

When assessing "visualization," the quality of the map must be measured not only with respect to environmental representation but also in terms of the capability of the user to understand and make associations between the environment that is familiar and understood and the information presented. It is not that the map should be carefully crafted, but rather that the map fit the user and the map-use situation. That is, very often, a tall order!

The *New York Times* provides, on a continuing basis, a perspective on this point. While the column-width location maps are a fixture in utility, composition, and style, the maps used in the Sunday Travel section have changed. For a long time, the maps of cities have been quite graphically sophisticated, with a carefully balanced color scheme and a topographic map level of precision. Recently they have changed, to a style involving more “exciting” colors and a less formal base map. Features are shown in a “cartoon” style. One could describe the change as having been one from conservative to popular, from formal to informal. One suspects that in this “new” approach the *Times* has begun to look at the reader differently.

Between these two extremes, on the one hand, the maps required by the navigator, the surveyor, the engineer, and other infrastructural operators and, on the other hand, those promulgated for news and sports fans, students in all levels of classrooms, tourists … etc., etc., and so forth, there are other types of maps and systems for navigation and environmental management. Someone makes them and many use them. It is more than just communication; it is interaction, and this leads to a behavior, a response not simply to the communicated information but more to the user-generated perspective of the environmental situation encouraged by the map [McCleary 1987].

3 Environments, Maps, and Users

There are, for unskilled map users, maps that provide representations of familiar, directly experienced environments. On the other hand, some users are confronted with maps portraying unknown, unfamiliar environments … the maps become surrogates for these environments, environments that are remote, and they have not been directly experienced by the map user … they are clearly “foreign.”

There are, as well, environments (actually attributes of environments) that, although they might be “local” or “down home” in terms of spatial location, are portrayals of features, abstractions, that cannot be directly experienced. One cannot go into the field and observe these features (attributes) directly, because they do not have a visible manifestation. Consider the environmental associations of a user looking at a map of the ratio of family income to poverty level, or one of the percentage of the population under five years of age, or something like the relationship between income and median school years completed. These are all characteristics of an environment, and a well schooled researcher could deduce differences in the environment that might suggest these types of characteristics for a previously studied geographic area. Most map readers will not “see,” *i. e.*, find these features visibly displayed, in the landscape.

When you get into cartography, involved in map making, you see that even a simple map is very complex. However, there are significant things to be considered, none the least of which is a clear understanding of what the map is supposed to do. Look at the map as a behavior-modification device. How is someone’s behavior supposed to be directed because of (or as a result of using) a map? There is, obviously, the “text,” and accompanying that the “subtext” that “lies behind and beneath the actual words…” [Halio, quoting Stanislavski, 1989]. For our purposes, convert “text” and “words” to “mapped features” and “symbols.” To carry the subtext concept further, see for one perspective McCleary 2003.

Then there is the context, for a single example, in the media situation. The context is the immediate or the familiar/associational environment. Maps of Kansas (the simple 200-mile by 400-mile outline), with a simple circle locating Kansas City, have become the only context for the location of a place in the state (although, in recent issues, the *Kansas City Star* has in some instances included interstate highways).

4 Representations and Surrogates … and User Abilities and Associations

Context, as it relates to maps and particularly to the map user, involves two different things: *representations* (what Schwartz [2002], dealing with the psychological study of picture perception, calls the “symbolic paradigm”) and *surrogates* (his “surrogate paradigm”).

> According to the symbolic paradigm, all that is required for representation, in its broadest sense, is that an item purports to refer, be about, stand for, denote, in other words, serve as a *symbol* for something. … [Maps, for example,] … can convey accurate or inaccurate information about real and imaginary worlds, [a map] can and does play a role in guiding behavior and informing the mind. On the symbolic account, [maps] are to be distinguished by their structural properties … What is distinctive of pictorial representation are the syntactic and semantic principles governing [their] use, not some unique alliance with vision that fixes and determines depictive meaning. [261-62]

In contrast,

> pictures represent by virtue of being *surrogates* for items and scenes in the world. The main difference between perceiving pictures and perceiving the actual environment is that in viewing pictures we are looking at stand-*in* objects, not the real things. Pictorial representation succeeds only when the surrogate ‘mimics’ the original, thus making it possible to find out about the latter by looking at the former. [257]
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> … A picture serves to convey information about the world by being an appropriate substitute. … ‘Realistic’ pictures are the coin of the realm. … we perceive these real pictures the same way we see the objects or scenes for which they serve as substitutes. … Pictures, therefore, do not serve as surrogates by mimetically rendering or copying most of the properties of the object represented. Instead, they convey highly selected information about the represented scene. [258-259]
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> … understanding realistic pictures is something our *visual* system does, without *cognitive* intrusion. The use and comprehension of other kinds of

> depictions and descriptions involve more than the visual faculty. Extracting the representational content of cartoons … like comprehending sentences in English, involves cognition or mind. By contrast, it is not necessary to interpret or read realistic pictures. They are simply *seen* to represent what they do. [265]

Schwartz provides us with a major distinction, one between lower order cognition of displays, totally perceptually organized displays, contrasted to those that require significant cognitive stage processing.

> Cognitive processes are those depending on prior experience. In order to comprehend a sentence, we must learn the syntactic and semantic features of the language. This is what makes understanding of a sentence a cognitive act. The same is said to hold for music notation, maps, diagrams, Egyptian and Cubist pictures. Skill at extracting the representational content of realistic pictures is different. It does not require experience or practice. … evidence for untutored comprehension of cartoons, caricatures, and other non-paradigm kinds of depiction my not be very different on this score. [266]

The question raised is what level of map is being read, visualized, and what type of information system processing will be involved. And, while we are looking at this, what difference is there processing the "text" of the map as contrasted to the "subtext."

Geographical Information Systems have extended the advantages of computer processing to the development of a broader range of maps … maps designed for all facets and all levels of environmental management. It is possible at one extreme for planners and politicians, for developers and managers, to use the plethora of maps that can be generated by a GIS to examine systematically many facets of an environmental situation. On the other hand, there are less significant uses … and users. Fomented by the media and the textbook, issues (with their carefully chosen words and carefully designed maps) are presented for consideration by an audience that is, collectively, less capable of understanding and using maps than the professionals that depend on them.

At issue here is an old problem, the "image" [Lynch 1960, Lewis 1996]. Long before that, there was the cartographic concern for mapping land surface form [Robinson 1995]. The physical landscape underwent, over centuries, a transition in representation from symbols to pictures to surveys [Harvey 1980]. With all of the representational capabilities available for the last two hundred years, the issue continues to be whether to represent land surface form "visually" (for example, shaded relief, or one of dozens of other options) or "commensurably" (contours). For cartometric purposes, contours provide the only reasonable solution. For maps in which user visualization of the structure and features of a landscape, understanding the spatial patterns, is important, the choice is more difficult. The scale of the map is a factor, as are a number of production issues (the least being time and money).

From a user perspective, however, it is a matter of whether the map will be a representation or a surrogate … what is the level of familiarity of the user not only with the different forms of land surface form presentation but also with the environment being portrayed.

5 Some Problems … and the Prospects

Consider, for a moment, the manner in which to deal with **map projections** (a topic obviously too large for a quick examination and one that seems to continue to avoid easy solutions).

The user and the map are the elements that fix the sequence of events that result in the choice of a map projection. There is a **purpose** for the map, a task to be performed. The user and the map work together to complete the task. As Denis Wood points out in his *Power of Maps* [1992], on page 1, "maps … work"

With the purpose clearly in mind, the task carefully considered, the first choice that needs to be made is of the **properties** of the map projection. What kind of task will be performed, and what of the characteristics on the sphere need to be retained on the map's flat surface. Simply, if you need angles to be represented correctly throughout the map, conformality is the choice. If the map is to portray certain types of data, then equivalence and the correct proportion of areas across the earth must be used. The repertoire of choices is large … cartographers have created a lot of projections with unique properties over the last several millennia [Snyder 1993].

Concomitant with the choice of the property of the projection is the determination of the **position**, or the arrangement and the extent, of the projection relative to the globe. This approach to projection selection has been articulated by Snyder [1987] and elaborated by many others. How large is the area to be mapped? Where does it lie on the globe? How does one handle this efficiently, so that the spherical surface is portrayed most efficiently (for the purpose of the map) on the plane.

This questions answered, a solution should be obvious … if the person making the map has the necessary background. Or if there is some online help in making the choice. Or if the default option (or the manual that explains how to use the program) leads to a single choice, or a small set of choices.

Projection choice, like a lot of other issues involved in designing a map, involves design … and effective design requires planning.

Then there is "word" choice … **vocabulary** … the graphic components that will be used to represent the features of the environment. The traditional approach articulated by Wright [1943] yielded to the semiotic-based visual variables, described by Bertin [1967] and extended by others [see MacEachren 1995 and Wilkinson 1999]. Though thoroughly examined and illustrated for decades, there are still problems converting numerical data to graphic formats. Some of these result from stupidity, others from misunderstanding, and still more from the lack of imagination!

How many erroneous choropleth maps are produced each year, the author (cartographer) lacking the correct understanding of data structures and the application of this technique to a mapping situation? How many maps are made without application of the more than half a century of perceptual research into the characteristics of the visual variables [for example, Wright 1938, Williamson 1982, and Stevens 1975]? Consider the work of Kosslyn [1985, 1989, and 1992] for an underappreciated perspective on this activity within the process of human information processing as a whole.

Finally, at his purely application level, consider the problem of **generalization** and the choice of an appropriate database. Why not a simple cautionary note when, as the default database for the software is used to develop a map, the software system provides the user with a note pointing out that "The database being used is appropriate for maps with scales between 1:x and 1:y."

6 Design = Planning

Design, and the planning that provides its foundation and increases the potential for success, is an iterative process. Berryman [1979] illustrates this nicely in several different ways.

At each stage in the process there is feedback … having completed a stage, the designer (cartographer, map author) re-examines and, with the purpose and goals of the map situation firmly in mind, decides whether the process of development continues or pauses for revision. At every stage there is retrospection … and when the product, the map, has reached an appropriate point in its development, it is examined by the client, a potential user, or a panel of users … is it working? Does it appear to have the characteristics necessary to do the job?

Before there were computer-supported production processes, many of these in-process examinations had to be performed using rough sketches (executed using pencils and pens and the other manual tools of the graphic artist). The "almost-final" version, the "design comprehensive" that preceded the production of the map and the "proof" were, at best, treated suspiciously, with hope that they really had met the goals for the display. Today, the series of rough sketches, the final one of these being almost a design comprehensive, yield quickly to a computer-produced version. This can produce a more realistic, and much earlier, approximation of the final document. And this can be revised and revised, again and again!

There is, however, no clear substitute for the pencil-and-paper planning process (for example, see Voegele 2006). It is easy to do a sketch, throw it away, then make a new one with modifications, then try again. When designing, it is probably very important to do so "outside the box!" The computer probably will not do it for you … unless you are really very good with a graphic design program. For most of us, sketching will probably work better … outside that box.

The sketch … and its meaning to the individual … create a personal shorthand. The result may be a continuous series of preliminary approaches where the designer is unsatisfied. It may be wrong, out of scale, and poorly formatted, and lacking in actual geography. But all of that gets better and better iteratively during the course of the design process. The base map will come in along the way … once properties, position, and all of the choices involved there have been accommodated through the groundwork in the planning, the design, process.

Krygier and Wood [2005], in their new textbook, endeavor to answer in a systematic fashion the question of "How do you make a map?" Reducing conceptual and philosophical discussion to a minimum and relying primarily on a graphic discourse (significantly more space is devoted to graphics than to words), they deal with the stages of creating and organizing a map, with the purpose and the user in mind from the outset.

This volume is significantly different in approach from the encyclopedic approaches of Robinson *et al.* [1995], Dent [1999], and others, not to mention the series of manuals that have been produced to support the use of GIS applications.

It might be said that we have yet to reach a "user-responsible" stage in the development of GIS software. More important, perhaps, is the recognition that there is an abundance of unsubstantiated (personal opinion-based) guidelines for map production. Further, there continues to be a propagation of fundamental errors in data organization and symbolization, not only in the textbooks and the manuals but also in the all-important practices of responsible map-producing organizations. Finally, and most disappointing, is the unrelenting lack of imagination; innovation is not simply overlooked … it seems to be lost in the high seas of technological change.

> Geographic visualization (GVis) refers to the ability of maps, graphics and images to make visible spatial relationships. As such one of its primary objectives is the very geographical desire to find spatial patterns in the data. To some extent, visualization is what cartographers have been doing all along in the sense of making aspects of the world visible, but there are important differences. Geographic visualization also refers to the added capabilities of interactive mapping software such as rotating the data in three dimensions, adding or stripping away data layers during data exploration, or querying the map interactively. [Crampton 2001, 244]

As this process of development continues, with the advent of new tools and toys to help us all find the spatial patterns in data, we need to recall what we already know about the users of maps, and then turn our attention to the kinds of things that we need to learn about users as they confront the new technology.

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