Usability Studies of Geovisualization Software in the Workplace

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Abstract

"Quality Graphics for Federal Statistical Agencies" is a three-year project funded by the National Science Foundation (under the Digital Government Program) and eight federal agencies. The project research objectives are to develop and assess software that will enable data exploration by federal-agency users (who are evaluating data quality and looking for trends in data) and that will communicate statistical summaries to the public. Of the larger research project, this paper covers one part: Census Bureau participation with The Pennsylvania State University in usability studies of software for geographic data visualization. The Census Bureau is working with the university researchers to provide early feedback, even as the researchers are creating and evaluating a variety of tools for visual representation, that ultimately federal agencies can share. Analysts at the Census Bureau were interviewed for information on types of data and analysis tools currently used and for opinions on geovisualization tools that would support their data exploration and analysis tasks. This paper discusses the workplace interview as a data-gathering technique. It reports the interview results, to-wit, users would like to explore their demographic data in adjacent and more remote geographic context, as time series, in conjunction with other variables, would like to be able to compare results of two models and see their differing effects in different geographic regions, and more. Even at early stages of software development, Census Bureau analysts need to be able to explore their own data (not a test data set). That function will be added to the geovisualization tools and analysts again will be interviewed as the next step in the iterative software development and usability checks.

1. Introduction

"Quality Graphics for Federal Statistical Agencies" (dgQG) is a three-year project funded by the National Science Foundation (under the Digital Government Program) and eight federal agencies with research objectives of

- Developing and assessing software that will enable exploration by federal-agency users evaluating data quality and looking for trends in data and
- Communication of statistical summaries to the public.

University participants in the research are geographers at The Pennsylvania State University (Penn State) and statisticians at George Mason and Rice universities. Federal-agency participants are the Bureau of Labor Statistics, Bureau of Transportation Statistics, Census Bureau, Energy Information Administration, Environmental Protection Agency, National Agricultural Statistics Service, National Cancer Institute, and National Center for Health Statistics. Industry participants are AT&T and SPSS.

Of the larger research project, this paper covers one part: Census Bureau participation with Penn State in usability studies of software for geographic data visualization. The Census Bureau participation is focused on three research tasks: 1) participate in research on mapping and graphing visualization tools that would be useful to analysts exploring statistical data; 1) be subjects in testing once those and other components are developed; and 2) be subjects in research on methods to effectively obtain user feedback. Census Bureau population-statistics experts first participated by describing current tasks and tools to inform software development through interviews in July 2001. This paper discusses both the information-collection method—open-ended interviews—and the interview results to date.

The geographic data visualization environment under development and employed here is GeoVista Studio, a Web-based workbench with java-based components that can be assembled without further programming by a data analyst. At the time of the interviews discussed here, Census Bureau participants could preview mapping, parallel coordinate plot, and scatter plot matrix functions for analysis of georeferenced statistical data in Studio.

2. Method Overview

2.1 Interviews in the Workplace

Authorities in geographic representation research call for real-world participants and usability studies in geovisualization research (Slocum et al. 2001) and assert the importance of qualitative evidence together with quantitative study (MacEachren and Kraak 2001). They draw on the work of usability professionals who preach consistently that including users at all stages of the software design process is a critical step towards human-centered software (Mayhew 1999, Nielsen 1993). My previous work includes advocacy for an expanded toolkit of research tools, including qualitative methods, as geographic representation research shifts from the controlled lab environment to real users in place (Suchan and Brewer 2000; Suchan 1998). Qualitative data-collection methods such as verbal reporting (questionnaires, interviews, or think-aloud protocols) and participant observation are well suited to eliciting information early in this collaboration, when researchers and users are learning each other's work environments, goals, and needs. By the end of this project, a report can be made on the benefits of open-ended interviews and other qualitative methods in developing "usable" software. Elsewhere in these proceedings is another report by dgQG researchers at the National Cancer Institute and George Mason University on quantitative testing of particular geovisualization components; see "Interactive Linked Micromap Plots and Dynamically Conditioned Choropleth Maps" by Daniel B. Carr, Jim Chen, Sue Bell, Linda Pickle, and Yuguang Zhang.

3. Participants

Participants are analysts in the Population Division at the Census Bureau who prepare inputs to population estimates. Population estimates are the numbers the Census Bureau produces for the nation, states, counties, and smaller geographic units in non-decennial years. Estimates use the decennial count as the base and update the base annually with other data series such as births, deaths, and domestic and international migration from other federal and state statistical agencies. The estimates are reported on up-to-date geographic units (for instance, Broomfield County, Colorado was created in 2001 so Census 2000 data will not be reported for it but the county population estimates published for 2002 will show its population base for April 1, 2000 and population estimates for each year thereafter. The four surrounding counties will show a compensating reduction in their population base). Potentially, then, there are multiple changes over time to be examined and analyzed in the population estimates data: how the population is estimated to change in number, which data inputs contribute to the change, and how the population is distributed in current geographic units. Beginning in the mid-1990s, population estimates were provided to the public on increasingly fine levels of geographic detail. In the current decade, there is interest in public release of more detail on demographic components (i.e. births, deaths, migration) and characteristics (race and ethnicity, age, sex) for the finer levels of geographic detail.

Typically in qualitative research and in the field of usability studies, researchers engage a small number of information-rich cases (Nielsen 1993, Patton 1990). These interviews involved three analysts, population-statistics experts who routinely evaluate data quality and look for emergent trends in their data. One analyst/ participant does quality control on migration data (originating with the Internal Revenue Service) as an input to population estimates. Another studies group quarters populations; her data are on populations in prisons, college dorms, nursing homes, military housing and so forth. Getting these right, in the right localities, affects the veracity of population estimates at the finer levels of geographic detail. A third analyst/participant works in the program to update the geographic areas.

In July 2001, Frank Hardisty of Penn State conducted interviews with the Census Bureau analysts to determine the analysis tasks, the kinds of data they typically work with, and to discuss tools that would support the analysts in their tasks. Hardisty demonstrated the geovisualization environment, Studio, and was able to observe the analysts' work environment. Several important observations surfaced because Hardisty was at the workplace. The analysts need to test the software with their own data and analysts are individual keepers of the Census Bureau confidentiality commitment. In July, analysts were able to see test data only. Analysts do not explicitly have time to participate in the dgQG research. They need to make the task a priority among competing job responsibilities and they can justify doing so only when they are finding insights into *their own* data. Thus, adding the ability to import data to the geovisualization software became the highest-priority follow-up to the interviews. Regarding the second observation, the exploration tools will be most useful to analysts—thus enabling them to give extensive input to the software usability studies—before data are in the public domain. That raises concerns, however, about confidentiality of data. One desired use of the geovisualization tools, for instance, would be to compare Census Bureau group quarters data on nursing homes with Medicare records. There are several issues of confidentiality here. The Census Bureau group quarters data are not published; the data stay in-house as inputs to broader published statistics. The Medicare data are in effect on loan to the Census Bureau and not in Census Bureau authority to release. There are procedures to manage confidentiality with the university researchers when on site, and when examples from the analysts are used in papers and presentations. The realization of confidentiality issues did not yield an action step for the software designers, rather, is an example of consequences that attend the benefits of research in the federal workplace.

4. The Interviews

4.1 Analyzing Qualitative Data

The interview goals were addressed by direct questions in each interview and a final group session. About two hours of interview tapes were produced in the first interviews. Tapes were professionally transcribed into simple digital text documents ready for use in qualitative-data-analysis software that facilitates coding variable-length chunks of text with categories developed specific to the project, which then enables comparisons, groupings, etc. of text chunks. This, in other words, is content analysis in its sense of a technique to pull out major themes, categories, and examples from non-numeric data (rather than the sometime alternative definition of counting frequencies of key words, content chunks, or other tallying functions) (Miles and Huberman 1994; Patton 1990). The transcripts were studied and coded for:

- Typical types of data
- Current tools used for data exploration
- Analysis tasks
- Geovisualization tools that would support analysts' tasks
- Desired usability for geovisualization tools

4.2 Interview Results

The table below shows comments selected and summarized from the interviews transcripts. *Types of data* the analysts use come from the Census Bureau and other federal agencies (e.g., previous census counts cast on current geography; tax return data) and from localities. Statistical data are transformed to variables needed to model population estimates; for example, analysts will calculate the migration rates between counties, between in- and out-of-state counties, and within and between states. *Tools applied now,* SAS and Excel, primarily produce tables; the rough plots from SAS supplement tables. GIS is available to analysts and is used more or less depending on analysts' interest and time to learn the software. As to *type of analysis,* currently analysts try to look at change across geographic units both adjacent and remote (such as migration flows from a county to the counties in the same state and flows outside the state); change over time; outliers in a data set; and discrepancies in geographic distribution in independent data

sets (for example, foreign-born population from Census Bureau then Immigration and Naturalization Service sources).

Desired characteristics of future analysis tools has two parts, function and usability. Ideal functions of a geovisualization tool would make visible tasks analysts already try to do (e.g., see a compensating problem in migration numbers in separate geographic units as might be caused by a large re-assignment from one military base to one in another state), and make them easy to do together. New functions that analysts hope geovisualization tools could provide are those that would enable more comparisons (see numerical and percent change at the same time; add a variable such as agricultural counties) with more detail (place level; data by type such as nursing homes separate from hospitals) and, where anomalies need more investigation, be able to dig down to the details. While asking for added dimensionality in geography, characteristics, and temporal components, analysts expressed usability wishes such as, make it visually easy to work—visually easy to interpret; make the data-exploration process quicker; make it more interesting. These statements may seem vague, but they touch on broad usability goals (and broad dgQG project goals) and eventually requests such as make the process quicker can be tested objectively.

5. Final Remarks

Two of these user needs that emerged from the workplace observations and interviews now are under development as Studio components: a function, which allows users to append their own data to geographic boundaries (so analysts can map their own data) and a set of animation facilities for visualizing time series. Analysts should have had a first look at this function by mid-May and will then provide the next round of user comments in the participatory design cycle.

The research just described is focused on agency experts (subject-matter experts who also are expert in computer-aided data analysis). Federal agencies contributing to this research project all are interested in how to deliver to the *public*, also, and the dgQG project plan proposes to enable communication of statistical summaries to the public. But it is increasingly understood that these are different design projects: “Whilst geovisualization products for experts might need support for customization, public access geovisualization tools may be more effective if some standardization is imposed” (Cartwright et al. 2001, 48). The MapStats for Kids demonstration project, added to the dgQG project, will provide statistical and geographic information to one segment of the public; see in these proceedings Supporting Statistical, Graphic/Cartographic, and Geographic Literacy through Online Learning Activities: MapStats for Kids by Alan M. MacEachren, Mark Harrower, Bonan Li, David Howard, Roger Downs, and Mark Gahegan. For the work at the Census Bureau just described in this paper, we expect that enabling analysts to do *their* jobs better with tools developed in this collaboration will serve the *public* better.

Types of data:
- Annual tax return data on county-to-county address changes
- In migration, out migration, net migration at a county level
- Calculated migration rate (includes calculating non-movers)
- Military data from the Department of Defense (group quarters component)
- Group quarters data from the Census Bureau and from states (by street address)
- The previous census counts cast on current geography
- Housing-unit counts

Tools applied now to analysis:
- Excel
- SAS
- Plots in SAS: "I produce zillions and zillions"
- GIS—map the outliers
- Contact a local source: call a city planner, call the nursing home and say, "Is this nursing home inside or outside [a place]?"

Type of analysis currently performed:
- One migration flow from county A to county C, over time
- All of the flows going out of county A to the counties in the same state
- Counties in other states
- Flows within the state
- Flows outside the state
- Identify artificial change because ZIP codes change: nobody moved, ZIP code was reassigned
- Look for consistency across time—any large jumps are flags
- Looking for anomalies within the data series
- Unusually high number or an unusually low number
- Dealing with two different sources and the discrepancies between them
- Look at areas where the data from the states is higher than the Census
- Looking at foreign born population from the Census and comparing with [INS] immigration data…not for a match [because different data sets use different inputs, methodologies, etc] but for distribution
- Pairwise comparisons of components: race by age, age by ethnicity
- Loss function that takes into account the numerical and percent difference

Desired characteristics of future analysis tools: Function
- Map the migration rates
- Complete comparison flows each county to all others
- One display of county ins and county outs
- State in and state outs
- See compensating problem in adjacent geographic units [ZIP code example above]
- See compensating problem in separated geographic units [e.g. mass re-assignment from one military base to another in another state]
- Another display that's non-movers
- Time series
- Show the current year's change from last year
- Study a county that is an outlier of multiple components
- See the numerical change and the percent change at the same time

Table. Selections from interviews.

Desired characteristics of future analysis tools: Function (cont.)
Context-sensitive anomalies highlighted: a county with large population loses 100 people, that's not an anomaly; but if it appears all 100 go to an adjacent lightly populated county resulting in a high percent population gain there, that should be flagged
Place level
Do it by type [for group quarters, type is nursing home, hospital, military, etc]
Producing different migration rates with a new method, looking at areas that have the largest difference between the two methods' results
Look at this geographically to see if there's regions of the country that are more impacted by new analysis method than others
If different, what are characteristics?
Add in some other variables…for example counties that are primarily agricultural, if they have very large differences if we shift to this new method
Desired characteristics of future analysis tools:Usability
Visually easy to work, visually easy to interpret
Make the process quicker
Make it more interesting

Table, cont. Selections from interviews.

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