Applied Geography xxx (2014) 1–6

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

# Evaluation of web GIS functionality in academic libraries

Ningning Kong*, Tao Zhang, Ilana Stonebraker

*Purdue University Libraries, Purdue University, West Lafayette, IN, United States*

ARTICLE INFO

*Article history:*
Available online xxx

*Keywords:*
web GIS
GIS functionality
Usability
Information seeking

ABSTRACT

The rise of web-based GIS resources has expanded the scale and scope of spatial information seeking in most, if not all, academic libraries. Even without formal GIS training, users can search for spatial information, create customized maps, as well as perform simple spatial analysis. However, few systematic evaluations have been conducted to summarize common web GIS functionalities as GIS moving from traditional desktop applications to the web. In this study, we evaluated and assessed the major functionalities of web GIS applications and their potential value for information discovery and access, using six most popular applications in the academic libraries. In addition, since web GIS targets non-GIS professionals, we also conducted an empirical usability evaluation of the six GIS applications in academic libraries. As the result, we identified eight major GIS functionalities that web GIS offers for information seeking purposes. The usability evaluation suggested that a user-friendly web GIS application should provide users a clear starting point, predictable map interaction, flexible customization capabilities, and familiar web experiences. Our study is one of the first studies to examine web-based GIS functionalities and their associated usability in a systematic way. The results will serve as an important reference for web GIS developers.



## Introduction

With an increasing number of web map standards (OGC, 2013) and web mapping Application Programming Interfaces (API), web GIS applications have reached new levels of sophistication and prominence unheard of in earlier decades (Batty, Hudson-Smith, Milton, & Crooks, 2010; Crampton, 2009; Haklay, Singleton, & Parker, 2008). As a result, the use of web GIS to deliver information is facing a dramatic expansion (Chow, 2008). This brings new opportunities for information-seeking and visualization in academic libraries (Bennett & Nicholson, 2007; Weessies & Dotson, 2013), as spatial information is often embedded in various library databases. Taking business data as an example, it is estimated that more than three-quarters of data in the libraries contains a geographic component (Brody, 1999).

Meanwhile, GIS functionality has also evolved (Kim & Kim, 2002; Kraak, 2004; Lu, 2005). Unlike traditional GIS software supports, it is unnecessary for each web GIS application to include all geospatial operation components. On the other hand, new expectations emerge, such as a user friendly interface design, as the number of users without formal GIS training increases (Newman et al., 2010; Nivala, Brewster, & Sarjakoski, 2008). Web GIS developers need to rethink and redesign traditional GIS tools and features to enhance their usability, especially in terms of learnability, flexibility and robustness.

In this paper, we conducted functional reviews and usability tests of six commonly used web GIS applications in academic libraries to explore the major functionality and usability factors that enhance the performance of web GIS as an information discovery application. We highlight the prevailing web GIS functions and their usability concerns, which will serve as a reference for web GIS researchers and developers.

## Background

GIS functionality has been classified and discussed from the very beginning of GIS technology (Goodchild, 1987; Maguire & Dangermond, 1991; Maguire, Goodchild, & Rhinds, 1991). Traditional desktop based GIS functionalities, including mapping, database, and spatial analysis, has been challenged when desktop GIS moves onto the web (Kraak, 2004). For mapping, web users pay more attention to map interactivity, manipulation capability, as well as usability, in addition to the traditional static map products

* Corresponding author. EAPS Library, Purdue University Libraries, Purdue University, 504 W. State St., West Lafayette, Indiana 47906, United States. Tel.: +1 765 496 9474.
*E-mail address:* kongn@purdue.edu (N. Kong).

http://dx.doi.org/10.1016/j.apgeog.2014.11.017
0143-6228/

(You, Chen, Liu, & Lin, 2007). For databases, data models are hidden in the back-end from web users, and database query function becomes more important than before. Spatial analysis is still an important component in web GIS, although it is not necessary for web GIS to include as many spatial analysis functions as traditional GIS. Web GIS applications should deliberately pick a reasonable number of goal-oriented spatial functions to provide users the query or analytic capability while not overwhelming them (Musser, 1997).

In the academic library research literature, there have been several review studies introducing web GIS for information users. Cobb and Olivero (1997) reviewed several online GIS services and listed some possible "pitfalls" GIS websites might have, including non-intuitive design, too intensive mapping functionality, lack of cartographic design, etc. A more recent review has considered the map import/export capabilities as the major GIS functions for information seekers (Kidd, 2010). From the research and education support perspective of academic libraries, Weessies and Dotson (2013) used three case studies to demonstrate the importance of historical data and data download functionality of web GIS. Although some important GIS functions and web GIS design flaws have been identified by information scientists, these web GIS functionality and usability issues have not been systematically studied to address the needs of web GIS users and assist developers in improving web GIS applications. In this paper, we extend previous research and identify major web GIS functions together with related usability concerns from an information seeking perspective.

## Research method

The six web GIS applications selected for this study were Reference USA (RU), SimplyMap (SM), PolicyMap (PM), Social Explorer (SE), Proquest Statistical Datasets (PQ), and ESRI Business Analyst Online (BAO). RU offers Google Map based database information on U.S. and Canadian businesses, employers, and residents. SM, PM and SE enable non-technical users to create custom maps and reports with focuses on business and marketing (SM), political science (PM), and current and historical census information (SE). PQ offers a collection of 17 subjects statistical data in both map and table formats. And ESRI BAO is a web map-based solution for business site evaluation and market analysis.

These applications were selected based on their prominence among academic libraries as could be ascertained by reviewing library resource pages. An email was sent to the business librarian listervs BUSLIB-L (2000 subscribers) and BRASS-L (900 subscribers) in May 2013 to request feedback on the working list of web GIS databases. These requests resulted in 18 responses, mostly affirming the list already gathered. The functionality and usability evaluation discussed here was based on the latest version of the six applications as of December 2013. For functionality evaluation, we collected product information from vendors and we documented and ran test cases of all listed functions for each web GIS platform. We then synthesized and classified the functions available in each application into different categories for comparison.

Based on the identified GIS functions, we designed four tasks for usability evaluation, which are commonly used in web GIS platforms and represent a typical workflow of using a web-based mapping application for users without GIS background. These four tasks include: (1) create a customized map about a business-related variable for Indianapolis, IN; (2) change the color and corresponding data range of mapping units on the map; (3) search for another location (Provo, UT) on the map; and (4) export the map and save it to a local computer. Seventeen university students were recruited through an advertisement posted on the Purdue University Libraries website for usability tests. The participants reported extensive experience with Google Maps or similar products but very little experience with other GIS software or web GIS applications. Response measures of each task include: (1) score of the participant's successfulness in completing the task (0 – completed with ease, 1 – completed with difficulty, and 2 – failed to complete); (2) time to complete; and (3) number of times an error occurred. In addition, we encouraged participants to "think aloud" and recorded their computer screen activity and voice using TechSmith Morae software during each test period. A researcher sat next to participants, answered questions and provided prompts when participants explicitly requested, and made observation notes about participant behavior. Participants completed the System Usability Scale (SUS; Brooke, 1996) questionnaire and answered open questions about their overall experience of each application. At the end of the evaluation, participants ranked their preferences of the applications they used. Each evaluation session lasted approximately 1 h.

## Results

Based on the traditional GIS functionality framework, we have identified eight core web GIS functions by summarizing the detailed function list of the six applications we studied and the notes from our GIS functionality tests (Table 1). In this section, we discuss the details of each function and associated usability test results.

### *Basemap availability*

The basemap varied in different web GIS applications from very simple state and county boundaries in PQ, to multiple choices of street map, imagery, and topography in BAO. Common basemap information in these applications included state and county boundaries, major cities, transportation networks, rivers and water bodies, parks, and landmarks. All of the applications except for RU used Choropleth maps, i.e. areas are shaded in proportion to the variable values, as the information delivery method. The basic mapping units in these Choropleth maps included state, county, census tract, and block groups. Three applications (BAO, SE, and SM) allowed users to turn on and off layers and labels.

To evaluate the basemap usability, we asked participants about their initial impression of the application and then gave them the task of creating a customized map using a business-related variable in the Indianapolis, IN area. For their initial impression, users preferred applications with an easy and clean interface, big upfront map area, and clear starting point. They liked basemaps with distinguishable colors, or ones familiar from their previous web map experience, such as the Google Map style. Usability test scores (Table 2) indicated that applications with an easy entry-point had higher task successfulness (e.g., SM), while applications with overwhelming functions (e.g., BAO) or confusing tool bars (e.g., PM) had relatively lower task successfulness. Although getting started

**Table 1**
Functions of web GIS applications in libraries.

| GIS functionality | Details for web GIS |
|---|---|
| Mapping | 1. Basemap availability |
| | 2. Legend customization |
| | 3. Map elements |
| | 4. Map products |
| Database | 5. Information query |
| | 6. Location search |
| | 7. Reporting |
| Analysis | 8. Selected sets of spatial analysis |

Please cite this article in press as: Kong, N., et al., Evaluation of web GIS functionality in academic libraries, *Applied Geography* (2014), http://dx.doi.org/10.1016/j.apgeog.2014.11.017