

An Evaluation of the Navigability of Web-based Mapping Applications

웹 기반 지도서비스의 탐색성 평가연구

Sung Jae Park*

Bradley Wade Bishop**

ABSTRACT

The purposes of this study are to evaluate the navigability of three web-based mapping applications and to suggest how to improve the navigability of all web-based mapping applications. With these purposes, this study conducted a web-based survey congruent with a think aloud and systematic observation for individual participants, followed up by a focus group with all participants. Based on the findings, recommendations are proposed for web-based mapping applications that include a standard click and drag panning function in mapping applications, a scaled zooming option, increased text for icons and buttons, and other potential changes to computer hardware for increased navigability in these applications. By improving the navigability of web-based mapping applications, the learning time may be reduced for each application and the speed at which users' geographic information needs are met will be quicker.

초 록

본 연구의 목적은 세 개의 웹 기반 지도서비스의 탐색성을 평가하고 탐색성 향상을 위한 제안을 하는 것이다. 실험 방법으로 참가자들에게 탐색성 평가지를 수행할 때 생각을 말로 표현하도록 하고 실험 후 웹 기반 설문지를 실시하였다. 또한 연구자들은 탐색성 실험과정을 관찰, 기록하고 모든 실험이 끝난 후 집단 토론을 실시하였다. 탐색성 향상을 위해, 선택과 끌기 기능의 표준화, 눈금이 있는 확대 기능, 아이콘과 버튼 기능의 설명력 향상, 컴퓨터 하드웨어의 가능한 변화를 제안하였다. 웹 기반 지도서비스의 탐색성을 향상함으로써 각 서비스의 이용법을 학습하는 시간은 물론, 이용자의 지리정보에 대한 요구를 만족하는 시간을 줄일 수 있을 것이다.

Keywords: web-based mapping, navigability, zooming, panning, questionnaire survey, think aloud, observation, focus group

웹기반 지도서비스, 탐색성, 확대, 이동, 설문지, 생각표현, 관찰, 표적집단면접법

* Florida State University, School of Library & Information Studies(sp07@fsu.edu)

** University of Kentucky, School of Library & Information Science, Assistant Professor
(wade.bishop@uky.edu)

▪ Received : 4 May 2011 ▪ Revised : 24 May 2011 ▪ Accepted : 12 June 2011

▪ Journal of the Korean Society for Information Management, 28(2): 159-175, 2011.
(DOI:10.3743/KOSIM.2011.28.2.159)

1. Introduction

Web-based mapping applications allow non-expert end-users to utilize spatial data through the Internet. These applications reconceptualized maps by allowing users to view different levels of detail and find turn-by-turn driving directions. Additionally, updated maps in real time can provide users with correct geographic information. MapQuest was the first web-based mapping application launched in 1996, its servers were making 20 million maps per day by 1999, and in 2008 remained the most widely used web-based mapping application (Peterson 2008). According to Hitwise US, the internet traffic monitoring website, however, Google Maps has overtaken the lead from MapQuest in 2009, and still rates the leader in the online interactive map market ("Top 20 Websites" n.d.).

Utilizing Asynchronous Javascript and XML (AJAX) and Application Programming Interface (API), these websites have enhanced the method of interaction between users and computers, and been popularly used. Despite their success, web-based mapping applications lack common standards for graphical user interfaces, syntax, or vocabulary (You, Chen, Liu, & Lin 2007). A major challenge for the development of standards has been the unidentified and assorted users compared to traditional geographic information system users. The lack of geographic information systems training and cartographic knowledge for most users makes creating a user-friendly design difficult (Tsou & Curran 2008). While user-centered design guidelines may assist programmers

during development, once applications are released further evaluation for usability can help to improve subsequent generations. A thesis (Naslund 2007) on evaluating web-based mapping applications suggests a combination of functionality, usability, and accessibility for a thorough assessment. This study focuses only on navigability in web-based mapping applications because that aspect of functionality is critical to utilizing geographic information systems and is also a relatively unexplored function in the literature. A prerequisite to use of any web-based mapping applications and their various features is navigability.

The purposes of this exploratory study are to evaluate the navigability of the three web-based mapping applications mentioned earlier and to make suggestions on how to improve the navigability of all web-based mapping applications. This exploratory study also focuses on clarifying the navigability definitions unique in the context of web-based mapping applications, since navigability issues exist in all web sites. With these purposes, the researchers attempt to define, measure, and assess three web-based mapping applications' navigability within the map display window. Results of the study may find some navigability options are easier and propose zooming, panning, and button standards.

2. Literature Review

Web site usability testing is conducted with many criteria proposed by many different people. Nielson (1993) suggested the following criteria as evaluation

criteria: accessibility, hardware and software, the homepage, page layout, navigation, and scrolling and paging. Among these criteria, this study focuses on navigation issues. Navigation means “the method used to find information within a web site”, that are geographic information in this case (Leavitt & Shneiderman 2006, 68). The navigability issues within a web-based mapping application are more specific than navigation within a web site, but exploring some researchers’ navigability criteria guided this study’s criterion and research design.

Leavitt and Shneiderman (2006) suggested these navigation criteria for a general website: (1) provide navigational options; (2) differentiate and group navigation elements; (3) use a clickable ‘list of contents’ on long pages; (4) provide feedback on users’ location; (5) place primary navigation menus in the left panel; (6) use descriptive tab labels; (7) present tabs effectively; (8) keep navigation-only page short; (9) use appropriate menu types; (10) use site maps; (11) use ‘glosses’ to assist navigation; and (12) breadcrumb navigation. Naslund’s (2007) usability criteria, a study more closely measuring navigability in web-based mapping applications, echoes this logic but is specific to the map display windows: (1) Clear terminology, avoid GIS - jargon; (2) Professional designers should be - used to improve the graphic design of the site; (3) A legend that is self explanatory; (4) A locator, or context map, to - show where the map is being viewed in relation to a larger; (5) geographic area, what are other navigation criteria; (6) Buttons should have text or icons - with tips showing the name and describing the purpose or action; and

(7) Help should be provided - appropriate error messages to assist user.

It is difficult to separate Naslund’s usability definition from other’s navigability definitions, because it also focuses on making web sites easier for users to understand where they are in a web site and how to move to where they want to go. It is the same for analyzing navigability of web-based mapping applications - the user must know where they are and how to go where they want to go next.

One approach was used by a researcher to establish a paradigm for these studies. The researcher had participants Sense-making about why they would use maps, and then asked them to describe in words the contents of maps provided, and then conducted a focus group about geographic information use (Gluck 1992). That study’s findings provided some insight into what users expect out of cartographic resources, but not specific navigability issues since this was done prior to the availability of web-based mapping applications.

Some researchers suggest a lack of usability methods for web-based mapping applications are because organizations are unable to understand the potential benefits to them by making their applications more usable, for example, saving users’ time (Nivala *et al.* 2007). Another reason for a lack of usability studies in this area are the issues often found by conducting usability studies suggest unaffordable changes and improvements to existing applications. Due to these inhibitors to usability research for web-based mapping applications, fundamental research questions are still not defined. “What is a good map application?”,

〈Table 1〉 Lim's evaluation criteria and related questions

Evaluation Criteria	Questions
Navigation options (for example, panning and zooming)	Are navigation options easy to control? Are navigation options briefly expressed? Are navigation options easy to find? Are navigation options distinct?
Visual metaphor in icons and buttons	Do icons and buttons include visual metaphor with tips showing the name and describing the purpose or action?
Cancel of actions	Are users able to cancel the executing works?
Minimal input actions	Is redundant data entry avoided?
Use of shortcuts	Are the shortcuts to reduce the number of interactions is provided?
User error handling	Do appropriate error messages assist users?

Note: Evaluation criteria and questions are translated into English by researchers

“What are the elements and measures that define it?”, “What is the conceptual structure for these elements?”, “Where is usability situated in the hierarchy of map design?” (Nivala *et al.* 2007).

The most useful source for navigability criterion was found in Lim (2007) who reviewed the works related to usability and identified criteria to evaluate the user interface of several web-based mapping applications. As Table 1 indicates, Lim identified the navigability factors and questions to address each factor. Lim also provided a calculation for each measurement based on a checklist that combined all the survey results from 10 users (5 novice, 5 experts).

3. Methodology

3.1 Research Questions

To evaluate the navigability of web-based mapping applications and make recommendations for its improvement, the following two research questions

were developed:

- (1) How intuitive are zooming, panning, and buttons related to navigability within web-based mapping applications?
- (2) Are there any standards for navigability functions across web-based mapping applications?

3.2 Research Design

To answer these research questions, the researchers utilized four different methods to examine the criteria from Lim's questions for evaluating the navigability of zooming, panning, and icons and buttons. The study included a web-based survey congruent with a think aloud and systematic observations for individual participants, followed up by a focus group with all participants.

During zooming and panning tasks for the three web-based mapping applications, participants were asked to think aloud and the participants' comments were audio recorded. At the same time, the researchers systematically observed the participants'

zooming and panning techniques and made note of each mouse movement. After the tasks for each web-based mapping application were completed, the participants were asked to complete a web-based Likert scale survey consisting of questions derived from Lim’s criterion. A focus group with open-ended questions also included all participants to follow-up the web-based survey and think aloud portions of the study.

Five doctoral students were selected using convenience sampling to evaluate the three web-based mapping applications - Google’s Google Maps (<http://maps.google.com/>), AOL’s MapQuest (<http://www.mapquest.com/>), and the National Atlas’ MapMaker (<http://nationalatlas.gov/natlas/Natlasstart.asp>). The web-based mapping applications were selected because Google Maps and MapQuest rank one and two respectively for usage in the U.S. according to Hitwise and the National Atlas’s MapMaker is an E-government mapping application, which provides a contrast between the commercial applications. Table 2 describes the navigability criteria the researchers were able to adapt from Lim’s criterion.

3.2.1 Think aloud, systematic observation, and web-based survey design

Researchers developed a script of tasks for participants to perform, which required the use of zooming and panning functions of the web-based mapping applications. Some of the zooming and panning functions could be performed with icons and buttons, so tasks were not icon or button specific. The tasks were designed to reduce the amount of geographic knowledge required to perform the tasks. Participants were expected to know the cardinal directions north and south as well as a general concept of where the states Florida and Georgia are located.

Prior to this portion of the study, the research environment was set-up. A laptop was used with all three web-based mapping applications already open at the bottom of the screen and the set of survey questions for each in windows at the bottom of the screen. For example, at the bottom of the screen from left to right the Google Maps window was followed by Google Maps web-based survey window and so on for each application. Researchers then asked each participant to sit down, read and sign

<Table 2> Navigability criterion

Evaluation Criteria	Questions	Measurement
Navigation option for zooming: tools to navigate	How easy are the zooming options to control? How easy is it to understand the zooming options? How easy are the zooming options to find?	Code “think aloud” comments: Likert scale Web-survey: analyze open-ended focus group questions
Navigation option for panning: tools to navigate	How easy are the panning options to control? How easy is it to understand the panning options? How easy are the panning options to find?	Code “think aloud” comments: Likert scale web-survey: analyze open-ended focus group questions
Visual metaphor in icon and button: depicts its purpose or action	How self explanatory are the icons and/or buttons for zooming and panning?	Code “think aloud” comments: Likert scale web-survey: analyze open-ended focus group questions

a consent form that explained the confidentiality and completely voluntary nature of the research. The two researchers stood on either side of the participant that sat at the laptop, and systematically wrote down the observations of every click and movement the participant made with the mouse, while an audio recorder documented the think aloud portion of the study.

The participant was asked to begin the web-based survey using SurveyMonkey and read an introductory page that described what a web-based mapping application was, as well as the provided definitions for zooming and panning, and the directions to think aloud, during this portion of the study. Next, the participant was asked two introductory questions regarding how often in the past thirty days they had used a web-based mapping application and when they first used a web-based mapping application, with ranges before 1996, between 1996 and 2004, and after 2004.

After the introductory questions, the participants were asked to move onto tasks for each mapping application and read as follows:

- (1) Open the *web-based mapping application* window located at the bottom of the computer in the task bar
- (2) Zoom to south Florida
- (3) Pan to north Georgia

Each set of tasks was followed by a set of survey questions based on Lim's criterion. At the end of each web-based survey, the researchers directed the user to the next window for an identical set of tasks

for the next web-based mapping application, followed by the same web-based survey questions.

The tasks for zooming to south Florida and panning to north Georgia could be executed in a number of ways in each web-based mapping application. The researchers wanted to systematically observe which ways each participant both attempted and actually executed the tasks. In an attempt to measure Lim's criteria for the three web-based mapping applications, the five users were asked to perform the tasks on each web-based mapping application and think aloud while they did them.

The Likert scale (very easy, somewhat easy, somewhat hard, and very hard) was used for each of Lim's navigability criterion. For example, "How easy are the applications' panning options to control?" was a question to measure the users' perceived ease of each application's panning options' controls. Each navigability criterion was assessed with a similar Likert scale survey question. This process was repeated each time for the three applications. Although users were asked to think aloud, during these tasks and questions, the users were not helped with any of the tasks or questions. Users' criticisms and compliments of the applications were recorded.

This final research design for the think aloud, systematic observation, and web-based survey portion of the study was modified from previous versions as a result of two pre-testing participants' feedback. Pre-test participants suggested inclusion of definitions for the terms zooming and panning in the context of web-based mapping applications. Pre-test participants also suggested making the wording of some

of the survey questions more succinct. The pre-testing was timed and indicated the tasks and survey should be easily completed in less than ten minutes.

3.2.2 Focus Group design

After the first portion of the study, all five participants reconvened to a focus group. The focus group open-ended questions addressed navigability criterion for zooming, panning, and the icons and buttons broadly. The focus group allowed the group to explore specific zooming, panning, and icon and buttons issues for all three applications through discourse with other participants as well as discuss why and how they usually seek geographic information. The researchers, as moderators of the focus group, asked questions and took notes. The focus group was audio recorded.

3.3 Data Analysis

The five participants provided a variety of data for the think aloud, systematic observation, and survey portion of the study. The focus group allowed the participants to build upon each other's experiences and voice concerns over the navigability of current zooming, panning, and icon and button controls of the three web-based mapping applications evaluated. Despite these differences, triangulation provided the researchers with some trends for each application. Survey results were analyzed first to assess the average response for each web-based application in regards to Lim's navigability criterion. The think aloud portion of the study was coded to view trends in the participants comments. The systematic

observations were tabulated in a graph and analyzed. The focus group recording and notes were also coded to look for trends in the discussion.

4. Results

4.1 Web-survey Results

The overall trends in the findings are presented in three categories, experience and frequency, zooming and panning usability, and the quality of self-explanation of the icons and buttons.

4.1.1 Experience and frequency

Before the evaluation of each web-based mapping application, the experience and frequency of such website functions was asked. Researchers divided the level of frequency in the last thirty days into 4 categories: 'never', '1 time', '2-9 times', and '10 times or more.' As Table 3 shows, at least one participant selected each category. Therefore, with only five participants the study had a good variety of participants' frequency of use.

4.1.2 Easiness of zooming/panning options

Table 4 shows the percentage of response on zooming and panning related questions for each website. The survey questionnaire had three questions for each zooming and panning option:

1. How easy are the zooming/panning options to control?

<Table 3> Usage of web-based mapping application in the last 30 days

Level of Frequency	Percent Response	Response Count
Never	20.0%	1
1 time	20.0%	1
2-9 times	40.0%	2
10 times or more	20.0%	1

<Table 4> Easiness of zoom/panning options for evaluated web-based mapping applications

Web-based Mapping Application	Level of easy	Zooming Options			Panning Options		
		Control	Understand	Find	Control	Understand	Find
Google Maps	Very easy	20 %	20 %	40 %	20 %	40 %	40 %
	Somewhat easy	60 %	20 %	0 %	40 %	20 %	20 %
	Somewhat hard	20 %	60 %	60 %	20 %	20 %	20 %
	Very hard	0 %	0 %	0 %	20 %	20 %	20 %
MapMaker	Very easy	60 %	60 %	80 %	0 %	40 %	20 %
	Somewhat easy	40 %	20 %	0 %	40 %	20 %	40 %
	Somewhat hard	0 %	20 %	20 %	20 %	20 %	20 %
	Very hard	0 %	0 %	0 %	20 %	20 %	20 %
MapQuest	Very easy	40 %	60 %	40 %	20 %	20 %	0 %
	Somewhat easy	40 %	40 %	60 %	60 %	80 %	100%
	Somewhat hard	20 %	0 %	0 %	20 %	0 %	0 %
	Very hard	0 %	0 %	0 %	0 %	0 %	0 %

2. How easy is it to understand the zooming/panning options?
3. How easy are the zooming/panning options to find?

For the respondents, the zooming options of Google Maps were typically easy to control, but were difficult to understand and find. Google Maps provides zooming and panning option icons and buttons on the left side of the map display window, but several of the options occur with various click patterns. Users are able to zoom in a specific area by using a double-click in Google Maps. The double-click for zooming is a hidden function, which

users did not intuitively understand, and that the zooming and panning option icons and buttons on the left side were difficult to find and understand, zooming navigability in Google Maps was harder to find and understand than the other applications. Google Maps zooming, however, was as easy to control as the other applications' zooming options.

All respondents answered that the zooming options of MapMaker are easy to control. Through just one click, a user gets the magnified or reduced scale of a map according to which button is selected either 'zoom in' or 'zoom out.' MapMaker zooming options might have been ranked easier to control, find, and understand because it only takes one click of the

mouse to access them.

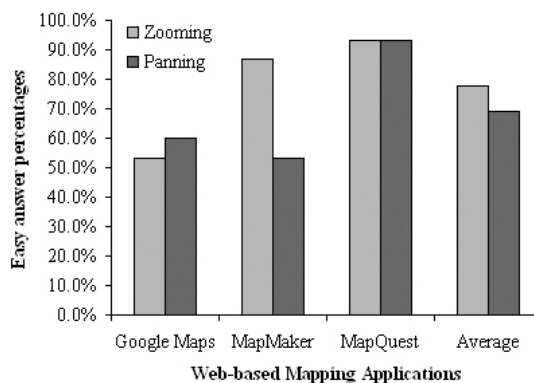
MapQuest zooming options were easy to understand and find by all users and the majority of users ranked MapQuest easy to control. These results may be because MapQuest has the easiest navigability functions for zooming, is the oldest web-based mapping application, or because it was the final application tested. These same potential reasons may be why only MapQuest was rated easy on panning. The survey results for panning options were all over the map and did not indicate trends in this small sample.

The answers to these questions were combined to view the overall easiness of the navigability of the applications based on the zooming/panning options. Among the answers, the count on ‘Very easy’ and ‘Somewhat easy’ was calculated and Figure 1 shows the results for overall easiness of each application. Some meaningful results were found through this graph. First, that the zooming and panning options of MapQuest were easier to use, find, and understand than Google maps, although they provide similar zooming and panning options. Sec-

ondly, MapMaker has much easier to control, find, and understand zooming options than panning options. MapMaker had the hardest to control, find, and understand panning controls of all the applications. The findings from this portion of the survey are supported from the results of the other methods.

4.1.3 Self-explanation of icons and button

To help people navigate a web-based mapping application, all evaluated websites provided icons and buttons. Two commercial websites, Google Maps and MapQuest group zooming and panning functions together in one area of the map display window. The 4-direction panning button with arrows and the degreed zoom button with ‘+’ for zooming in and ‘-’ for zooming out and in is located on the left side of map display window. MapMaker, the E-government website, uses a different style for zooming and panning options. 8-directional panning buttons are distributed along the edges of map display window and zooming buttons are located outside the map display window. Another difference is that buttons



〈Figure 1〉 Easiness of zooming and panning for each website

〈Table 5〉 Self-explanation of Icons and Buttons of Web-based Mapping Applications

Level of self-explanatory	Google Maps	MapMaker	MapQuest
Very self explanatory	20 %	0 %	20 %
Somewhat self explanatory	40 %	100 %	60 %
Not self explanatory	40 %	0 %	20 %
Did not use icons and buttons	0 %	0 %	0 %

used in MapMaker include both text and symbol to explain the functions of icons and buttons. For example, if a user presses the button '+ Zoom In' and then clicks a specific area on the map viewer, a user gets a magnified and re-centered image of where they clicked. In this case, re-centering is a hidden function which users cannot intuitively understand and only learn from trial-and-error (You et al. 2007).

Table 5 shows the percentage of responses on how self-explanatory the icons and buttons for zooming and panning are for each application. According to the Table 5, all users responded that MapMaker's buttons and icons were somewhat self-explanatory. This was the best of the three applications. While Google Maps and MapQuest provide such symbols as arrows, '+', and '-' to explain the function of each button and icon, MapMaker offers additional text, for example, 'Zoom in', 'Zoom out', and 'North' in addition to the symbols. Therefore, buttons and icons with text are more explanatory icons and buttons to users than symbol used alone.

4.2 Think Aloud Results

The five participants embraced the think aloud portion of the study differently. For example, some

were more and some were less talkative. The comments were divided into three separate areas during coding - issues directly related to the direction of the study, complaints, and compliments. Issues related to the study were few, but only occurred during the first attempts at the tasks and included "how far am I zooming?" and "Is there any directions on how to zoom?" The verbal complaints and compliments were the most useful for evaluating the three web-based mapping applications based on Lim's criterion.

For Google Maps, the complaints included "clicking not working the way I thought it would" and "what is wrong" when frustrated. Only two of the five participants made complaints about Google Maps. The lack of compliments or comments of any kind, during Google Maps might be due to the fact the navigability was easy to control. The survey results indicated that Google Maps' zooming options were somewhat hard to understand and find and the same results are reflected in the complaints when users were frustrated getting started with Google Maps.

For MapMaker, the complaints were more frequent and included "panning is hard", "can't figure out the pan button", "can't see it", "it moves too slow", and "eww." All but one participant said something

negative about MapMaker, but the complaint abstaining participant only made one comment during the entire study. Some compliments that MapMaker received were more or less also complaints, for example, “easy to control but kind of annoying” and “better than Google Maps, but Google Maps made it easier to start.” One compliment about MapMaker was genuine, for example, “like them [arrows] on the sides of the map.” Based on these comments, MapMaker’s panning was not easy to control, understand, or find than Google Maps, but zooming was easier. Perhaps, as one participant pointed out because “you can zoom accidentally.” One’s first reaction to right click where they want to go makes MapMaker zooming options easier to control. This replicates the findings of the survey.

For MapQuest, the complaints and compliments were minimal. As the last web-based mapping application tested, participants were familiar with several possible navigability options and possibly fatigued from the study. One participant expressed this with the comment, “similar to Google Maps, otherwise it would have been difficult.” A lack of complaints and compliments may indicate that MapQuest’s navigability was easy to control, understand, and find or for the other reasons mentioned. The complaint of “ending up in Canada” occurred twice out of the five participants and occurred when users zoomed too far into the ocean and attempted to reset, but actually ended up zooming into the middle of North America, somewhere in Quebec. This occurred because those participants thought MapQuest had stalled out, while it was “taking awhile to load.” Overall

the lack of think aloud compliments and complaints matched the survey results that MapQuest’s zooming and panning options were easy to control, understand, and find.

4.3 Systematic Observation Results

Table 6 shows the five actions taken by participants, during the zooming and panning tasks. Clicking the left mouse button, clicking the right mouse button, double-clicking, click and drag, and using the application’s icons and buttons were the five distinct actions users attempted when charged with the tasks of zooming and panning. Icons and buttons are options for all three applications when zooming and panning, but the other actions functions are unique to each application. Click and drag can be used in the two for-profit applications for panning, but in the E-government application click and drag zooms. This troubled two of the five participants. Three participants attempted to click the left mouse button, but this action does nothing without another action in any of the applications. One participant clicked on the right mouse button, which works only in Google Maps to zoom. Three participants double-clicked, which zooms in Google Maps and re-centers in MapQuest.

The variety of first attempts for both zooming and panning in all applications do not indicate any preferred options. The amount of time each participant took to find and use all options was relatively small and very difficult for the researchers to measure. Still, these delays from several miniscule zooming

<Table 6> Systematic observation results

Five actions of participants for panning and zooming • works ○ doesn't work	Participant 1			Participant 2			Participant 3			Participant 4			Participant 5		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
click a left button on a mouse only	○	○	○	○	○								○	○	○
click a right button on a mouse				•	○	○									
double-click							•					•	•		
click and drag	•		•		○, •	•	•	○, •		•	•		•		
Use options provided by each application's icons and dropdown	•	•	•	•	•	•	•	•	•	•	•	•		•	•

Five actions of participants for panning and zooming
 • works
 ○ doesn't work
 Note. (1) Google Maps, (2) MapMaker, (3) MapQuest

and panning actions in more complex tasks using web-based mapping applications add up and the increased duration using these systems by non-expert users is a weakness to study further. Without video recordings of the participants, time could not be measured accurately to determine if some applications had options that took longer.

4.4 Focus Group results

The focus group recording and notes were coded to look for trends in the discussion. The five participants enjoyed sharing some of the same complaints and compliments with the rest of the group and researchers. A few study flaws came to light in the focus group. For example, the touchpad used was hard for those who do not normally use a touchpad on a laptop. Another issue was that four participants do not use maps at all. The participants either rely on a global positioning system (GPS) for directions or only follow text printouts of driving directions

from web-based mapping applications.

Most of the complaints stemmed from the fact that each application has different controls for zooming and panning and participants expected the controls to be similar. One participant mentioned gaming software allowed for more motion, but the input devices and icons and buttons did not allow for motions similar to gaming. Similarly, the participant turns physical maps to face the direction headed, but all the web-based mapping applications tested are always north oriented without the option to change alignment. Older cartographic resources were also complimented for their superior legends than all the web-based mapping applications.

All web-based mapping applications were criticized for difficulty in finding the zooming and panning options and the unknown scales of zooming. A pyramid to visualize the scale of zooming had helped some participants in the past, but the pyramid was not seen on these applications. For example, zooming four bars ahead was likened to “jumping

off a building and not knowing where you were going to land.” Zooming and panning options were not intuitive.

MapMaker was criticized the most by the group because of its odd zooming controls and lack of panning controls. Click and drag are used in documents and web sites to pan, but in MapMaker click and drag is for zooming. This is opposite the convention of other applications and complicates the navigability for both controls. MapMaker’s zooming and panning issues disappointed all participants; however, participants liked MapMaker’s dropdown box button to zoom and pan to states that the other applications did not offer. The icons and buttons of MapMaker were the only icons and buttons that had words, which made them easier to understand. Participants thought these reasons might make MapMaker easier to use for the novice user. The group found that all the web-based mapping applications had areas to improve upon to make zooming and panning controls easier to control, understand, and find.

5. Recommendations

Based on these findings, recommendations include reserving no function for the left click, a standard click and drag function in mapping applications for panning, a scaled zooming option, increased text for icons and buttons, and other changes to computer hardware for increased navigability in mapping applications.

As mentioned in the results section, this study found different kinds of tool options for the applications. Some options were easier to use and made navigating the map display window more intuitive. Other options were more difficult to use and no application had the perfect combination of options for panning and zooming.

According to Shneiderman’s eight golden rules (1987), appropriate feedback is given to every user action. The action ‘click’ is a meaningful action for the interface design of a map viewer; in that the action is the initial action several participants took to begin map searching. When one click does not cause a meaningful action, users start to get frustrated. The first click could be reserved as the tool that highlights the functions of the applications, instead of any one function related to navigation itself.

When three of the five participants clicked and dragged to pan to south Florida in MapMaker, they encountered what they did not expect, a zoom function. Generally, click-and-drag changes one position to another in most computer-based applications, such as word processing and websites. In web-based mapping applications, click-and-drag functions are used for panning in commercial websites. MapMaker’s click-and-drag is for zooming and caused confusion for all participants despite the fact that the action zoomed. Consistency with the more widely used applications might help users understand the zooming and panning options in this and other E-government mapping applications, for example The National Map (nationalmap.gov).

Zooming and panning options were either grouped

together on the map display or distributed away from each other in the map display options. While Google Maps and MapQuest grouped the zooming and panning options in one place, MapMaker had them distributed around the map. For example, the pan east button is on the left hand side of the map display. Zooming options were either scaled or non-scaled. Google Maps and MapQuest used a scaled zoom option. For example, a scale that provides some insight into how far a user has zoomed into the map and how much farther a user can zoom. MapMaker does not have scaled zooming as an option. A user just zooms in and out without knowledge of scale unless they read the map scale in the corner of the screen. MapMaker could easily add a pyramid requested by some users or a scale like the more popular applications.

MapMaker's faults did not come to light with the survey method alone, but with the systematic observation, the think aloud, and focus group comments the E-government application's shortcomings were revealed. Web-based mapping applications changed with AJAX and the release of Google Maps, but MapMaker did not adapt. AJAX makes use of these applications smoother for users with seemingly instant reactions to users input.

Despite a lack of standards, the common tools of the popular application should be incorporated into MapMaker and other E-government mapping applications. Click and drag for panning, grouped buttons for controls, and included a scale for zooming. The commercial applications can benefit from MapMaker in one respect; however, our participants

liked the text on icons and buttons. Perhaps, MapQuest and Google Maps would benefit from more text on their tool options to increase navigability in map display windows. Making all of these applications more intuitive would save all users time and increase the speed of dissemination of geographic information.

6. Conclusion

Web-based application evaluation requires further study, especially navigability. Some criteria can be adapted from other web usability studies, but web-based mapping applications present their own unique challenges. As geographic information systems grow in popularity through easier access to spatial data and applications, the non-expert user will benefit from advancements in navigability of these applications. E-government mapping applications must keep pace with for-profit versions or their spatial data will be underutilized by non-expert users. Standards for navigability tools will reduce the learning time for each application and save all potential users time.

7. Limitations and Future Study

The study included several limitations stemming from both time and budget constraints and unforeseen flaws in the methodology. This study's unavoidable limitations were the number of sites included, the

lack of established navigability criteria and other mapping application literature, as well as the total number of participants. The study's avoidable limitations were the computer workstation used, the survey tool used, the ordering of applications, tasks used, and issues related to the think aloud method.

First, five doctoral students participated in this exploratory study. Even though five participants can be good enough for a focus group, it is small for the survey questionnaire. Regarding the exploratory study, the survey findings from small samples could be valuable. However, for deeper understanding on navigability of web-based mapping applications, future studies will recruit more participants for the survey. Additionally, although the researchers randomly selected the students, doctoral students may have increased experience with other web-based applications that made navigating web-based mapping applications easier to use, but at any rate, most of web-based mapping application users are not doctoral students. Despite adding definitions to the survey of zooming and panning, participants were still confused. Future studies would include an imbedded video that shows what zooming and panning are.

Second, the study did not assess participants' prior knowledge of geography and computer skills or participants' experience with web-based mapping applications. Future study would include questions that would determine users' knowledge, skills, and experience with web-based mapping applications.

Third, the study did not prevent order effect or carry over effect. Order and carry-over effects gave MapQuest, as the final web-based mapping applica-

tion evaluated, some advantages and disadvantages. Order effect means a participant rushes through later tasks to finish the project or is more fatigued and therefore provides invalid answers. The carry-over effect problem occurs when participants learn from the first few applications and perform better on later applications, not because it might be easier to use, but because of what they learned from experiences. To control for these effects, future study will consider three subject groups and randomly assign them to each mapping application. The groups might not have equal representations of experience and knowledge this way, but it is necessary to prevent order and carry-over effect.

Fourth, the tasks of this study were to 'zoom to south Florida' and 'pan to north Georgia.' One participant asked 'is it OK?' during completion of the zoom task. Since the researchers did not provide participants with detailed directions for what zoom level, the participants did not know if they had fully completed the zoom task. In addition, one participant completed the panning task without actually panning. He or she only zoomed slightly in and still could see both south Florida and north Georgia and then zoomed again to move to north Georgia. For the future studies, clear and detailed tasks are needed, but these may require participants to have a higher level of geographic knowledge and experience operating web-based mapping applications. Future studies, would require participants to pan in more directions than north to give a more comprehensive assessment of panning.

Finally, one of the methods used in this study

was think aloud. As mentioned before, the think aloud method requires participants to talk about their thoughts during performing tasks. Due to limitations on working memory, it is difficult to verbalize thoughts during performance (Jordan 1998). In this study, three of the participants faced a verbalizing problem. Therefore, in future research, ways to motivate participants to think aloud would be prepared, like conducting a mock task before the real task and also asking or reminding during the tasks

(Cennamo, Chung, Leuck, Mount, & Turner-Vorbeck 1995). The former is to train participants to do a think aloud and the latter is for an observer to ask a question such as 'what are you thinking?' to remind participants to keep talking. The tasks of zooming and panning can be completed very quickly and leave little time to talk about what a participant might be thinking, but these techniques might help increase the think aloud method's value.

References

- Cennamo, Katherine S., Mi-Lee. Chung, Vivian. Leuck, Veronica. Mount, and Tammy. Turner-Vorbeck. 1995. "An exploratory study of the cognitive processing of videotaped materials on a familiar and unfamiliar topic." *International Journal of Instructional Media*, 22(4): 305-320.
- Gluck, Myke. 1992. "Prospecting for user-based GIS processes." Paper presented at the *The ASIS Annual Meeting*, Pittsburgh, PA.
- Hopkins, Heather. 2008. "Google Maps Making Inroads Against Leader, Mapquest." [cited 2011.5.10]. <http://weblogs.hitwise.com/us-heather-hopkins/2008/01/google_maps_making_inroads_aga.html>.
- Jordan, Patrick. 1998. *An Introduction to Usability*. Philadelphia, PA: Taylor and Francis.
- Leavitt, Michael O. and Ben. Shneiderman. 2006. "Research-based Web design and usability guidelines." [cited 2011.5.10]. <<http://usability.gov/pdfs/foreword.pdf>>.
- Lim, Kyung-Ran. 2007. "Analysis of user interface evaluation in map information service on Web." *Journal of the Korean Contents Association*, 7(2): 202-211.
- Naslund, Magnus. 2007. *Web-based mapping: An evaluation of four JavaScript APIs*. Linköping University, Linköping, Sweden.
- Peterson, Michael P. 2008. International perspectives on maps and the Internet: An introduction. In M. P. Peterson (Ed.), *International Perspectives on Maps and the Internet*. (3-10). N.Y.: Springer.
- Shneiderman, Ben. 1987. *Designing the user interface: strategies for effective human-computer interaction*. Reading, Mass.: Addison-Wesley.

- “Top 20th Sites & Engines.” [cited 2011.5.10].
<<http://www.hitwise.com/us/datacenter/main/dashboard-10133.html>>.
- Tsou, Ming-Hsiang. and Judd M. Curran. 2008. User-centered design approaches for web mapping applications: A case study with USGS hydrological data in the United States. In M. P. Peterson (Ed.), *International Perspectives on Maps and the Internet*. (301-318). New York: Springer.
- You, Manlai, Chun-wen. Chen, Hantsai. Liu, and Hsuan. Lin. 2007. “A usability evaluation of web map zoom and pan functions.” *International Journal of Design*, 1(1): 15-25.