Patterns and determinants of variation in the use of maps on the web

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Abstract. The paper aims to clarify variations in map usage among average users of both web-based and paper maps, and to analyze the factors that contribute to those variations. Data were collected through an online survey of 635 people in the Tokyo metropolitan area, to obtain information showing how frequently and for what purposes various map types are used. Factor analysis applied to the map use frequency data revealed that maps can be classified into three types: web maps, guide maps, and multipurpose maps. Subsequently, the relationship between the use of these maps and the attributes of the respondent were analyzed using structural equation modeling.

Keywords: Web map, Map use, Web survey, Geospatial information, Structural equation modeling

1. Introduction

The widespread availability of digital mapping technology has led to increased use of web-based maps; this is reflected in the frequent utilization of map pages in several search engines, including Google and Yahoo!. This type of web map has attracted the attention of cartographers: a commission on maps and the Internet was established by the International Cartographic Association (ICA), and several books (Peterson, 2005, 2008) and special issues (Cartography and GIS, 2005; Cartographica 2006) on web maps were also published.

Although previous studies emphasized the conceptual or technical aspects of web maps, a few studies attempted to conduct empirical analyses of map use. Wakabayashi (2003) conducted a survey of university students concerning the use of various maps, spatial abilities, and personal attributes. Based on the map use patterns obtained from the survey, maps were classified into three types: guide maps, digital maps, and multipurpose maps. A

subsequent examination of the factors affecting map use revealed that PC use, gender, and sense of direction have a significant effect on map use patterns. The findings obtained were further examined and confirmed by Takeuchi (2003).

However, several issues remained. One of the issues involves evaluating the effects of web maps. Because these previous studies were conducted before the advent of Google Maps in 2005, they could not anticipate the role of web maps in today's world. Murakoshi (2006) partially analyzed the role of online maps. He conducted a survey of university students concerning the use of maps, including web maps. A major finding of this study was that, according to the survey respondents, web maps were easier to use than paper maps. Furthermore, several studies (i.e., Nivala et al. 2008) evaluated the usability of web maps.

The second issue involves the limitation of samples. Because most of the previous studies only queried university students, it is unclear whether the findings can be generalized to include the general public.

Hence, few empirical studies have been conducted to examine the manner in which average users employ web-based maps. This study examines variations in the use of web-based and paper maps among average map users, and analyzes the factors that contribute to those variations.

2. Data and method

To this end, I made three improvements in data collection and analysis: 1) Data collection concerning how people use maps focusing on web maps, 2) Web-based survey to various respondents, and 3) Analysis of map use patterns and factors affecting them by considering respondents' spatial abilities and interest in maps.

Data were collected through a web survey in March 2014. I outsourced the data sampling and collection tasks to an internet-based marketing company that had more than two million monitors in Japan. The respondents were residents of the Tokyo metropolitan area; they included 635 subjects equally distributed among age groups, divided equally by gender. I used 624 valid samples in the analysis.

The questionnaire was designed to gather data about the current state of map usage, and focused on web maps. Evaluations were conducted on a 4-grade scale. I also asked about usage of information and communications technology (ICT) devices, degree of interest in maps and geography, spatial thinking abilities, and personal attributes such as gender, age, and educational background, to examine the factors affecting map use patterns.

The analysis was carried out in two stages. The first stage analyzed map use patterns. The usage frequency of the map types was analyzed by aggregating and cross-tabulating the data. Subsequently, factor analysis was used to classify map types according to their usage patterns.

In the second stage, factors affecting map use patterns were examined. This stage was divided into two parts. In exploratory analysis, I conducted statistical tests to establish the relationships between map use patterns and personal attributes (i.e., gender, age, interest in maps, and spatial abilities). In confirmatory analysis, I applied structural equation modeling to confirm the findings obtained in the exploratory analysis.

3. Role of web maps in the overall map use of average users

The usage percentage for each type of map was calculated as shown in Table 1. The results show that a considerable portion of the respondents still use conventional maps such as guide maps and road maps.

Table 1. Percentages of map users: conventional maps

Type of maps	N*	%
Conventional maps		
Tourist maps	320	67.5
Guide maps on outdoor signboard	297	62.7
Vehicle navigation system	263	55.5
Road maps	230	48.5
Guide maps in magazines	215	45.4
Housing map	107	22.6
Topographic map of GSI	43	9.1

*: "frequent use" or "occasional use."

Concerning web maps, a variety of thematic maps are available on Japanese web sites (i.e., hazard maps, medical/welfare maps, and radiation dosage maps), as shown in Table 2. However, few of them are used by the respondents (except for tourist maps). In contrast, the majority of the respondents use general web maps on major search engines such as Google and Yahoo!.

Table 2. Percentages of map users: web maps

Type of maps	N*	%
Thematic web maps		
Tourist maps	227	81.1
Hazard maps	72	25.7
Medical/welfare maps	53	18.9
Radiation Dosage maps	37	13.2
GSI maps	34	12.1
Crime maps	23	8.2
Childcare/childrearing maps	17	6.1
General web maps		
Google	466	85.7
Yahoo!	299	55.0
Mapion	106	19.5
iOS maps	97	17.8
Mapfan	47	8.6
Bing	17	3.1
Other	12	2.2

*: "frequent use" or "occasional use."

Two major reasons for choosing the general web maps were "easy to operate" (68.1%) and "easy to understand" (44.1%). This suggests that the representation and content of the map is irrelevant, and that a map's usability, rather than its aesthetic appeal, is an important factor in their choice of web maps. The reasons for selecting web maps are closely related to the application of those maps. Two major reasons, "searching destination and route" (87.6%) and "checking present location when going out" (35.3%), indicates that web maps are used mainly for wayfinding or navigation. It is interesting that 20% of the respondents carry printed web maps when going out. This suggests that digital and paper maps coexist.

Concerning the changes resulting from the use of web maps, the majority of the respondents answered "hardly ever get lost" (55.0%) and "improved the efficiency of activities" (53.1). Some people expanded their range of activities (19.5%) and concerned area (17.8%). However, only 16.3% of the respondents answered "became less reliant on paper maps", which suggests that the practice of substituting web maps for paper maps is limited.

4. Patterns and determinants of map use

4.1. Exploratory analysis

Factor analysis of the map usage frequency data yielded three factors, indicating that maps can be classified into three types according to their usage: web maps, guide maps, and multipurpose maps (Table 3). These three factors correspond to the ones obtained by previous studies (Wakabayashi, 2003; Takeuchi, 2003). Unexpectedly, Google and Yahoo! Maps are closely related to Factor 2, which is related to guide maps. This implies that general web maps are mainly used for wayfinding or navigation, as mentioned in the previous section.

Table 3. Percentages of map users: web maps

Type of maps	Factor 1	Factor 2	Factor 3
	Web map	Guide map	Multipurpose map
Hazard maps*	0.709	0.298	0.034
Crime maps*	0.819	0.126	0.091
Childcare/childrearing maps*	0.740	0.049	0.124
Medical/welfare maps*	0.754	0.144	0.171
Radiation dosage maps*	0.706	0.130	0.188
GSI maps*	0.600	0.085	0.447
Tourist maps*	0.433	0.553	0.087
Google map*	0.100	0.413	0.099
Yahoo! map*	0.081	0.331	0.231
Tourist maps	0.139	0.822	0.196
Guide maps in magazines	0.117	0.815	0.234
Guide maps on outdoor sign-board	0.076	0.811	0.145
Road maps	0.183	0.467	0.492
Vehicle navigation system	0.027	0.278	0.589
Housing map	0.218	0.211	0.750
Topographic map of GSI	0.239	0.145	0.744
Cumulative variance explained (%)	22.05	19.35	13.63

*: web maps

To examine the determinants of map use patterns, I used factor scores to analyze the relationships between the map types and the respondents' attributes. Concerning gender differences, guide maps were used more frequently by women, who tend to rely on maps owing to anxiety about becoming lost (Table 4). This is consistent with the findings of previous studies (Wakabayashi, 2003; Takeuchi, 2003), which pointed out that women who have less confidence in their sense of direction tend to rely on guide maps. In contrast, multipurpose maps were used more often by men. This may result from a tendency for these maps to be used in jobs or hobbies preferred by men.

Table 4. Mean factor scores by gender

Gender	Factor 1 Web map	Factor 2 Guide map	Factor 3 Multipurpose map
Male	0.015	0.095	-0.136
Female	-0.015	-0.095	0.136

Concerning age groups, only scores for Factor 3, which represents multipurpose maps, vary with the groups (Table 5). This suggests that multipurpose maps are mainly used by the middle-aged and elderly for work or hobbies. Another interpretation may be that young people substitute digital maps for multipurpose maps.

Table 5. Mean factor scores by age group

Age group	Factor 1 Web map	Factor 2 Guide map	Factor 3 Multipurpose map
10s	0.049	0.207	0.471
20s	0.011	0.052	0.247
30s	-0.024	-0.003	0.155
40s	-0.072	-0.146	-0.172
50s	0.042	-0.035	-0.324
60 or over	-0.005	-0.075	-0.377

To examine the effects of spatial abilities or interests on map use patterns, I conducted a correlation analysis. Correlation coefficients between factor scores and an interest in maps/geography and spatial abilities are summarized in Table 6. This table shows that guide maps tend to be used by people

with an interest in maps/geography and ICT skills. Multipurpose maps are used by people with an interest in maps/geography and spatial abilities. However, web maps have no clear relation to personal attributes.

Table 6. Correlation coefficients between personal attributes and factor scores

| Personal attributes of spatial abilities/concerns | *Factor 1* | | *Factor 2* | | *Factor 3* | |
	Web map		Guide map		Multipurpose map	
Interested in maps	-0.101	*	-0.278	**	-0.198	**
Interested in geography	-0.096	*	-0.241	**	-0.234	**
Good at science subjects	-0.007		-0.080	*	-0.133	**
Good at using ICT apparatus	-0.080	*	-0.179	**	-0.150	**
Good sense of direction	-0.023		-0.110	**	-0.135	**
Frequently drive a car	-0.025		-0.112	**	-0.349	**
Good at model building or paper folding	-0.085	*	-0.129	**	-0.123	**

**: p<0.01, *: p<0.05, ns: not significant at 0.05 level

4.2. Confirmatory analysis

To confirm the findings obtained in the exploratory analysis, structural equation modeling (SEM) was conducted using an AMOS program. The full structural equation model relating the predictor variables to the measures of map use patterns is shown in Figure 1.

The fit parameters (Chi-square value, Standardized Root Mean Square Error of Approximation, and Goodness of Fit Index) show that the model successfully fit the data. Findings obtained in the exploratory analysis are also confirmed by SEM as follows:

1) Interest in maps/geography, which varied with gender and age, is strongly related to the map use patterns.

2) The other latent variable, spatial/scientific abilities, only has a significant effect on the use of multipurpose maps.

3) Among the three types of maps, the web map is not significantly affected by personal attributes. This implies that variation in the use of web maps is relatively minor.
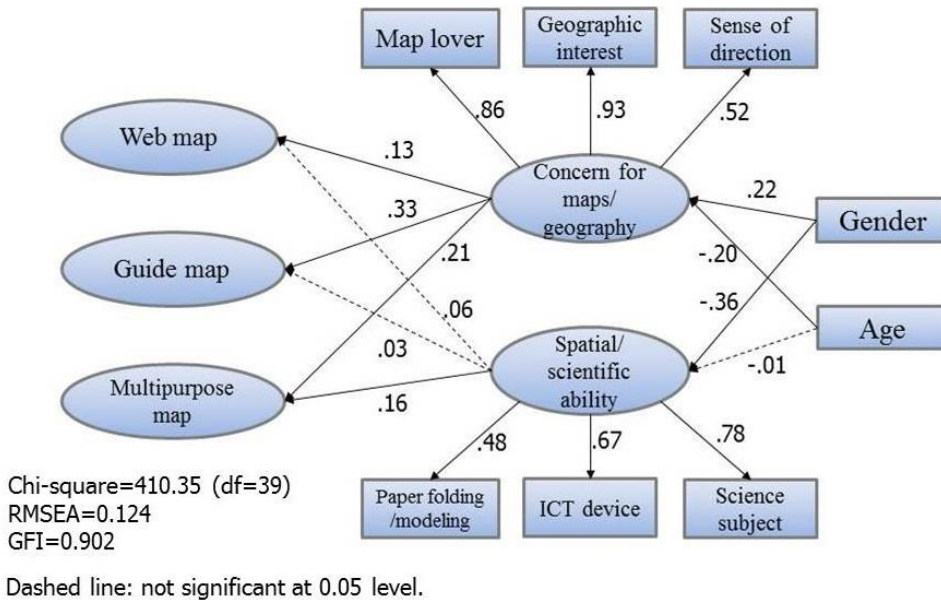
Figure 1. Result of the structural equation modeling.

5. Conclusion

The major findings obtained by this study are summarized as follows. Most people use general-purpose web maps, but few people use thematic web maps except as guide maps. Instead, conventional maps are still widely used. Maps are classified into three types, based on map use patterns: web maps, guide maps, and multipurpose maps. This supports the findings of previous studies. Map use patterns are affected by personal attributes related to spatial concerns/abilities.

The findings indicate the importance of web maps in the current map use patterns of the general public, and explain factors affecting the variation in current map use. In particular, there are few variations in the use of web maps. Murakoshi (2006) also reported that variations in the use of web maps are smaller than those of paper maps. Because using web maps requires few skills, the study asserted, variation in their use is minimal. Hence, web maps can be a useful tool for disseminating participatory mapping and GIS data involving various entities.

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