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Geoportal Usability Evaluation*

Xin HE[1,3], Hans Persson[2,3], Anders Östman[4]

[1]Future Position X, Gävle, Sweden, xin.he@fpx.se

[2]Institute for Humane Technology, Bollnäs, Sweden, hans.persson@iht.se

[3]Royal Institute of Technology, Stockholm, Sweden

[4]University of Gävle, Gävle, Sweden, Anders.Ostman@hig.se

Abstract

GeoTest is a project initiated by Future Position X (a GIS cluster organization in Gävle, Sweden), the National Land Survey of Sweden (NLS) and the University of Gävle. The project aims to test Swedish geodata, services and geoportals and make sure they comply with the INSPIRE the other specifications. GeoTest has developed a method for testing the usability of geoportals. The method is based on the ISO 9241-11 framework, which splits the usability evaluation into three sub-parts consisting the effectiveness, efficiency and satisfaction. By providing feedbacks from users in an organized way, the usability test provides geoportal developers with tools to validate the functions and the layout and to find possible problematic parts to be able to make better applications to meet both the organization and the end users' needs. As a pilot test, the Swedish national geoportal, Geodataportalen, was tested for the usability. It validated the suggested method for testing the usability of geoportals.

Keywords: Geoportal, Usability

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1. INTRODUCTION

The usability is an important quality of information systems (ISO, 1991). From the organizations' point of view, it is about how a system can support people to perform their tasks effectively and efficiently. It is then about the task effectiveness and resource efficiency. From the end users' point of view, the usability is about how a tool is perceived, in a satisfying manner, to support their tasks (ISO, 2011). Therefore, the usability, as an important issue for the user (Bevan and Macleod, 1994), should be a considerable factor that influences the procurement decisions.

It has been a long way to reach a common understanding of usability. Much effort has been spent to define the usability and to specify the respective measures. There are at least 40 different usability elements have been proposed (Hunter et al, 2002). Even within the ISO, which is an organization promoting common understanding, the definitions of usability are made from at least two different points of views. The ISO 9126 (1991) considers, for instance, the usability as a quality feature of a tool itself. One the other hand, the ISO 9241-11 (1998) and ISO 25010 (2011) standards define the usability as the quality of use of the overall system, which includes the tool, the user, the task, and the environment. In addition, it is difficult to specify a reliable way to measure usability (Bevan and Macleod, 1994; Wachowicz et al, 2007). Most of the proposed usability definitions even lack in feasible measurement (Hunter el at., 2002).

Since ISO 9241-11 provides a detailed and reliable framework for measuring usability, this standard is employed by this study. It defines the usability as the,

"*extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.*" (ISO, 1998)

Considering the usability in the context of use is the core of this definition (Bevan and Macleod, 1994; Bevan, 1995). The context of use consists of the tasks, the users, and the environments. The context in which a tool is used determines the usability of the tool. It is not meaningful to talk about the usability of a tool without mentioning the context of use (Shackel, 1991). For an example, the usability of the steering board of a Boeing 747 could be rather different for a 1,000-hour experienced jet plane pilot compared to one of the authors of this paper who has only 100-hour experiences in taking flights.

The ISO 9241-11 also provides a feasible way for measuring usability. It defines the usability as the quality of use of an overall system in a specified context of use. The quality of use can be measured by the outcomes of interactions. By

specifying and controlling a proper context of use, the usability of a system can be measured.

Along the lines of this logic, the ISO 9241-11 specifies the measures for usability as the user performance and user satisfaction. The user performance can be further specified into the effectiveness and efficiency. According the definitions in the ISO 9241-11,

- the effectiveness concerns the completeness and accuracy when users carry out the tasks when using the product,
- the efficiency relates to the resources expenditure, and
- the satisfaction is about the user attitude to the use of the product.

Another feature of this usability definition is that it implicitly requires user-based measurements. For identifying usability defects of a design, it is possible to invite the experts of users (Nielsen and Mack, 1994). However, this approach is not as reliable as the user-based test, which tests a product by inviting representative users (Karat et al, 1992). Beside, by using a user-based test conforming to the ISO 9241-11, an objective comparison among different tools becomes possible (Bevan and Macleod, 1994).

A geoportal is a web application which acts as an access point to the shared geographic information (GI). It is the place where distributed geographic data and services can be discovered (Tait, 2005; European Commission, 2007). One example is the Geospatial One-Stop, which deals with the US public geographic information (FGDC, 2005; DATA.GOV, 2011). In Europe, the INSPIRE directive requires that the EU commission shall operate a geoportal at the European level (European Commission, 2007). The INSPIRE directive also states that member states may provide access to the INSPIRE services through their own access point. As a result, a large number of geoportals have been established in Europe.

Web applications handling geographic information require different design as compared to other types of web applications (Peterson, 2001; Wachowicz, 2006). A need for inspecting the usability of different GI web applications has been expressed by for instance Wachowicz et al (2007) and Tait (2005).

To become an access point to the distributed GI resources, a geoportal provides at least four basic functions, including the searching, mapping, publishing, and administration of the infrastructure (Tait, 2005). It serves at least three different types of users, including the

- Geographic data users,
- Geographic data publishers, and
- System administrators.

For the geographic data users, the primary goal may be to discover the most relevant data sets for their needs. This is one of the simplest use cases of the GI web applications. The searching function is the only mandatory requirement. Visualizing the candidate geographic data sets is preferred since it allows the users to examine the contents. But a visualization tool is not mandatory in order to carry out the discovery task. Therefore, the discovery service is a good starting point for studying the usability of GI web applications.

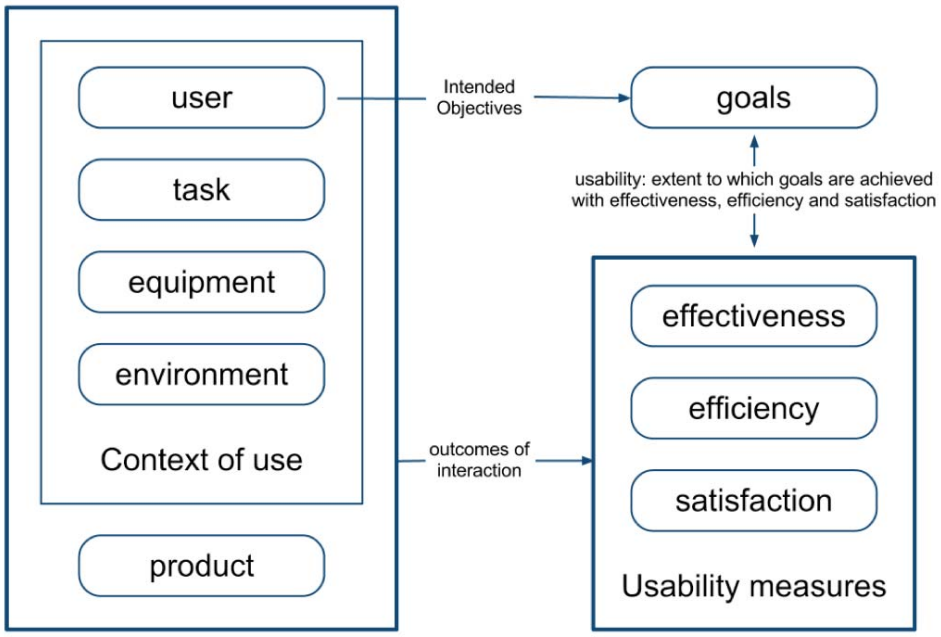
The rest parts of this paper describe a usability evaluation of a geoportal. The usability evaluation is established according to the ISO 9241-11 framework. The portal being studied is the Swedish national geoportal named “Geodataportalen” (Geodata, 2011). The usability of this geoportal is evaluated by geographic data users. The main findings of the usability evaluation are also presented here.

2. METHODS

In this study, the beta version of Geodataportalen was tested with respect to usability by applying the ISO 9241-11 framework. The test was carried out at the Geo-usability lab of Future Position X, Gävle, Sweden. 14 individuals who were characterized as “registered data user” of the Geodataportalen formed the test panel. Eleven test tasks were specified based on the basic functions of the Geodataportalen. The test panel was asked to perform these test tasks and then to answer relevant questions for checking the degrees of task performance. The test panel was also asked to fill in a psychological questionnaire for measuring the degrees of user satisfaction at the end of the test.

ISO 9241-11 (1998) provides a framework which guides the measurement of usability. This framework consists of three major parts, namely, the objectives of the product use, the context of using the product, and the usability measures. The context of use, which is the special concept of this standard, includes the “users” for which the product is designed, the “tasks” for achieving the objectives, and the “equipment” and “environment” where the product is used. During a usability evaluation, the information about the studying product is required in forms as these three parts. Figure 1 below illustrates this framework.

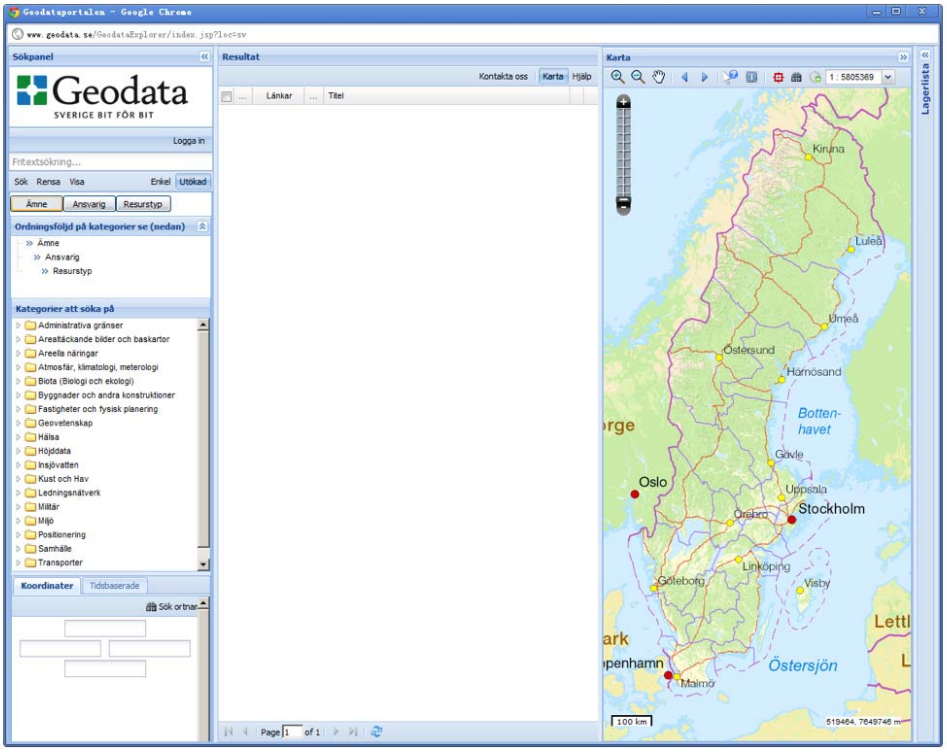
Figure 1: Usability Framework



Source: (ISO 9241-11, 1998)

The Geodataportalen is an access point to Swedish geographic data sets and web services. As a typical geoportal, the Geodataportalen provides its users with the functions of searching, mapping, publishing, and administration. The users of Geodataportalen are classified into four groups, namely, the public data user, the registered data user, the data publisher, and the system administrator (Geodata, 2011). Figure 2 shows a screen shot of Geodataportalen.

Figure 2: Screenshot of Geodataportalen



As required by the owner, the focus of this study was the searching and mapping functions of the Geodataportalen. The publishing and administration components were not covered. The owner also specified that only the group of "registered data user" should be tested in this study. The persons in this group were considered as the users who use GIS in their daily works. As understood by the owner, this group of users would be the main user group of the Geodataportalen at its early stage.

2.1. Test Tasks

To find certain data sets, the characteristics of these data sets have to be specified. The Geodataportalen enabled the users to search for data sets by entering a keyword, by specifying a category, and by specifying a geographic extent. The users can use those functions solely or in combinations to form their searching criteria.

In this study, three different tasks were specified to test the single uses of the three basic single search functions. Additional four tasks were also specified in order to test the combined uses of these basic functions.

For assisting the examination of the candidate web map services (WMS), the Geodataportalen provided the users with a visualization tool. The users can display the candidate WMS on the background map of Geodataportalen. They can then interact with the map and layers. For other purposes, the users can also display an external WMS on top of the background map by entering its URL. For example, the users could compare the candidate WMS with their own WMS which were not published on the Geodataportalen. Three tasks were specified to test the uses of these functions.

In principle the tasks were supposed to be as simple as possible in this study. It was the tool to be tested, not the skills of the test panel. The pre-conditions of each task was predefined and presented to the test panel along with the task description in an obvious way. For example, the test panel was asked to “search for web map services by entering keyword “water””.

The order of doing tasks might have effects on the user performances. Since the test panel of this study was comparatively small, the task order was controlled for the whole test panel instead of presenting them was randomly ordered tasks. Table 1 lists the tasks specified in the test.

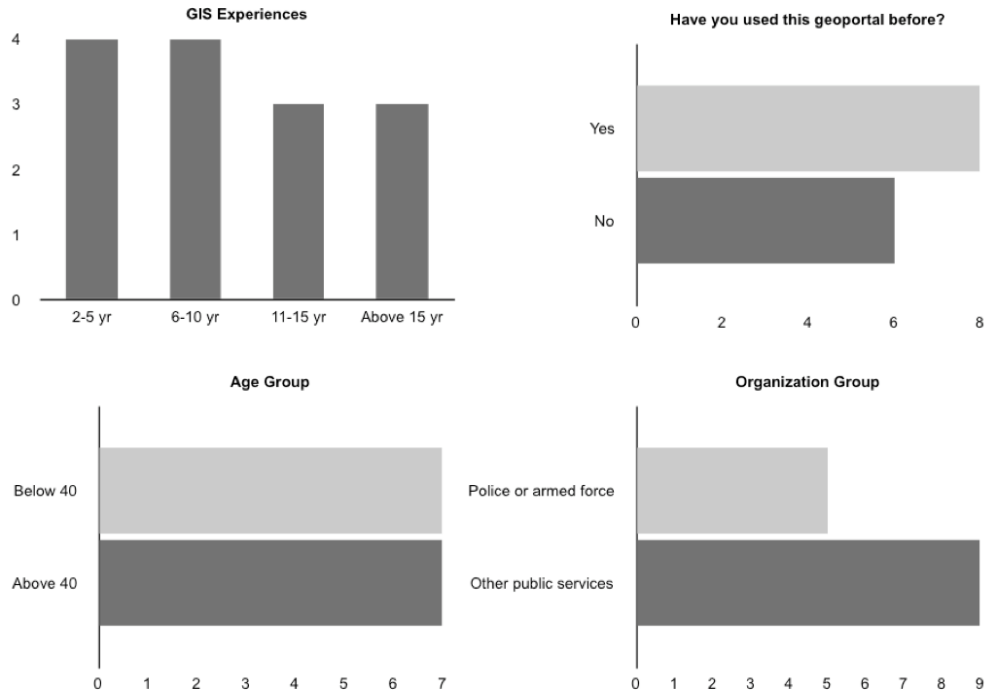
Table 1: Test Tasks

TaskID	Descriptions
1	Open the Swedish geoportal from the project homepage;
2	Search for a data set by entering a free text;
3	Search for data sets by specifying a category;
4	Search by specifying a geographic extent;
5	Search by entering a free text and specifying a category;
6	Search by entering a free test and specifying a geographic extent;
7	Search by specifying a category and a geographic extent;
8	Search by entering a free text, specifying a geographic extent and a category at the same time;
9	Show and remove a web map service (WMS);
10	Add a WMS by entering the URL;
11	Exercises on the map and layers.

2.2. Test Panel

Since the “registered data user” was decided to form the test panel, invitations for GIS professionals were sent to various Swedish authorities and municipalities. 14 individuals finally came to the test. All of them had used GIS for several years. In the test panel, 8 individuals had used the Geodataportalen before, 7 individuals were younger than 40-year old, 5 individuals were from the discipline force, such as the armed force or police. Figure 3 presents an overview of the test panel.

Figure 3: Test Panel



2.3. Usability Measures

In this study, the effectiveness was measured as the degree of task completion. The user performances were judged and classified into three groups, namely, “complete”, “complete with errors”, and “incomplete”. The judgment was made mainly based on the answers from the test panel. The video records, showing the procedures that the test panel used when performing the tasks, were also used. Based on the video records, the logics that the test panel used in finishing the

tasks were analysed if the answers they provided were different to the standard ones. If an individual in the test panel could not answer a question at all, the relating task was marked as incomplete for him/her.

Meanwhile, the efficiency was measured as the time spent to finish a task.

For measuring the user satisfaction in a reliable way, a validated psychological questionnaire is required (Kirakowski, 2000). The software usability measurement inventory (SUMI) was used in this study (Kirakowski and Corbett, 1993). It is a 50-item questionnaire but it further splits the user satisfaction into the Efficiency (user perceived), Affect, Helpfulness, Control, Learn and Global (Table 2). Each individual in the test panel was asked to fill in the SUMI questionnaire when they finished all the test tasks.

Table 2: Software Usability Measurement Inventory (SUMI)

Measures	Descriptions
Efficiency	*Degree to which users feel that the software assists them in their work and is related to the concept of transparency.*
Affect	*User's general emotional reaction to the software.*
Helpfulness	*degree to which the software is self-explanatory, as well as more specific things like the adequacy of help facilities and documentation*
Control	*extent to which the user feels in control of the software, as opposed to being controlled by the software, when carrying out the task*
Learnability	*speed and facility with which the user feels that they have been able to master the system, or to learn how to use new features when necessary*
Global	*a single construct of perceived quality of use*

2.4. Test Procedure

This study was carried out at an indoor and office-like environment. Each individual of the test panel was equipped with a laptop with 13.3 inches screen. The resolution of the screen was 1366x768 which was sufficient to display all the components of the user interface of the Geodataportalen. The operating system was Microsoft Windows Vista and the Internet browser was Microsoft IE 8. These computers were connected to the Internet with 10 Mbit connections.

The user actions, such as the keyboard strokes, mouse movements and clicks, were recorded. The times that the test panel spent in the test were also measured and their facial and oral expressions in the test were also recorded.

On arrival, the test panel was informed that the objective of this test was to find out the degree that the current version of Geodataportalen could meet the needs of users like them. An introduction about the testing process was presented, as well as the usability test environment. They were clearly told that this test was not about their own abilities to handle the geoportal, rather the abilities of the geoportal to serve them. They were also informed that all the testing processes were going to be recorded.

The test instructions were provided to the test panel. They were asked for finishing the test tasks according to the instruction. They were clearly told that they should try to finish all the tasks by themselves and discussions were not allowed during the tests.

When they finished all the test tasks, the test panel was asked for filling in a questionnaire. Free talks about their experiences were welcome at the final wrap up session.

3. RESULTS AND ANALYSIS

3.1. Usability Measures

Eleven different tasks were specified for testing the use of Geodataportalen. A test panel consisting of 14 individuals who had had years GIS experiences joined this usability test. Table 3 and 4 summarizes the measured user performances and satisfactions, respectively.

Table 3: User Performances (Time Measured in Minutes)

Task	Successes	Errors	Incompletion	Mean Time	75% Time	Max Time
1	14	0	0	1.1	1.4	1.9
2	14	0	0	3.4	4.2	9.2
3	9	3	2	3.6	4.9	12.7
4	7	5	2	6.7	10.2	12.1
5	13	0	1	2.3	2.9	10.7
6	13	1	0	2.5	1.9	15.7
7	9	5	0	2.5	3.8	5.0
8	11	3	0	2.6	3.0	11.5
9	11	0	3	9.6	10.9	15.4
10	10	1	3	6.5	8.4	18.1
11	7	3	4	7.0	7.9	14.3

In this test, only two tasks (2/11) were completed by all members of the test panel without any mistakes. Additional three tasks (3/11) were completed but with some mistakes. For the remaining six tasks (6/11), parts of the test panel could not complete the task.

Table 4: User Satisfaction

SUMI Measures	Average	StDev	Median	Instances >=50
Affect	53.7	8.8	51	10
Control	49.9	8.8	44.5	6
Efficiency	52.1	6.5	50.5	8
Helpfulness	50.0	6.9	49.5	7
Learnability	51.9	7.7	49	6
Global	53.2	6.1	53	10

The SUMI evaluation is designed with a mean of 50 and standard deviation of 10. The larger the score the higher level is the user satisfaction.

In this test the panel in average scored the Geodataportalen 53, which was an above average level of user satisfaction. However, among the sub-scales, the “control”, “helpfulness”, and “learnability” were scored at comparatively low levels. Especially for the sub-scale of “control”, it was scored either above 55 or below 45. It indicated that the test panel had quite different attitudes towards the Geodataportalen.

3.2. Reasons to the Errors and Incompletions

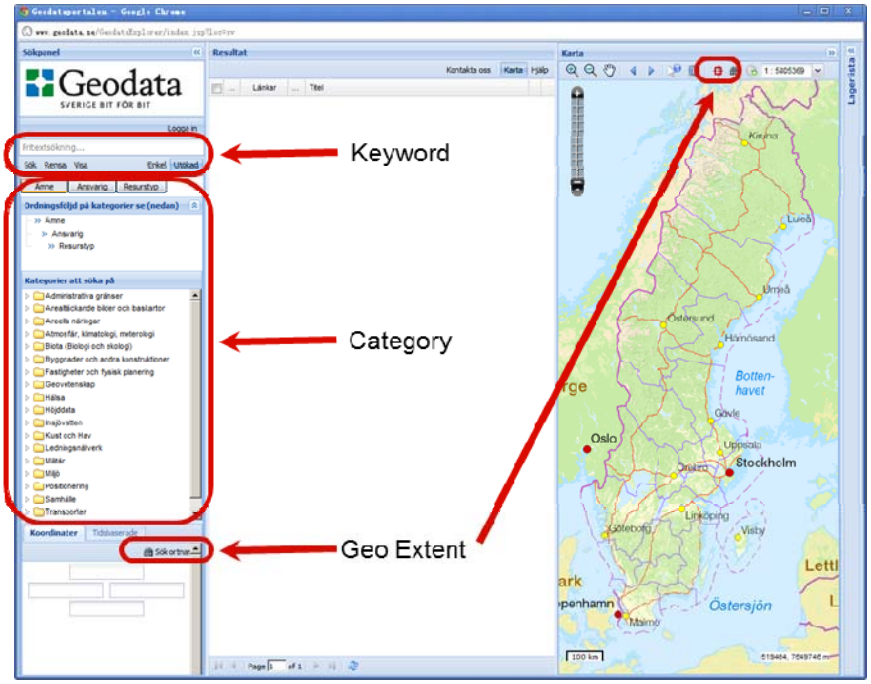
In order to identify the reasons to the errors and incompletions, the relevant video records were examined. Nine main reasons were found, namely

- Unclear display of active search criteria;
- Google-like data entry was not supported;
- Unclear procedures for entering geospatial search criteria;
- Unreadable symbols;
- Obscure presentation of search results;
- User interface was not suitable to smaller screen;
- Hidden buttons for enabling WMS functions;
- Unclear procedures for WMS operations;
- Unclear cartographic rendering.

A serious problem was that the Geodataportalen did not provide the users with a clear display of the active search criteria. The Geodataportalen allowed the users to add search criteria including keyword, category, and geographic extent on top

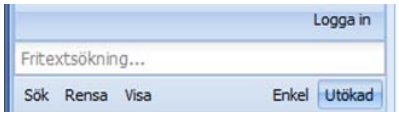
of each other (Figure 4). Without an instant reminder, the users had no idea about which criteria they had entered. It tended to cause mistakes when the users were shifting from one search task to another and when the users were entering multiple search criteria.

Figure 4: Multiple Search Criteria



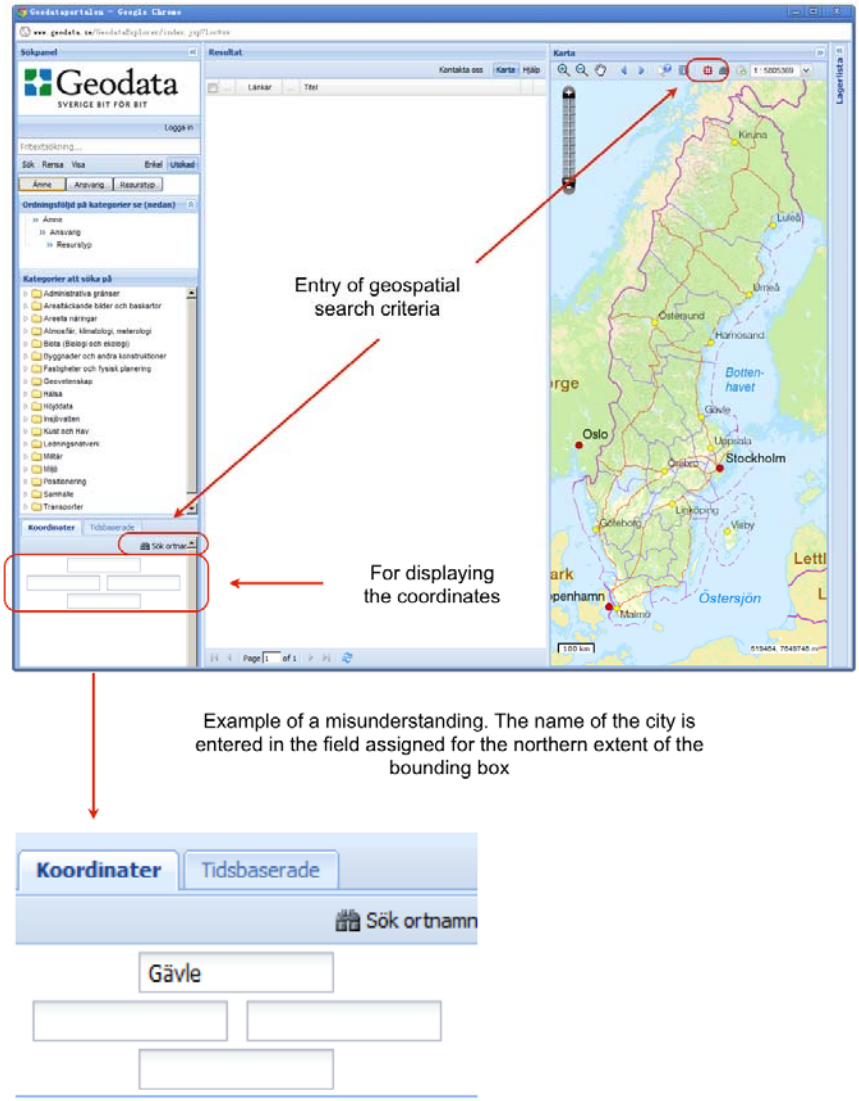
The Geodataportalen provided the users with a field for entering keyword. Below was a button for triggering the search (Figure 5). Without any demonstration, the users tended to use this Google-like search bar in the Google-like ways. The test panel tried to enter all the search criteria here. However, the Geodataportalen did not support this operation. It was able to match only by comparing the input string to the title and metadata of the datasets character by character.

Figure 5: Keyword Search Bar



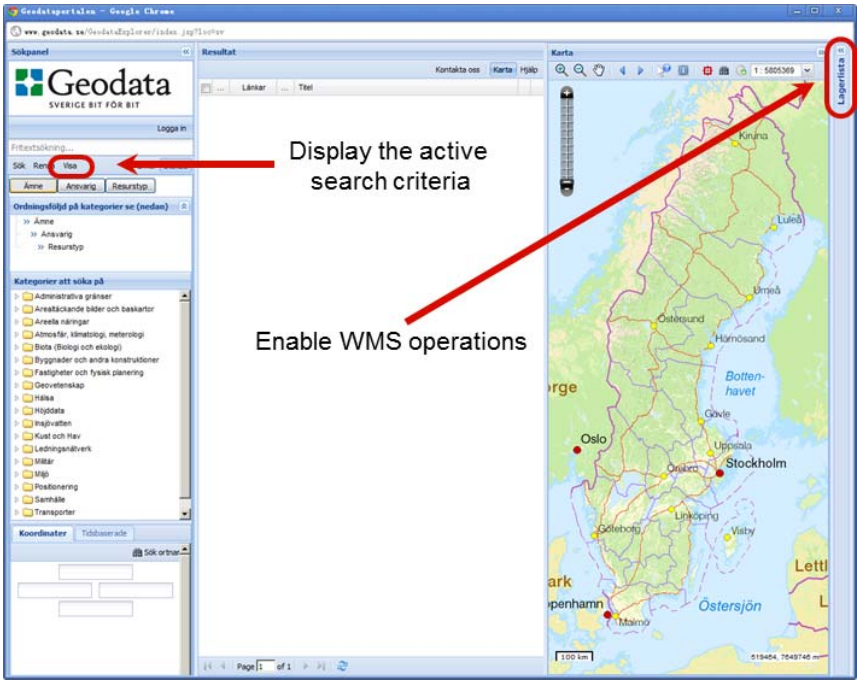
For specifying the geographic extent of search, the Geodataportalen provided the users with the bounding box operation and the geographic name search. The test panel was familiar with these functions. However, the Geodataportalen used a four-box panel to display the coordinates of the defined geographic extent. This display was distractive and misled the test panel (Figure 6).

Figure 6: Entering the Geospatial Search Criteria



In summary, the Geodataportalen had some limitations in the presentation. Some symbols were not intuitive and therefore hard for the users to connect their appearances to their meanings. A number of functions were also hidden from the default user interface (Figure 7). Most of these were the WMS operations. Even if asked to perform a task by using such a certain function, the test panel tended not to be able to find it.

Figure 7: Hidden Functions



3.3. Variations in the Test Panel

Some patterns within the test panel were found related to the measured user performances and satisfactions.

In the test panel, the individuals who were younger than 40-year old had statistically significantly better level of effectiveness comparing to the individuals who were older than 40-year old (Table 5). It was found that the older group were affected by the absence of Google-like data entry, the unclear procedures for entering geospatial search criteria, and the hidden buttons for enabling WMS functions. The younger individuals did not show such a tendency.

Table 5: Usability Evaluations in Different Age Groups

Measures	Below 40		40 and above	
	Avg	StDev	Avg	StDev
Success	9.6	1.3	7.3	1.0
Error	1.3	1.4	1.7	1.5
Incompletion	0.1	0.4	2.0	1.6

The individuals who were working for the discipline forces, such as the police and armed force, had a similar level of performance comparing to the others in the test. However, they had a lower level of satisfaction as compared to the rest of test panel. This difference was statistically significant (Table 6).

Table 6: Usability Evaluations in Different Organization Groups

Measures	Discipline Forces		The others	
	Avg	StDev	Avg	StDev
Success	8.2	1.5	8.6	1.7
Time Spent	47.3	9.1	48.5	10.2
SUMI Global	47.2	4.8	57.3	8.6

4. DISCUSSION

The results show that the test is a feasible way in studying the usability of geoportal. It organizes the observations about the use of geoportals. It is also helpful in finding the design weakness in the user interface and work process. The efforts for improving the service quality of geoportals can therefore benefit from such a test.

4.1. Findings from this Usability Test

There are several weaknesses in the design of Geodataportalen that were detected by this study.

The most serious one is the lacking of a clear display of active search criteria. Due to this weakness, the users do not get feedbacks about their operations instantly. As a result, the users are not sure if they have entered the correct search criteria. When multiple data entry steps are involved, it is difficult for the users to remember what have entered and what will be the next.

This is a kind of feedback problem. As argued by Norman (2002), a design is preferable if it can release the cognitive workloads of users when they are performing tasks. Norman states that the short-term memory and focus of human being are limited. A system should be designed considering this fact. However,

the consideration about this fact seems not sufficient in the design of Geodataportalen.

In fact, the tested version of Geodataportalen has a function to display the active search criteria. But this function is hidden in the default user interface. The users have to press a button to trigger it. Such a simple but additional step prevents the users to get instant feedbacks. Some users are aware of the existence of such a button. However, they still make mistakes in entering search criteria due to the lack of feedbacks.

Norman (2002) suggests making the important components visible. It is easy for the users to find and to user a visible function. Avoiding hiding the important functions may improve the usability.

Making the important components visible means making the less important components invisible. Improper choices can mislead the users. The Geodataportalen uses a large space at the tag for entering the coordinates of the geographic extent. The users can misunderstand the function of this component due to this arrangement and make mistakes in entering such geospatial search criteria.

4.2. Implementation of Such a Test

This study builds up a usability test based on the ISO 9241-11, which defines the usability and provides a general framework for measuring usability. The measurement is dependent on the specifications of test tasks, test panel, and the other components of the context of use. Different specifications might result in different evaluations.

This study considered only the situation that a group of GIS specialists who are working for the authorities and municipalities are searching for GI data sets in the indoor and office-like environment. However, a geoportal should also be used by the people without professional GIS backgrounds, such as health care persons, policemen or firemen. They might have quite different conceptual models about a geoportal. They might use the geoportal on a small screen tablet computer with comparatively slow speed 3G connection in an automobile. It is possible to have different contexts of use for different geoportals. The baseline is to specify a representative context of use of the tested geoportal.

This study used the SUMI for measuring the user satisfaction since it is able to provide more information about the user attitude. However, it is a big questionnaire and consists of 50 items. Filling such a questionnaire is time-consuming. Other validated but shorter questionnaire may be employed. The software usability survey (Brooke, 1996) is such an example. The software

usability survey (SUS) produces a single and overview score but it consists of only 10 items. It can be used for measuring the user attitude after every task.

4.3. Future Work

This study describes a method for evaluating the usability of geoportal. The method is based on the ISO 9241-11 framework. It splits the usability evaluation into three sub-scales including the effectiveness, efficiency and satisfaction. For evaluating the representative use of a geoportal, the representative test panel, test tasks and context of use are required.

During this study, a number of weaknesses in the design of Geodataportalen were detected. These weaknesses are related to the breaches of some general design rules, such as providing adequate feedback mechanism and making important components visible. The detection of these weaknesses validates this usability test.

From a non-excluding point of view, a working tool within EU shall be “accessible for all” as intended in the EC MANDATE 376 (EC, 2005) of e-inclusion in public procurement. Although this is not the target audience of the current version of Geodataportalen, future versions might have such requirements. Therefore the development of a guideline for both accessibility and usability issues should be a priority for future works.

There are some patterns within the test panel with respect to the measured user performances and satisfactions. For examples, the difference of user performances in different age groups of the test panel and the difference of user satisfactions in different organization groups. These patterns suggest the connections between the age and user performance and between the working organization and user satisfaction might exist. However, considering the sample size of this study, it is hard to predict the level of representation of this sample. No conclusions about these connections can be made in this study. It could be a starting point for the further studies, for example, the connection between the test panel profiles and their behaviours in using a geoportal.

In order to improve the current test method and to evaluate its validity, other geoportals and GI applications have to be tested.

ACKNOWLEDGEMENTS

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