

Master Thesis
Computer Science
Thesis no: MCS-2010-04
January 2010



Usability Evaluation of Web-based GIS Applications

A Comparative Study of Google Maps and MapQuest

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This thesis is submitted to the School of Computing at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Computer Science. The thesis is equivalent to 20 weeks of full time studies.

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ABSTRACT

The use of geographical data is increasing in real world applications and due to this, Geographic information systems (GIS) are a growing interest area for research nowadays. Today, GIS is combined with the World Wide Web (WWW) to provide information to a lot of people. Web-based GIS applications have gained popularity because of their easy use and simplicity. Through browsers, web-based GIS applications can display maps with features like buildings, forests, roads and even traffic. Furthermore spatial data can be analyzed and large amounts of data can be viewed on small screens by zooming and panning the map. So having all the above features, effective web-based GIS applications should be designed in a way that they should be easy to use and understand for users.

Usability evaluation is becoming an important part of Interaction Design to find out the user's needs and requirements. In this study two web-based GIS applications (Google Maps and MapQuest) are evaluated to find out usability problems. To accomplish the main goal of this study, different techniques are used.

Special criteria are adopted for usability evaluation of these two web-based GIS applications. Usability tests have been performed with six graduate users and questionnaires were filled out by these users. Interviews were conducted with six users to validate the results.

The authors have provided a number of suggestions based on the problems that were identified in this study for Google Maps and MapQuest to improve the usability of these applications.

Keywords: Usability, Usability Evaluation, GIS, web-based GIS, Google Maps, MapQuest.

ACKNOWLEDGMENT

First of all we are thankful to Almighty Allah who gave us the strength, courage and opportunity to do this thesis. Without His countless Blessings it would not have been possible.

Secondly, our sincere gratitude goes to our supervisor **Sara Eriksén** for her kind supervision who constantly encouraged us in accomplishing this task. Her useful critics, suggestions, feedback and support made us capable to contribute something useful to human knowledge.

We are indebted to all those fellows who spared their precious time for conducting usability tests and interviews with them. We are very thankful to our friend Arshad Ahmad for giving us time to review our thesis.

We are also thankful to all faculty staff of BTH who increased our capabilities by sharing their expertise and knowledge. Our special thanks also goes to Library staff at BTH for helping us throughout thesis and all those friends who were real source of inspiration directly or indirectly.

At last but not least we are thankful to our parents and family members who sent us abroad for higher education. Without their finance, encouragement and kind support it was not possible to successfully complete the degree.

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INTRODUCTION

In recent years web-based GIS applications got popularity rapidly. The reason behind this popularity is its low cost, everywhere availability, ease of use and availability to large population. Although the development of GIS applications was started in 1950's until late 90's GIS applications were limited to some people and to some standalone computers. With the emergence of internet and WWW GIS applications got a new ride which brings them to the new era of web-based GIS applications.

Today, almost all businesses, government agencies and common people are regular users of web-based GIS applications and use them for different purposes like decision making, planning and as problem solving techniques. Web-based GIS applications have unique capabilities to integrate and allow access to disparate data sets in bringing together into meaningful shape.

The reason behind the popularity of web-based GIS applications among public is the availability of these applications without buying and installation of software. The use of these applications doesn't need any expertise because of its simple and easy to use interfaces. As internet is spreading day by day and more people are getting access to it, moreover a lot of people are traveling in different directions and they need to browse these GIS applications for looking for directions to different places and print directions to carry them while traveling and view satellite images to be familiar with that place.

In this study the authors evaluate usability issues of web-based GIS applications. For this purpose the authors conducted usability test, distributed questionnaire and interviewed those who participated in usability testing, to know the user's needs and their understanding towards these applications. Furthermore our supervisor arranged visit to ESRI S-Group in Karlskrona (Sweden) to get good understanding of the development of GIS applications and how usability issues are taken into consideration in the development process. The authors also attended presentations of two researchers from Finland at BTH Karlskrona campus regarding their research about public participation in urban development through web-based GIS applications.

Structure of the Thesis

The structure of the thesis is as follows.

Chapter 1 (Background) is about the background of the topic which the authors want to investigate in the thesis. Section 1.1 provides knowledge about web-based GIS applications. Section 1.2 explains the usability role in web-based GIS applications.

Chapter 2 (Problem Definition/Goals) describes why usability evaluation of web-based GIS applications is important. Section 2.1 is about the applications which are evaluated during this study. Section 2.2 is about research questions and in section 2.3 goals/results are discussed.

Chapter 3 (Research Methodology) describes research methodology used during this study. Section 3.1 gives an overview of the chapter. Section 3.2 is about the literature review. Section 3.3 explains think aloud protocol. Section 3.4 describes questionnaire while section 3.5 describes interview.

Chapter 4 (Theoretical Work) is basically a presentation of our literature study of the area. Section 4.1 explains usability definitions and its role. Section 4.2 explains what a web-based

GIS application is. Section 4.3 explains the architecture of web-based GIS applications. Section 4.4 is about the role of web-based GIS applications. Section 4.5 explains main features of web-based GIS application. Section 4.6 describes advantages and section 4.7 describes limitations of web-based GIS applications. Section 5.8 is about Google Maps and section 4.9 provides knowledge about MapQuest.

Chapter 5 (Empirical Work) explains empirical study and usability testing procedure. Section 5.1 describes usability testing of Google Maps and MapQuest. Section 5.2 is about piloting usability testing. Section 5.3 explains testing environment. Section 5.4 explains test conduction. In section 5.5 selection of users is discussed. Section 5.6 is about designing of tasks. Section 5.7 describes tasks. Section 5.8 is about the questionnaire for usability testing. Interview is described in section 5.9.

Chapter 6 (Results/Analysis) Section 6.1 explains usability test results. Section 6.2 is about the task timing analysis for both applications. Section 6.3 describes usability test observation for Google Maps and MapQuest. Section 6.4 is about the questionnaire results. Section 6.5 describes distribution of questionnaires. Section 6.6 explains comparison of Google Maps and MapQuest against adopted criteria. Section 6.7 describes interview analysis.

Chapter 7 (Discussion) Results are discussed and analyzed in this chapter. Section 7.1 contains discussion. Section 7.2 is about the validation of the results. Section 7.3 is about the selection of usability criteria.

Chapter 8 (Conclusion) Section 8.1 is about answers to the research questions. Suggestions are given in section 8.2 and section 8.3 is about future work.

1 BACKGROUND

In this chapter, the authors discuss background of the web-based GIS applications that helps the readers to know main theme of this study. Furthermore role of usability in web-based GIS applications is also discussed.

1.1 Web-based GIS applications

A Geographical Information System (GIS) is a tool that contains information of a specific geographical area, while that information can be analyzed for different purposes. GIS applications have the same functionality as conventional maps but have some more dynamic features, which enhance their performance. Data's integration is the most valuable part function of GIS (Bernhardsen 2002). GIS can be defined as a specialized class of database management system through which users can analyze, relate, and display location based data in addition to conventional relational data (West 2000). According to Vonderohe (1993) GIS is a system that integrates hardware, software, data, people, organizations, and other institutional arrangements for the purpose of collecting, storing and analyzing information about specific areas of the earth. By studying both definitions of GIS author's can describe GIS as a powerful tool that can integrate, visualize, store, manipulate and analyze spatial data (Dragicevic 2004). It organizes and exploits digital data from databases. The benefits of GIS over the traditional manual maps are zoom in and out of a map, selected area can be displayed, area can be calculated between places and data from different sources can be combined by working with different layers of map based information (Bernhardsen 2002).

The term "*Geographical Information System (GIS)*" was coined by the researchers of Man Machine Interaction at MIT but was visualized successfully on monitors in early 1990's. Later in 1992 the term GIScience was coined. With the passage of time when common users started taking interest in these applications, the development of these applications dramatically increased (Haklay & Zafiri 2008). In a very short time with the integration of internet and GIS technology, the research in the area of GIS applications has been dramatically changed. Furthermore, that research refers to different names like Web-based GIS, Internet GIS, Internet Distributed GIServices and Online GIS.

In the last decade there has been a rapid increase in the use of web-based GIS applications in fields like education, transport, criminology, marketing, sociology, business and disaster recovery. Today almost all businesses and government agencies use GIS applications as a tool for decision making and problem solving (Goldin & Rudahl 1997). According to estimate made in 2002 fifty percent of public administration needs geographical data (Bernhardsen 2002). This need has probably grown even more since then and with the passage of time more and more people are becoming regular users of GIS applications (Goldin & Rudahl 1997).

Web-based GIS applications are online services over the internet that provide maps to the users and help them to search and browse spatial information like locating different places and routes. With the passage of time, it is becoming more popular due to its convenience, easy to use and cost effective nature for the retrieval of geographical information (You 2007).

The use of Web-based digital maps is not always simple, because these maps are used by people having different backgrounds and these sites may not always function according to their expectations (Nivala et al. 2008). The usability of GIS applications needs special attention. Moreover, in terms of end user requirements these applications need consistent usability evaluation in the development process and also after development (Koua & Kraak 2004). Thus, Usability evaluation is becoming an important part in digital maps for users (Nivala et al. 2008).

1.2 Role of usability in web-based GIS applications

According to the well known usability expert Jakob Nielsen (Nielsen 2000) usability is necessary for survival in the market, because if the product or application has problems with usability and users don't get the results they want then they will simply leave the web site. Usability means that people can use the product easily and can perform their task in expected time. Usability is defined in the ISO 9241 standard as "the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments" (Nivala et al. 2007). With the help of above definitions authors can say that usability can be measured by different attributes like learnability, efficiency, effectiveness, utility, memorability, error tolerance and satisfaction (Barnum 2002).

Usability is important concerning the web and if any website has problems like file downloading takes time, no clear navigations and not oriented towards the needs of the users, then users get frustrated and they will not use this website in future (Barnum 2002). The interface of the website must be so simple that experienced and non experienced users can easily use it and fulfill their requirements with it. The users are only satisfied when they can achieve their goals in a successful and efficient way. There are more things to write about usability but they are discussed in later chapters in detail (Dillon 1994)

As web-based GIS applications are a combination of complex systems, its interfaces should be designed in a way that normal users can interact with it easily and can fulfill their requirements without problems.

Usability evaluation has methodologies that help to measure usability aspects in system interfaces and also identify the problems. During the interface design process, Usability evaluation has an important role that includes interactive cycle of designing, prototyping and evaluating (Ivory & Hearst 2001). Usability evaluation methods play an important role in the designing of most GIS applications because usability aspects included in product design give credibility to company and customers are more satisfied with the products. Map applications are nowadays used by many users who have less experience in using the geospatial data, so usability aspects give benefits to the users accessing internet based services which contain easy to use and attractive exploring functions. Usability thus has an important contribution in the development of successful web-based GIS applications (Nivala et al. 2007). Koua et al. (2006) proposed usability evaluation criteria for GIS applications, this evaluation helps to assess the ability of GIS applications regarding user performance and satisfaction. This evaluation is very important for evaluation of web-based GIS application because many usability issues can be taken care of through usability testing.

2 PROBLEM DEFINITION/GOALS

This chapter consists of problem definition which explores the problems faced by users while using web-based GIS applications. The names of applications targeted in this research study are given. The research questions are given which authors investigate throughout this study. At last the goals of this research study are also presented.

Originally, GIS applications were used by specialists who have already knowledge of visualizing, manipulating, and analyzing of spatial data. However, with the introduction of web applications, now common people regularly use GIS applications. With the integration of web and GIS applications opportunities for inexperienced users arise to look at maps over the internet (Nivala et al. 2007).

The use of Web GIS is increasing day by day. Web GIS helps users access maps through which they can search and browse spatial information. These applications have gained popularity due to their convenience, low cost and dynamic characteristics. The usability of GIS applications mostly depends on the interface design. If the interface is not designed well according to the user's expectations and does not fulfill their requirements then errors and frustrations occur. Web maps are different from general web pages or other computer applications, but at the same time these maps can be accessed through web browsers in graphical user interface. The interface of the web maps is difficult to learn and understand because special functions are needed to manipulate these maps. All web maps use different interfaces, and therefore users have to learn different interface style with each web map (You 2007).

Maps can also be considered as user interfaces. Peterson (1995) mentioned that the word interface has the relation to maps in two ways, firstly, interfaces to the world and secondly they consist of user interface elements. The layout of the map, its legend (a small table that explains symbols used on the map), colors, and designs are all features of the map's user interface that allow the users to interact with these maps (Nivala et al. 2007). To design user interfaces for web based GIS applications important usability issues like satisfaction, learnability, efficiency, effectiveness and error prevention should be considered (You 2007), which are highly relevant to web-based GIS applications.

2.1 Web-based applications to be targeted

In this study the authors compared and evaluate the usability of two web-based GIS applications Google Maps and MapQuest. These two web-based GIS applications are well-known. Both applications have same features like navigation (zooming and panning), get directions, and users can print the map. Furthermore, these two applications have same functionalities but with different legends, colors and design. The authors feel that the usability of these web-based GIS applications could be interesting to explore and compare.

For this purpose the authors carried out a comprehensive literature review to get some understanding about web-based GIS applications and also the role of usability in these applications. Furthermore authors conducted usability tests to evaluate web-based GIS interfaces. This study explores and maps experiences regarding the interaction of end users with map interfaces. By observing end user's experiences the authors have analyzed results and based on these offer recommendations to improve the usability of both applications.

2.2 Research questions

The research questions we have addressed in our study are the following:

1. Why do we need usability evaluation of different GIS applications like Google maps and MapQuest?
2. How can different GIS applications like Google maps and MapQuest be evaluated?
3. What are the usability issues in Google Maps and MapQuest?
4. What are the suggestions for improvements in usability of both applications?

2.3 Goal/Result

The main goal of the study is to compare and investigate the end-users requirements and needs regarding Google Maps and MapQuest by conducting usability test, questionnaires and interviews.

The results have been archived by addressing the following sub goals.

- To compare and evaluate Google maps and MapQuest against various parameters for usability.
- To identify the strengths and weaknesses of Google maps and MapQuest.
- To identify various usability issues.
- To explore various web based evaluation techniques.
- To identify different aspects after comparative study concerning which GIS application is more efficient.
- To explore such criteria for usability evaluation that can be especially relevant for web-based GIS applications. These criteria could be in relation to the specific challenges that these applications have, and might be somewhat different than traditional usability criteria, due to the fact that usability evaluation was developed earlier than web-based GIS applications.

3 RESEARCH METHODOLOGY

This chapter is about research methodology used in this study. First overview of research methodology is given then literature review is discussed. Think aloud technique is discussed further which is used in usability test. Finally questionnaires and interview have been discussed regarding this research study.

3.1 Overview

Research methodology is an essential part for conducting research (Mellenbergh et al. 2003). Today research work is carried out through three types of research: qualitative, quantitative and mixed methodology (Creswell 2003). Johnson & Onwuegbuzie (2004) argued that mixed methodology is the natural complement of the qualitative and quantitative methods. Moreover, mixed methodology should be considered the third methodology in the field of research which brings research beyond the qualitative and quantitative methods. In this study authors adopted a mixed methodology approach, in which qualitative results have been obtained from literature review and quantitative and qualitative results through usability testing. Figure 1 gives an overview of methodologies we have applied in our study. The various methods we have used are presented in the following.

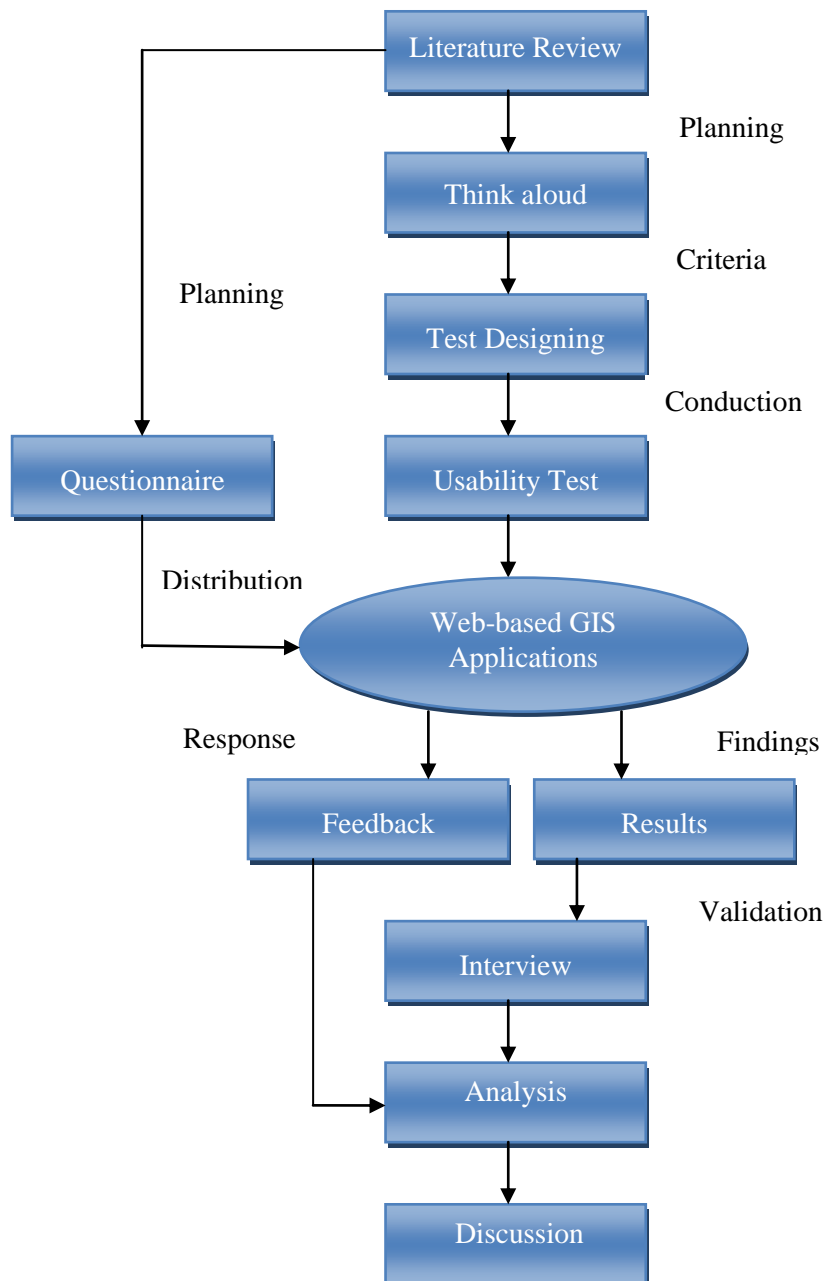


Figure 1 Methodologies used for this study

3.2 Literature review

The authors have done a thorough systematic literature review for accomplishing their thesis. This has been done in two steps; first literature search aimed at finding sources and second synthesizing information (Reed 1998). Initially authors needed information for study, so we did a literature review in order to get an overview of the area under investigation. Literature review helped the authors to understand what other researchers have done in related fields of study (Reed 1998; Blaxter et al. 2006). For literature search the authors have used BTH digital library to access relevant information related to our topic. We have searched important information in ACM, IEEE, Scopus and Springer databases on the BTH library web site. Authors have also borrowed books from BTH library. During literature search we have asked for advice from our supervisor and senior students in order to get better understanding (Blaxter et al. 2006).

Through literature review authors have gained an in-depth understanding about GIS applications and usability issues. Authors have studied books, articles, journals, research papers for usability evaluation of these GIS applications to gain knowledge on usability, usability testing techniques and usability inquiry approaches for our study.

3.3 Think aloud

Think aloud refers to a method of inquiry where users explain aloud what they think as they carry out a task or assignment. Think aloud is a way of testing humans concurrently and their actions directly towards the solution of a problem. This method consists of two stages. First collecting observations through think aloud protocols from users and secondly analyzing the human behavior while dealing with a problem. In think aloud protocol investigators give detailed instructions before testing, like “keep talking while performing tasks” (Jaspers 2009).

The think aloud method has a high value in evaluating systems for looking deeply for the usability flaws. That’s why researchers frequently use it to gather information about a system from the potential users (Jaspers 2009). The authors selected this type of method because in this technique the user interacts with the system and also explains verbally what he is doing or what kind of problem he is facing while performing tasks. Furthermore the authors also made video recordings while conducting test on users, making video of users while interacting with web-based GIS applications. We had originally planned to record the videos through video camera but due to unforeseen circumstances, in the end we decided to record it through Camtasia Studio (2009) software. This software is able to record user’s interaction with the application together with their voice. The advantage of this technique is that it can be reviewed next time (van Velsen et al. 2007; Jaspers 2009). Recording of the usability testing sessions made it easy for the authors to investigate usability problems in a detailed way while the user interacted with the system. Benefits of the think aloud protocol is that it is a rich source of attaining data, and it gives a detailed insight of the usability problem (Jaspers 2009), as the user himself/herself perceives it.

There are many usability evaluation techniques available like expert based evaluation which includes cognitive walkthrough and heuristic evaluation (Jaspers 2009) and testing in usability labs. But the reason for selecting think aloud was that expert based evaluation needs expert people from industry who have enough knowledge of usability and web-based GIS application. But because of their tough schedule and time limitations of our study it was not possible to wait for them for a long time. Other technique which is testing in usability lab was also impossible because there is no usability testing lab available in our university.

3.4 Questionnaire

Questionnaire is an inquiry approach which we have chosen to use for interface evaluation, as a way to gather more data from users (Usability Evaluation 2009; Barnum 2002). After conducting Think aloud test with users, we distributed questionnaires to students involved in the test and also gave them to experienced students who have used Google maps and MapQuest for their requirements. The authors used this approach for collecting data because questionnaires can be distributed to larger number of people to get broad response and it is a cheap approach (Barnum 2002). In our case, we also used questionnaires deliberately as a form of data triangulation that is comparing data from different methods of data collection to get a richer picture.

Authors designed simple and unambiguous questions that helped the users to answer these questions without difficulty. Authors used close-ended questions in the questionnaire because it saves time to complete the questionnaire (Barnum 2002). Moreover, 5-point scale (1-5) known as Likert scale was used because it is easy to interpret and users can choose neutral central point (Laerhoven et al. 2004; Barnum 2002).

3.5 Interview

Interview is also an inquiry technique through which evaluators can obtain detailed information from users (Folmer & Bosch 2004; Barnum 2002). In usability research context, such detailed information may contain user requirements, what users think about system (Folmer & Bosch 2004). After getting results from usability testing and questionnaire authors conducted an interview with those students who participated in the test. Results from testing and questionnaires were validated by the interviews. During the interviews, authors observed and noted user's responses regarding Google map and MapQuest applications. Questionnaire and interview provided valuable information that helped authors to understand the requirements and experiences of the users regarding Google Maps and MapQuest applications (Barnum 2002).

4 THEORETICAL WORK

Chapter 4 presents usability definitions and the role of usability and usability evaluation for interface design. This can be helpful for readers in order to get a better understanding on usability. Furthermore web-based GIS applications are discussed from scratch and this is further expanded up to the architecture, role of web-based applications in daily life, features of these systems, advantages and limitations. In the last section the interfaces of Google Maps and MapQuest are discussed more specifically.

4.1 Usability definitions and its role

Usability plays an important role in the software development process. Usability has many definitions like other software engineering terms (Folmer & Bosch 2004). According to the International standard organization (ISO 9241-11) usability can be defined as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (Jokela et al. 2003). Shackel & Richardson (1991) were some of the authors who recognized the importance of usability engineering and proposed to measure usability by four different criteria. The criteria are **effectiveness**, **learnability**, **flexibility** and **attitude**. Effectiveness concerns the performance in accomplishment of tasks, learnability means degree of learning for achieving tasks, flexibility is about the ability to adapt to the variation of tasks and attitude relates to the users satisfy with the system (Folmer & Bosch 2004).

Usability is defined by Nielsen (1993) in a more detailed way. Nielsen associated five important attributes with usability and these attributes are **learnability**, **efficiency**, **memorability**, **errors** and **satisfaction**. Although usability has been defined by many people, the authors would like to give brief description of the five most important attributes of usability defined by Nielsen as they have a key role for the user’s perspective and perception of most interfaces. A brief description of these attributes is the following (Nielsen 1993).

- **Learnability:** The system must be so simple and easy to learn that users can learn it quickly in order to do their work on the system without difficulty.
- **Efficiency:** The system should be efficient and save time for users when they work with it.
- **Memorability:** The system should be easy to remember by the users so that when they use this system after some time, they should not need to learn everything again for doing their work.
- **Errors:** The system must have low error rate and should help the users to make few errors while using the system.
- **Satisfaction:** The system should work in a pleasant way that assures that the users are likely to use it and are satisfied with the system.

Nielsen presented how these different criteria operate that shows clearly the concept of usability and its role in the larger issue of acceptability. Acceptability can be comprised into practical and social acceptability. Usability and utility can help in product usefulness which improve the ability of user to carry out a task. According to Nielsen, usability influences product acceptability among users, as shown in the Figure 2 (Folmer & Bosch 2004).

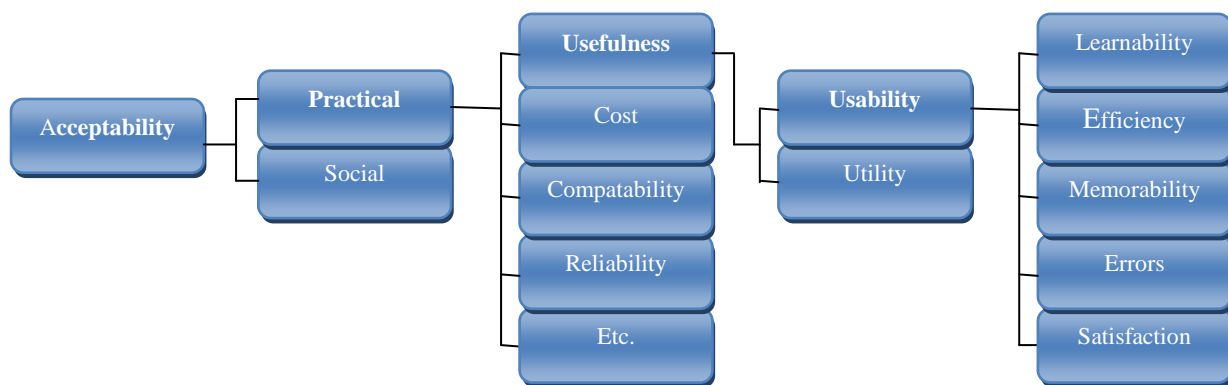


Figure 2 Usability goals according to Nielsen as presented in (Folmer & Bosch 2004)

The ISO organization has played an important role in the development of many Human Computer Interaction (HCI) and usability standards for the last 15 years. These standards are used in the industry to impose consistency. These not only have developed standards for software interface but also for its components like icons, cursors controls etc.

The three attributes of usability presented by the ISO 9241-11 are described as follows:

- **Effectiveness:** The users achieve their specified goals with accuracy and completeness. The system must be accurate and contain complete functions such that users have no difficulty in achieving their goals.
- **Efficiency:** The resources of the system must be used with accuracy and completeness through which users achieve their goals.
- **Satisfaction:** The users must be satisfied from the use of the system.

This definition accommodates two different views from the user's perspective. One is the user performance view that includes effectiveness and efficiency and the other is the user view which is concerned with the issue of satisfaction. The ISO 9241-11 standard is used to identify the important information which must be considered for evaluating usability of user performance and satisfaction (Folmer & Bosch 2004).

Products that are used as part of every day life that have no usability and cannot fulfill the users' requirements, lead to frustration of users, and frustrated users are unwilling to use these products again (Jordan 1998).

Usability is an important aspect concerning web applications, as is obvious from the statement of Jacob Nielsen "Usability rules the web, simply stated that if the users have difficulty in accessing the website contents, they will not use it". Websites with poor usability may have many problems like downloading file takes time, no clear navigation, not oriented towards the needs of users etc. If users face many and repeated problems in websites then they do not use these websites and also can inform others to not use these websites (Barnum 2002; Nielsen 2000).

Any website or interface should be designed in a way that both expert users and non experienced users can easily use it. The success of any website or interface depends upon the user's satisfaction and users are only satisfied when they are able to do their work in an easy and efficient way. In addition to the attraction of websites regarding using well thought

through colour schemes, web sites also need to help the users to accomplish what they want to use them for. Even if a website performs well due to its functionalities, but users are unable to understand how to use it, then it is not a usable website because it does not fulfill users requirements (Dillon 1994). The quality of product or interface can only be successful when important usability evaluation criteria are taken into consideration during the design and development process (Stone 2001).

Koua et al. (2006) propose usability evaluation criteria for GIS applications for user-based and task-based evaluation. They argue that this evaluation intends to assess GIS application's ability to meet user performance and satisfaction. Moreover their assessment focuses on the effectiveness, usefulness and performance of the application. It is important for such applications because usability testing based on these criteria can provide good understanding of usability issues in web-based GIS applications. Their proposed assessment methodology includes three criteria which are: effectiveness/user performance, usefulness and user reaction.

According to Koua et al. (2006) effectiveness deals with application functionality and effectiveness evaluation is based on observations of user performances and experiences of the tasks. It also deals with the gathering of data and any parameters available to complete a task. It is measured by the time which is spent on completing tasks, how many tasks are complete and incomplete, errors and error rate, whether the task which is carry out is correct or not and their performance and response, ease of use and level of difficulty and time spent for getting help.

Usefulness has to do with the user's expectations and demands while carrying out different tasks. It depends on whether the application is supportive of user's goals and tasks, if users can easily understand and interpret the application results, whether it is flexible according to user expectations. All this data can be gathered through users comments, task performance, verbal protocols and responses to questionnaires (Koua et al. 2006).

User reaction deals with user's opinions, views, attitude and user preferences towards application. This also can be measured by questionnaires, rating and interviews (Koua et al. 2006).

Information Services and Technology (IS&T) at Massachusetts Institute of Technology (MIT) is a group working on usability aspects of websites. Their services include group reviews of the websites (heuristics reviews), accessibility testing, usability testing, Card sorting, Pluralistic walkthroughs and Consultation for usability tests of products (Usability @ MIT, 2009). They also work continuously for developing guidelines for usability evaluation of websites. According to them most factors that could be evolved in usability evaluation of any web sites concern the following (but it should be kept in mind that it is not necessary to apply all factors to all web sites) navigation, functionality, user control, language and content, online help and user guides, system and user feedback, web accessibility, consistency, error prevention and correction, and architectural and visual clarity (Usability Guidelines, 2009).

The criteria proposed by Koua et al. (2006) have been adopted for our usability evaluation of the system. The reason for this selection of criteria is that it is specially developed for GIS applications. Furthermore, the authors also adopted IS&T guidelines along with selected criteria of Koua et al. (2006) for designing of questionnaire. As our focus is on usability evaluation of web-based GIS applications, the selection of Koua et al. (2006) will cover the specific usability evaluation of GIS application and IS&T will cover the broader web aspects of our selected web-based GIS applications.

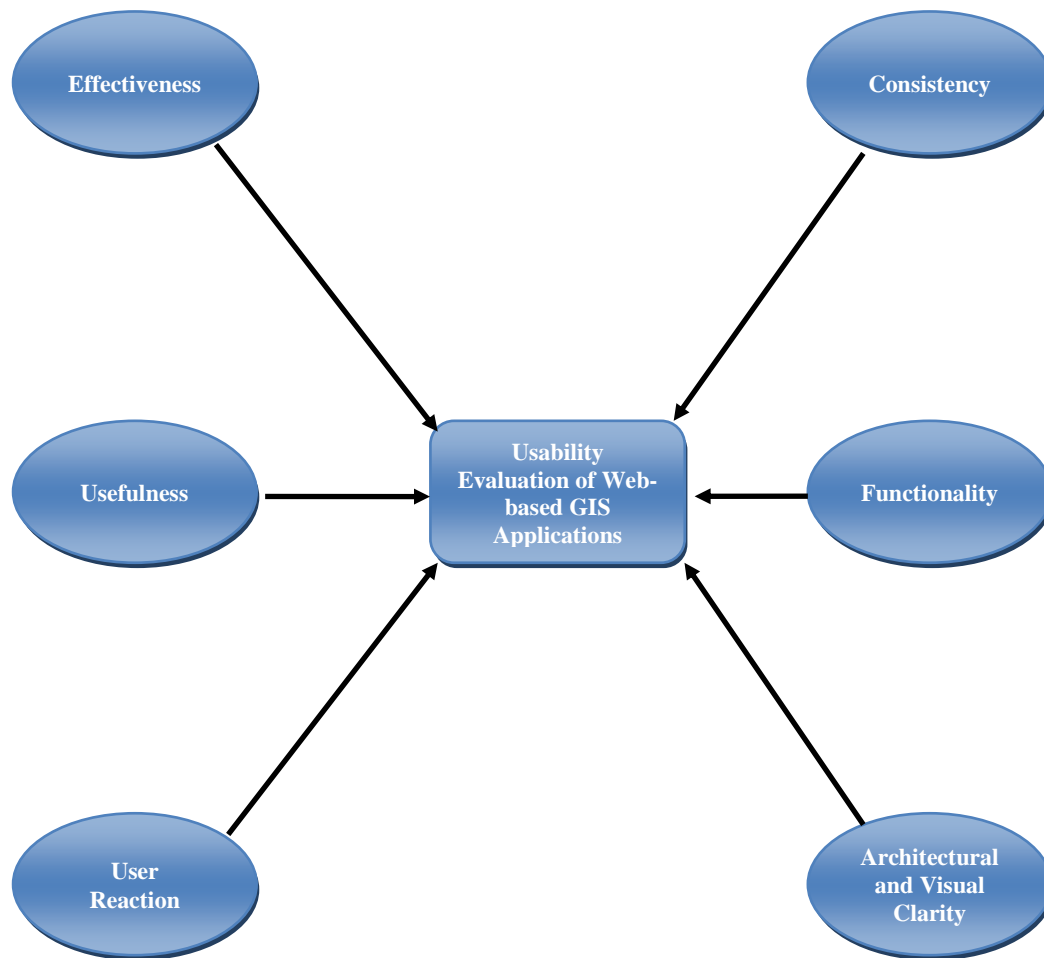


Figure 3 Adopted criteria for Usability Evaluation of web-based GIS applications in this study

4.2 What is a web-based GIS application?

A web-based GIS application is an application that is accessible through a browser. It makes it possible for the users to access GIS with its basic functionalities like searching locations, getting directions, zooming and panning and printing maps via web browsers. In other words, web-based GIS means that geo spatial information can be published, searched, analyzed, displayed and processed over the internet. Web-based GIS brings a lot of ease to the users (Shen et al. 2008). With the coming of web-based GIS a person who doesn't know anything about geography can use the application through any standard browsers (Schimiguel 2008).

Web-based GIS applications are enhancing the capabilities of users in three different directions. The first one is access of spatial data and different information. With the web-based environment, a simple GIS gets the ability to become interactive, dynamic, and accessible to large groups of users as a visual communication tool. The second direction is spatial data exploration and geovisualization which offer business minded people support for better decision making for their business. The third direction is processing, analyzing and modeling of spatial data (Dragicevic 2004).

Web-based GIS becomes disrupting technology for traditional GIS applications, because interactive maps and beautiful cartography are now available on any standard browser

without any special installation and plug-ins. Traditional GIS applications have deficiencies like lack of simplicity, accessibility, immediacy, responsiveness, and low cost. The above are the deficiencies which normal users are looking to solve. So web-based GIS applications are trying to overcome these deficiencies. Traditional GIS applications still have richer and deeper solutions compared to the web-based GIS applications but this gap will probably be filled in near future (Vermes 2006).

4.3 Architecture

Web-based GIS applications have client/server architecture, which has a client side and a server side. In this architecture users interact with the GIS application through a browser. The web browser is a client which performs presentation functions while the web server is to be considering as a remote server which performs data storage, extraction and processing. (Alesheikh et al. 2002; Soltanieh et al. 2003; Abel et al. 1998).

The web-based GIS application presented in Figure 4, a web browser for example Internet Explorer or Firefox, acts as a client that can be run on any computer through which users get access to the internet. This browser plays the role of interface between users and GIS. The application server performs important functions as processing data, doing complex analysis, calculations and communication between client and the GIS is allowed by this server. Application servers also help organizations to share their information through easy web services. The database server includes a database management system which stores and manages the data used by the application server (Hossack et al. 2004; Lan et al. 2009). Many GIS applications make use of more than one database, and different databases may be stored on and accessed from different servers, which can sometimes cause long answering times for GIS applications while the necessary data is being compiled and returned to the user interface.

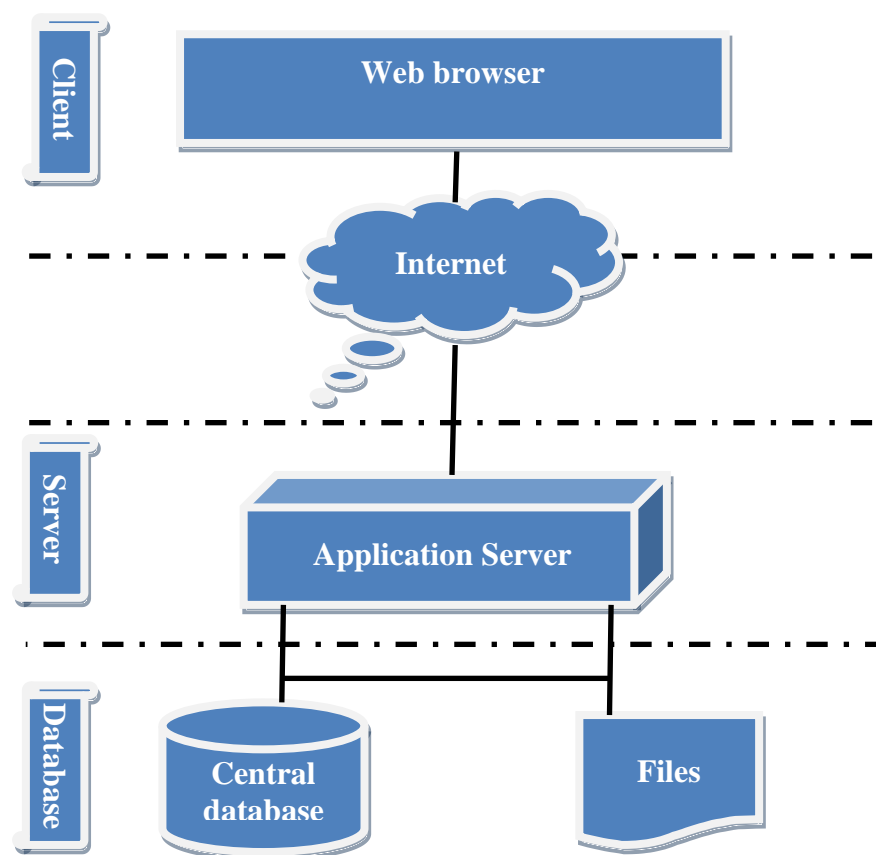


Figure 4 A typical Architecture of Web-based GIS (Lan et al. 2009; Hossack et al. 2004)

4.4 Role of web-based GIS applications

Today, it is the age of information and information means power. Especially the people have this power of information who can collect, analyze and process geospatial information. Web-based GIS applications can provide access to spatial information efficiently to people. Traditional GIS applications were only available for government, various experts, military use and public administrations, but now with web-based GIS it is accessible to common users through any web-browser without any cost and any installation (Caldeweyher et al. 2006).

According to Raheja et al. (2001) web-based GIS applications can play a big role in disaster management by providing cost-effective information at different stages of the disaster life cycle, with a faster and wider reach. This information might be about flooding, earthquake, landslide, cyclone, and wildfire. Thus, these applications could help in disaster management cycle like, disaster preparedness, response, recovery and mitigation.

The use of web-based GIS applications can play a big role for public participation for urban planning. For urban planning the knowledge of local people can be gathered on the basis of people's daily life experiences regarding where people live, work and act. People can mark the dangerous spot on the road while they drive their cars, people can suggest new locations for bus stops and also can suggest new places for parks by providing them with web-based GIS applications through which they can mark the places where they want to see improvement made (Nuohua & Kuutti 2008).

With the help of web-based GIS applications more informed environmental decisions can be made. Web-based GIS applications can contribute in the enhancement of environmental decisions by functions like multimedia and visualization of data representation, spatial analysis of multi-criteria for decision making, user's values elicitation and interaction facility with users through interactive reporting and communication (Dragicevic 2000).

4.5 Main features of web-based GIS applications

Web-based GIS applications provide many features designed for specific functions. Authors will give brief description of the most important features present in web-based GIS applications (Steinmann et al. 2005). These features are discussed below.

4.5.1 Searching Locations

This is the most important feature in web based GIS applications. Users can search for different places. They can easily find the address of places by entering the address, city name, zip code. If the users have difficulty in finding a hotel, airports, businesses etc they can easily find these places through web based GIS applications. Even if the users do not know the exact address of the location, these applications can provide relevant matches for that location (Steinmann et al. 2005; MapQuest Help 2009; Maps Help 2009).

4.5.2 Navigation

This feature helps the users to pan the map into four directions and it can be zoomed in or zoomed out easily. Navigation control contains the arrows through which users can move the location towards north, south, east or west by clicking them. Through zooming, users can zoom in or zoom out shifting swiftly between overview and detailed versions. (Steinmann et al. 2005; MapQuest Help 2009; Maps Help 2009).

4.5.3 Get Direction

This feature facilitates for the users to get directions for getting from one location to another. Depending on different web based applications, direction on the map can be seen in different colors so that users can easily recognize the places they are looking for. There are also other

options that help users, such as skipping the major highways between two locations and changing the starting and ending directions (Steinmann et al. 2005; MapQuest Help 2009; Maps Help 2009).

4.5.4 Printing Maps

This feature is very easy and facilitate for users who want to have their maps in printed form. When the users set their direction from one place to another place they can also make a printout of it. Different web based map applications offer different options in printing the maps, such as the option to optimize the view by dragging and zooming, add notes and options for printing directions, including creating a map of each step in direction, text-only printing in that direction and to print the entire route on the map (MapQuest Help 2009; Maps Help 2009).

4.5.5 Sharing Maps

This feature allows users to share their chosen maps with other people. Once a map is adjusted or provides directions then it can be sent to an email address, phone numbers, mobile devices etc (MapQuest Help 2009; Maps Help 2009).

4.5.6 Creating Maps

Users can easily create personal maps through this feature. Place marks, lines and shapes can be included in these maps. If this personalized map is created, text can be added, videos or photos can be inserted in it and also sharing of these maps is possible with others. With the help of this feature users don't need to create maps again and again, once a user sets directions, finds places and business he can save it and then can retrieve it when he needs it in future (MapQuest Help 2009; Maps Help 2009).

4.6 Advantages

There are a lot of advantages offered by web based GIS applications. Citizens, investors, local government, business community, tourists etc., all are involved in getting benefits from these applications (Stachowicz 2004; Hossack et al. 2004). Some of the advantages are described below.

- The main advantage of web-based GIS applications over traditional GIS is that traditional GIS was restricted to specific people but web-based GIS applications are accessible to a large number of people (Shaig 2001; Peng & Tsou 2003; Zhao & Coleman 2007).
- Web-based GIS applications are very cost effective; basically users can get information without any cost (Shaig 2001; Hossack et al. 2004; Peng & Tsou 2003; Zhao & Coleman 2007).
- One of the good features of these web-based GIS applications is that they are easy to learn and easy to use. These applications mostly follow internet standards (Shaig 2001; Hossack et al. 2004; Peng & Tsou 2003; Zhao & Coleman 2007).
- Web-based GIS is an excellent way for citizens to communicate with the local government on the net. Citizens can easily achieve services and information from authority using interactive map-based services (Stachowicz 2004; Peng 2001; Saad-Sulonen & Cabrera 2008).
- Interaction of users and application through browsers, no installation on the user's own PC or other artifact is needed (Hossack et al. 2004).

- Web-based GIS can display wide regions on small screens (Hossack et al. 2004).
- Web-based GIS applications do not only provide free access to maps and other tools like zooming and panning but also provide other map related services (Stachowicz 2004; You 2007).
- To report a problem in a specific area is also possible via web based GIS. After reporting the problem, information is transferred to the official problem dealing authority. This could save time and money because citizens then do not need to call the authority for reporting of problem. Problems like blocked drains, neighbor noise, failing of traffic lights can be reported (Stachowicz 2004; Saad-Sulonen & Cabrera 2008).
- Through web-based GIS, authority can easily communicate with people 24 hours a day and citizens can get updated information from time to time. For example, concerning road repair and construction work, citizens can see those locations in which road repair work is going on roads for repairing. So travelers can take alternative routes to avoid road congestion for saving time (Stachowicz 2004; Peng 2001).
- Web-based GIS applications can play an important role in natural disaster management. Furthermore, with the help of these applications, land sliding in different areas can be explored and reported (Raheja et al. 2001; Lan et al. 2009).
- Web-based GIS helps users to swiftly find the closest school, library, sport clubs etc. It is the new way of communication with citizens for reporting problems. E.g. web based GIS helps citizens avoid spending time in queues for finding the right person for problem reporting (Stachowicz 2004).
- Investors can see the sites of those locations from their offices abroad where they are planning to invest. So they able to see the nearest parks, banks, restaurants and other businesses. In this way, investors are able to make their decisions, processes in quicker ways. After making contact with the investors, authority can deliver extra information to citizens about all the process (Stachowicz 2004; Hossack et al. 2004; You 2007).
- Web based GIS plays an important role in providing information to the visitors and tourists. Tourists often search for the ideal places for staying. Web-based GIS helps them to find many places and then a desired place is selected (Stachowicz 2004).
- The main advantage of web-based GIS applications is their cross-platform nature. It doesn't matter what operating system the user is running because internet is not limited to any machine or operating system. Anyone who can access internet can use these applications (Peng 1997).
- Web-based GIS applications can enhance the potential for future developments in the areas of wireless and mobiles (Dragicevic 2004; Peng & Tsou 2003).

4.7 Limitations

- The limitation of web-based GIS applications is the problem of bandwidth. If the internet speed is slow then response time will be high and user will get frustrated (Shaig 2001).
- The performance of web-based GIS applications will also be affected by the speed of computers on client or server side. If one of them is slow then response time will be high (Shaig 2001).
- Only people who have internet connection can access these applications, so large groups of people still cannot use these applications (McCall 2003; Nedovic-Budic 1999; Craig et al. 2002).
- While web-based GIS applications are accessible through browsers and for this purpose they require specialized functionalities, this increases the complexity in conventional browsers (Zhao & Coleman 2007).
- High speed internet connections are available but at a high cost. Most people still use maximum of 56K modem connections to use web-based GIS applications (Shaig 2001).
- One of the big issues for web-based GIS applications is interoperability. Accessing and sharing remote data, functions and application program is quite difficult (Peng 1999; Beaumont et al. 2005; Nedovic-Budic 1999; Sarjakoski 1998)
- Because of the speed issue, it's still difficult to manipulate raster images which enhance the visualization capabilities (Shaig 2001).
- Web-based GIS applications still provide limited functionalities. There are problems in performing advanced geographic operations such as overlay (Shaig 2001).
- Some skills in using GIS systems are needed to make good use of the web-based GIS applications. Most common users don't know how these actually work and they also don't understand how the maps themselves actually work (Kingston et al. 2000).
- According to Cobb & Olivero (1997) one of the big problems in web-based GIS applications is that most web sites are not designed well and most users are unable to interact with these easily because of the lack of cartographic design principals.
- As web-based GIS applications are available 24 hours a day, they need consistent maintenance. For this purpose organizations providing these services need to hire personnel or consultant who can take care of the application maintenance for long time (Kingston et al. 2000).
- Sometimes politicians and local government just don't want the public to be capable of participating in the decision making and they don't want to promote it (Carver et al. 2000).
- The collection of public data for web-based GIS applications could generate security and privacy issues (Maguire & Longley 2005)

4.8 Google Maps

The service of Google Maps was presented for the first time by Google Inc. in February 2005. This new service brought with it nice features including simple interface, fast loading pages, easy navigations and the function of API (Application Programming Interface). Google maps offers features on the web for people to search locations, get directions, zooming and panning with addition to many innovations in the user interface. Google Maps offers ability to navigate through global maps of any given country. Through Google Maps users can see street view of some of the cities of the world. It provides unique and comprehensive facility of searching for viewing high resolution images, however some places are blurred for security reasons (Gibson & Erle 2006; Hernandez 2009; Google Maps 2009).

The central part of the page is covered by the world map that users can zoom in on or zoom out of and pane through navigation controls. Users can find their desired location by entering text address in the text box after clicking the “search maps” button. Google Maps also provides the facility of different options in searching like to search a specific location, business, real estate etc. Many links have different functions like viewing traffic information, to view maps as satellite imagery, printing the desired maps and sharing the maps with other people. Getting direction is the feature through which users can get directions from one place to another. The getting directions function has different options, for different forms of mobility such as through public transit, by walking and by car. Google Maps also provides opportunity to create personalized and customized maps. Once a personalized map is created photos and videos can be embedded in it. This map can be share with others and it also can be opened in Google earth (Google Maps 2009).

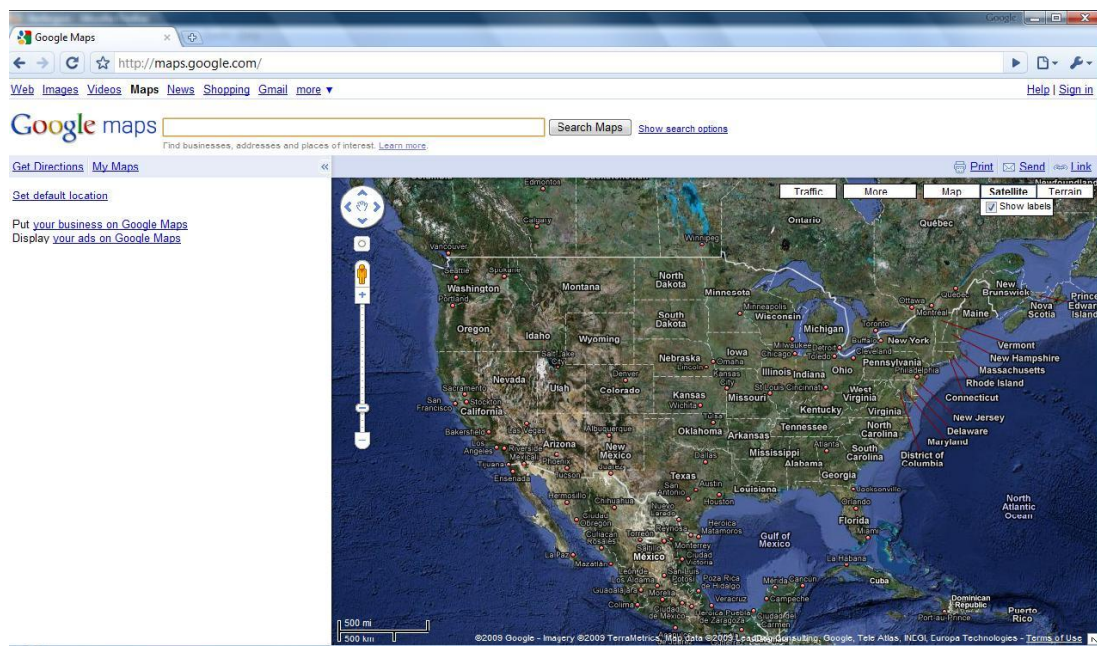


Figure 5 Main Page of Google Maps

4.9 MapQuest

MapQuest is a free online service for web mapping. It was acquired by America On-Line (AOL) in 2000. MapQuest is one of the best, trusted mapping websites for maps and directions. It allows users to view addresses on the satellite imagery through browsers. Furthermore, it also allows them to get directions turn by turn by providing starting point and ending point. Through a “my places” option MapQuest allows users to create their route and save these for later use. According to Geller (2007) market leading online mapping is

MapQuest which in 2007 had a 56.2 percent market share (Hernandez 2009; About MapQuest, Inc. 2009).

The interface of MapQuest has many links and buttons for different purposes. By opening the website, users can see the map at the centre of the page depends on location of access point. However this default location can be changed by simply clicking the “change default location” over the map. The maps can be zoomed in, zoomed out and can be panned in four directions by navigation controls. On the map there are two buttons, one is “Street Map” and other one is ”Aerial Map” which offer street view and satellite view of the map respectively. MapQuest also provides weather forecasting in the specific location of the map. MapQuest allows users to search for different locations by entering address, city, state and zip code in text boxes. The user can get direction between two places by clicking the “Direction” button. There is also an option for finding any business. Users can have easy access to yellow pages, local news and gas prices through this interface. “International” popup menu provides three different options for selecting one of them; these are US/Canada, Europe and All countries. Depending on these options, searching locations is only possible in that area. New users can be registered on this and use MapQuest web application for their requirements. “My places” has the facility to save personalized maps by adding titles and notes on it (MapQuest 2009).

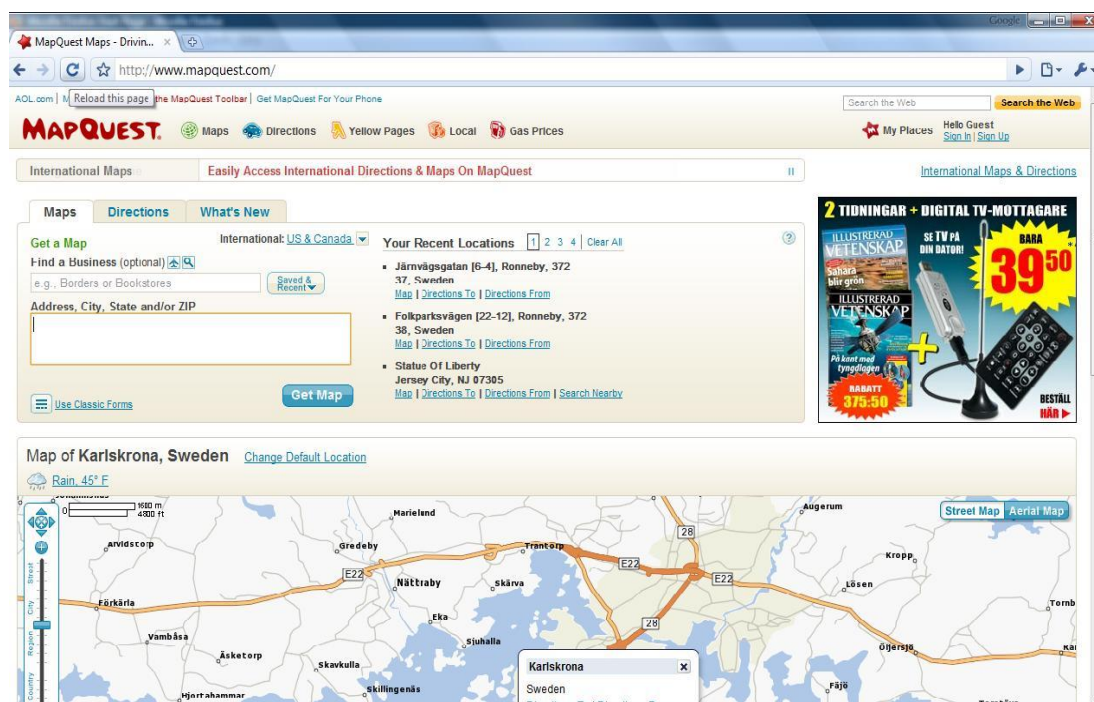


Figure 6 Main Page of MapQuest

5 EMPIRICAL WORK

In this chapter, the authors discuss the empirical work of this study. It contains what methods/techniques the authors used in the collection of results. In the beginning, overview of usability testing is discussed. Then Pilot usability test is discussed. The test environment is discussed which explains the environment during tests. Furthermore designing of tasks and also four tasks are presented for both applications. At the end questionnaires and interview are explained as to that how the authors distributed questionnaires and carried out interviews with users and got results in return.

5.1 Usability testing of Google Maps and MapQuest

Usability testing played an important role in this study, because it helped the authors to observe different users (Novice and experienced) while interacting with Google Maps and MapQuest web-based GIS applications. What are the usability issues in Google Maps and MapQuest? The authors conducted usability testing to understand these issues better. For this purpose the authors booked a silent room in the university for conducting usability test. For selecting the users to test, authors met with many students in the campus one by one and asked questions regarding their IT related background, department, and their knowledge about web based GIS applications. For this purpose six users from different departments (Computer Science and Software Engineering) were selected for testing.

Authors did testing of web-based GIS applications on one student at a time because it was easily for authors to observe them carefully this way. Recording of the users has been done through Camtasia Studio (2009) software which is freely available on net for 30 days trial. It helped authors to record user's voices and their interaction with the screen while performing tasks. The authors also noted time per task on stop watch. Users were divided into two groups. Four were intermediate users who already used these web-based GIS applications for various requirements, while the other two were new users who had not used these applications before.

5.2 Pilot usability test

Before starting actual usability tests, authors selected two students for pilot testing. This testing was important in this study to design the actual tasks well. The results based on pilot testing are not mentioned in the actual results but this helped the authors in refining all tasks, so that the users in actual testing would not have problems in performing the assigned tasks.

5.3 Test Environment

In this study, the authors selected the group room for testing due to the calm environment there, so the users did not feel any disturbance while performing tasks. All the users have performed tests on a laptop one by one. All the necessary equipment for testing was checked before the testing to avoid technical problems in performing tasks. The calm environment helped the users to concentrate on the tasks. Furthermore, same computer, browser, connection speed were used for testing because it gave accurate results.

5.4 Test Conduction

Before conducting the usability test, users were carefully guided through the entire test conduction procedure. The authors gave them useful information regarding usability evaluation and tasks of web based GIS applications. This information helped users to know in a general way what was expected of them. Think aloud technique was used for testing in this study and users have been informed to think aloud while performing the tasks. During the test, authors observed each user while performing the tasks. Think aloud method (Nielsen 1993) was useful in this testing, and much information was collected by the authors regarding interactivity of users with web based GIS applications. By using this technique, the

authors both observed the users and could share how the users perceived the web-based GIS applications. Before starting the test, the tasks list was distributed to the user for performing the tasks. Time was noted for each task and one author noted down all the observations and observations expressed by the user while performing the tasks. The authors used “Cam Studio 6” software for recording that helped them to record each user test task with audio recording and also noted the time taken for performing each task.

5.5 Selection of Users

The users have the main role in performing the usability test. For this purpose, six users were selected from two different departments of the school. Two users were novice who had not use Google Maps and MapQuest before and other the four were the kind of users who had experience of using both web-based GIS applications. The selection of suitable users was important which is why the authors met with many students in the school and six users were finally selected.

Novice Users (NU): Students who don’t have any experience of using either of two applications.

Experienced Users (EU): Students who had used both applications before.

Table 1 Selection of Users

No	Type	Program	Male/Female
1	Novice Users(NU)	Computer Science/ Software Engineering	1/1
2	Experienced Users(EU)	Computer Science/ Software Engineering	3/1

5.6 Designing of Tasks

Before designing tasks for usability testing the authors met with several students and asked them for what purposes they use web-based GIS applications. Most students replied with similar answers like “Get Directions” to know how far two places are from each other, “Printing” in order to bring these directions along while traveling, “Finding Location” for finding specific location on the map and “Zooming and Panning” to view Satellite/Ariel view of any location to be familiar with that location. It helped authors a lot for defining of tasks which can be helpful for evaluating usability of web-based GIS applications.

5.7 Tasks

The authors designed 4 tasks for testing.

Table 2 Usability Task list for Google Maps

<div><div><div>Usability Test Tasks</div><div>Google maps</div></div><div><div>Task 1: Get Directions</div><div><ol style="list-style-type: none">1. Go to the Google maps service provider at http://maps.google.com2. Select the “Get Directions” under Google maps.3. In text box “A” write “Järnvägsgatan, 37237, Ronneby, Sweden”.4. In text box “B” write “Folkparksvagen, 37238, Ronneby, Sweden”.5. Select “By walking” from drop-down menu.6. Click on “Get Directions” button.</div></div><div><div>Task 2: Print Map</div><div><ol style="list-style-type: none">1. Now click on “Print”.2. Select “Text only” (if it is not selected).3. Click on check box “Include large map” which is just next to the “Text only”.4. Again click on “Print” button.5. Select the printer and press Ok.</div></div><div><div>Task 3: Find Locations</div><div><ol style="list-style-type: none">1. Go to the Google maps service provider at http://maps.google.com2. Write “Statue of Liberty, Liberty Island” in the text box3. Press “Search Maps” button.4. Now click on “Liberty Island”.</div></div><div><div>Task 4: Zooming and Panning</div><div><ol style="list-style-type: none">1. Click on “Satellite” button.2. Now click on “Zoom here” from the dialogue box of Statue of Liberty.3. Now zoom and pane according to your requirement.</div></div></div>

Table 3 Usability Task list for MapQuest

Usability Test Tasks

Task 1: Get Directions

1. Go to the Map Quest service provider at <http://www.mapquest.com>
2. Select “Directions” from tab option, if it is not selected.
3. Select “Europe” from “International” drop-down menu (By default it will be US & Canada).
4. Beneath “Start” Select “Sweden” from country lists.
5. Write “Järnvägsgatan, 37237” in “Address” text box (which is the address of Ronneby train station) and write “Ronneby” in the “City” text box.
6. Now write “Folkparksvagen, 37238” in “Address” text box and write “Ronneby” in “City” text box.
7. Click “Get Directions”

Task 2: Printing Map

1. Now click on “Print”.
2. Select “Text & Map” radio button (if it is not selected by default)
3. Click again on Print.
4. Select the printer and press Ok.

Task 3: Finding Locations

1. Go to the Map Quest service provider at <http://www.mapquest.com>
2. Select the “Maps” from tab options if it is not selected.
3. Select “US & Canada” from “International” drop-down menu.
4. Enter “Statue of Liberty, Liberty Island” in “Address or Intersection” text box
5. Press “Get Map” button.
6. Now you have two results, click on “Map” from the 2nd option “Liberty Island, NJ”.

Task 4: Zooming and Panning

1. Click in “Aerial Map” button.
2. Now click on “Zoom to Street” from the dialogue box of Statue of Liberty.
3. Now zoom and pane according to your requirement.

5.8 Questionnaire for Usability Evaluation

After the usability testing the designed questionnaire for evaluation of usability of web-based GIS applications for different criteria were distributed to the participants. The questionnaire was designed in such a way that the authors can get quantitative results from it. The questions in the questionnaire are related to the criteria that were selected by the authors such as effectiveness, usefulness, user reaction, consistency, architectural and visual clarity, and functionality. Three of these criteria are presented by Koua et al. (2006), which suffice for assessing user performance and satisfaction with the GIS applications while the remaining three criteria are adopted from IS&T guidelines, which covers its web-based nature. All six users gave feedback via the questionnaire. The results and analysis of the questionnaire are presented in the next chapter.

5.9 Interview

After each participant had completed the usability test and filled in the questionnaire, a formal interview was conducted. The questions in the interview were open ended which encouraged the users in explaining their view in depth after testing of web-based GIS applications (Nielsen 1993). One author posed questions to the participants in a friendly environment and other author noted down their answers and responses regarding the interfaces of both GIS applications in a note book. Those interviews with participants helped the authors a lot in understanding more about the user's likes and dislikes, benefits and drawbacks of each application, their opinions and the purposes for which they are using these applications.

6 RESULTS/ANALYSIS

All the results from the usability tests, questionnaires and interviews are presented in this chapter. First the usability test results are presented then an analysis is presented for both web-based GIS applications regarding time spent on each task. Task observations for Google Maps and MapQuest are presented, questionnaire results are presented and comparison of Google Maps and MapQuest against adopted criteria is discussed. Finally the interview results and analysis is discussed.

6.1 Usability Test Results

The results have been collected through usability tests and questionnaires feedback. Six users were involved in the usability test in which two were novice users and four were intermediate users. For this purpose authors met several students at the university to find out about their knowledge and experience of web-based GIS applications. During tests on users, authors noted down the time spent on each task and also observed the users while performing the tasks. The observations were noted in notebook. The timing results of tasks for two web-based GIS applications are shown in the Tables 1 and 2 respectively.

Table 4 Google Maps Test Results

User ID & Type	Task 1	Task2	Task3	Task4
1 (NU)	02:45	01:04	02:30	01:47
2 (NU)	02:40	02:00	02:08	01:37
3 (EU)	02:28	01:01	01:47	01:00
4 (EU)	02:39	01:21	01:34	01:05
5 (EU)	00:40	00:40	01:45	00:45
6 (EU)	02:32	00:44	01:29	00:47

Table 5 MapQuest Test Results

User ID & Type	Task 1	Task2	Task3	Task4
1 (NU)	03:55	00:45	02:22	01:42
2 (NU)	03:20	01:15	02:15	01:03
3 (EU)	02:36	00:33	01:55	00:48
4 (EU)	02:12	00:36	02:13	00:53
5 (EU)	01:40	00:55	01:35	00:47
6 (EU)	02:56	00:31	02:25	00:48

6.2 Task Timing Analysis for both Applications

The authors calculated average time of tasks of all users for both applications i.e. Google Maps and MapQuest. Task 1 was about to getting directions between two places for which average time taken by users for Google Maps and MapQuest was 137 and 166 seconds respectively. In task 2, users were asked to print the result of task 1 for which the average taken time for Google Maps was 68 seconds and MapQuest 46 seconds. In task 3 users had to find a specific location on the map, average time taken by users for Google Maps and MapQuest was 112 and 127 seconds respectively. Task 4 was about zooming and panning of the specific location. All the users completed this task in average time of 70 seconds for Google Maps and 60 seconds for MapQuest. Figure 4 shows graphical representation of average time (in seconds) taken by both applications.

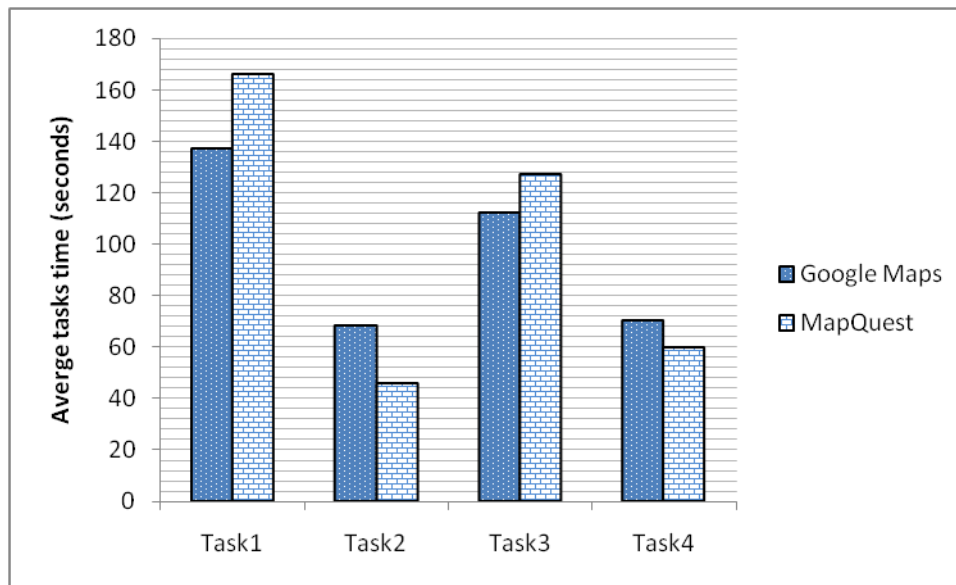


Figure 7 Average Task Timing for Google Maps and MapQuest

Figure 7 shows that MapQuest took more average time in Task 1 and 3 compared with Google Maps, while in Task 2 and 4 Google Maps took more average time compared with MapQuest. Total time taken by users for all tasks for Google Maps was thirty eight minutes and eight seconds, while MapQuest took forty minutes and zero seconds. Authors observed that both applications are very similar to each other, which seems to fit with the observation that there is very little difference in total taken time (only one minute and 52 seconds). However, it is worth noting that certain tasks were performed more quickly in one GIS application and certain other tasks more quickly in the other. This indicates that there may be different usability issues involved for certain features in each application.

6.3 Test Observations for Google Maps and MapQuest

In this section the authors present the observed users performance while performing different tasks on both applications. Testing tasks for both applications were the same. These observations are discussed below task wise.

6.3.1 Task 1

Task 1 was about getting direction between two places.

6.3.1.1 Google Maps Observations

While opening the application, it looks very simple and everything is organized. But novice users had some difficulty in finding the “get direction” link because they were expecting some kind of button for it. Most of the users easily filled text boxes for both destinations.

They appreciated the drop down menu for different mobility for getting directions, like by walking, by car and by public transit. Most users were happy with the results of task 1. One of the users suggested that there should be a button and standardized icon for “Get Directions” link. Furthermore, several users thought that drop down menu for different modes should have caption.

6.3.1.2 MapQuest Observations

Novice users found its interface a bit messy because of the many buttons and text boxes. There was also an advertisement on the main page which is mentioned by most users. Overall users liked the button for directions. One of the big problems in MapQuest was to locate the international dropdown menu for selecting Europe and US&Canada. However, most users liked it because they don’t like to write text, and here there was already an option available from the dropdown menu with captions. They found everything well organized and “Get direction” button was very visible. All users noticed that there is no option for selecting different modes of mobility for getting directions, like “by walking” and “by car”. Users also noticed that after getting directions they have to scroll down to view full directions and details on the map which is time consuming.

6.3.2 Task 2

Task 2 was about printing the map resulting from task 1.

6.3.2.1 Google Maps Observations

The task was very smoothly performed by most of the users. The print option is easy to find. But again one user mentioned that there should be a button instead of a link and the printing icon should be more visible.

6.3.2.2 MapQuest Observations

The printing option in MapQuest is very nice. All users found this task easy to perform. They didn’t find any difficulty at all. There is an icon for the print option which was appreciated by most of the users.

6.3.3 Task 3

Task 3 was about finding a specific location on the map.

6.3.3.1 Google Maps Observations

For this task users found it very simple and easy to use. On the left side of the page there are a lot of search results. Sometimes users got confused in making a selection of the right option.

6.3.3.2 MapQuest Observations

In this task users didn’t find any difficulty. They all liked the boxes to fill in and the buttons. Some were confused in selecting the accurate result of the search.

6.3.4 Task 4

Task 4 was about zooming and panning of the search result from Task 3.

6.3.4.1 Google Maps Observations

Users easily located the zoom and panning option on the map. Especially the “zoom here” on the dialog box is very good and time saving. Zooming and panning controls are easy to use. All users were very pleased with the street view option. Average taken time was high compared to MapQuest because of its attractiveness and good results. Users were very well satisfied with that they could view the location very clearly. Despite this some users noticed that view mode buttons on the map like Satellite, Map, Terrain, and Traffic are clearly

visible but difficult see which mode they are in, i.e. which one is selected and which ones are not selected.

6.3.4.2 MapQuest Observations

All users were happy about the visibility of the buttons on the maps. They didn't find any difficulty in locating the "Ariel Map" button. Some users were confused because of the advertisement on the page. Because of the advertisement at the top, the map was not fully visible on the page, so users have to scroll down to view the location which has to be zoomed in.

6.4 Questionnaire Results

The questionnaires were distributed to collect quantitative and qualitative data from the users in addition to the observations and think aloud method used during the usability test. The questionnaires were designed according to the adopted criteria for the evaluation of web-based GIS applications. The adopted criteria were based on the criteria proposed by Koua et al. (2006) and the guidelines of IS&T Department, MIT (Usability Guidelines 2009) for usability evaluation of websites. As common users don't understand the criteria of evaluations, for this purpose the authors designed questionnaire according to Likert scale (5-point scale) and designed easy and understandable questions for all six criteria so that common users can answer it without difficulty. The questionnaire contains 24 questions all of which were close-ended, and the respondents have to check only one option for each question. The relation of each question to the adopted criteria is shown in Table 3.

6.5 Distribution of Questionnaire

The questionnaires were distributed among the users in the form of hard copies. The questionnaire was handed out to all six participants after completing the usability test. Questionnaire was used to capture their sense of satisfaction concerning both applications. The designed questionnaire can be find in Appendix A.

Table 6 Relation of Questions to Adopted Criteria

Usability Evaluation Criteria	Question Nos
Effectiveness	1. It looks to be more effective. 2. Every time I can use it successfully. 3. It saves my time when I use it. 4. Overall the performance of application is satisfactory. 5. It's just do what I want to do. 6. While working on it I can meet my requirements. 7. While using it, it helps me to recover from mistakes quickly and easily.
Usefulness	8. It is simple to use. 9. Only fewer steps are needed to accomplish a task. 10. It is effortless to use. 11. Occasional and regular users would like it. 12. I easily remember how to use it. 13. It gives me more control for searching different locations.
User Reaction	14. New users can easily learn it. 15. I quickly became skillful with it. 16. It does everything what I expect from it. 17. I would like recommend it to a friend. 18. I think, I should have it.
Consistency	19. Does the system remain consistent while navigating to different pages?

Architectural and visual clarity	20. Every page has same organized information. 21. Symbols on the screen are very effective. 22. Designed for all level of users.
Functionality	23. New users can easily use it. 24. All functions are so simple.

After getting response from users through the questionnaire, authors calculated each scale of questionnaire. The scale of these questionnaires was based on Strongly Agree, Agree, Less Agree, Disagree and Strongly Disagree. Results of both web-based GIS applications are shown in Table 7.

N = Number of occurrences for each degree on scale marked by users.

% = Percentage of each question answered.

The questionnaires were distributed to users who participated in the usability test for both web-based GIS applications. The authors analyzed from the questionnaire results that the percentage of **Strongly Agree** for Google Maps and MapQuest was 35 % and 24% respectively. 45% users were **Agree** for Google Maps and 26% for MapQuest. 17% of users were **Less Agree** for Google Maps and 29% of users for MapQuest. Similarly 3% users were **Disagree** with Google Maps and 15% for MapQuest and 0% users were **Strongly Disagree** for Google Maps and 6% for MapQuest.

Table 7 Analysis of degree Google Maps and MapQuest

Answers	Google Maps		MapQuest	
	N	%	N	%
Strongly Agree	51	35	34	24
Agree	65	45	37	26
Less Agree	24	17	42	29
Disagree	4	3	22	15
Strongly Disagree	0	0	9	6
Total	144	100	144	100

According to Table 7 and Figure 8, testing results show that the percentage of Strongly Agree and Agree was high for Google Maps while percentage of Less Agree, Disagree and Strongly Disagree was high for MapQuest. It is worth mentioning here that “Strongly Agree” always positive and “Strongly Disagree” always negative concerning usability.

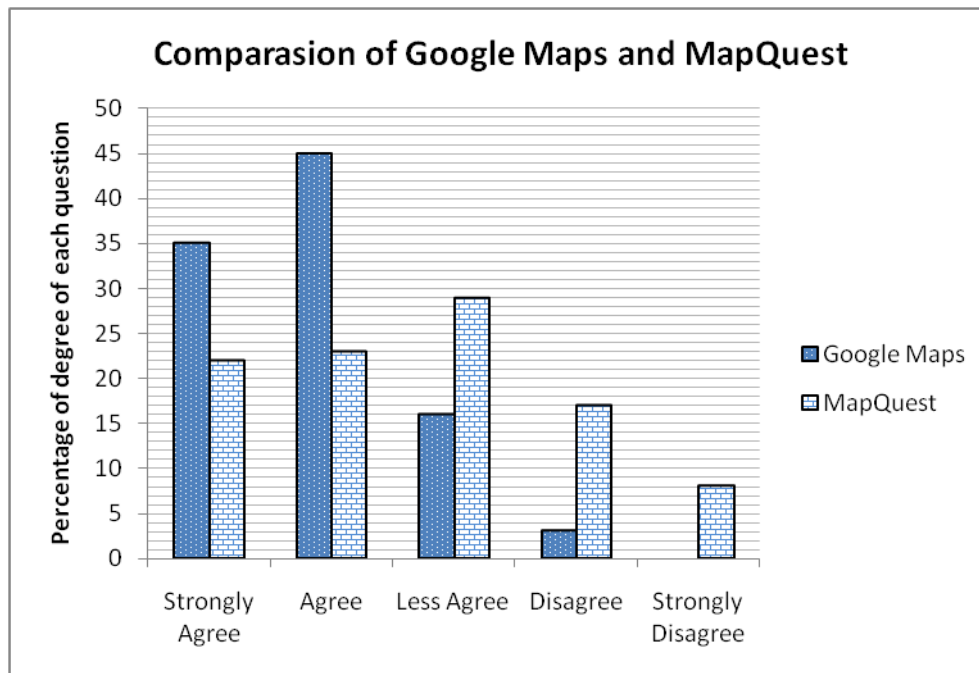


Figure 8 Graphical Analyses of Google Maps and MapQuest

6.6 Comparison of Google & MapQuest against Adopted Usability Criteria

The authors compared both web-based GIS applications against adopted criteria for usability evaluation. The graphical representation of this comparison is shown in Figure 9.

6.6.1 Effectiveness

According to Figure 9 33% of users strongly agree concerning questions about effectiveness for Google Maps and 29% for MapQuest. 52% agree concerning Google Maps while 23% of users agree concerning MapQuest effectiveness.

6.6.2 Usefulness

According to Figure 9 36% of users strongly agree concerning Google Maps and 19% concerning MapQuest usefulness. 44% of users agree concerning Google Maps and 26% agree concerning MapQuest usefulness.

6.6.3 User Reaction

Figure 9 shows that 43% of users strongly agree concerning Google Maps while 23% strongly agree concerning MapQuest user reaction. 40% of users agree concerning Google Maps and 30% of users agree concerning MapQuest.

6.6.4 Consistency

Figure 9 shows that 16% of users strongly agree concerning each application. 67% of users agree that Google Maps is consistent while 16% of users agree that MapQuest is consistent.

6.6.5 Architectural and Visual Clarity

Figure 9 shows that 28% of users strongly agree concerning Google Maps and 16% of users strongly agree concerning MapQuest. 33% of users agree concerning each application.

6.6.6 Functionality

Figure 9 shows that 42% of users strongly agree that Google Maps is functional and 33% of users strongly agree regarding MapQuest functionality. 33% of users agree about Google Maps functionality while 8% of users agree about MapQuest functionality.

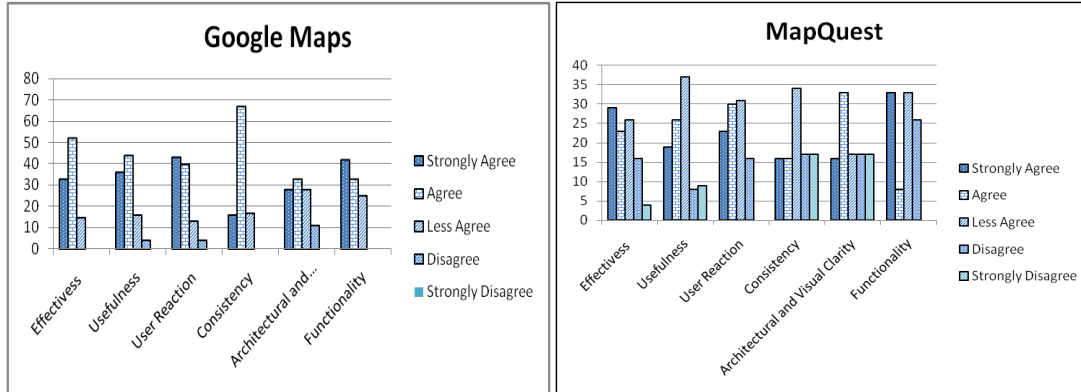


Figure 9 Comparisons of Google Maps & MapQuest

6.7 Interviews Analysis

After conducting the usability test and getting feedback on questionnaire, the authors conducted interviews with those who participated in the test. The purpose of the interview was to validate the results of testing and questionnaire feedback. All six users agreed to being interviewed. The details of interview are given in Appendix D.

Table 8 Interview scope and distribution overview

Interview Type	No. of Questions Asked	No. of users involved in interview
Open ended	5	6

7 DISCUSSION

This chapter contains a discussion about the interface of both applications regarding adopted criteria for usability evaluation.

7.1 Discussion

The authors analyzed the results from the usability test and questionnaire. This analysis helped the authors in finding various usability issues in the web-based GIS applications. Those problems are discussed regarding both GIS applications in the context of adopted criteria for this study.

7.1.1 Effectiveness

According to Koua et al. (2006) effectiveness deals with application functionality and observations of user performances and experiences of the tasks. It also deals with the gathering of data and any parameters available to complete a task. In the questionnaire effectiveness was measured by time taken by each task, errors rate, whether performance of the application was satisfactory or not, the correctness of outcome of the tasks, whether the application fulfills user requirements and application response against mistakes.

In the case of **Google Maps** users liked it and felt it was effective because requirements can be fulfilled successfully by using it. It can also save time during searching a specific location because of the simple search boxes but it gives too many options in search results, which makes it problematic for common users to select the right option. It helps in giving error messages clearly but it is not always in informative form. Although it is difficult for users to find help easily in GoogleMaps, overall the performance of the GoogleMaps was appreciated by the users.

While in case of **MapQuest** the users considered it to be effective but not totally so, because it does not save their time in searching of specific location because there are separate text boxes for 'direction', 'locations' and 'businesses' and they need to fill it all in correctly. If none of these text boxes are filled in then no results come out and they have to start a new search which is time consuming. It provides help topics for guidance of users but does not provide any help for looking for streets and directions. Overall performance of MapQuest is good and requirements can be fulfilled by using this application.

7.1.2 Usefulness

According to Koua et al. (2006) usefulness deals with the user's expectations and demands while carrying out different tasks. It looks as though either application is supportive for users goals and tasks, users can easily understand and interpret the application results, is it flexible according to user expectations, is it simple to use and how many steps it requires while carrying out a task.

Most users found that **Google Maps** is more useful compared to MapQuest because it gave positive feedback on different tasks that was in line with their expectations. The results shown on the left side of the screen for "Get Directions" for Task 1 were very informative, there were step by step direction details. Finding location is very effective in Google Maps, specific location can be found by providing less information than in MapQuest. The problem with this application is that the links are not very visible and attractive.

Meanwhile users didn't find **MapQuest** as useful compared to Google Maps. According to users the links are very much visible but overall the interface is very messy. Users have to fill out too many boxes. Most users forgot to select region which lead to frustration. But new users who don't have any idea about searching find it useful because it provide an interface

in which they can easily write address, city, state and ZIP code etc. In MapQuest print option is very easy compared to in Google Maps.

7.1.3 User Reaction

According to Koua et al. (2006) user reaction deals with user's opinions, views, attitude and user preferences towards an application. In the questionnaire it was measured by how this application is for new users, easy to learn or not, should I use it permanently or not and should I recommend it to a friend or not.

For **Google Maps** the users reaction was positive. The authors observed that new users feel familiar with it and can learn it quickly. Most users recommend to use Google Maps. The Users reaction towards **MapQuest** was not as good. In the authors opinion, new users find it difficult to carry out a task the first time. Most of the users also did not like advertisements and other sponsor links on the website.

7.1.4 Consistency

According to Usability Guidelines (2009), consistency means navigation through different pages of the website should reflect the home page. Icons, words and phrases should be consistently described for the same item.

Consistency of any application makes it easy to learn because a consistent system uses the same basic steps for different tasks. In the authors opinion **Google Maps** and **MapQuest** are equally consistent and both applications need to improve their consistency. For example in MapQuest while navigating different pages, the usage of advertisements and sponsored links make its interface inconsistent because on different pages these appear in different places.

7.1.5 Architectural and Visual Clarity

According to Usability Guidelines (2009) architectural and visual clarity means that the site is organized well from a user perspective, for instance the usage of colors, enough white space on the page, and unnecessary animations are avoided.

In the authors opinion, the main page is the first interaction point of any application with users, so it should be good looking. **MapQuest** uses nice colors, buttons and icons which attract the users but all the links and advertisements make its interface confusing. In contrast most users like **Google Maps** for its simple and clear interface, but most users pointed out that its buttons and links are not very visible.

7.1.6 Functionality

According to Usability Guidelines (2009), functionality of any website means that necessary functions are available, it accommodates both new and expert users and all functions are simple enough.

The users found **Google Maps** good in terms of functionality because all the functions were simple enough to carry out most tasks while they felt difficulty in some tasks, for instance printing a map was confusing. On the other hand, **MapQuest** had problems regarding its functionality as the user had to do many things while searching for locations, like filling many text boxes and the selecting options from dropdown menus.

7.2 Validation

In this study, the authors have used a mixed methodology approach. Mixed methodology approach includes quantitative and qualitative methods. Quantitative and qualitative results were gathered through questionnaire and think aloud protocol while qualitative results were gathered through literature study and observations were noted down while performing

usability test using think aloud protocol. Most of our study depends on qualitative approach which helps the authors to find usability issues in both web-based GIS applications. For enhancing the trustworthiness of this study, the authors have assessed the results in relation to the criteria given by Trochim (2006).

7.2.1 Credibility

This criterion is based on the assessment of the results in terms of believability of selection of participants via initial interviews (Trochim 2006). A stepwise approach was adopted throughout this study. Literature study helped the authors in conducting usability study and designing of questionnaire. After that interview was conducted with all those six participants who participated in the usability test. These interviews and usability testing has helped the authors in validating the credibility of this study.

7.2.2 Transferability

Transferability means that results of qualitative research can be transferred to other contexts, setting and population (Trochim 2006). One possible threat can be the level of usage of web-based GIS applications, for example changing in tasks can change the results. Other possible threat can be the participant's educational and cultural background. So the results could be changed by the level of usage of web-GIS applications and participant's educational and cultural background. The sample of users was of course very limited, which means the results cannot be widely generalized.

7.2.3 Dependability

Dependability means that it is important for researcher to describe the circumstances and setting which affect the results (Trochim 2006). In this study the authors selected all students from university and usability test was performed individually (in think aloud authors have to observe the participant actions against tasks so it is impossible to conduct the test with several users at the same time) in the group rooms. All participants conducted this test on the authors own computer because change of hardware can change the results. There was not any specific time of day for testing, rather it was dependent on the participant's availability. During the usability test two methods of data collection were used; observation with time taken and think aloud combined with video recording. This gave a kind of triangulation of methods already during the usability test.

7.2.4 Conformability

According to Trochim (2006) conformability means results of the study can be confirmed by the study of other researchers. It also deals with the results of different phases of the study and whether these reflect each other or not. The authors adopted step by step approach for the conduction of this study. Think aloud technique was adopted for usability test and observations were noted down during test, questionnaires were distributed and interviews were taken from each participant. Each phase of the study was carefully analyzed and documented.

7.3 Selection of Usability Criteria

In this study, the main challenge was to adopt such criteria for usability evaluation that can fit in web-based GIS applications, as per authors knowledge there is no standard available for evaluation of web-based GIS applications. It was also difficult because it was not just the evaluation of simple websites, neither was it just evaluation of conventional GIS applications. So it was a challenge for the authors how to overcome these problems because this study was based on web-based GIS applications which accommodates both a GIS application and the web. According to Ładniak & Kałamucki (2007), while evaluating web-based GIS applications the criteria should be grouped in several parts like (I) criteria connected with map contents evaluation and (II) criteria connected with interface evaluation.

For this purpose the authors selected six criteria for usability evaluation in this study. The first three criteria were effectiveness, usefulness and user reaction which are related to the first group, in which we looked in-depth at the contents of the GIS applications like how functional they are, as GIS is comprises of different layers. It helped us a lot in finding different usability issues. While other three criteria were consistency, architectural and visual clarity and functionality, which are related to the second group which is criteria for interface evaluation. The second group of criteria helped us very much in finding usability issues for our study. All these six criteria helped us in designing of questionnaire as well.

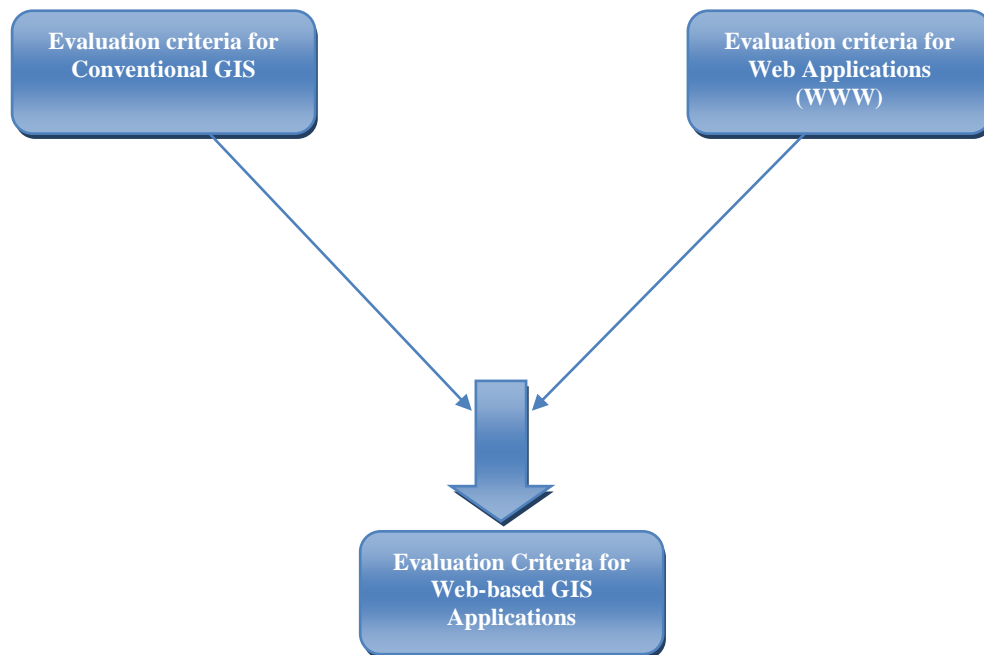


Figure 10 Selection of Usability Criteria (Ładniak & Kałamucki 2007)

8 CONCLUSION

The main goal of this study is the usability evaluation of web-based GIS applications. For this purpose the authors compared two well known web-based GIS applications, Google Maps and MapQuest. To achieve this goal, the authors used water fall model as a timeline. This study started from a literature review and ended with interviewing users. Four important tasks were prepared for the usability test. The usability tests were carried out six users. Data collection during the usability test was carried out through observation, think aloud method and video recording for later analysis. The time spent on each task has been noted. Questionnaires were distributed to the users who were involved in the test and finally an interview was conducted with those users. The interview helped the authors in validation of results.

By reviewing the overall results from the usability test, questionnaires and interviews, authors concluded that both web-based GIS applications are very popular but Google Maps comparatively to MapQuest is preferred by the users in terms of usability features because of its clean, easy to use, simple interface and some extended features which make it fun while using it. MapQuest can also fulfill the requirements of users but new users (Novice) experienced difficulty in the beginning. Although both are popular web-based GIS applications, both of them have some usability problems regarding their interfaces. So it could be possible to offer recommendations and to design such interfaces for web-based GIS applications that are easy to use, attractive and fulfill user's requirements.

8.1 Answers of Research Questions

The authors analyzed results of the usability testing and literature which helped them to answer the research questions.

1. Why do we need usability evaluation of different GIS applications like Google maps and MapQuest?

After reviewing literature and conducting usability testing the authors came to know that usability evaluation of web-based GIS applications is very important because these applications are used by large numbers of people with different backgrounds. Most people are not satisfied with the usage of these applications. Furthermore these web-based GIS applications are not very effective with current interfaces. Our hypothesis is that the main reason behind this is that usability evaluation of these applications has not been done properly and people fail to achieve their goals. In author's opinion, these web-based GIS applications need consistent usability evaluation during development and after development regarding user's requirements.

2. How can different GIS applications like Google maps and MapQuest be evaluated?

The main purpose of usability evaluation is to find out various problems regarding user requirements. In this study, the authors have done usability evaluation of Google maps and MapQuest. The important contributions in usability evaluation were the usability test (Think aloud technique) on users, Questionnaires and interviews. Think aloud method helped the authors to observe the users while performing their tasks and understand their reactions from a user's perspective. The Questionnaires feedback concerned getting access to the opinions of the users about these web-based GIS applications and interview helped in validation.

3. What are the usability issues in Google Maps and MapQuest?

During this study, authors found out various usability issues in both web-based GIS applications through usability test and noticed that these applications have some usability issues concerning current interfaces. These issues are mentioned in the section 6.3.

4. What are the suggestions for improvements in usability of both applications?

Through the usability test, the authors found some usability issues in both web-based GIS applications. On the basis of these issues the authors would like to make some suggestions for both applications. These suggestions can be helpful to improve these applications concerning end user's requirements. Suggestions for Google Maps and for MapQuest can be found in the section 8.2.

8.2 Suggestions

After evaluating and comparing usability of both web-based GIS applications, authors can make some recommendations. These suggestions/recommendations are based on the authors' observation during usability test, questionnaire results and analysis of interviews. The authors aim is that these suggestions could help these web-based GIS applications to improve their usability features.

8.2.1 Suggestions for Google Maps

- In the authors' opinion Google Maps should increase the visibility of the direction button (compare with MapQuest, where this feature was better designed).
- There should be a visible button with a standard icon for the "print the maps" feature.
- Buttons on the map for changing map view like "Satellite View" and "Terrain" are visible but sometimes users get confused about which one is selected and which one is not. Therefore the buttons should be designed in such a way that users can recognize easily if it is selected or not.
- While searching directions, there is an option for choosing modes like "by walking" and "by car" from dropdown menu. There should be caption with this menu so that users can recognize it easily.
- There must be a list of countries which can help users choose a desired country where they want to search a specific location.
- There should be a legend on the maps which reflects the purpose of all icons used on the maps.
- Sometimes a lot of search results are presented, which can make users frustrated. Thus, search techniques should be improved so that users can get only relevant results.
- Errors messages should be easy and informative, so that a common user can understand it.
- Google Maps provides the street view which is an excellent and much appreciated idea. But it should be expanded to more and more cities of the world.

8.2.2 Suggestions for MapQuest

- The home page of MapQuest should be simple and clear.

- The use of advertisements and other links should be avoided. (This of course has economical consequences and might need to be compromised, for instance by presenting advertisements below instead of above the map to reduce scrolling.)
- MapQuest searching capabilities must be improved in a way that it can provide help in form of spelling corrections and recommendations. (compare Google Maps)
- The international dropdown menu for selecting regions like US&Canada, Europe and All countries should be more visible.
- While finding directions, there should be option for choosing different modes like “by walking” and “by car” as used in Google Maps, which can be selected by users according to their needs.
- The suggestions for search results are not very clear as compared to Google Maps. MapQuest should improve this.
- The map on the main page is not placed well, users have to scroll down to view the whole map. In the authors’ opinion MapQuest should manage the main page in a way that the map can be seen without scrolling down.
- Zooming in MapQuest should be done smoothly.
- The search boxes have the main role for searching different places so these should be placed on the main area of the web page.
- There should be a standard icon for each button like Print, Save etc, which will improve the usability.
- While using “Get Direction” option MapQuest should also use the style of Google Maps in which the map is placed on the right side of the screen and direction details are placed on the left side of the screen so that user can see both at the same time.
- Errors messages should be easy and informative so that a common user can understand them.
- The information on the site is too dense and messy. There should be enough white space on the page to make it readable.
- And of course MapQuest should also introduce street views like Google Maps which will attract more and more users.

An indication of how fast these applications are developing is the fact that during our study MapQuest has actually released such a solution though it is still not as elegant as the Google Maps Street view.

8.3 Future Work

In this study the authors evaluated two well-known web-based GIS applications i.e. Google Maps and MapQuest. For this purpose the authors conducting usability testing through think aloud protocol, got feedback through questionnaire to know user’s opinion towards each application and results were validated through interviews.

For future work authors suggest that some other web-based GIS applications should be evaluated using same usability criteria to help them in improving usability features. Furthermore, the authors suggest that for the web-based GIS applications Google Maps and MapQuest that were tested in this study, some other usability evaluation methods should be used to compare the results with this study and further explore usability issues.

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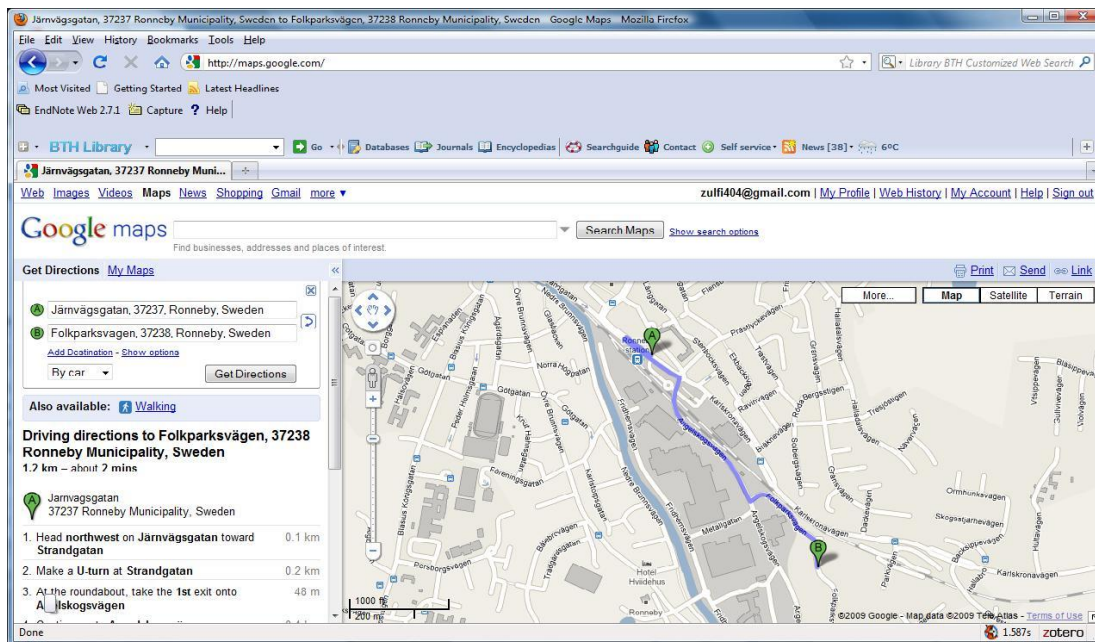
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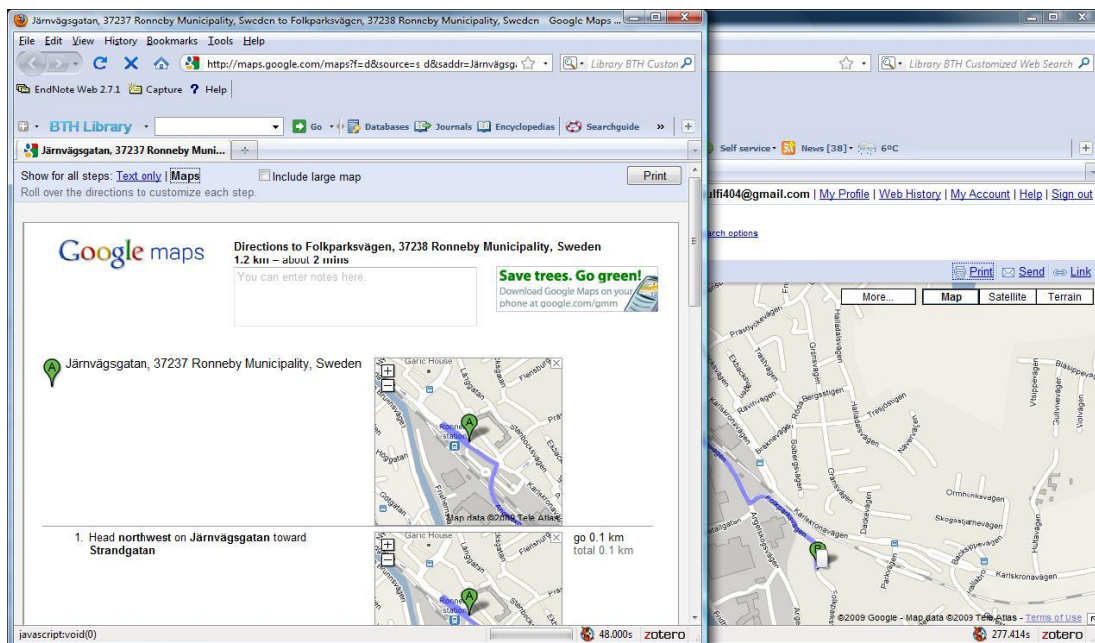
APPENDIX A: QUESTIONNAIRE FOR USABILITY TEST

No.	Questionnaire for Usability Evaluation	Strongly Agree	Agree	Less Agree	Disagree	Strongly Disagree
		1	2	3	4	5
1	It looks to be more effective.					
2	Every time I can use it successfully.					
3	It saves my time when I use it.					
4	Overall the performance of application is satisfactory.					
5	It's just do what I want to do.					
6	While working on it I can meet my requirements.					
7	While using it, it helps me to recover from mistakes quickly and easily.					
8	It is simple to use.					
9	Only fewer steps are needed to accomplish a task.					
10	It is effortless to use.					
11	Occasional and regular users would like it.					
12	I easily remember how to use it.					
13	It gives me more control for searching different locations.					
14	New users can easily learn it.					
15	I quickly became skillful with it.					
16	It does everything what I expect from it.					
17	I would like recommend it to a friend.					
18	I think, I should have it.					
19	Does the system remain consistent while navigating to different pages?					
20	Every page has same organized information.					
21	Symbols on the screen are very effective.					
22	Designed for all level of users.					
23	New users can easily use it.					
24	All functions are so simple.					

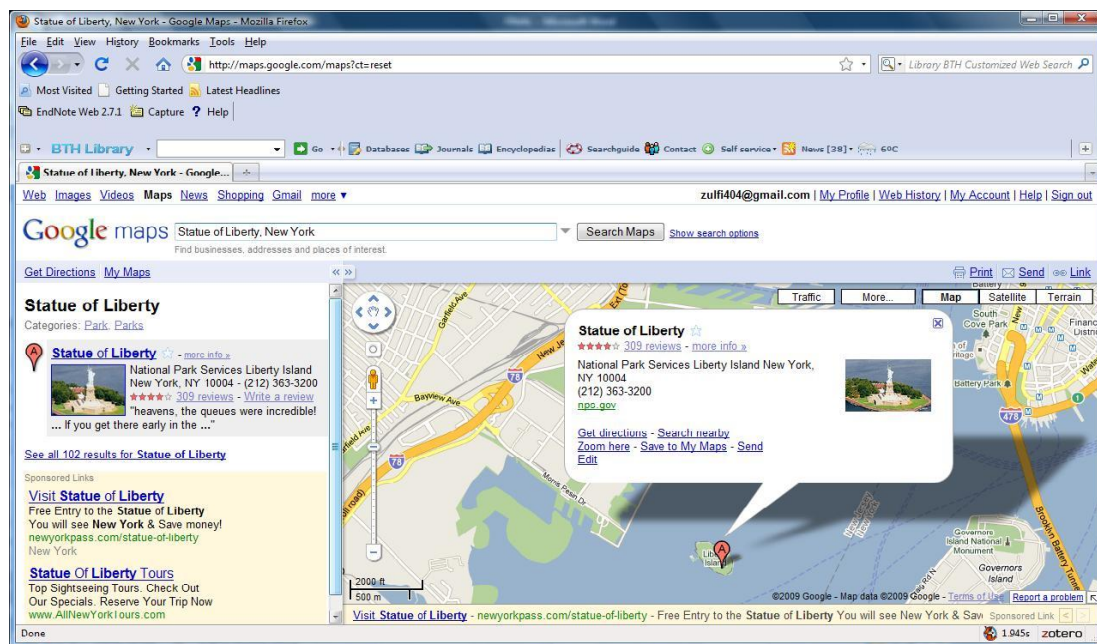
APPENDIX B: SCREEN SHOTS OF GOOGLE MAPS



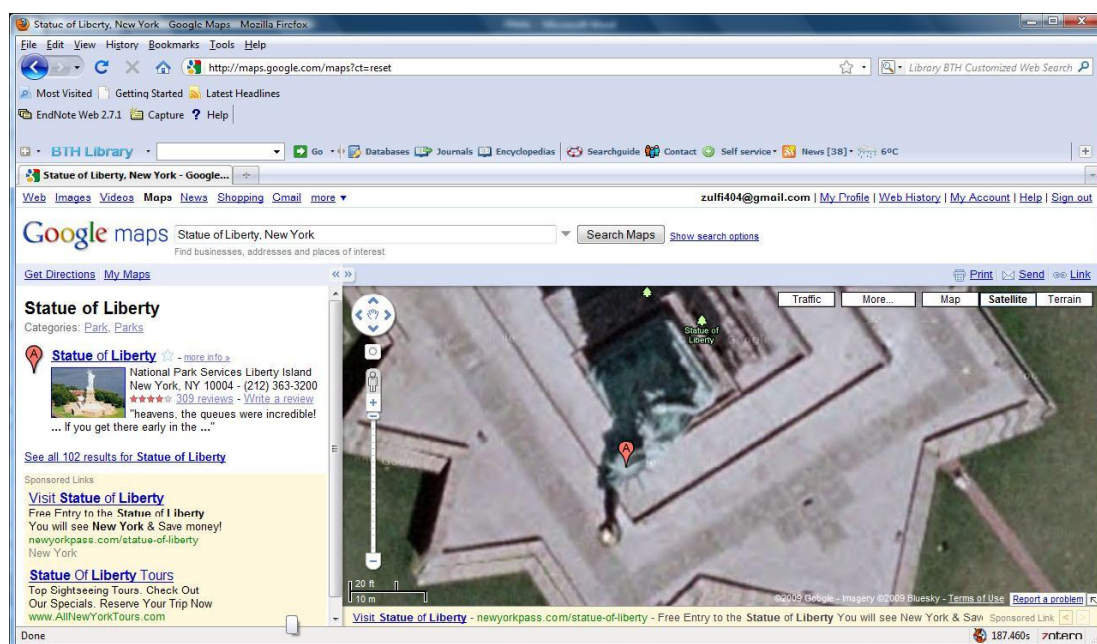
Screen1. Getting Directions



Screen2. Printing Map

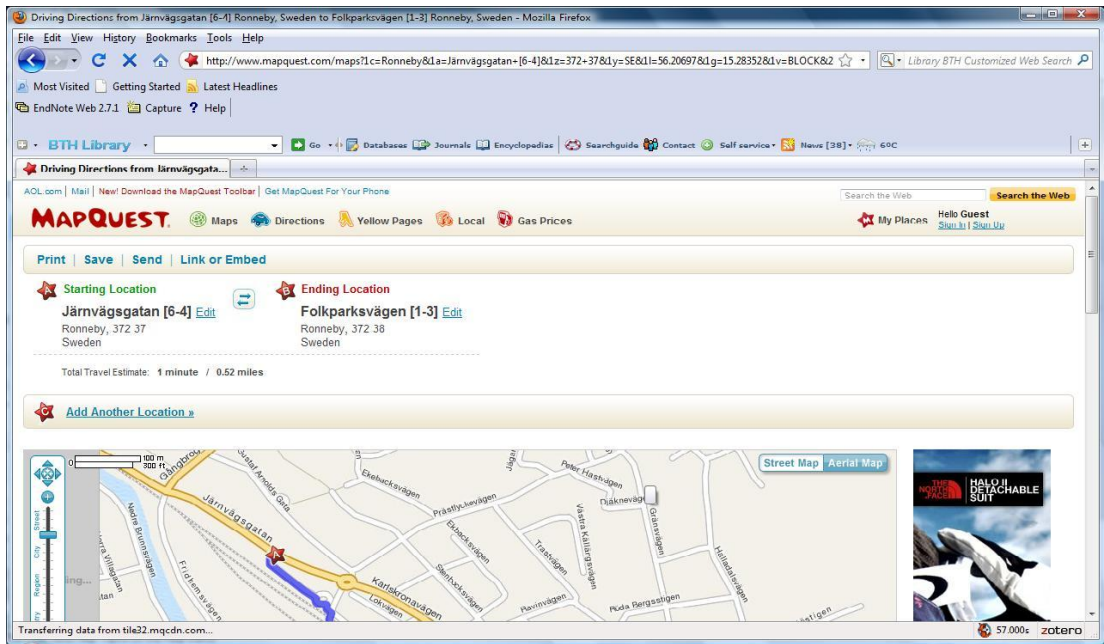


Screen3. Finding Specific Locations

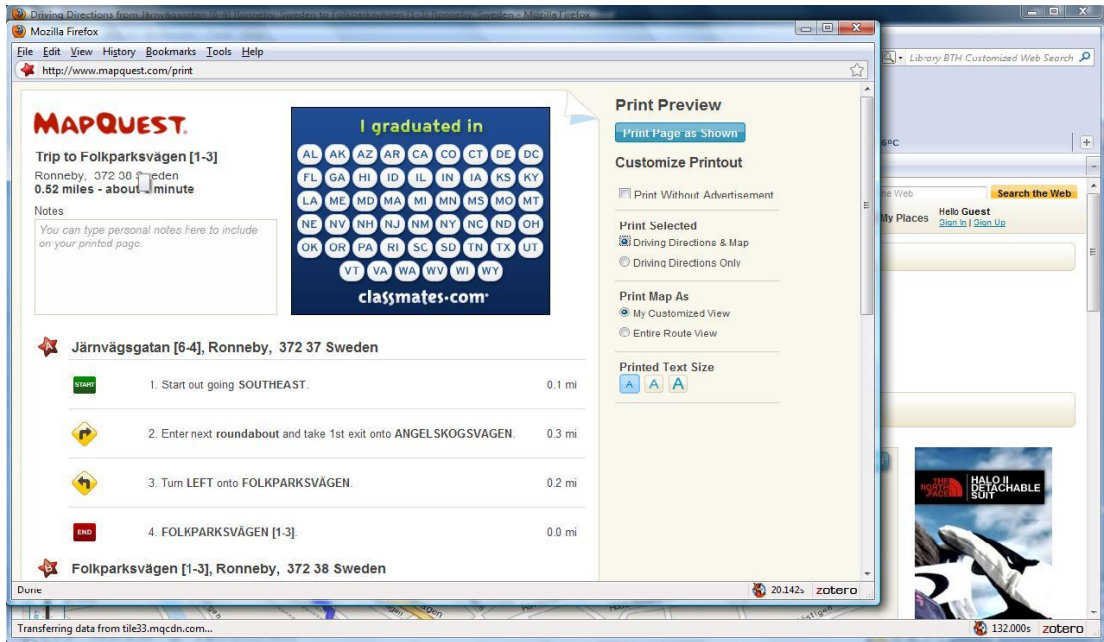


Screen4. Zooming

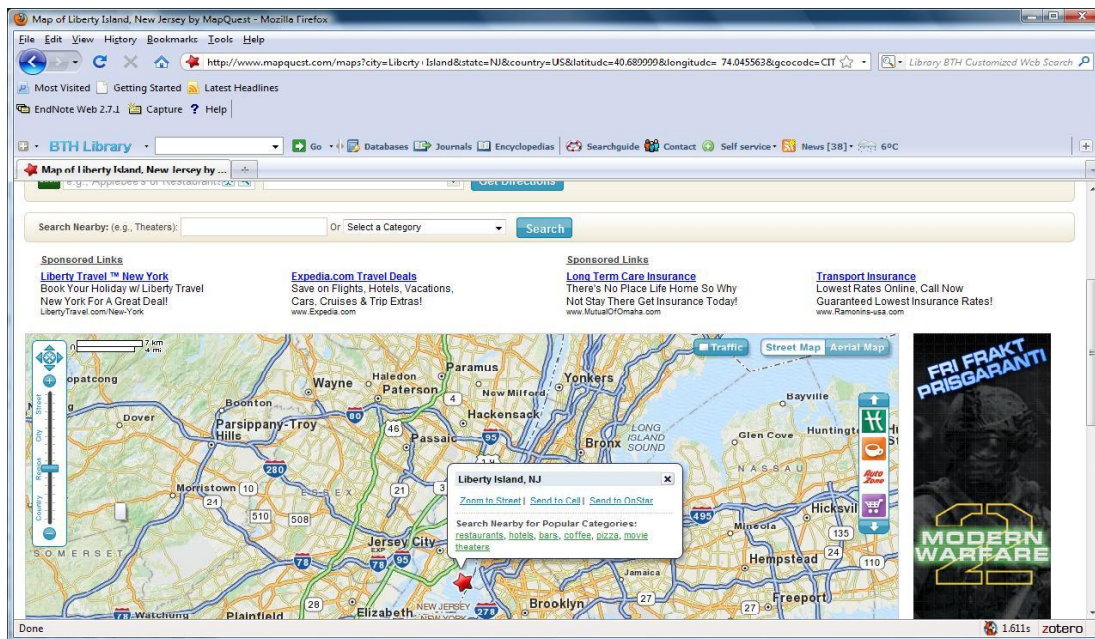
APPENDIX C: SCREEN SHOTS OF MAPQUEST



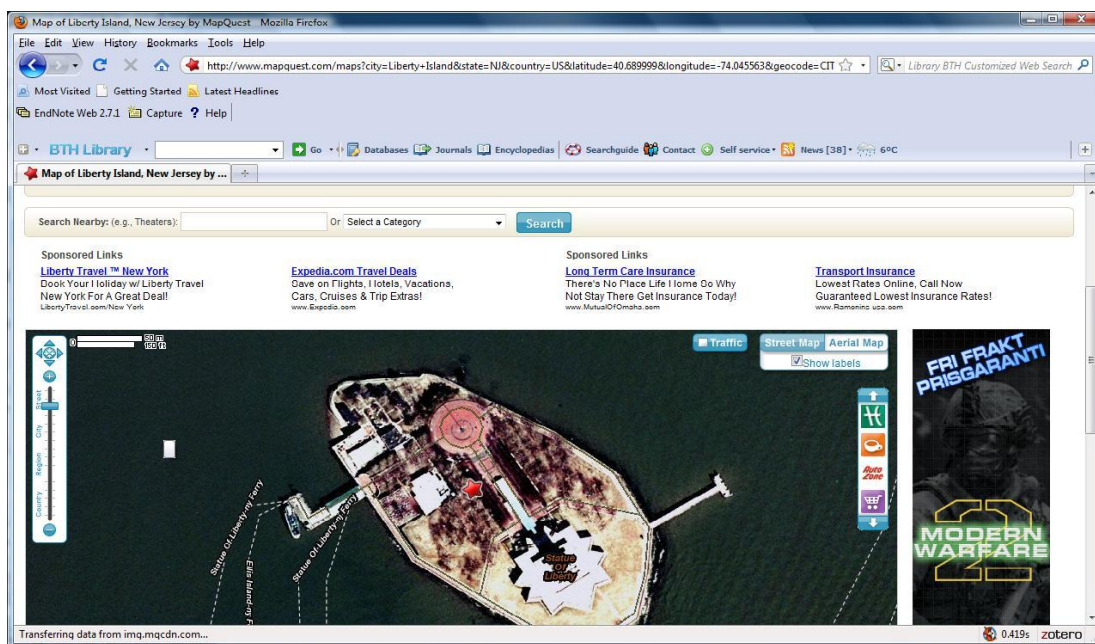
Screen1. Getting Direction



Screen2. Print map



Screen3. Finding Specific Location



Screen4. Zooming

APPENDIX D: INTERVIEWS CONDUCTED WITH USERS

User 1

Q1: What was your first impression, when you used Google Maps and MapQuest?

Answer:

Google map: It was my first application for map service in the internet. It combines satellite view (with very good resolution in most of the earth surface) and map view that shows the roads and their names. Furthermore it can give direction and Google adds its search engine to find places in the world along with the photos uploaded by Google users. However, the Google map good resolution does not cover the earth's entire surface. In other words their satellite representation is not in the same resolution quality in all places on earth. There are places with good resolution and there are places with bad resolution.

MapQuest: I also used MapQuest many times and the purposes are moreless same like Google Maps. The only difference I can spot in MapQuest is that it doesn't provide resolution as good as Google maps.

Q2: Generally for what purposes you use Google Maps and MapQuest?

Answer: To find places on earth and direction to get those places. How to get to those places and how long?

Q3: What are the benefits and drawbacks of Google Maps?

Answer: Google maps provide comprehensive yet simple way for mapping solution in the internet. Backed up with Google technology it can have many benefits like photo uploading, the power of Google search engine to search places, Maps API to open possibilities for developing applications that use Google maps, etc.

As I mentioned before, Google maps doesn't provide same resolution to all places in the world. Some get a good resolution and some get a bad resolution. Another example is like the one I showed to you guys this afternoon when we conducted the experiment in group room.

Q4: What are the benefits and drawbacks of MapQuest?

Answer: AS I mention before in MapQuest the drawback which i can spot is the resolution is bad compare to Google maps. The benefit is that from the first expression, MapQuest has a good interface that self-explanatory and provide easy-to-use for new users.

Q5: In your opinion which application fulfills your requirements the most?

Answer: Google Maps

Q6: Which Web-based GIS application would you like to recommend?

Answer: Google Maps

User 2

Q1: What was your first impression, when you used Google Maps and MapQuest?

Answer: About Google Maps, At first glance the main page was very well organized and I could see the whole page without scrolling so I felt that I have a better control on it in comparison with MapQuest.

Q2: Generally for what purposes you use Google Maps and MapQuest?

Answer: If I want to search about a place which I am not sure about the exact spelling or the spelling is hard to type I prefer to use Google Maps. While if I want to find a place in my city or somewhere that I am sure about the name I select MapQuest.

Q3: What are the benefits and drawbacks of Google Maps?

Answer: The benefit is the format of the page and the symbols of the map, it's beautiful and readable. I think the most annoying thing in Google maps is that it does not correct or complete your address spell and even if you type correct spell without space Google maps doesn't correct you and return an insufficient error!

Q4: What are the benefits and drawbacks of MapQuest?

Answer: If you have complete address with post code then MapQuest is good because it gives you the accurate result. In my opinion, MapQuest also have many drawbacks like it have unwanted advertisements and interface is very messy.

Q5: In your opinion which application fulfills your requirements the most?

Answer: I will not rely only on one application. Mostly I use both for different purposes.

Q6: Which Web-based GIS application would you like to recommend?

Answer: I suggest both for the complete answer, because for finding exact location MapQuest is better choice but you can find better and more readable symbols in Google Maps.

User 3

Q1: What is your first impression, when you used Google Maps and MapQuest?

Answer: I have been using Google maps for a long time. I used it for my travel plans. But I also used MapQuest several times. I found Google Maps to be quick enough than MapQuest. Moreover Google Maps gave me the option to calculate the distance between two places and it further tell me how much time it will take me to reach from one point to another if either I travel by car or if I simply walk between the two points. I think MapQuest has graphical interface than Google Maps and also I like the searching technique used by MapQuest as I got more accurate results.

Q2: Generally for what purposes you use Google Maps and MapQuest?

Answer: I used these applications for my journeys and to make a travel plan. It's quite helpful because I can know how much time it will take me to travel from one place to another.

Q3: What are the benefits and drawbacks of Google Maps?

Answer:

Benefits of Google Maps are:

- Very quick in performing an action
- Satellite view is very clear
- Has the options to calculate the travel time if one travels by car or by walking

Drawbacks that I found in Google Maps are:

- Very less use of icons and graphics
- Searching technique is not good; I have to type the full address along with city and country name.
- Graphical interface is not pleasing
- It is difficult to find which option is selected because it's not highlighted properly.

Q4: What are the benefits and drawbacks of MapQuest?**Answer:**

Some benefits according to my opinion are:

- Very rich graphical user interface.
- Searching results are far more accurate.
- Searching technique was really good; I did not have to write the country and city name.

Drawbacks of MapQuest are:

- Not very quick as compared to Google Maps.
- Satellite view was not clear as compared to that of Google Maps.

Q5: In your opinion which application fulfills your requirements the most?

Answer: I use online maps for three purposes. One is for finding the location of a place, second the satellite view of a place and third to find the distance and calculate my travel time between two places. All of my requirements are fulfilled by Google Maps in a normal situation however if I am in a hurry then typing the whole address in Google Maps is a bit messy thing to do.

Q6: Which Web-based GIS application would you like to recommend?

Answer: It depends on what my friends need. But personally I would recommend MapQuest because it has a richer graphical interface and a good searching technique. The searching results returned by MapQuest are also better than that returned by Google Maps.

User 4**Q1: What is your first impression, when you used Google Maps and MapQuest?****Answer:****Google Maps**

Google Maps mainly focus on the simplicity. The first impression of Google Map product is very simple.

MapQuest

MapQuest, the design user interface is very attractive.

Q2: Generally for what purposes you use Google Maps and MapQuest?

Answer: Mostly I use it for searching locations and finding distance between two different locations. But seldom used for find alternative and short paths.

Q3: What are the benefits and drawbacks of Google Maps?**Answer:****Google Maps****Pros**

- Easy to used for new user
- Simple User Interface
- More Clear

Cons

- Less Functionality
- 3D Technology not include

Q4: What are the benefits and drawbacks of MapQuest?

Answer:

MapQuest

Pros

- More Functionality
- Graphically Interface

Cons

- Complicated for new User
- Complex Functionality

Q5: In your opinion which application fulfills your requirements the most?

Answer: Google Maps as compared to MapQuest.

Q6: Which Web-based GIS application would you like to recommend?

Answer: For Beginner level I suggest a Google Maps while for expert I recommend the MapQuest.

User 5

Q1: What is your first impression, when you used Google Maps and MapQuest?

Answer: Both are good for searching maps but I like Google map because the locations I found in Google map is more visible than MapQuest.

Q2: Generally for what purposes you use Google Maps and MapQuest?

Answer: Generally I use Google map and MapQuest for searching different locations and for travel guidance.

Q3: What are the benefits and drawbacks of Google Maps?

Answer: Easy to learn and use to found a specific location, no drawbacks.

Q4: What are the benefits and drawbacks of MapQuest?

Answer: Also good like Google Maps, but I found some problems in the final step, while finding a specific location, I didn't find it as much clear and zoomable like Google Maps.

Q5: In your opinion which application fulfills your requirements the most?

Answer: Google Maps will fulfill my requirements.

Q6: Which Web-based GIS application would you like to recommend?

Answer: I recommend Google map.

User 6

Q1: What is your first impression, when you used Google Maps and MapQuest?

Answer: Google Maps is user friendly and more focus on the usability perspective. According to my point of view it provides better solutions for the purpose to follow quality standards. While on the other hand MapQuest give me the impression, its bit confusing the icons puzzle me more than the Google Maps.

Q2: Generally for what purposes you use Google Maps and MapQuest?

Answer: Normally I used to find the locations from one place to another place. The products give me an edge to find the shortest path between the two places and calculate the actual distance and time.

Q3: What are the benefits and drawbacks of Google Maps?

Answer: Well, while using Google Maps you can easily find the places. It's a perfect solution for the traveling guide. Even you can visit and see different places by street view. The complete traveling guide with you on the move thanks to Google Maps the technology for the present and future trends.

The main problem of the Google Maps is the performance issue. It is slow some times when you using it.

Q4: What are the benefits and drawbacks of MapQuest?

Answer: The benefits are the same as compare to Google Maps. It is a good competitor of the Google Maps.

The MapQuest icons are not according to the usability standards means much confusing. We can't see the whole without scrolling which is bad.

Q5: In your opinion which application fulfills your requirements the most?

Answer: I found Google Maps good and it is according to my expectations.

Q6: Which Web-based GIS application would you like to recommend?

Answer: I would like to recommend the Google Maps.