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Usability Requirements for GIS Application

Comparative Study of Google Maps on PC and Smartphone

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ABSTRACT

Context: Smartphone is gaining popularity due to its feasible mobility, computing capacity and efficient energy. Emails, text messaging, navigation and visualizing geo-spatial data through browsers are common features of smartphone. Display of geo-spatial data is collected in computing format and made publically available. Therefore the need of usability evaluation becomes important due to its increasing demand. Identifying usability requirements are important as conventional functional requirements in software engineering. Non-functional usability requirements are objectives and testable using measurable metrics.

Objectives: Usability evaluation plays an important role in the interaction design process as well as identifying user needs and requirements. Comparative usability requirements are identified for the evaluation of a geographical information system (Google Maps) on personal computer (Laptop) and smartphone (iPhone).

Methods: ISO 9241-11 guide on usability is used as an input model for identifying and specifying usability level of Google Maps on both personal computer and smartphone for intended output. Authors set target value for usability requirements of tasks and questionnaire on each device, such as acceptability level of tasks completion, rate of efficiency and participant's agreement of each measure through ISO 9241-11 respectively. The usability test is conducted using Co-discovery technique on six pairs of graduate students. Interviews are conducted for validation of test results and questionnaires are distributed to get feedback from participants.

Results: The non-functional usability requirements were tested and used five metrics measured on user performance and satisfaction. Through usability test, the acceptability level of tasks completion and rate of efficiency was matched on personal computer but did not match on iPhone. Through questionnaire, both the devices did not match participant's agreement of each measure but only effectiveness matched on personal computer. Usability test, interview and questionnaire feedback are included in the results.

Conclusions: The authors provided suggestions based on test results and identified usability issues for the improvement of Google Maps on personal computer and iPhone.

Keywords: Usability requirements, ISO 9241-11, GIS application, Google Maps

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CHAPTER 1: INTRODUCTION

This chapter describes motivation related to the background knowledge, related work and a brief introduction about the structure of this thesis.

1.1. Background and Motivation

GIS stands for Geographical Information System concerning data related information [1]. GIS is defined as a set of tools used to collect, store, retrieve, transform, display and analysis of spatial and non-spatial data from the real world [2] [3] [4] [5] [6], these tools store geographical queries, inquiries and provide easy access to graphical user interface. These accesses enable the users to retrieve relevant information for finding any destination or route [7] [8]. GIS applications provide tools support for different computing devices for example Personal Computer (PC) and smartphone through which the users can browse, search information and plan routes using Google Maps [9] [10]. Smartphone is becoming more and more popular due to its similar abilities to PC. About three billion people are carrying them almost all the time [11]. It allows the users to write questions, get help, latitude, messages, browse web, take snaps and navigate their way through web-based GIS Applications [11]. Due to fast development in science and technology, smartphone GIS is the extension of GIS technology from office to field, moreover computer applications have moved fast into the smartphone applications. These devices are popular due to their small size, light weight, portability, increased computing and power capacity [16]. Due to the need of society and technological developments, GIS and embedded devices became more popular [11] [17].

In early 1990's the GIS application was successfully implemented by the researchers but later on it developed into GIScience [12]. With the addition of internet in GIS technology the research in the field of GIS also increased. The research efforts in the area of web-based GIS made it possible to publish maps with geographical information on the web. As a result these web-based applications became accessible through the internet during the last decade. With the launch of GIS application, a person who doesn't have any knowledge of geography can use this application with standard browsing facility. It is providing the facility of publishing spatial information, searching, analyzing, displaying and processing over the internet. Later on it became more facilitative and easy for the users to retrieve geographical information [7] [8]. Map creation and geography analysis are not new, but GIS applications are performing these tasks better and faster than old manual methods.

GIS applications are daily used in private and public sectors [4], private sector is paying to use these applications for [14] decision support system, planning strategies, predicting outcomes, explaining events in organization and is providing cartographic interface [6]. Public sector is using GIS to retrieve information without purchasing it, and provide simple features to network based application in financial and government organizations [13]. GIS is taught in universities, colleges, schools worldwide [95]. Originally GIS was a complex system operated by specialized users, however the change in technology and upgradation in hardware gave birth to web applications, which made the GIS applications usable for the common users. Thus the users can use these maps and GIS applications on the internet. Due to the rapid change in technology smartphone is selected for observing usability requirements [11].

Usability is considered as an important attribute for the system acceptance by the end users. Nielson defined usability by five attributes as Efficiency, Memorability, Errors, Satisfaction, and Learnability [18]. International Standard Organization (ISO) 9241 part 11 defines usability as the degree to which the features of a product are used by novice and experienced users performing tasks to achieve the intended functionalities of a product with measurement specification in specified context of use [19]. ISO 9241-11 provides guidance for usability measures as effectiveness, efficiency and satisfaction in a particular context of data [19]. Context of data means users, tasks, materials and environment in which a product is used [19] [20] [21]. According to International Standard [19], "*Measure of the performance and satisfaction of the users can provide a basis for the comparison of the relative usability of products with different technical characteristics which are used in the same context*". For this purpose it is important to specify the acceptable level of usability requirements to evaluate GIS application using usability attributes.

Usability requirements are used to set goals with its associated measures for the intended system [22] [23] [24]. Unlike functional requirements in software engineering, one needs to set target value for non-functional requirements [20]. Non-functional usability requirements are identified as to how the user interface performs its intended functions (tasks) in an easy and well-mannered way [36] [96]. In general, there is no rule for how the usability measures can be combined [7] [21]. Hornbæk [25] defined usability measures as objective and subjective. Objective measure is the user's interaction with the system to perform tasks while subjective measure means the attitude of users toward interaction or outcome of usability evaluation [26] [27] [28]. Usability goals consist of various ranges associated with system properties such as effectiveness, learnability, efficiency and understandability [23]. According to International Standard [101], defines user-centered process as an iterative process containing four steps: specifying context of use, specifying usability requirements, producing solutions for design and finally evaluating designs. This process starts when anyone in organization recognize the need of user-centered design.

GIS applications are commonly used in societal organizations and businesses where logistics issues need to be resolved. These applications are commonly used for decision making and problem solving related to geographical concerns. The users are bound to system with little choice of using the product [31]. In everyday life, users use the product that have no low usability and cannot fulfill the users requirements, it will create a frustrating situation for users as a result the users will not use the product again [38]. According to Nivala et al [29] & Nivala et al [30], the usability evaluation methods of GIS applications are always centered on testing the effectiveness and efficiency of maps use, whereas the maps still does not fulfill the user requirements because the end user consideration is always ignored. The main concerns of the GIS application are the maps, the different functionalities to be performed on maps and the user interface design to display maps. ISO 9241 standards on user interface evaluation are reported in couple of studies [15] [31], but standards specifically focusing on GIS are missing in literature [32]. ISO 9241-11 Guidelines or attempts to produce usability specific tools, which can make the process of evaluation and design more suitable specifically towards GIS systems are lacking. To fulfill the user's needs in GIS, these applications need usability evaluation based on ISO 9241-11 usability guidance for achieving high level usability goals.

The primary intention of this study is to evaluate and improve the GIS application (for example Google Maps) by comparing the usability of Google Maps (GIS) on both stationary and mobile computing devices (PC & iPhone). The authors set target value for usability requirements by using ISO 9241-11 measures (use metrics) to evaluate the Google Maps. Co-discovery technique is used to conduct test, interviews and questionnaires are distributed to get participants responses and their expectations. The data collected is therefore analyzed through ISO 9241-11 usability guide.

1.2. Related Work

Research in 1970s mainly found issues concerning usability such as attention, memory, learning and problem solving to influence computer and interface design [103]. During 1980's interest in usability of single user computer has moved rapidly to personal computer explosion [104]. The theoretical base foundation of Human Computer Interaction (HCI) has formalized and developed theories and methods of designing for users. HCI can be defined as "*a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them*" [105]. It also concerned to improvement in quality of human and computer system interaction within environment make systems that are usable to use safely [106] and to develop system design which aims to fulfill the user needs to carry out their task safely, effectively and enjoyably [107]. Software developments has increased focus in the improvement of usability problems and integrating usability practices into their software engineering process. ISO 13407, guide on how to achieve the user needs by user centered design approach of the system [101]. Usability engineering is explaining methods for analyzing and improving the software usability to collect information in order to better understand user requirements in specific environments for the designing of product [68].

GIS applications are combined with websites and usability is one of the important aspects to evaluate GIS application, for this purpose provider has developed their own user interface style and layout. These GIS applications provide support to different platforms because web based GIS applications do not have common user interface for interaction, presentation and syntax. Different studies have been carried out by different researchers for usability evaluation on GIS application. Usability of GIS on PC is quite mature and a lot of work has been done in this field [7] [9] [10] [11] [15] [29] [30] [31] [33] [34]. Zulfiqar et al carried out study of comparing usability evaluation of Google Maps and MapQuest through adopted criteria using think aloud technique [23]. Shoaib et al carried out study on the "*performance of two different usability evaluation methods in the context of collaborative writing systems*", and concluded that Co-discovery learning technique has better performance than think aloud protocol [110].

Usability requirements are target levels for realizing in design and to evaluate new system for usability problems. Six different approaches are specifying and measuring usability requirements, i.e. performance, defect, process, subjective, design and guideline [96]. Recently case studies have reappeared on which usability measures are suitable and how to understand relation between different usability measures [25]. It is impossible to measure usability directly, but it can be measured with the help of several attributes. The usability requirements attributes are generally measured on different scales that are task completion rates, mean time for task completion and average task satisfaction response [108]. According to NIST [85], task acceptance

scale consists of separate definitions of target value and minimum acceptance value. Possibilities for different scales are used to generalize the poor, planned, best and current levels of a product [109].

1.3. Structure of the thesis

Following is a brief overview of all the chapters of this thesis.

Chapter 1 (Introduction) Section 1.1 discusses about the background and motivation, Section 1.2 discusses related work and Section 1.3 structure of this thesis.

Chapter 2 (Problem Definition) describes the problem definition and usability evaluation of web-based GIS application of PC and smartphone. Section 2.1 deals with the problem definition. Section 2.2 deals with usability requirements to be set for GIS application. Section 2.3 deals with the aims and objectives. Section 2.4 is about research questions. Section 2.5 deals with the expected outcomes.

Chapter 3 (Research Methodology) presents the research methodology of this thesis work. Section 3.1 provides an overview of the chapter. Section 3.2 deals about the literature review. Section 3.3 deals with usability evaluation method. Section 3.4 describes Co-discovery learning technique. Section 3.5 explains the interview and section 3.6 is the discussion about the questionnaire.

Chapter 4 (Theoretical Work) is a brief discussion about our theoretical study. Section 4.1 gives a brief introduction of usability. Section 4.2 deals with ISO 9241-11 Usability Guide. Section 4.3 deals with the web-based GIS applications and section 4.4 describes Google Maps application on PC and IPhone.

Chapter 5 (Empirical work) discusses empirical work of usability test. Section 5.1 deals with specifying usability requirements for GIS application. Section 5.2 describes Pilot test, interview and questionnaire. Section 5.3 deals with test conduction information. Section 5.4 deals with the Co-discovery learning technique for usability test. Section 5.5 deals with the task designing. Section 5.6 describes interview and section 5.7 describes questionnaire for usability evaluation.

Chapter 6 (Results) is the brief discussion of collecting results. Section 6.1 explains about usability test results of Google Maps. Section 6.2 deals with Google Maps tasks observations. Section 6.3 deals with the usability problems and suggestion for improvements. Section 6.4 deals with the interview results and analysis. Section 6.5 describes the questionnaire feedback through ISO 9241-11. Section 6.6 deals with summary of usability test and questionnaire results and section 6.7 describes comparison of usability requirements.

Chapter 7 (Discussion) describes the discussion. Section 7.1 deals with the discussion on ISO 9241-11 measures. Section 7.2 deals with discussion about design of task document and co-discovery methodology Section 7.3 deals with the validity and reliability of results and section 7.4 deals with answers of research questions.

Chapter 8 (Conclusion) describe the conclusion of thesis. Section 8.1 deals with conclusion and section 8.2 describe the thesis future work.

CHAPTER 2: PROBLEM DEFINITION

This chapter relates to the problem definition which points to those problems that are creating difficulties for the user's needs while using the web-based GIS application, and comparing it on PC and smartphone. The name of the application that is to be discussed in this chapter is given. The authors also discuss the usability requirements to be set for GIS application, aims and objectives, research questions and expected outcomes which are the part of this study.

2.1. Problem Definition

Now a day, smartphone play an important role in everyday life. Many web interactive interfaces of PC can be seen in smartphone. The role of usability evaluation cannot be ignored in this change, related mobility and space [35].

In case of smartphone, the users could not be limited in interaction to the screen but should be considered additional interactions through application in the real environment [35]. According to Nielson [37], in iPhone (smartphone) usability studies, iPhone have specific applications (apps) for particular uses e.g. Google Maps in iPhone etc, but instead people prefer to go on web for using these apps. Smartphone optimized improve the websites issues but they have poor usability comparatively smartphone apps. Use, user and usability research is important but focus should not only be on maps display [40]. Usability attributes (measures) can be used to evaluate maps presentation as well web user interface, it could be interesting to investigate and compare Google Maps on PC and smartphone.

From the developer point of views, the possibility of making such systems that fulfills all the usability attributes i.e. ease of learning, task efficiency, ease of remembering, understandability and subjective satisfaction are very rare. It is important for usability requirements to specify target values for each of the attribute [36] [96]. The quality of GIS user interface is to achieve acceptance criteria attributes for effectiveness, efficiency and satisfaction for end-user [100]. After developing usability evaluation of Google Maps, it is important to identify requirements that to what extent it achieve its implemented acceptance criteria (target and minimum acceptable values) on each attribute to evaluate Google Maps on user performance and satisfaction in both devices.

2.2. Usability Requirements to be set for GIS application

In this study the authors are comparing and evaluating the usability of GIS application on PC and smartphone through ISO 9241-11. Same set of features (search address, get direction and navigation etc) are selected with different user interface for example presentation of maps, colors, design and legends. Setting usability requirements are easy if you have knowledge about the intended purpose and the users [20] [97]. Gulliksen set four usability requirements; user, environment, domain of knowledge and task [20].

For this purpose the authors selected Google Maps as GIS application, identify basic usability requirements after a thorough literature survey, specified usability requirements, set acceptance criteria for non-functional requirements on user's tasks and agreement using Google Maps to check user performance and satisfaction.

2.3. Aims and objectives

The aim of our research is to compare and investigate the end-user need regarding Google Maps on PC and smartphone by conducting usability test, interview and questionnaire for usability requirements identification. The following objectives will lead us to our goal.

- Description of usability importance for Google Maps
- Exploring basic usability requirements through ISO 9241-11
- Choosing performance and satisfaction measures
- Setting acceptance criteria on Google Maps features
- Making non-functional requirements testable and measurable using metrics
- Evaluating and comparing quality of Google Maps on two different devices through ISO 9241-11.
- Identification of different usability issues regarding user interfaces
- To identify acceptance criteria of user performance and satisfaction on both devices

2.4. Research questions

Q1: How to define basic usability requirements for GIS application?

Q1.1: How can these requirements be made testable and measurable?

Q2: To what extent can usability evaluation method be used when measuring the usability to evaluate user performance and satisfaction in stationary and mobile computing devices?

Q3: What suggestions of improvements based on the identified usability issues and requirements can be made for future technology?

2.5. Expected outcomes

This study is conducted for the usability evaluation of Google Maps in the light of ISO 9241-11 on end-user. The possible outcomes are: Usability requirements are identified through ISO 9241-11, in usability test, performance measures are used for participant's observations while satisfaction measures are used orally in interview and questionnaire. Google Maps usability problems are encountered and comparison with usability requirements in PC and smartphone. The results are in ISO 9241-11 measures.

CHAPTER 3: RESEARCH METHODOLOGY

In this chapter the authors present research methodology overview and procedures followed by the literature review in order to discuss usability evaluation of GIS application on PC and smartphone through usability testing (end-user). The procedure defines usability evaluation method; usability testing as Co-discovery learning technique in order to observe group of participants during the test and also by conducting interviews with the participants after the test for validating the results. Interview and questionnaire are discussed in the research study.

3.1. Overview

In this thesis, the approach is to develop an empirical based study on usability evaluation of Google Maps on PC and smartphone. Authors used qualitative and quantitative research approaches [41], in order to provide answers to the questions how to, how can, to what extent and what respectively.

Qualitative research belongs to data such as words or non-numerical data that is collected from observations of participants during performing tasks, interview and making a meaningful data that users bring to them. Quantitative research belongs to any numeric data, measures of data and analysis of statistical techniques [42].

To evaluate the product systematically it is helpful to get both perspectives. Qualitative data is gained from observation of users, responses and are analyzed toward the product usage during the test and preference in interview, the submission of user feelings, thoughts and preferences with ranking. Answers to the questions, the procedures are known as preference. Whereas quantitative data is counted quantitatively [43]; Usability measures (metrics) are used for the test and questionnaire to get qualitative and quantitative data [43]. The compared data of Google Maps on PC and smartphone is used for further analysis. In this context quantitative data can focus on user performance (tasks status; errors rate, time spent, clicks and taps) and satisfaction, while qualitative data is useful from participants perspective (preferences and comments).

There are various usability evaluation methods and techniques however preference is given by authors to usability testing as evaluation method and Co-discovery technique as usability test procedures on end-user [43], because previous study is carried out using think aloud protocol technique [15]. Co-discovery learning technique is used for better observations and is relevant to think aloud protocol because of one difference, i.e. a single task is performed by a single participant using the think aloud protocol while in the Co-discovery technique the same task using the same system is performed by a group of two participants [44] [110]. Questionnaire, interview and usability test provide data triangulation and more realistic results are expected instead of using single data collection method. Three methods namely; usability test conduction, interview and questionnaire are used for data collection in order to answer the overall research questions. Interviews are used to validate the user perception against usability tasks and questionnaire is used get user response. Authors used interview technique which provides more robust view about system usage.

Figure 1 demonstrate that the authors have done relevant literature review in order to get the in depth understanding of ISO 9241-11 standards for defining basic usability requirements for Google Maps (RQ.1). Relevant usability requirements for user interface of Google Maps are identified through empirical study and are set target value on user tasks and user agreement according to ISO 9241-11 for measuring, furthermore, tasks and questionnaire are designed according to ISO 9241-11 (RQ.1.1). To evaluate user performance and satisfaction in step1, Co-discovery learning technique is used for conducting tests on end-users (experienced and novice) and interviews are conducted to validate the test results. Moreover in step2, after test questionnaires were distributed to collect user's satisfaction. After collecting qualitative and quantitative data are discussed in the results chapter 6 (RQ.2). In the end a discussion has been done on findings and users feedback in order to provide possible proposed suggestions and recommendation for the improvement of the GIS user interface, which is presented in chapter 7 and Appendix D (RQ.3).

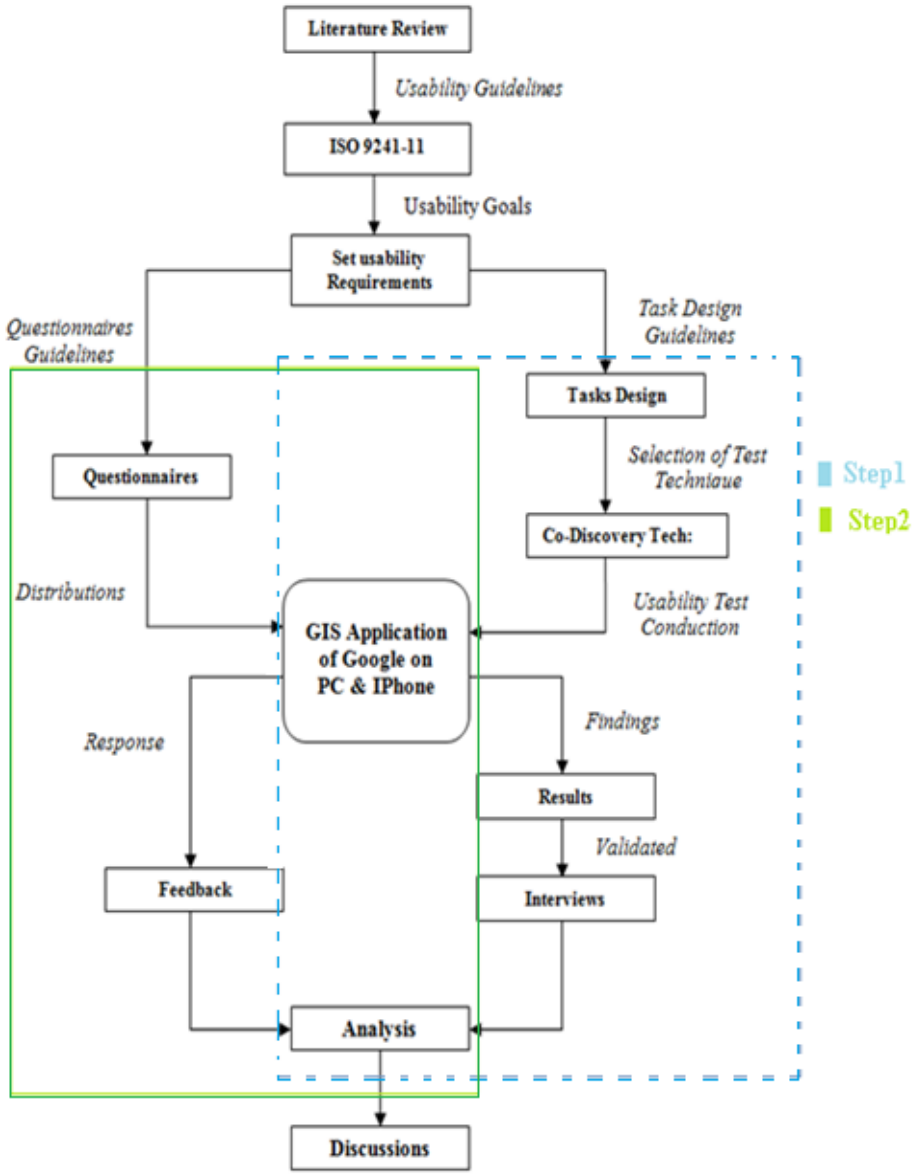

Figure 1 Research Methodologies used in this study

3.2. Literature Review

In literature review, authors draw different aims of studies, problem definition, usability requirements, ISO 9241-11 criteria, different usability evaluation methods to compare Google Maps on PC and smartphone to carry out usability requirements goal. Literature review helped the authors to understand what related studies already have been published by different researchers. Authors used books from Blekinge Institute of Technology (BTH), Karlskrona, Sweden library and regularly used Electronic Library Information Navigator (ELIN) as a net surfing tool to search the available literature. Authors have made search query on related topics and found relevant important research papers and eBooks using different databases like the ACM, IEEE, SpringerLink and search engines like Scopus, Google Scholar and Compendex Inspect [102]. Throughout literature review search, authors asked for guidance from senior students and supervisor to refine the search queries. On the basis of literature review the focus of this thesis is to solve research questions [102]. Authors selected usability test through Co-discovery technique, interview, questionnaire and set acceptance criteria for GIS applications of Google Maps on PC and smartphone.

3.3. Usability Evaluation Method

Before Usability evaluation, goals are set for usability attributes which are used for the usability judgment criteria of a product and assigning different metrics to those attributes which allow measures for specifying the usability of a product. Usability testing has five goals: Product usability, real users' participation, giving the real tasks to achieve goals, observer collecting data and observing the participants attitude using the product and finally tester making analysis on collected data and providing possible recommendation for the product [73].

The purpose of usability testing is to collect data about a product in order to know the extent of the product usability [74]. Usability testing is a process in which we can learn from users about product usability by observing them performing different tasks. The popularity of usability testing is increased due to end-user characteristics. It can be used to improve usability of product, represent real users, user doing the real tasks, evaluators observation and recording of the users in the light of what they are doing and saying [74]. The testers then make a record (e.g. time, events, actions, concern & comments) of the user successful and unsuccessful tasks, level of performance and satisfaction. Authors will use usability evaluation method as end-user testing through Co-discovery technique, interview and questionnaire.

3.4. Co-discovery Learning Technique

In this usability test technique, a group of two participants are given tasks to be performed. The participants are allowed to complete the given tasks together and verbalize their thoughts by communicating to each other while being observed by the testers [43] [44] [45]. Participants can help each other, while interacting with one another in order to achieve a common objective of the same task and verbalizations between the group participants provide help to the observers in collecting data during test more naturally. In this technique, two participants must already have some cultural connection, friendship and feel less shy while communicating in testing environment [46]. The observers are sitting with participants for providing instruction

regarding the tasks list and are giving preset tasks to the participants to explore and evaluate the performance model of product [44].

The authors will use Co-discovery technique in this study in order to overcome the interaction between participants and evaluators during the test.

The advantage of Co-discovery technique is that it is used for better performance, promising the effectiveness of the social technique as compared to the individual test technique [45] [46], The main disadvantage of this usability testing technique is that, for the usability test more number of participants are required instead of one participant [45] [46].

3.5. Interview

Generally interview is a conversation between interviewer, asking question and interviewee answering questions. It is an inquiry technique to collect data about the product from users and is used for usability evaluation. Moreover the answers provided by the participants about the conceptual model and consideration of like and dislike of the product [47]. Interview has two types structured and unstructured interviews. Structured interview relates to closed-ended question while the unstructured interview belongs to opened-ended questions [99]. The aim of the interview is to achieve feedback on how, which, in what way participants used Google Maps on both devices. Authors will use general interview guideline [48] [49] [50] for conducting structured interviews including closed-ended questions to validate the test results [99].

3.6. Questionnaire

In general questionnaire is used for the comparison of the product usage [18] [51]. To gain the quantitative data, it is used for different level of measures. Authors used questionnaire in this thesis for the purpose to carry out the effectiveness, efficiency and satisfaction level of Google Maps on PC and smartphone [19] [47]. Likert scale series of questions are used for the respondents [53]. Lists of questions are distributed to gather the participant's subjective response for the Google Maps functions tested. The degree of agreement and disagreement of the participants while answering each question is marked from "agree" to "disagree" in "Strongly" and participant having neutral choice is in the middle [52] [53]. Authors used ISO 9241-11 guideline for the design criteria of closed ended questions scalar in order to evaluate the usability of Google Maps on both devices [19] [44] [47].

CHAPTER 4: THEORETICAL WORK

In this chapter, authors have discussed usability and ISO 9241-11 usability guidance. Furthermore GIS applications, architecture, components and Google Maps features are explained on PC and iPhone etc.

4.1. Usability

Usability is a term, easy to use where human interacts with system interface and its functions. According to Rhodes [54], usability is easy to understand and but difficult in explanation to others. Usability has been defined by different researchers in the field of HCI [55] [56] [57] [58] [59] [60]. According to Nielsen [18] [61], **Usability** is one of many attributes of system acceptability and must be able to satisfy the user requirements. The **system acceptability** has two components which combine the social and practical acceptability, furthermore practical acceptability is the collection of Reliability, Cost, Compatibility and Usefulness etc. **Usefulness** is the issue which is further divided into utility and usability. **Usability** means how users interact with system functionalities to be easy to use.

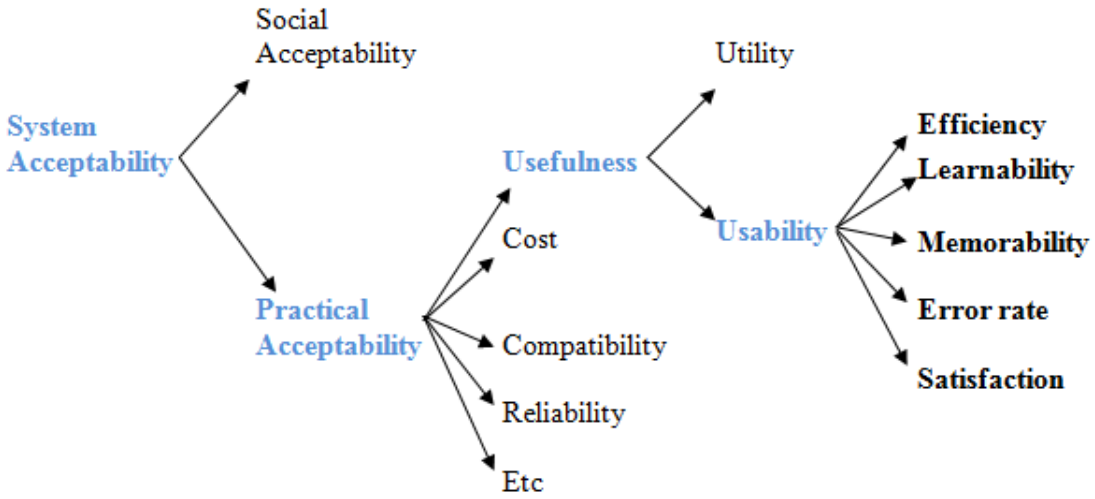

Figure 2 Systems acceptability by Nielsen [54]

Thus, all directly and indirectly connected elements in the system acceptability are very important from a holistic approach and usability is just one of many attributes; however it is not considered in many projects [61]. Usability evaluates the application where user interaction is involved [62]. According to Rhodes [54], usability is further divided into five important factors or attributes of user interface which are efficiency, learnability, memorability, error rate and satisfaction. According to Quesenbery [63] usability has five E's such as effective, efficient, engaging, error tolerance and easy to learn. According to Laurusdottir [64], Nielsen's five usability attributes are almost different from the three attributes of ISO 9421 part 11 except satisfaction. Whitney five E's are also different except effective and efficient in term of definitions. In usability objective of ISO 9241-11, learnability, error tolerance and memorability has described with the use of effectiveness and efficiency measures. Nielsen's definition is sometimes known as "small" usability as compared to ISO 9241-11, which is a well known definition for high level usability [64].

4.2. ISO 9241-11 Usability Guidance

According to ISO 9241 part 11, **usability** is 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" [19].

The definition consists of four elements in usability: the user, the user's goals, the product, and the context of use. **The user** must belong to a group of users "*a person that interacts with product*" [19]. **The product**, "*the part of the equipment (software and hardware materials) for which usability is to be specified or evaluated*" [19], means software usage by users including material (hardware) [19] [63] [64]. A **goal** of the specified users is the desired result in a free way [19]. **Context of use** means "*the user, tasks, equipment and the physical and social environment in which a product is used*" [19] [63] [64]. Usability of ISO 9241 part 11 has three measurable elements effectiveness, efficiency and satisfaction [19] [63] [64].

Effectiveness is "*the accuracy and completeness with which users achieve specific goals*" [19]. Effectiveness means measurements of user's task completion rate, errors rate and users help rate provided by testers. It does not mean how users achieve the specific goals, only how user's completed the goals with accuracy [19] [63] [64]. **Efficiency** is **"***resources expended in relation to the accuracy and completeness with which user achieve goals*" [19]. It means time spent on completing the tasks with level of effectiveness measure and another measure is clicks and taps [19] [63] [64]. **Satisfaction** is "*freedom from discomfort, and positive attitude towards the use of the product*" [19]. It means to rate the questionnaire with user perspective after usage of product and also the user emotional expression can be observed about the product used during the test [19] [63] [64].

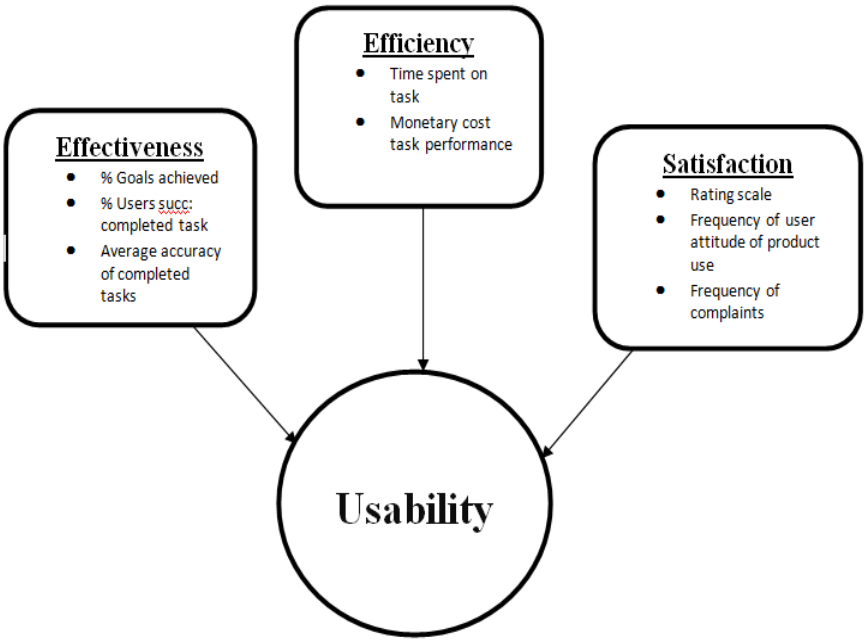

Figure 3 Part model of ISO 9241-11 Usability Overall Objective Model [19] table B.1, Including for examples are as: effectiveness, efficiency and satisfaction. These examples are used as input for concrete measurements and methods see model 8 chapter 5

In this situation, a product can be compared through summative usability evaluation, with aim to deal with the user requirements, user attitude toward the best products in term of task completion, task completion time, task complexity and user satisfaction

[65] [66]. Usability is also dependent on the user characteristics and environments [67]. Usability requirements can be set in context of use to achieve the user goals and its related measures for the intended outcome for the comparison of system [48] [68] [69].

Any user interface should be in such a way, that expert and novice users can easily use and interact with it. The user interfaces should be successfully evaluated when important evaluation criteria are used for usability in the process of design and development [70]. According to Koua [66], proposed user and task based usability evaluation criteria for GIS application suggests that usability evaluation method is useful for assessing the capability of GIS application in order to overcome user performance and satisfaction regarding observation. It is also concerned with the gathering of information and any metrics available to complete the task and observe the time spent on tasks, task completion and incompletion, task difficulty level, errors and help from tester etc [66].

Usability of user interface design can be evaluated in many approaches [55] [56] [57] [58] [59] [60]. Many evaluators used different evaluation criteria, based on their own interest and purposes for usability of a product [49]. Usability measures on user performance and satisfaction provide a basis for usability investigation and comparing the product with other design features in the same context [60]. For usability requirements it must be noted that either these requirements are clear regarding the context of use and its associated measures. To know about the users, who they are and what their goals are, and which kind of conditions they will use for the system in order to meet their desired goals [71].

Authors followed the ISO 9241 part 11 in this study and motivation for selecting ISO 9241-11, usability model for this study work have advantages which are as follow:

- It specifies the measure of usability requirements
- It fulfills the comparison of two products having same features and different user interfaces in the same context of use
- This is the only well organized model which can address usability in good way [72]
- Well structured model which addresses the issues of usability in a correct manner
- Based on three measures which are effectiveness, efficiency and satisfaction [49]

4.3. Web-based GIS applications

GIS is defined as a set of tools used to collect, store, retrieve, transform and display spatial data from the real world as defined previously [2] [3] [4]. A web-based GIS application means a browser supporting an application in order to make its information accessible. This makes the application usable for the user for accessing functions on GIS application such as get direction, Zooming and Panning, search location and taking a print of map on the web browser.

4.3.1. GIS Components

GIS is a set of computing systems having five key components like software, hardware, user, data and procedure [6] [41] [75].

4.3.1.1. Hardware

Hardware includes the range from computer, mobile, PDA etc which operates GIS application, monitor, LCD, mobile Screen, Scanner, mouse, keyboard, Projector, and printer. The GIS applications data information is large in size; hardware must have fast processing speed and high RAM [6] [75].

4.3.1.2. Software

Software is used for providing functions. GIS tools require storing, analyzing and displaying GIS information. The Data Base Management System (DBMS), which support GIS search queries, analysis, Graphical User Interface (GUI) and Visualization for accessing the tools [6] [75].

4.3.1.3. Data

The most important component of GIS is the information or spatial data. GIS combines important spatial data with other data features in term of integration of data used DBMS in most of the companies to maintain, organize and manage their data or information [6] [75].

4.3.1.4. People

GIS application operators are the people who operate and maintain GIS system for daily use. The GIS team consists of technical and non technical personals who handle the GIS systems within their respective domains [6] [75].

4.3.1.5. Procedures

GIS application system is performing data input, output, storage, management; transform the data into information and analysis. Analysis can be performed whenever GIS users need it [6] [75].

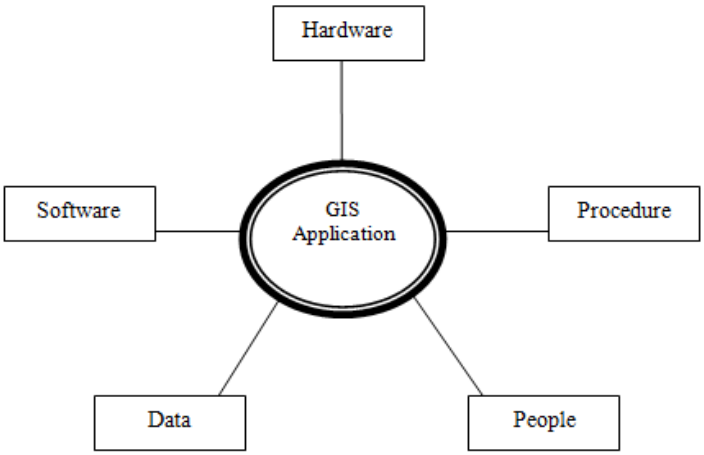

Figure 4 GIS components [75]

4.3.2. GIS applications Architecture

A typical GIS application is a set of tools that is capturing, storing, analyzing, managing and showing data that are linked to locations in the World. Web/based GIS applications have client side and server side architecture over network. Client side is capable to edit and improve performance, user access the GIS functions (information)

through any internet browser on computer or mobile where people interact with GIS interface [45] [75].

Server side is using web remote in application server and address matching, where server is performing storage and process the data (file) from Central database to user query [75] [76] [77]. Database side is responsible, and consists of many different databases for different functionalities like store and access the server in order to return the data to the client server. Web browser is used for generating server requests and displays the data results [75].

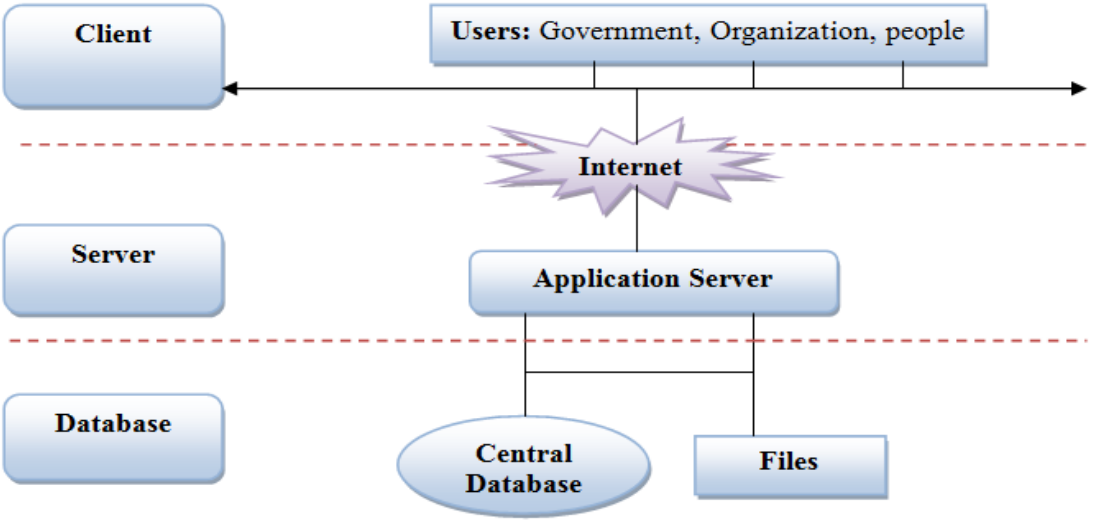

Figure 5 Typical Web-based GIS architecture [70] [72]

4.3.3 GIS application Features

GIS applications perform many specific functions on PC, Mobile, PDA, etc through web-browser. There are number of functions which are as follows:

4.3.3.1. Search Location

The most important feature in web-based GIS application is the search location, which provides a variety of access for different places, in order to search for street address, zip code, city, hotels, airports, restaurant etc by entering the required information and clicking on the search button [78] [79].

4.3.3.2. Navigations

Navigations features provide user, the panning and Zoom facilities into four directions. The control functions using the cursor arrow is taking place in moving the desired location in all four directions [78] [79].

4.3.3.3. Get Direction

This feature provides the facility of getting direction by giving the name of desired locations in text boxes. In mobile, users using the web-based browser can only enter the desired location from the current location. The web-based maps also provide the facility of giving different routes in a specific color between two or many locations. Users can select suggested possible and modified routes easily [78] [79].

4.3.3.4. Sharing, Printing, Creating and Saving Maps

These features provide the facilities to the users, who desire to have the maps in sharing, printing, creating and saving form. These features can be achieved when users are taking their direction for their desired places. Printing maps also provide the users some additional options such as add text note, dragging and Zoom the maps. In sharing facilities, users can share the desired maps with other people by sending through e-mail address or cell number. In creating maps, users can create their personal maps into different categories. In saving location, user can save the maps by signing in to their account in different categories [78] [79].

4.4. Google Maps

Google Maps service was launched for the first time by the Google incorporation in February 2005 [80]. Google Maps version 5.0 supports many features on different devices which are as follow in table 1:

Table 1 Google Maps table for different platform (Devices) [78] [79]

Features	Windows/PC	iPhone	Android	BlackBerry	Nokia S60
Navigation			✔		
Labs			✔	✔	
Search by Voice	✔		✔	✔	✔
My Location	✔	✔	✔	✔	✔
Business Listings	✔	✔	✔	✔	✔
Places			✔		
Business Reviews	✔		✔	✔	✔
Driving directions	✔	✔	✔	✔	✔
Transit and Walking directions	✔	✔	✔	✔	✔
Biking directions			✔	✔	
Latitude	✔		✔	✔	✔
Layers	✔		✔	✔	✔
Street Views	✔	✔	✔	✔	✔
Satellite View	✔	✔	✔	✔	✔
Traffic	✔	✔	✔	✔	✔
My Maps	✔		✔	✔	✔
Starred Items	✔		✔	✔	✔
Buzz	✔	✔	✔	✔	✔

4.4.1. Google Maps on PC

Google Maps are the applications providing web-based free facilities to users. It also provides some facilities like street maps, route planner, satellite view, earth view and bird view. Google Maps are providing features on web browser for searching location, address, getting direction, sharing, creating, printing, saving etc maps. Some of the cities of the world having street view facility can be seen through Google Maps. High resolution images can also be viewed through it [15] [78].

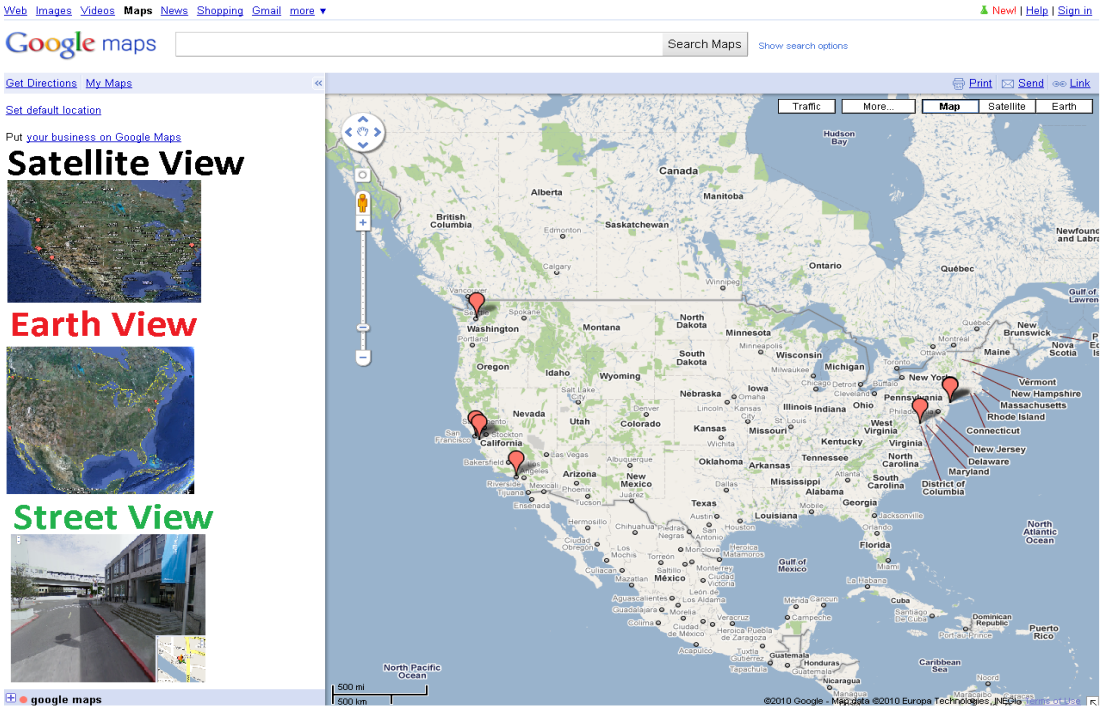

Figure 6 PC Google Maps main page and left side different views

4.4.2. Google Maps on iPhone

Java application has been come in 2006 which was known as Google Maps for mobile which made Java based mobile run able [78]. These applications contain a lot of web-based site features. Google Maps for mobile 2.0 came into being in November 2007 and that launched GPS service. In December, 2008 Google Maps supporting different platform came into being which are mentioned above in table 1 [78].

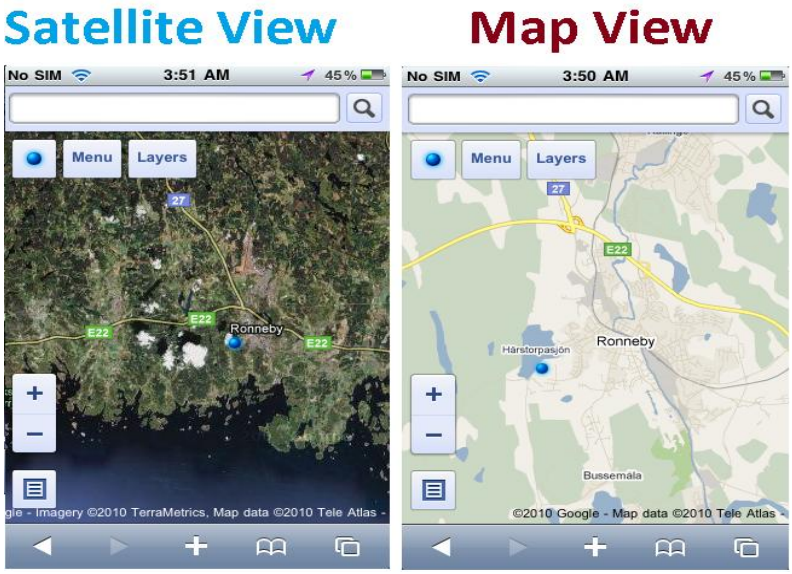

Figure 7 iPhone Google Maps main page

CHAPTER 5: EMPIRICAL WORK

In this chapter the authors have discussed setting acceptance criteria for usability requirements in terms of usability objectives and test criteria for usability evaluation of GIS application of Google Maps on PC & iPhone. Specifying usability requirements for Google Maps, planning for the task requirements, test materials and test environment are discussed. Pilot usability tests are conducted. Pilot test provide help to test procedure itself and also for conductors to refine usability tasks, interview and questionnaire. Tasks are designed for performing test on Google Maps features. After performing usability tests; interviews are conducted to capture the users perspective to validate the test results. Questionnaire is designed according to ISO 9241-11 which measures effectiveness, efficiency and satisfaction, and is distributed among users to achieve subjective responses.

5.1. Specifying Usability Requirements for GIS application

Usability requirements can be specified into two main sections that are context of use and usability measures of relevant factors [19]. Usability requirements are set for tasks design and user types [19] [81]. According to Trump [81] usability requirements provide actual objectives for usability criteria for test and highlight the importance of usability in early development. At the late phase, the product usability is to be evaluated against the usability requirements. When the quantitative requirements are matched, usability test (end-user test) is used in order to determine it [82] [108]. Requirements can be divided into sub categories in order to make them measurable for test planning, running session and test results reporting [81]. Usability requirements indicate user performance and satisfaction in context of use of GIS application on PC and iPhone.

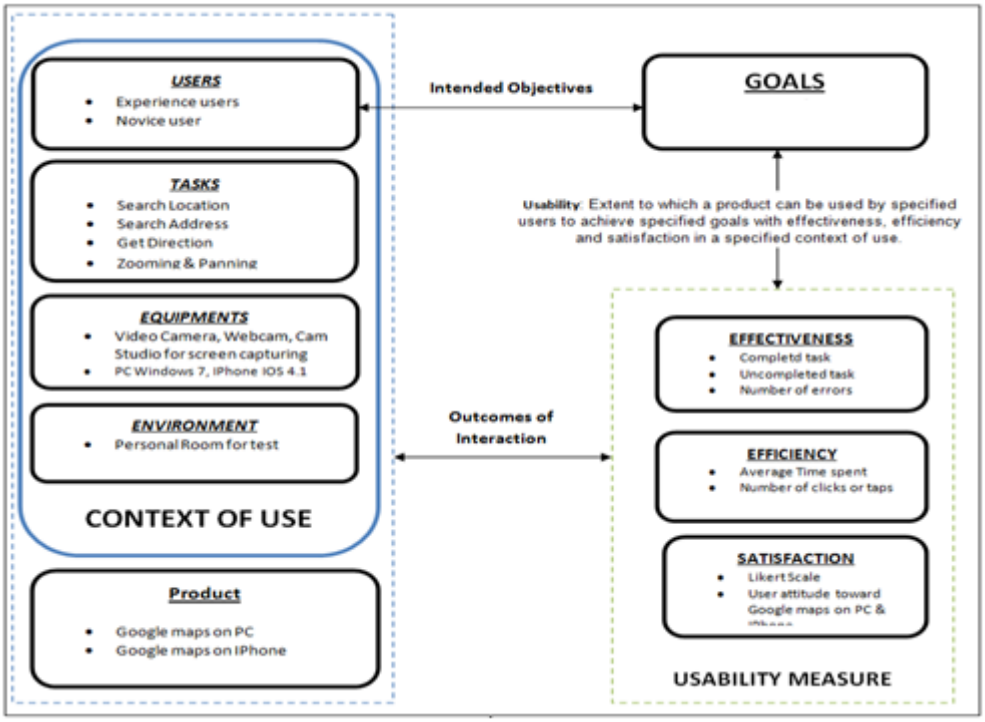

Figure 8 specified our measurements for usability goals, fig: 1 usability framework [19] Extension of figure 3 & ISO 9241-11 applied in GIS context

Authors specified criteria level for effectiveness, efficiency and satisfaction as usability requirements on GIS application evaluation. These requirements are divided into sub categories in order to make them testable and measurable using metrics. Usability measures are specified for participant's performance and satisfaction according to usability test criteria. Authors set usability goals and target value directly related to web-based GIS application in the same context of use and related measures. Based on above requirements, the authors adopted ISO 9241-11 criteria for usability test. Figure 8 entails the detail usability testing model for the required study.

5.1.1. Specifying Context of Use

This section describes specified information related to the aspects of context of use that is important for the usability [19]. Context of use defines user types, tasks to be performed by users to measure usability, test environment and material required while performing tasks [19]. Authors identified usability of GIS application on PC and smartphone in the same context of use. Google Maps is used as web-based GIS application, Laptop as PC running MS Windows 7 and iPhone 3GS using IOS 4.1 as smartphone.

5.1.1.1. Selection of user Types

According to Nielsen [18] & Nielsen [61] 85% of usability studies are carried out with the help of five participants while performing tests. Analyzed usability requirements depend on the user types and test environment [67] [81]. In order to carry out usability studies, the authors visited Blekinge Institute of Technology (BTH) and selected 12 Students from school of computing for usability evaluation. Authors arranged these students into six groups, each group consisting of two students for performing test on Google Maps on PC and iPhone. In these six groups, four groups were experience users and two groups were novice users.

1. **Novice Group (NG):** Novice Group represents participants who don't have any prior experience using Google Maps on PC and smartphone.
2. **Experience Group (EG):** Experience Group represents participants who have already used Google Maps on PC and smartphone.

Table 2 Group of participant's characteristics

Group #	Participants Name		Education Program		Age in year		Google Maps Experience in months				Sex	
							PC		iPhone			
	Name1	Name2	Edu.1	Edu.P2	Y1	Y2	X1	X2	X1	X2	P1	P2
NG1	Majid Khan	Rizwan	MSc. CS	MSc. SE	27	27	0	0	0	0	M	M
NG2	Majid Nasir	Abdul Rauf	MSc. CS	MSc.SC	29	31	0	0	0	0	M	M
EG1	Nisar Khan	Fazal Ullah	MSc. CS	MSc.SC	28	30	5	72	4	4	M	M
EG2	Zahid M.	Tabassum	MSc. CS	MSc.SC	31	30	6	60	12	12	M	M
EG3	Asar Jan	Waqas	MSc.SE	MSc.EE	32	24	18	24	6	7	M	M
EG4	M. Adnan J	Ali Raza	MSc. CS	MSc.SC	25	26	12	11	3	5	M	M

5.1.1.2. Tasks

The task is normally written as a scenario and must be in user language [67]. The tasks should possibly be representative of the real tasks of the product and will cover

the important areas of the functionalities of the product [19] [81]. The test tasks should be planned in such away in order to be completed within time limits [81]. It is very difficult to test all features of Google Maps on PC and iPhone but authors designed some basic tasks consistently to achieve the intended goals. According to [82], usability requirements depend on target level of product e.g. the rate of tasks successfully completed by the users is (90%) while minimum level of acceptability is (80%). The authors set maximum predefined time for each task. Two minutes for task 1 & 2 and five and four minutes for task 3 & 4 respectively for the purpose to achieve usability requirements. When the time is doubled the chances of task success rate also get doubled and become 200% for users. The predefined maximum completion rate of efficiency is calculated 61.53% for both devices in section 5.1.2.2. Authors set acceptance criteria for usability requirements such as effectiveness and efficiency for measuring tasks, which are as follow:

- Acceptability level of tasks completion is 80%
- Completion rate of efficiency is 50%

Section 5.5 for designed tasks for Google Maps for each PC and iPhone.

5.1.1.3. Test Environment

Special usability labs are used to perform usability test. Usability labs are equipped with specific equipment and have isolated environment [18]. Due to unavailability of usability lab the authors selected personal room for performing tests. The room was isolated and the users performed tests without interruption in order to get accurate measure.

5.1.1.4. Usability Equipments and Material

Necessary usability equipments are required to complete tests [18] [83] [84]. Usability test material [85] [86] collected for the observation of Google Maps on PC and iPhone:

- An Intel Processor 1.7 GHz dual core, RAM 3 GB PC with LCD 15 inch running at 1280 x 800 pixel as Laptop (PC)
- 16M colors, RAM 256 MB and 320 x 480 pixel as iPhone 3GS (smartphone)
- Testing scripts for participants to inform them about test
- 4Tech Cam used for the smartphone [83] and “Camtasia Studio 7” software for the PC to record the screen during testing [87]
- For Participants observation Sony camera used for recording
- Usability test data sheets are prepared to gather participants performance

5.1.2. Specifying Usability Requirements for measuring

The usability requirements are set for measuring tasks performance measures on ISO 9241-11 criteria [19] [84] [86]. The ISO 9241-11 criteria is made clear to all participants involved, that in which way and under which circumstance Google Maps are usable, and to check whether this usability level matches the evaluation of Google Maps. The objective data so collected, such as measurement of performing task or occurrence of particular events, while subjective data collected from participants expressions [19]. The necessary requirements to record the above measures are gathered in a data sheet table [67].

5.1.2.1. Effectiveness

Effectiveness measures are concerned with the goals and sub-goals of participants using product (Google Maps on PC and iPhone) for accuracy (quality) and completeness (quantity) to achieve goals. The accuracy measures are, tasks completion rate, frequency of errors and frequency of commands functions can be included in the measurement of effectiveness [67] [84] [86] [88]. Authors' specified metrics for measurements are as follow:

- The success in completing tasks (to failure ratio)
- Number of errors

5.1.2.2. Efficiency

Efficiency measures are concerned with effectiveness level to evaluate the product by the time spent on documentation, task time, mean time taken for achieving completed task and the total cost [67] [84] [86] [88]. User's efficiency is measured by the rate of tasks completion per mean time tasks. [85].

$$\text{User efficacy} = \frac{\text{Rate of completion tasks}}{\text{Mean time taken by task (min)}}$$

$$\text{Therefore, User efficiency} = \frac{200\%}{13} = \mathbf{61.53\%}$$

Mean time 13 represent the summed up of 6 group of participants and 4 tasks (78 divided by 6 is equal to 13)

Authors' have specified metrics for measuring test are as follow:

- Time spent on task completion (and uncompletion)
- Total number of clicks/ taps

5.1.2.3. Satisfaction

It is the participants response of interaction with product [19]. Satisfaction is assessed by subjective measures (quantity) based on questionnaire while objective measures (quality) are based on the observation of participants. Participant's overall attitude of product and maximum requirements to achieve the usability level represents satisfaction [67] [86] [88]. After test and interview, authors distributed questionnaire to each group of participants based on performance of Google Maps, which provide subjective response based on subjective Likert scale satisfaction [53] [86]. Authors have specified metrics for test as follow:

- Positive/ negative comments during the test.

5.1.2.4. Specifying Usability Test Method

Authors proposed usability testing (end-user), interview and questionnaire for evaluation of Google Maps against the group of participants measuring performance and satisfaction criteria with usability test technique as Co-discovery learning [43] [89].

5.2. Pilot test, Interview and Questionnaire

According to Nikov et al [27], one or two pilot tests will be enough to try out the test method subjectively. Pilot testing is used to refine the test procedures itself and to specify the definitions of different items that are to be measured [18]. It is conducted for the purpose to minimize system errors and is helpful in determining the validity and reliability of the product [98]. Authors conducted pilot test before conducting the actual tests using Google Maps on PC and iPhone. Furthermore, pilot test was performed to gather maximum information regarding usability evaluation. Two groups (novice and experience) were selected for testing. After pilot test, short interview was conducted. Pilot questionnaire was sent to participants to have an idea of user attitude. All information helped the authors in the selection of tasks for co-discovery technique, interview and designing a questionnaire. Furthermore, Pilot test is important to refine actual tasks, interview and questionnaire for usability evaluation procedures [18]. The results collected from the Pilot test are not mentioned in the actual result in this report.

5.3. Test Conduction Information

According to Nielsen [18], the observer noted the time and number of quantifiable usability measurements when task started and stopped. It is necessary for the conductors to identify, what the tester did during the usability test and under what situation, the tester observed the participants experience and information to test participants [44]. Prior to usability testing of Google Maps, authors provided information about usability, purpose of testing and usability evaluation of Google Maps, no stress for testing the abilities of participants. Furthermore, explained the usability test on Co-discovery technique, interview and questionnaire procedures to each group. One author used data sheet to record participants task performance at a time and instructed the participants to talk to each other loudly to better understand their mental level [89]. Camtasia Studio 7 Software and 4Tech cam were used to capture PC and iPhone screens respectively. Another author was recording the entire usability test session; audio and video during participants actions and comments for further analysis. The observed effectiveness, efficiency and satisfaction measures were noted during test for performing each task [39] [89]. In this study, authors used five metric on each measure for usability which are as follow [89]:

1. Completed and Uncompleted task
2. Number of errors
3. Time spent on task
4. Number of clicks and finger taps
5. Positive/ negative comments

5.4. Co-discovery learning technique for usability test

Authors used Co-Discovery learning technique for usability testing to observe interaction of group participants. In this method, two participants in one group performed tasks in testing procedure and are allowed to communicate verbally and also encouraged the other participant by verbal communication with each other while performing tasks [44] [73] [90]. Co-discovery procedure shows better results while communicating verbally between paired participants than single participant [44]. The verbal interaction of two participants carried out during single task provides more help to each other [44] [73].

5.5. Task designing

Authors designed four tasks based on tasks analysis of Google Maps on PC and iPhone. These tasks are designed in the same context of use which presents coverage of the main features of Google Maps user interface. Both the devices are having same tasks. The tasks are presented as under:

Table 3 Tasks document for Google Maps on Personal Computer

Tasks for Personal Computer

1. Task for Search Place: You got admission in Blekinge institute of technology in Sweden and planning to go to Ronneby city. So for this purpose you are searching airport in Ronneby, Sweden.

S1. Go to service provider address at "http://www.maps.google.com" and click enter
S2. Select "My Maps" if it is not selected
S3. Click on "Text Box"
S4. Write "Ronneby Airport Sweden" in text box
S5. Click "Search Maps" button
S6. Now Click on searched place to confirm the result

2. Task for Search Address: You have appointed room in hostel at Ronneby, Sweden and you need to search hostel address in Ronneby Sweden.

S1. Go to service provider address at "http://www.maps.google.com"
S2. Select "My Maps" if it is not selected
S3. Click on "Text Box"
S4. Write "Studentvagen Ronneby Sweden" in the "Text Box"
S5. Click "Serach Maps" button
S6. Now Click on searched address to confirm result

3. Task for Get Direction: Now you find out the distance from Ronneby airport to hostel address and save efficient route map.

S1. Go to service provider address at "http://www.maps.google.com"
S2. Select "Get Direction"
S3. In text box "A" Write "Ronneby Airport Sweden"
S4. In text box "B" Write "Studentvagen Ronneby Sweden"
S5. Click on "Get Direction"
S6. Selected any "Suggested routes"
S7. Scroll down the page to "Save to my map"
S8. Click on "Save" map to any showed categories

4. Task for Zooming and Panning: You need to find out again Ronneby airport (Task 1) for capturing the picture into your mind.

S1. Then Select "Satellite" from map menu located at upper right
S2. Zoom in & out be done with available control functions at left corner of the map or touch pad

Table 4 Task document for Google Maps on iPhone

Tasks for iPhone

1. Task for Search Place: You got admission in Blekinge institute of technology in Sweden and planning to go to Ronneby city. So for this purpose you are searching airport in Ronneby Sweden.

S1. Go to service provider at "http://www.maps.google.com" and tap on "Go".
S2. Tap on "Search box" clear it if not clear by tapping on "clear" button.
S3. Write "Ronneby airport Sweden" in search box
S4. Tap on "Search" button located at the left bottom side and confirm the desire search
S5. Now tap on searched place to confirm the result

2. Task for Search Address: You have appointed room in hostel at Ronneby, Sweden and you need to search hostel address in Ronneby Sweden.

S1. Go to service provider at "http://www.maps.google.com" and tap on "Go"
S2. Tap on "Search box" clear it if not clear by tapping on "clear" button
S3 . Write "Studentvagen Ronneby Sweden" in search box
S4. Tap on "Search" Button located at the left button side and confirm the desire search
S5. Tap on searched address to confirm the result

3. Task for Get Direction: Now you find out the distance from Ronneby airport to hostel address and save efficient route map.

S1. Go to service provider at "http://www.maps.google.com" and tap on "Go"
S2. Tap on "Menu" to select
S3. Tap on "Get direction" button
S4. Tap on "A" text box; clear the text box by tapping on "clear" button, if not clear.
S5. In text box "A" write "Ronneby airport Sweden".
S6. Tap on "B" text box; clear the text box by tapping clear button, if not clear.
S7. In text box "B" write "Studentvagen Ronneby Sweden"
S8. Tap on "Go" or "Get direction"
S9. Tap on "list" button located at the left side of buttons
S10. Page down with finger gesture
S11. Tap on "save to my page maps"
S12. Tap on "save" to selected option
S13. Now confirmed the result

4. Task for Zooming and Panning: You need to find out again Ronneby airport (Task 1) for capturing the picture into your mind.

S1. Go to task 1, search the desired address
S2. Tap on "Layers"
S3. Select "Satellite" from the list
S4. Zoom in and out with the help of left control function or with the help of gesture
S5. Do panning in all directions with the help of your gesture

5.6. Interview

Authors designed eleven closed-ended predefined questions for validation of test results that encouraged the participants in explaining their views using Google Maps on PC and iPhone. Proper interviews were conducted for the purpose of how participants performed the tasks in an effective and efficient way. The interview provided help to the authors in term of satisfaction, that whether participants like or dislike the Google Maps on both devices.

5.7. Questionnaire for usability evaluation

After users testing and interview, each group of participants were given the questionnaire to collect user satisfaction for quantitative subjective data. The questionnaire was designed according to ISO [19], criteria such as Effectiveness, Efficiency and Satisfaction for Google Maps on PC and iPhone separately, which provided users feedback as performance and satisfaction. The questionnaire includes 48 questions which are according to Likert scale or closed ended questions scalar [52] [53], if response is 90% then requirements is achieved [67]. Authors set user agreement for usability requirements on effectiveness, efficiency and satisfaction, which are as follow:

- The overall participants agreement for each measure is set to 80%

The results and analysis from the questionnaire were collected and represented by a set of questions. See Appendix A for questionnaire designed.

Table 5 Question Division

Usability measures	**Question number in Questionnaire list**	**Total**
Effectiveness	1-2, 3-4, 5-6, 7-8, 9-10	10
Efficiency	11-12, 13-14, 15-16, 17-18, 19-20	10
Satisfaction	21-22, 23-24, 25-26, 27-28, 29- 30, 31-32, 33-34, 35-36, 37-38, 39-40, 41-42, 43-44, 45-46, 47-48	28

CHAPTER 6: RESULTS

After usability test conduction of Google Maps using PC and iPhone, the authors collected test results, interview and the participant's feedback through questionnaire. This chapter is structured as follow: Section 6.1 discusses Google Maps test results. Section 6.2 contains the author's tasks observation about the errors made by the test participants. Section 6.3 describes usability problems and suggestion for improvements divided into PC and iPhone. Section 6.4 contains interview results. Section 6.5 contains test participants feedback through questionnaire. Section 6.6 contains usability test and questionnaire results. Section 6.7 describes discussion and comparison of usability requirements.

6.1. Google Maps Test Results

Six groups participated in the test and twenty four attempts were attended by the group of participants for each device according to the predefined time and schedule. The authors noted completed and uncompleted tasks, tasks time, number of clicks and taps, number of errors and comments by each group during their discussion with each other.

6.1.1. Task Status Results

Four different tasks were designed robustly to cover broad spectrum of usability of Google Maps on PC and iPhone in section 5.5. Six groups each consisting of two participants, performed these tasks. Figure 11 represent tasks comparison of PC and iPhone in term of percentage.

Tasks Status Results on PC

The number of successfully completed and uncompleted tasks noted by the authors performed by each group of participants on PC was 23 while the number of uncompleted task was 1. Table 6 shows a detail description of completed and uncompleted tasks noted by the authors while performing task by each group of participants on Google Maps using PC.

- Successfully completed tasks = done
- Uncompleted tasks = fail

Table 6 Task Status on PC

Tasks #	**Group Participants ID**					
	NG1	**NG2**	**EG3**	**EG4**	**EG5**	**EG6**
Task 1	done	done	done	done	done	done
Task 2	done	done	done	done	done	done
Task 3	fail	done	done	done	done	done
Task 4	done	done	done	done	done	done

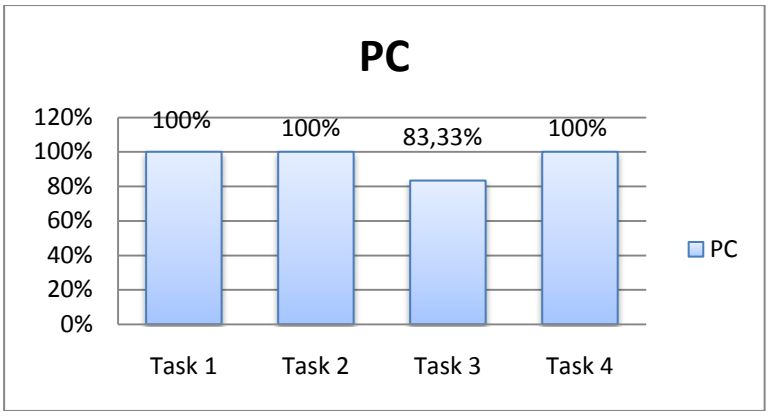

Figure 9 PC indicate per task completion in percentage

Figure 9 indicates tasks success rate in percentage by group of participants that is *Task 1*, *Task 2* and *Task 4* are completed 100% using Google Maps on PC within predefined time, while the success rate of *Task 3* is 83.33% because one novice group of participants did not complete the *Task 3* within predefined time.

Tasks Status Results on iPhone

Out of the 24 attempts attended by the group of participants, 18 of them were noted completed successfully while 6 were noted as uncompleted within predefined time. Table 7 shows a detailed description of the total number of completed and uncompleted tasks using Google Maps on iPhone.

Table 7 Tasks status on iPhone

Tasks #	**Group Participants ID**					
	NG1	**NG2**	**EG1**	**EG2**	**EG3**	**EG4**
Task 1	fail	done	fail	fail	done	done
Task 2	done	done	done	done	done	done
Task 3	fail	fail	done	done	fail	done
Task 4	done	done	done	done	done	done

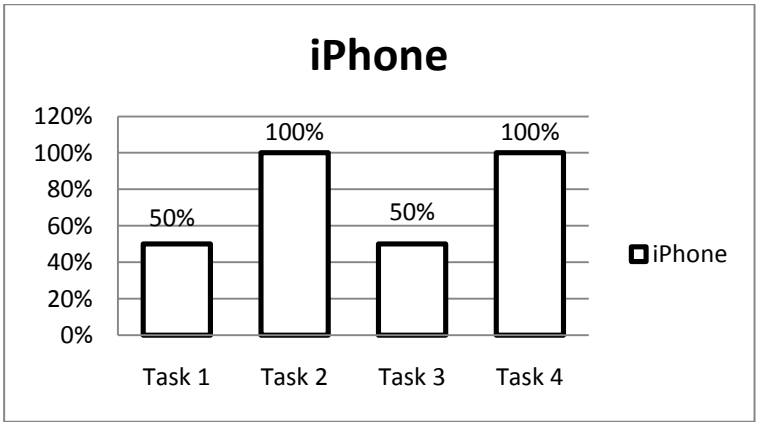

Figure 10 iPhone indicate per task completion in percentage

Figure 10 indicates tasks success rate in percentage by the participants that is *Task 2* and *Task 4* are completed 100% using Google Maps on PC within predefined time,

while the success rate of *Task 1* and *Task 3* is 50% because one novice and two experience group of participants did not complete these tasks within predefined time.

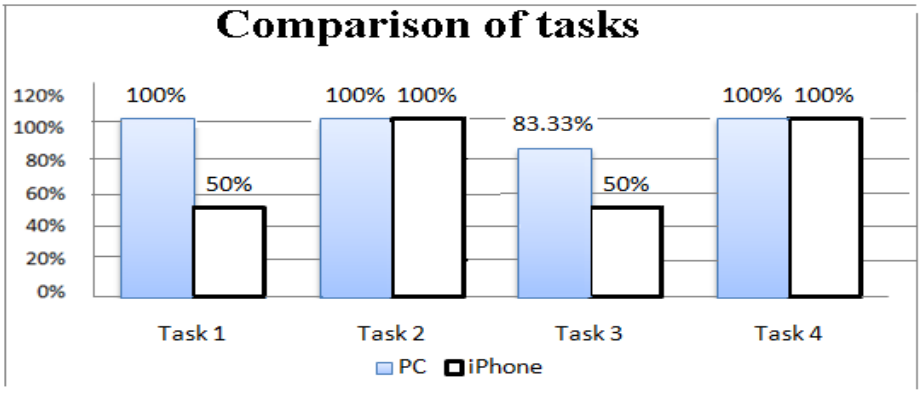

Figure 11 Effectiveness represent tasks comparison of PC and iPhone in term of percentage

Figure 11 indicates Comparison of tasks success rate in percentage by group of participants using Google Maps on PC and iPhone. *Task 2* and *Task 4* on both devices were completed 100%, while *Task 1* and *Task 3* were completed on PC 100% and 83.33% respectively and the same tasks were completed 50% on iPhone.

6.1.2. Google Maps Test time, Clicks &Taps Results

The authors noted the minimum, maximum, mean and total time for all group of participants while performing test on Google Maps using PC and iPhone, which is given in Table 8 and Table 9 respectively. Number of clicks and taps performed by each group of participants is given in Table 10 and Table 11 respectively for each device.

Tasks Time Results on PC

The total time noted by the authors taken by each group of participants on PC was about 41 minutes. Table 8 shows a detailed description of total time noted by authors while performing task by each group of participants on Google Maps.

Table 8 Tasks Timing (Seconds) on PC

Tasks #	**Group Participants ID**						**Total time**	**Min time**	**Max time**	**Mean time**
	NG1	***NG2***	***EG1***	***EG2***	***EG3***	***EG4***				
Task 1	55	49	101	84	55	81	425	49	101	70.83
Task 2	53	50	76	49	89	77	394	49	89	65.66
Task 3	319	77	190	133	62	125	906	62	319	151
Task 4	123	159	71	99	119	164	735	71	164	122.5
Total	550	335	438	365	325	447	2460	231	673	**410**

Time Results on iPhone

The total time noted by the authors taken by each group of participants on iPhone was 61 minutes and 33 seconds. Table 9 shows a detailed description of total time noted by the authors while performing task by each group of participants on Google Maps.

Table 9 Tasks Timing (Seconds) on iPhone

Tasks #	Group Participants ID						Total time	Min time	Max time	Mean time
	NG1	*NG2*	*EG1*	*EG2*	*EG3*	*EG4*				
Task 1	169	102	145	128	56	58	658	56	169	109.66
Task 2	67	131	95	83	50	81	507	50	131	84.5
Task 3	330	379	175	280	417	158	1739	175	417	289.83
Task 4	150	379	173	128	76	140	776	76	173	129.33
Total	716	721	588	619	599	437	3680	357	890	**613.33**

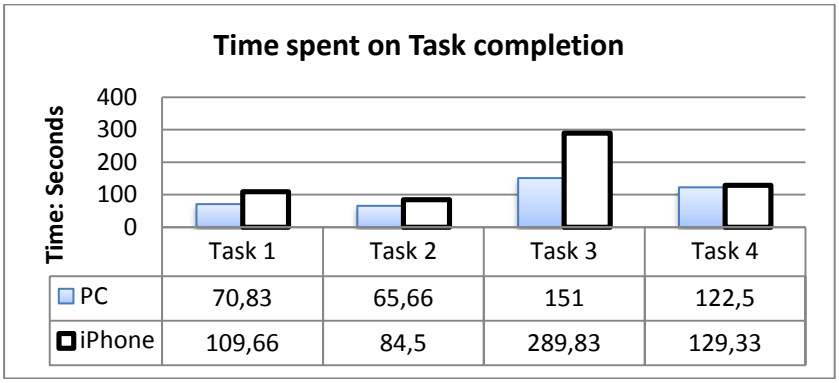

Figure 12 Google Maps mean task time (sec) comparison of PC & iPhone

According to figure 12, the mean time taken for *task 1*, to *Search Place* by PC is 70.83 seconds while iPhone took 109.66 seconds. Similarly the mean time taken by *task 2*, for *Searching Address*, by PC is 65.66 seconds while iPhone took 84.5 seconds. *Task 3, Get Direction*, took 151 seconds on PC while iPhone took 289.83 seconds and finally for *task 4, Zooming and Panning*, the task was completed on PC took 122.5 seconds while iPhone took 129.33 seconds.

Authors observed Google Maps on both PC and iPhone very similar in terms of efficiency. PC is 203.33 seconds (3 minute & 23 seconds) shorter in mean time than iPhone. Similarly total time taken by PC is 2460 seconds (41 minutes and zero second) while iPhone took 3680 seconds (61 minutes and 33 seconds). PC is 1233 seconds (20 minutes and 33 seconds) shorter in time than iPhone.

Number of clicks Results on PC

The total number of clicks performed by participants represents action and is noted by the authors on PC were 162. Table 10, shows a detailed description of number of clicks.

Table 10 Number of clicked on PC

Tasks	Group Participants ID						Total clicks	mini clicks	max clicks	Mean clicks
	NG1	NG2	EG1	EG2	EG3	EG4				
Task 1	4	4	6	4	4	5	27	4	6	4.5
Task 2	4	4	4	4	4	5	25	4	5	4.166
Task 3	11	6	8	6	8	7	46	6	11	7.666
Task 4	11	11	12	10	6	14	64	6	14	10.66
Total	30	25	30	24	22	31	162	20	36	**27**

Number of Taps Results on iPhone

The total number of taps performed by participants represent action and is noted by the authors on iPhone were 189. Table 11, shows a detail description of number of taps.

Table 11 Number of Tapped on iPhone

Tasks	Group Participants ID						Total taps	mini taps	max taps	Mean taps
	NG1	NG2	EG1	EG2	EG3	EG4				
Task 1	4	7	5	5	4	6	31	4	7	5.166
Task 2	6	6	5	5	4	5	31	4	6	5.166
Task 3	9	10	9	10	7	14	59	7	14	9.833
Task 4	11	13	7	10	17	10	68	7	13	11.33
Total	30	36	26	30	32	35	189	22	40	**31.5**

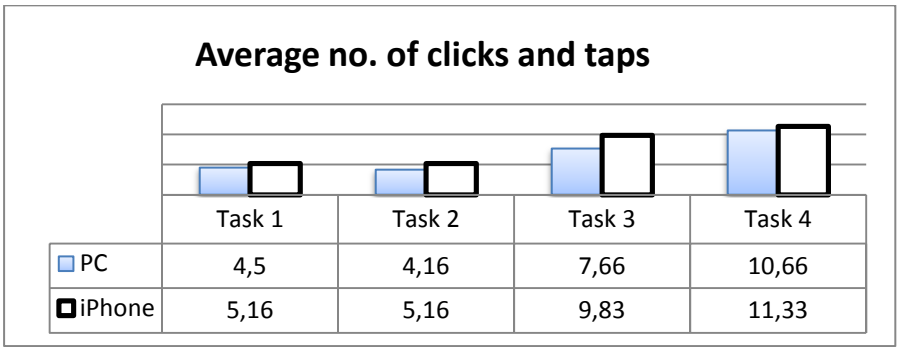

Figure 13 Average no. of clicks and taps comparison during tasks

According to figure 13, the average number of clicks/taps noted while performing tests over PC and iPhone were 27 and 31.5 respectively and 4.5 taps less in favor to PC.

6.2. Google Maps Tasks Observations

Authors observed participants conducting usability test using Google Maps on PC and iPhone. The authors were carefully observing the test participants in order to find out participants perceptions and some issues that had been faced. The authors have discussed the observed participants attitude and issues faced by them while performing task on Google Maps using PC and iPhone, which are as follow:

6.2.1. Task 1 Search place

6.2.1.1. PC Observation

The first task was about *"Search place"* on Google Maps using PC. The participants had to go to the service provider address, click on "My Maps" then they wrote a particular place name in the "Text Box" and clicked the "Search Maps" button. At the end group of participants clicked on the searched place in order to confirm the result. The following comments were noted by the authors while performing test.

- The advertisement text was shown on the first option while the desired text result on second which was confusing for the group of participants
- The participants were satisfied with suggestion feedback and also with the spelling correction feedback

6.2.1.2. iPhone Observation

The first task was about *"Search Place"* on Google Maps using iPhone. The participants had to go to the service provider address and tap on "Go" button. Then tap on the "Search Box" and cleared the search box by tapping on "Clear" button in case if not cleared. In the next step they wrote a place name in the "Search Box" in order to find it. Then they tapped on the "Search" button located at the left bottom side and confirmed the desired search. At the end they tapped on the searched place in order to confirm the result. The following comments were noted by the authors while performing test.

- While tapping the searched result, it was shown at the bottom of the page while they were expecting it at the top of the searched balloon.
- While writing for a search place in the "Search Box", the participants selected the suggestion of Google Maps which gave them a wrong search result.

6.2.2. Task 2 Search Address

6.2.2.1. PC Observation

The second task was about *"Search Address"* on Google Maps using PC. The participants had to go to the service provider address, click on the button "My Maps" and wrote a particular address in the "Text Box". Then they clicked on the "Search Maps" button and at the end clicked on the searched address in order to confirm the task result. The following comments were noted by the authors while performing test.

- The participants suggested that the searched address must be drawn by a boundary line to the whole region.
- The Google Maps must provide a customize map facility.
- The search result is visible but the search location/address name is missing.

6.2.2.2. iPhone Observation

The second task was about *"Search Address"* on Google Maps using iPhone. The participants had to go to the service provider address and tap on "Go" button. Then tap on the "Search Box" and cleared the search box by clicking on "Clear" button in case if not cleared. In the next step they wrote an address in the "Search Box" in order to find it. Then they tapped on the "Search" button located at the left bottom side and confirmed the desired search. At the end they tapped on the searched place in order to confirm the result. The following comments were noted by the authors while performing test.

- While writing address in the "Search Box", the writing speed was slower than the suggestion feedback, which was interrupting the participants.
- The participants suggested that the searched address must be drawn by a boundary line to the whole region.
- The Google Maps must provide a customize map facility.
- The search result is visible but the search location name is missing.

6.2.3. Task 3 Get Direction

6.2.3.1. PC Observation

The third task was about "*Get Direction"* on Google Maps using PC. The participants had to go to the service provider address, select "Get Direction", and wrote a current

place name in the first “Text Box” and destination place name in the second “Text Box”. Then they clicked on the “Get Direction” button and selected the suggested routes. After that they scroll down the page to the “Save to My Maps” button and clicked on it. The following comments were noted by the authors while performing test.

- The route optimization was confusing for all the participants, some of them suggested that the suggested route should be prioritized on time bases and some suggested it on distance bases.
- Some participants suggested that the “Save to my map” button should be on the top of the page instead of the bottom while some suggested it on the right corner of the map.

6.2.3.2. iPhone Observation

The third task is about “*Get Direction*” on Google Maps using iPhone. For this purpose the participants had to go to the service provider address and tapped on “Go” button. Then tapped on the “Menu” in order to select and tapped on the “Get Direction” button. Then they tapped on text box “A” and cleared the text box by tapping the clear button for clearing it. In the text box “A” they wrote the first specified address and tapped the text box “B” and cleared it by tapping the clear button. Then they wrote the specified destination address name and tapped on “Go” or “Get Direction” button. They tapped on the “list” button which was located at the left side of the buttons. By gesture they made the page down for tapping “Save to my maps” button. Then the group of participants tapped on “Save” for selecting option and confirmed the result. The following comments were noted by the authors while performing test.

- The novice participants had some difficulties in finding “Get Direction”, they were expecting it as visible button instead of selecting it from the menu and they also suggested it to be as a visible button on map.
- The participants suggested that the search query must be clearly visible while writing it in text box “A” and “B” which was not visible during entering the search query.
- The search query should be visible up or down the text box “A” and “B” instead of inside the text boxes.
- The participants suggested that suggestion must be needed only in that case, when any mistake arises in a search query.
- The participants suggested for a clearing button facility in the text box.
- The close button in the “Get Direction” has to be large enough to cover the gesture in one attempt.
- The novice participants mistakenly closed the “Get Direction” page and selected map button, due to which they repeated the same task again. So they suggested for “Get Direction” button in order to select the current “Get Direction” result.
- The participants suggested for “Save my map” button to be at the top of page instead of the bottom.
- The suggested routes was confusing for all the participants, some of the participants suggested for the route optimization, to be prioritizing on time bases and some suggested it on distance bases.

6.2.4. Task 4 Zooming and Panning

6.4.4.1. PC Observation

The fourth task was about "*Zooming and Panning"* using the Google Maps on PC. For this purpose the participants had to repeat the first task step by step and after that they selected "Satellite" button from the map menu which is located at the upper right corner. Then they did Zoom in and out with the available control functions at left corner of the maps and touch pad. The following comments were noted by the authors while performing test.

- Panning should be move at 360 degree.
- The participants were satisfied with the "Panning" and "Zooming" facility of street view in all direction.

6.4.4.2. iPhone Observation

The fourth task was about "*Zooming and Panning"* using Google Maps on iPhone. For this purpose the participants repeated the first task in order to search the desired address and then they tapped on "Layers", selected "Satellite" from the list. In the next step the participants did the "Zoom" in and out with the help of left corner function and also with the help of gesture, they also did "Panning" in all directions with the help of fingers gesture. The following comments were noted by the authors while performing test.

- While tapping on "Layer" button the Google application hanged for all participants. Which kept the participants stuck and they start the same step again.
- One of the participants suggested that being a novice participant and having no solution of hanging problem, if I will face a hanging issue I will either tap the home button or power button.
- The participants were satisfied with the "Zooming" and "Panning" facility with the gestures.
- There was no street view facility so that the participants could check the "Zooming" and "Panning" facility.

6.3. Usability Problems and Suggestion for Improvements

After a careful usability evaluation study of Google Map both on PC and iPhone, the authors would like to present some suggestions for attaining a better level of effectiveness, efficiency and satisfaction after solving the presented problems. The suggestions are attained by the authors after observing usability test, questionnaire results and analyzing the interview. Apart from this, one novice participants didn't complete task 3 in predefined time (5 minutes) on PC. While one novice and two experience participants' in task 1 (2 minutes) and two novice and one experience participant in task 3 (5 minutes) didn't complete the tasks in predefined time on iPhone. Total number of error observed during Google Maps test on PC were 9 and on iPhone they were 17.

6.3.1. Problems and Suggestions for PC

6.3.1.1. Task 1 Search Place

***Problem 1*:** In figure 17, the advertisement text on the page was shown on the first option while the desired text results on second, which was confusing for the

participants. Some participants selected advertisement text instead of their desired text result.

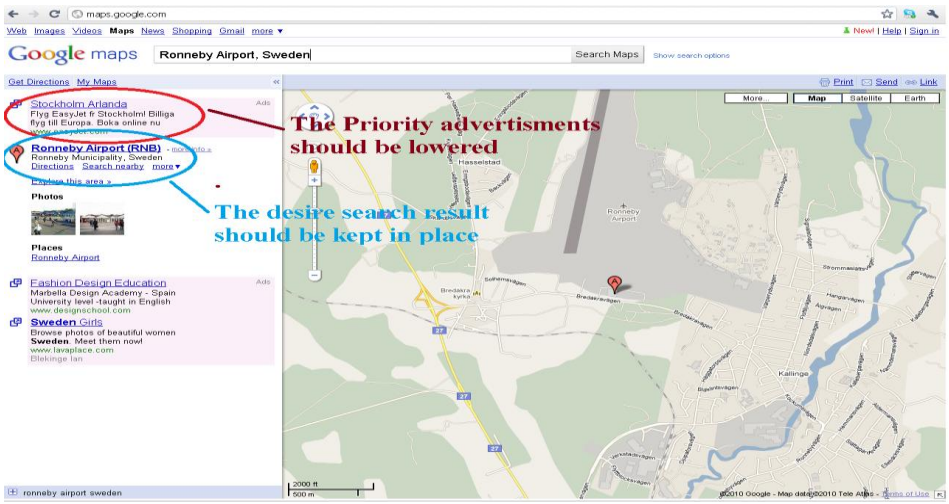

Figure 14 indicating Problem 1 in Task 1 (PC)

Suggestion 1: In figure 17, the authors suggest that the marketing value of various advertisements and animations have to be prioritized to make it user friendly.

6.3.1.2. Task 2 for Search Address

***Problem 1*:** In figure 18, there was no boundary around the search address result in order to know the area limit of the searched result.

Problem 2: In figure 18, the search result was visible but the search location name was missing, which was a bit confusing for the participants.

Problem 3: There was no customized map facility in Google Maps regarding customer services.

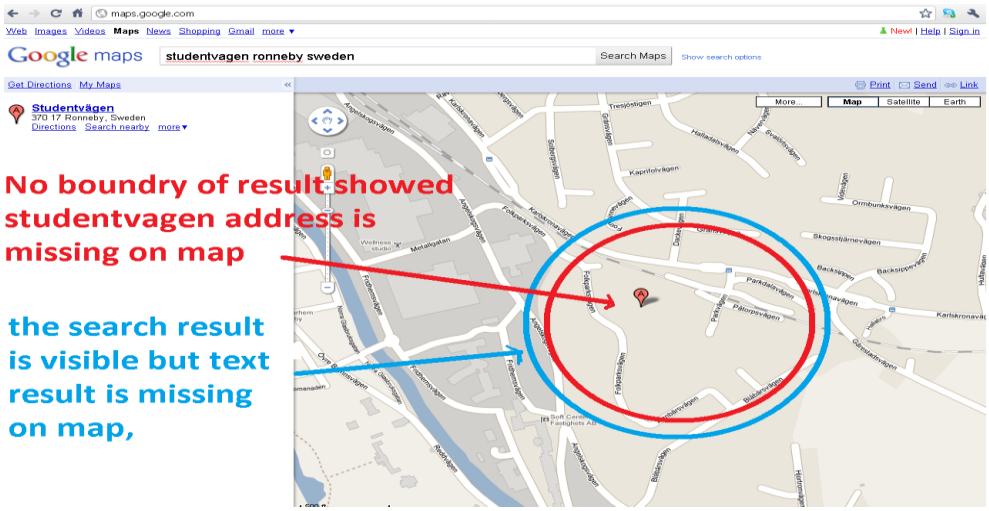

Figure 15 indicating Problem 1, 2, 3 in Task 2 (PC)

Suggestion 1: The authors suggest that if the searched address result is drawn by a boundary line to the whole region. It would look more clear and visible for the end-users.

Suggestion 2: It would be better to show the search result name along with the search result.

Suggestion 3: The authors suggest that if Google Maps provide a customized map facility, it would be easier in case of delivery or any other customer services, a person would be able to directly create, edit, modify and download his or her desired map.

6.3.1.3. Task 3 for Get Direction

***Problem 1*:** In figure 19, the *suggested routes* were confusing for the participants, because they were searching the shortest and best possible route in the suggestion list.

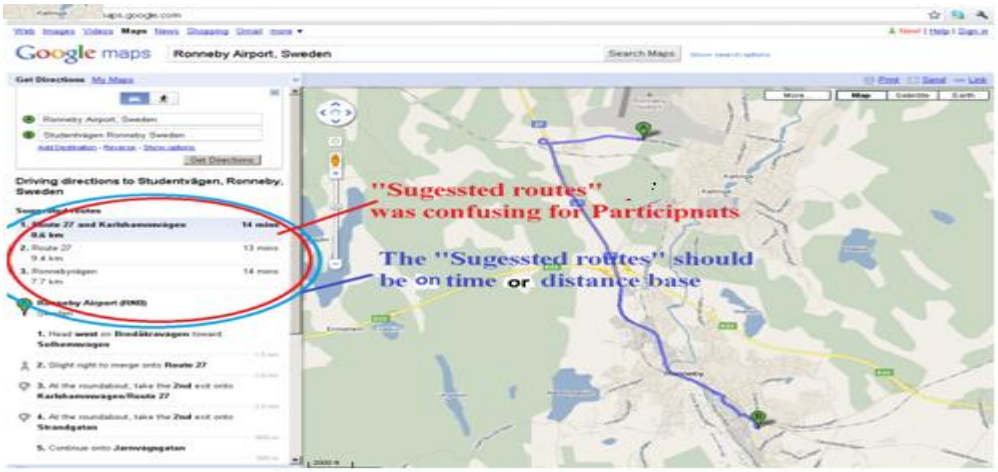

Figure 16 indicating Problem 1 in Task 3 (PC)

Suggestion 1: The authors suggest that it would be better to have the routes suggestion either on minimum time base or shortest distance base, so that the user can choose the best option for a desired route.

Problem 2: In figure 20, The "Save My Maps" button is in the bottom of the page which is not visible in the front page but needs to scroll down the page to the bottom, which was confusing for the novice participants because they were searching the "Save My Maps" button on upside of user interface map.

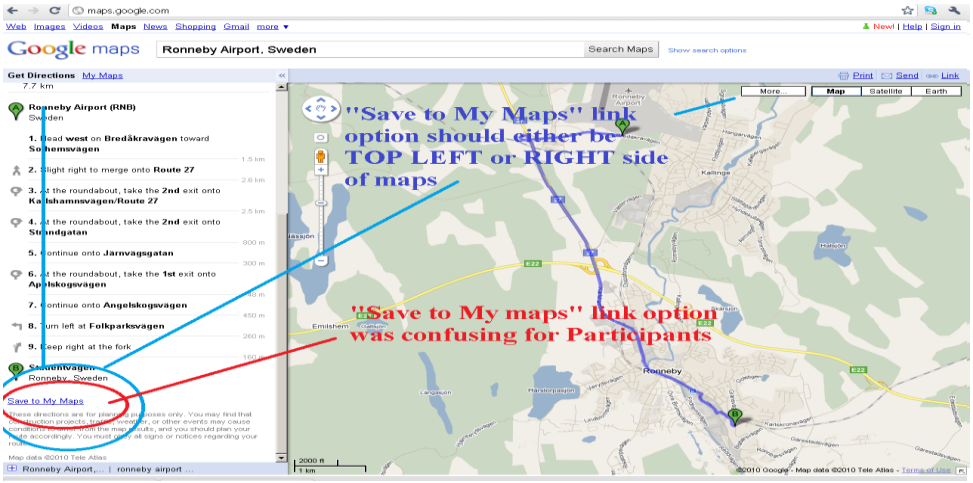

Figure 17 indicating Problem 2 in Task 3 (PC)

Suggestion 2: The authors suggest that it would be better to place the button either on the top of the page or on the right top corner of the map with the buttons.

6.3.1.4. Task 4 for Zooming and Panning

Problem 1: The participants experienced panning left right or up and down only. There was no rotating facility at 360 degree or in all direction in available control tools.
Suggestion 1: The authors suggest that it would be better to have rotating map facility at 360 degree and provide a continuous drag and clickable for panning available control tools.

6.3.2. Problems and Suggestions for iPhone

6.3.2.1. Task 1 for Search Place

Problems 1: In figure 21, the search result in Google Maps on iPhone is mentioned in the bottom of the page which was confusing for the participants because they were searching it close to the search balloon.

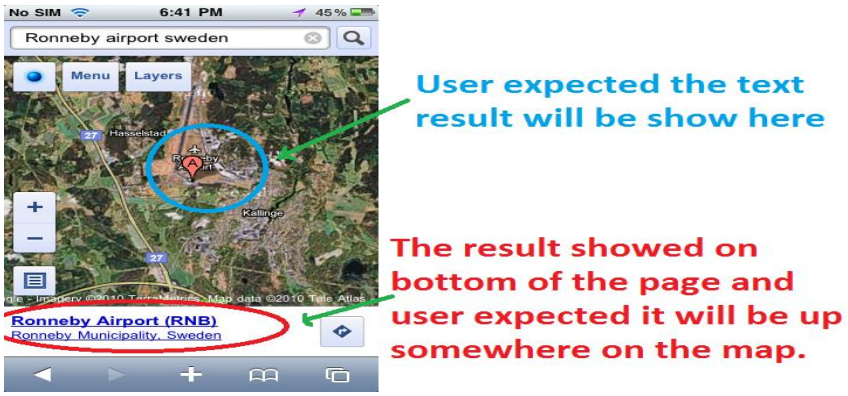

Figure 18 indicating Problem 1 in Task 1 (iPhone)

Suggestion 1: The authors suggest that it would be better to mention the search result near to the search balloon.

Problem 2: In figure 22, while writing for a search place in the search box, the user selected the suggestion of Google Maps which gave the user a wrong search result.

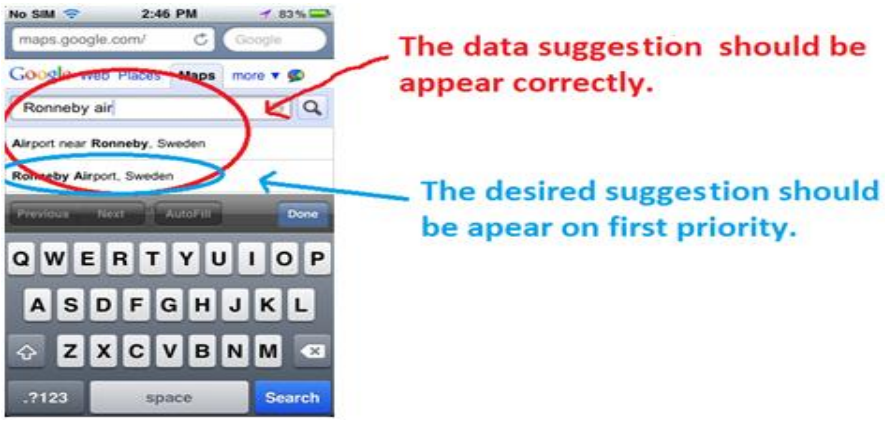

Figure 19 indicating Problem 2 in Task 1 (iPhone)

Suggestion 2: The authors suggest that it would be better if the suggestions are more accurate according to the search query and data accuracy. So that in order to select the suggestion of Google Maps on iPhone the possibility of wrong search result may not occur.

6.3.2.2. Task 2 for Search Address

Problems 1: In figure 23, the participants were facing problem while writing address in the search box, the writing speed was slower than the suggestion feedback, which was interrupting the participants.

Problem 2: In figure 23, there was no boundary around the search address result in order to know the area limit of the searched result.

Problem 3: In figure 23, there was no customized map facility in Google Maps regarding customer services.
Problem 4: In figure 23, the desired search result was visible but the search location name was missing.

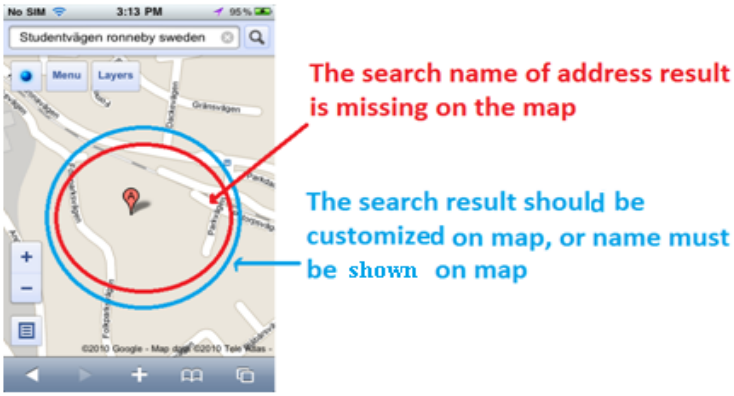

Figure 20 indicating Problem 1, 2, 3, 4 in Task 2 (iPhone)

Suggestion 1: The authors suggest that it would be better if the suggestion feedback is following the writing of query word by word and provide the feedback after writing each word of the query in the search box.

Suggestion 2: The authors suggest that if the searched address is drawn by a boundary line to the whole region, then the searched address can be seen more visible and clear.

Suggestion 3: It would also be better if Google Maps provide a customize map facility. For example in case of delivery or any other customer services, a person can be able to create, edit, modify and download his or her desired map easily.

Suggestion 4: It would be better if the search name is also visible along with the search result.

6.3.2.3. Task 3 for Get Direction

Problem 1: In figure 24, the novice participants had some difficulties in finding get

direction; it can be selected by first clicking on the menu button while they were expecting it as visible button.

Problem 2: In figure 24, while writing the search query in text box A and B, the participants experienced that it was not visible in the text box at the time of writing.

Figure 21 indicating Problem 1, 2 in Task 3 (iPhone)

Suggestion 1: The authors suggest that it would be better if get direction button is shown as a visible button on map instead of selecting it from the menu button.

Suggestion 2: The authors suggest that it would be better if the search queries become visible while writing it in the text box A and B.

Problem 3: In figure 25, while writing the search query in the text box A and B, the suggestion feedback was displaying inside the text box due to which the search query was not visible.

Problem 4: In figure 25, when the participants were entering search query, they were getting a suggestion feedback and this was confusing for them.

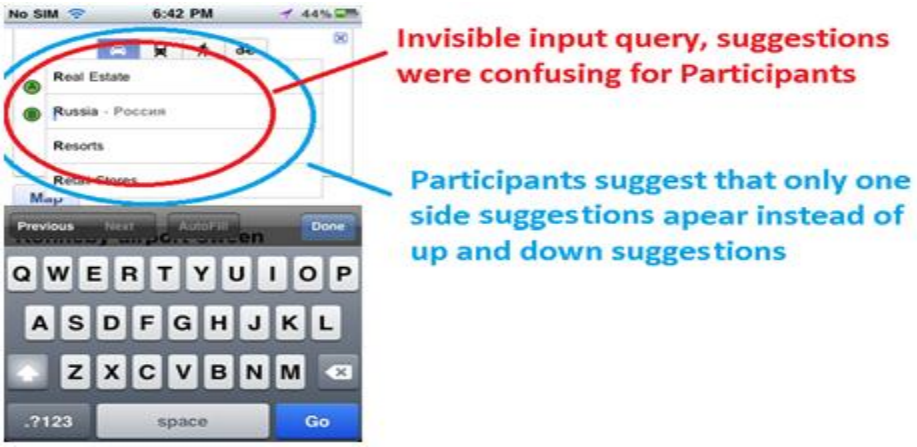

Figure 22 indicating Problem 3, 4 in Task 3 (iPhone)

Suggestion 3: The authors suggest that it would be better if the suggestion feedback is visible up or down the text box A and B instead of inside the text boxes.

Suggestion 4: The authors suggest that it would be better if the suggestion feedback is displayed only in that case, when any mistake arises in a search query. In case of a correct query the suggestion should not be displayed.

Problem 5: In figure 26, the close button in the get direction is too small which made it difficult in selecting it.

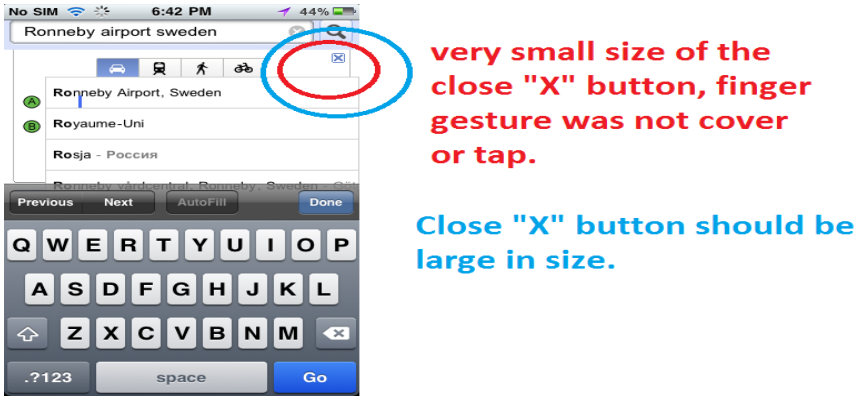

Figure 23 indicating Problem 5 in Task 3 (iPhone)

Suggestion 5: The authors suggest that it would be better to enlarge the size of close "X" button, to cover the user single gesture in one attempt.

Problem 6: In figure 27, the *Save to My Maps* button is in the bottom of the page which is not visible in the front page but needs to scroll down the page to the bottom, which was confusing for the novice participants because they were searching the *Save to My Maps* button.

Figure 24 indicating Problem 6 in Task 3 (iPhone)

Suggestion 6: The authors suggest that it would be better to place the button either on the top of the page or on the right top corner of the maps with the buttons. In this case the button can be shown visible on the screen.

Problem 7: In figure 28, the *suggested routes* were confusing for the participants, because they were searching for the shortest and best possible route in the optimized list.

Problem 8: While clearing the text box, participants were feeling the need of clearing button in the text box.

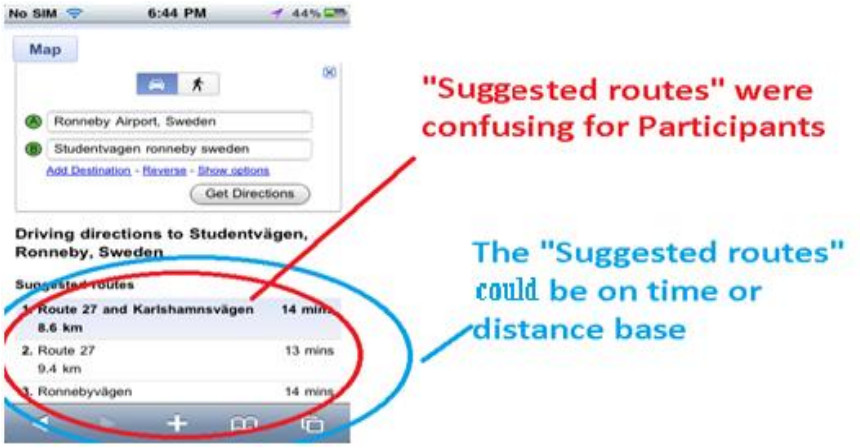

Figure 25 indicating Problem 7, 8 in Task 3 (iPhone)

Suggestion 7: The authors suggest that it would be better to have the routes suggestion either on minimum time base or shortest distance base, so that the user can choose the best option for a desired route.

Suggestion 8: The authors suggest that it would be better if there would be a clearing button facility in the text box *A* and *B*. To clear the text boxes by tapping the clear button instead of removing the whole text one by one.

6.3.2.4. Task 4 for Zooming and Panning

Problem 1: In figure 29, while tapping on *Layers* button the Google Maps hanged for all the four groups of participants. One of the participants suggested that being a novice user and having no solution, "*if I will face a hanging issue I will either tap the home button or power button*".

Problem 2: There was no street view facility so that the participants could check the Zooming and Panning facility.

Problem 3: The novice participants mistakenly closed the get direction page and selected map button due to confusion, due to which they repeated the same task again.

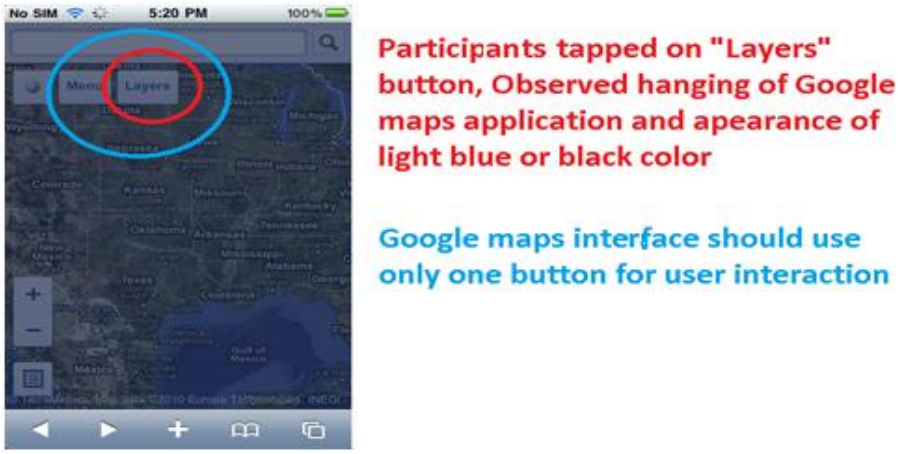

Figure 26 indicating Problem 1 in Task 4 (iPhone)

Suggestion 1: The authors suggest that it would be better to resolve hanging issue in *Layers* button of user interface on iPhone.

Suggestion 2: The authors suggest that it would be better to launch a street view facility in iPhone applications.
Suggestion 3: The authors suggest that if there would be a *Get direction* button, then it would be possible to not lose the same result and reselect the current get direction result.

6.4. Interview Results

After conducted the usability test, the authors interviewed to validate the test results. One author was asking questions from group of participants and was noting their responses in a note book concerning Google Maps using PC and iPhone. Another author was recording a video for further analysis. All six groups of participants explained their views confidently after performing test. After conducting interview the authors took more help in understanding the participants expectations, benefits and drawbacks, their opinion and purpose of using Google Maps. The groups of participant's interview details are reported in Appendix C.

6.5. Questionnaire Feedback through ISO 9241-11 Criteria

After completing usability test and interview of Google Maps on PC & iPhone, the questionnaires were distributed through email to each group of participants. The questionnaire was designed with the intention of being understandable questions according to ISO criteria to get their response in term of effectiveness, efficiency and satisfaction. The authors presented the structure of questionnaire in the previous Section 5.7. A questionnaire consisting of total 48 questions made on Likert scale turns in usability satisfaction of 24 questions for PC and 24 questions for iPhone.

After receiving feedback from each group of participants through questionnaire, authors calculated each scale of questionnaire which was based on Strongly Agree, Agree, Moderate, Disagree and Strongly Disagree. The response from participants is shown in Appendix A.

6.5.1. Effectiveness

In following table 12, the authors collected results that the sum of percentage of Strongly Agree & Agree (Agreement) was 87% on PC and 63% on iPhone while the sum of percentage of Moderate, Disagree and Strongly Disagree (Disagreement) was 13% on PC and 37% on iPhone.

Table 12 Effectiveness analyses from questionnaire for PC and iPhone

Answers	***Google Maps PC***		***Google Maps iPhone***	
	No: of occurrences	**Percentage**	**No: of occurrences**	**Percentage**
Strongly Agree	22	73.33%	8	27%
Agree	4	13.33%	11	37%
Moderate	4	13.33%	10	33%
Disagree	0	0%	1	3%
Strongly Disagree	0	0%	0	0%
Total	30	100%	30	100%

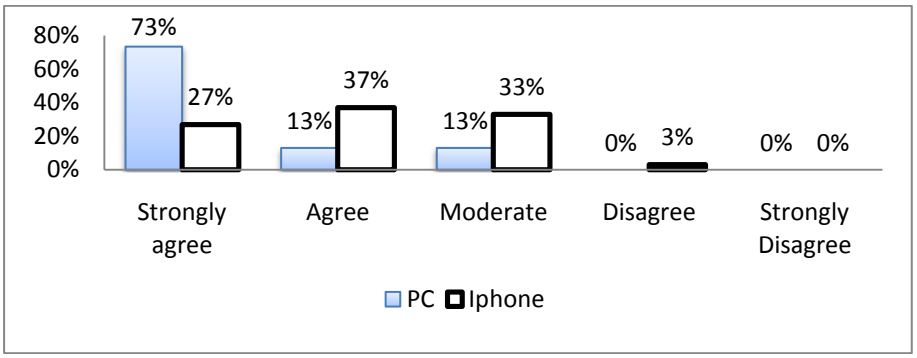

Figure 27: Effectiveness analyses from questionnaire for PC and iPhone

In figure 14, from questionnaire feedback authors collected results about the effectiveness related questions from participants, 73% of the participants strongly agreed that Google Maps is effective on PC while 27% on iPhone, 13% of the participants marked Agree on PC while on iPhone 37%, 13% of the participants marked Moderate on PC while on iPhone 33%, zero percent of the participants marked Disagree on PC while 3% on iPhone and zero percent of the participants marked Strongly disagree for each device.

6.5.2. Efficiency

In the following table 13, the authors collected results that the sum of percentage of Strongly Agree & Agree (Agreement) which was 73% on PC and 60% on iPhone while the sum of percentage of Moderate, Disagree and Strongly Disagree (Disagreement) was 27% on PC and 40% on iPhone.

Table 13 Efficiency analyses from questionnaire for PC and iPhone

Answers	***Google Maps PC***		***Google Maps iPhone***	
	No: of occurrences	**Percentage**	**No: of occurrences**	**Percentage**
Strongly Agree	18	60%	10	33%
Agree	4	13%	8	27%
Moderate	1	3%	5	17%
Disagree	4	13%	6	20%
Strongly Disagree	3	10%	1	3%
Total	30	100%	30	100%

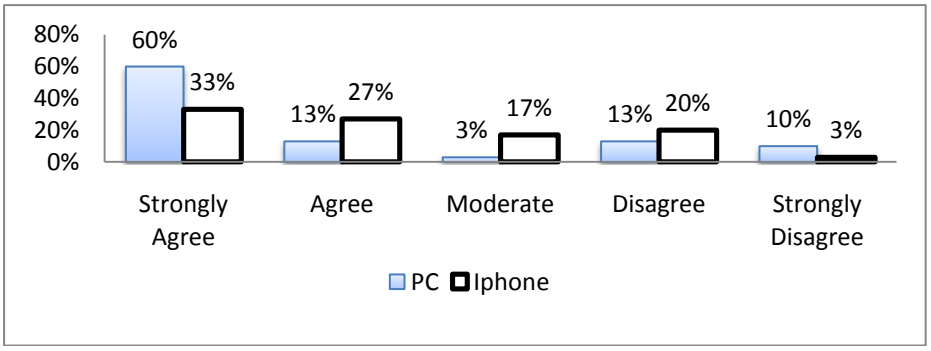

Figure 28 Efficiency analyses from questionnaire for PC and iPhone

In figure 15, from questionnaire feedback authors collected results about the efficiency related questions from participants, 60% of the participants strongly agreed that Google Maps is efficient on PC while 33% on iPhone, 13% of the participants

marked Agree on PC while on iPhone 27%, 3% of the participants marked Moderate on PC while on iPhone 17%, 13% of the participants marked Disagree on PC while on iPhone 20% and 10% of the participants marked Strongly disagree on PC while on iPhone 3%.

6.5.3. Satisfaction

In the following table 14, the authors collected results that the sum of percentage of Strongly Agree & Agree (Agreement) was 67% on PC and 64% on iPhone while the sum of percentage of Moderate, Disagree and Strongly Disagree (Disagreement) was 33% on PC and 36% on iPhone.

Table 14 Satisfaction analyses from questionnaire for PC and iPhone

Answers	***Google Maps PC***		***Google Maps iPhone***	
	No: of occurrences	**Percentage**	**No: of occurrences**	**Percentage**
Strongly Agree	38	45%	24	29%
Agree	18	21%	30	36%
Moderate	13	15%	17	20%
Disagree	9	11%	9	11%
Strongly Disagree	6	7%	4	5%
Total	84	100%	84	100%

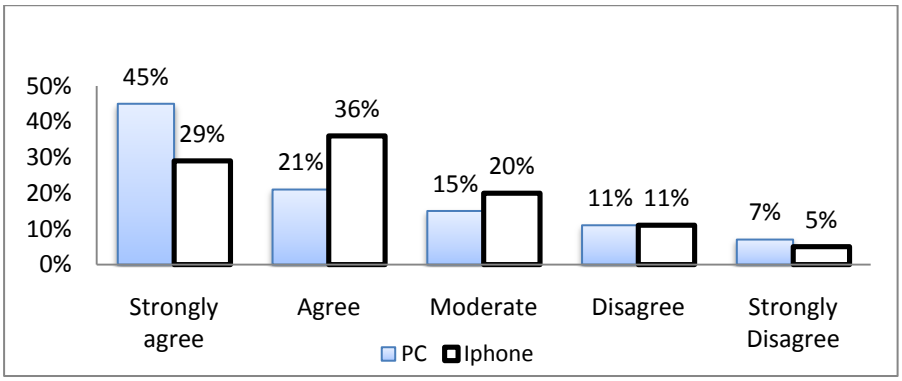

Figure 29 Satisfaction analyses from questionnaire for PC and iPhone

In figure 16, from questionnaire feedback authors collected results about the satisfaction related questions from participants, 45% of the participants strongly agreed that Google Maps is satisfactory on PC while 26% on iPhone, 21% of the participants marked Agree on PC while on iPhone 36%, 15% of the participants marked Moderate on PC while on iPhone 20%, 11% of the participants marked Disagree for each device and 7% of the participants marked Strongly disagree on PC while on iPhone 5%.

6.6. Summary of usability test and questionnaire results

Table 15, represents the description and comparison of usability test assessment for Google Maps on PC and iPhone according to ISO 9241-11 criteria. The below facts and figures clearly indicates that the group of participants performance and satisfaction level of Google Maps is better on PC than iPhone.

Table 15 Description of usability test results/ objective model (representing figure 3) for Google Maps on PC & iPhone

		Usability features	Google Maps on PC	Google Maps on iPhone
ISO 9241 part 11	**Effectiveness**	Successfully task completed (done) or success rate in percentage %	**23** or **95.83%**	18 or 75%
		Unsuccessfully task uncompleted (fail) or failure rate in percentage %	**1** or **4.17%**	6 or 25%
		Number of Error (problems)	**9**	17
		System failure	**0**	4
	Efficiency	Average time (sec) per task completion or Completion rate of efficiency	**102.5** or **56.37%**	153.33 or 29.41%
		Total number of clicks and taps to complete tasks	**162**	189
	Satisfaction	Positive attitude of Group participants during test	**10**	6
		Negative attitude of Group participants during test	**4**	7

Table 16 Description usability questionnaire results model for Google Maps on PC & iPhone

		Questionnaire Occurrences	Google Maps	
			PC	iPhone
ISO 9241 part 11	**Effectiveness**	Group of participants Agreement in percentage Strongly Agree + Agree	**87%**	63%
		Group of participants Disagreement in percentage Moderate + Disagree + Strongly Disagree	***13%***	37%
	Efficiency	Group of participants Agreement in percentage Strongly Agree + Agree	**73%**	60%
		Group of participants Disagreement in percentage Moderate + Disagree + Strongly Disagree	***27%***	40%
	Satisfaction	Group of participants Agreement in percentage Strongly Agree + Agree	**67%**	64%
		Group of participants Disagreement in percentage Moderate + Disagree + Strongly Disagree	***33%***	36%

Effectiveness: In table 16, User's successful tasks completion rate for PC is 95.83% while 75% is recorded for iPhone, User's tasks failure rate on PC is 4.17% while 25% is recorded for iPhone in predefined time due to some usability problems related to Google Maps. Number of Errors occurred while using Google Maps on PC is 9 and for iPhone it is 17. The system failure rate for PC is NIL while for iPhone it is 4. In table 16, collectively Strongly Agree and Agree occurrences are scaled as Agreement while Moderate, Disagree and Strongly Disagree are scaled as disagreement. Agreement summed up to 87% on PC and Disagreement summed up to 13% while for iPhone Agreement summed up to 63% and Disagreement summed up to 37%.

Efficiency: In table 15, the mean time (in second) taken by each group of participants for completing per task on PC is 102.5 seconds while for iPhone it is 153.33 seconds and completion rate of efficiency on PC is 56.37% while for iPhone it is 29.41%. Groups of participants took 162 clicks while for iPhone it is 189 taps. More number

of clicks and taps indicates more time taken while performing task, which clearly indicates complex user interface. In table 16, as per defined criteria for Agreement and Disagreement, the Agreement summed up to 73% and 60% while Disagreement is 27% and 40% for PC and iPhone respectively. Here the Agreement represents the extent of efficiency of Google Maps on PC and iPhone.

Satisfaction: In table 15, the number of positive comments recorded from participants while performing tests on PC is 10 and for iPhone it is 6. Number of negative comments from PC is 4 and for iPhone it is 7. In table 16, the Agreement summed up to 67% and 64% while Disagreement is 33% and 36% for PC and iPhone respectively.

6.7. Comparison of usability requirements

Authors have defined a set of usability requirements for the achievement of acceptability level, user's efficiency and participant's agreement on each attribute of the task performance and questionnaire of Google Maps on both computing devices respectively. The following table 17 is describing the overall the results of identified usability requirements:

Table 17 comparison of usability requirements

ISO 9241-11 Measures		**Comparison of Usability Requirements on Google Maps on both computing devices**			
		PC	**iPhone**	**Matched/Meet**	**Unmatched/unmeet**
Acceptability of Tasks (80%)		**95%**	75%	PC	iPhone
User Efficiency (50%)		**56%**	29%	PC	iPhone
Satisfaction agreement 80%	*Effectiveness*	**87%**	63%	PC	iPhone
	Efficiency	73%	60%	-	Both devices
	Satisfaction	67%	60%	-	Both devices

The usability requirements were tested and measured on user performance through usability test and user agreement, questionnaire provides a subjective response for related measures. The task completion acceptability rate on PC is 95% and on iPhone it is 75% (PC matched the usability requirements which was set to be 80% but iPhone did not match) and user efficiency on PC is 56% and on iPhone it is 29% (PC matched the usability requirements which was set to 50% but iPhone did not match). The group of participants responses in agreement to effectiveness with questionnaire on PC is 87% while for iPhone it is 63% (PC fulfill the usability requirements criteria which was set to 80% but iPhone did not match). The group of participants response in agreement to efficiency and satisfaction with questionnaire on PC is 73%, 67% while on iPhone it is 60%, 64% respectively (Both devices did not fulfill the usability requirements).

However, it is quite obvious that there are possibilities to improve iPhone in GIS. Based on the results of the thesis, it is foremost to have such user interface for the PC and mobile computing that presents and design user interface identification, maps design and services such as adding, creating, modifying, sharing, and other features that can act as a vanguard for the Cloud GIS technology. These features are used in real time technology in the future keeping identified usability requirements in mind.

CHAPTER 7: DISCUSSION

This chapter relates to the discussion of the analysis done in this thesis. Section 7.1 describes the discussion on ISO 9241-11 measures. Section 7.2 describes discussion about design of task document and Co-discovery technique. Section 7.3 describes the Validity and reliability of results. Section 7.4 describes answers to research questions. Furthermore a discussion about the design of task document presented in section 5.5 is made.

7.1. Discussion on ISO 9241-11 measures

The study was conducted in connection with the usability assessment of Google Maps on PC and IPhone. ISO 9241-11 criteria are used for usability evaluation. Results analyses from tests and questionnaire helped authors in finding various usability issues in iPhone and PC. Five metrics are used to measure Effectiveness, Efficiency and Satisfaction. Due to the increased usage of iPhone, it needs to identify and compare the usability of Google Maps over PC.

7.1.1. Effectiveness

Effectiveness of results in applications is measured by tasks goal achieved by users with accuracy and completeness. Tasks completion rate consists of successful tasks completion, unsuccessful task completion, frequency of errors and frequency of use function commands [81]. It does not mean that how participants achieved the tasks but rather how participants completed tasks in predefined time to achieve the goal. All task performed by participants on Google Maps using PC were carried out in simple way as compared to iPhone in predefined time, however, they faced some difficulties in some tasks, for instance *Get Direction* was confusing for both devices. The task completion rate of Google Maps on PC was more encourage able and accurate than iPhone. The reason for this is that the participants encountered more issues on iPhone such as dubious nature of buttons (*Layers*), links and complex presentation of maps. The rectification of errors, handling errors and help provided by Google Maps on PC were high as compared to iPhone, which indicate that the participant's response in agreement to questionnaire was more on PC.

7.1.2. Efficiency

Efficiency evaluates application by the time spent on documentation, total time, mean time taken for achieving completed task and the total cost while using the application [81]. The tasks took less time on PC as compared to iPhone. The reason is that the number of clicks performed on iPhone indicates number of action. Therefore higher the number of clicks/taps higher will be the time taken. For instant while performing task for *Zooming and Panning*, the participants took more clicks on control function for getting the desirable result on PC while in iPhone they followed multiple steps for the desirable result in the same task. On the other hand PC was saving time in features like *Search Place*, *Search Address*, *Get Direction* and *Navigation* during searching as compared to iPhone. The tasks were performed in first attempt and more number of functions were learned using Google Maps on PC as compared to iPhone, which indicate that the participants response in agreement to questionnaires were occurred more on PC.

7.1.3. Satisfaction

According to ISO, satisfaction can be measured by subjective rating on scales and comments (like and dislike) [19]. The authors used questionnaire based on Likert Scale and the number of positive and negative comments recorded during the use of Google Maps, satisfaction during the use of Google Maps and discomfort experience. The ratio of positive comments on PC was more as compared to iPhone and the ratio of negative comments on PC was low as compared to iPhone. The feedback, suggestion and information were explicit on PC and body language of participants was positive toward PC as compared to iPhone. In *Get Direction* task, the feedback suggestions were confusing for the users on iPhone due to which they commented negative for iPhone. Furthermore, some of the button links were not working which created frustrating situations for the users. The use of Google Maps on PC was more pleasant as compared to iPhone. The street view facilitated the participants on PC in *Zooming and Panning* task but iPhone missing the service. The users had enough control and the results were desirable on PC as compared to iPhone, which indicate that the participant's response in agreement to questionnaire was more on PC.

7.2. Discussion about design of task document and Co-discovery technique

The task document in table 3 and 4 in section 5.5 was designed with the intention that it should be easy to follow to understand how to carry out the tasks. In retrospect, perhaps the detailed description of the tasks lead to that almost all participants completed the tasks. It can then be discussed to what extent the test measured usability or measured the design of the task document and choice of methodology. We would recommend for further tests to be aware of the impact of the design of task document, and consider the possible impact of task document in results if making a very detailed task document. Furthermore the task document included more steps in the iPhone test. This fact could as well have impacted the results. The task document is also designed for group of participants performing usability test through Co-discovery technique. Co-discovery technique is used in thesis to overcome interaction between participant and tester. One participant performing test and other participant providing support orally by reading the task document aloud step by step. The choice of methodology along with the design of task document is of importance for the outcome of the results of test and is to be carefully considered.

7.3. Validity and reliability of results

According to [91], in quantitative research, any action or piece of work is said to be true or valid if it represents accurately the described characteristics of its nature. Quantitative research validity is commonly observed as internal validity, External validity, Reliability and Objectivity. While the results as trustworthiness and truthfulness in qualitative research is being observed as Credibility, Transferability, Dependability and Conformability [92]. Any research irrespective of its nature should exhibit validity. Therefore, the authors assessed their research validity according to [92] [93] [94]. The trustworthiness and truthfulness of the research is in compliance with the following qualitative research validity principles.

7.3.1. Credibility

The results should be believable from the participant point of view [91]. In this thesis work the authors gathered data from usability tests performed on participants through Co-discovery technique, from questionnaire distributed among same group of

participants and through interview. Interview gives participants a chance that the results are real and believable. Interview was closed-ended and participants were provided with freedom of their expression. Detailed interview from all participants is provided in Appendix C.

7.3.2. Transferability

It refers to the extent to which the results of the research can be generalized for the other contexts [91]. According to ISO [19], the results obtained from the usability with a single use of context especially within short period of time, cannot be generalized. In this usability evaluation, all the subjects have almost the same gender, educational and cultural background. Instead from different use of context a subset of the result can be used. The results may be different if different contexts are used for the usability evaluation. The result of this thesis research provides a baseline for other tests with different use of contexts.

7.3.3. Dependability

Dependability refers to the fact that research must describe any change potential to make changes in results [91]. In current setting the results of the usability tests can be varied considerably if usability tests, interview and questionnaire feedback are obtained from different participants. Therefore the authors used same group of participant for tests conduction, interview and questionnaire feedback. Moreover considerably different results are expected if context of use is changed.

7.3.4. Confirmability

Confirmability refers to the fact that research results can be confirmed by other researchers in a meaningful way [91]. The study was conducted in compliance with Co-discovery technique using ISO 9241-11 criteria on end-user. Thorough relevant literature is studied prior to test conduction. Test procedure, interview and questionnaire are well documented for future confirmation by others.

7.4. Answers of Research Questions

Research question RQ1: How to define basic usability requirements for Google Maps?
Answer: This question is answered through literature review which guided us to identify the basic usability requirements for Google Maps such as context of use and measures in detail (section 4.2). These requirements led us to the usability of Google Maps on PC and iPhone. These initial requirements are:

- User types
- Tasks types
- Test environment
- Usability equipements and materials
- Measures

Research question RQ1.1: How can these requirements be made testable and measurable?
Answer: It is answered empirically in chapter 5 in detail (section 5.1). Authors set usability requirements based on user tasks of Google Maps on PC and iPhone for intended output (Non-functional usability requirements). For this purpose users must

complete the tasks within predefined time to achieve specified goals or to match usability requirements. Usability requirements (acceptability level of tasks completion is 80%, rate of efficiency is 50% and the overall participant's agreement for each measure is set to 80%.) were set for both devices using Google Maps, i.e. designed same set of features with different user control functionalities for both devices. These usability requirements were tested and measured through *effectiveness*, *efficiency* and *satisfaction.* Section 5.1.1.2 and sections 5.1.2.1, 5.1.2.2, 5.1.2.3 represents setting and measuring usability requirements respectively.

Research question RQ2: To what extent can usability evaluation method be used when measuring the usability to evaluate user performance and satisfaction in stationary and mobile computing devices?
Answer: This question is answered empirically, Usability testing on end-user as method and Co-discovery learning as technique is used for evaluation of Google Maps on PC and smartphone (iPhone). The usability evaluation method comprised of tests conduction over different tasks, interview and distribution of questionnaire. The method and technique covered wide range of usability features for both PC and iPhone. The authors noted the following performance (used five metrics) and satisfaction measures for both PC and iPhone during the test and questionnaire respectively:

- **Used metrics for usability test (Performance measure)**

1. Task completed and uncompleted
2. Number of error
3. Time spent on task
4. Number of clicks and taps
5. Positive/ negative comments

- **Used satisfaction measures for questionnaire**

1. Effectiveness
2. Efficiency
3. Satisfaction

Section 6.1.1 (Table 6 and Table 7) represents task completed and uncompleted and section 6.2, 6.3 and Table 16 represents number of error. Section 6.1.2 (Table 8, Table 9 and Table 10, Table 11) represents time spent on completed and uncompleted task and number of clicks and taps. Section 6.5 (Table 12, Table 13 and Table 14) represents summary of usability measures through questionnaire of Google Maps on PC and iPhone and Section 6.6 and Table 16 represents positive and negative comments.

Research question RQ3: What suggestions of improvements based on the identified usability issues and requirements can be made for future technology?
Answer: This question is answered in section 6.3 and APPENDIX D usability problems and suggestion for improvements, recommendation respectively and 6.7 represents comparison of usability requirements for future technology improvement.

CHAPTER 8: CONCLUSION

This chapter presents conclusion and proposed extension of this thesis work.

8.1. Conclusion

This thesis was primarily conducted in order to compare usability evaluation and identify usability requirements of Google Maps on both PC and smartphone in the light of ISO 9241-11 measures. Authors identified basis usability requirements such as context of use and usability measures for evaluation. Usability requirements were set on target value for tasks and user agreement on both devices in order to meet the intended goals. The authors used five metrics for measuring usability requirements. Test was conducted using Co-discovery technique to check user performance (novice and experience) and interviews were held to validate the test results. After the results validation questionnaires were distributed to capture the level of the participant's subjective satisfaction.

The analysis of results from test, interview and questionnaire proved that the usage of Google Maps on PC met the usability requirements (Target value) such as acceptability level of tasks completion, rate of efficiency and participants' agreement on effectiveness, while iPhone did matched these requirements. The overall usability level of Google Maps in term of effectiveness, efficiency and satisfaction on iPhone was low as compared to PC. Because iPhone showed more task difficulties and issues like time consuming, maximum cost monetary to complete task, lake of information and helpless feedback as compared to PC. However, it is a matter of fact that there is always scope for improvement; both devices have usability issues regarding their user interfaces. The authors provided suggestions and recommendation for improvements in the use of Google maps on both PC and iPhone in order to have easy use and to fulfill the user requirements in real time environment.

8.2. Future work

The authors suggest to measure usability of GIS application on iPhone in different contexts which will provide a subset of the possible usability issues. This will lead to opportunities to have context based evaluations for usability of iPhone.

The local GIS have moved to Cloud GIS for connected resources. Evaluation of the Cloud GIS for example ArcGIS application on smartphone through ISO 9241-12 (presentation of information) and identify user requirements to design user interface for computing devices through ISO 13407 could be other opportunities for future work.

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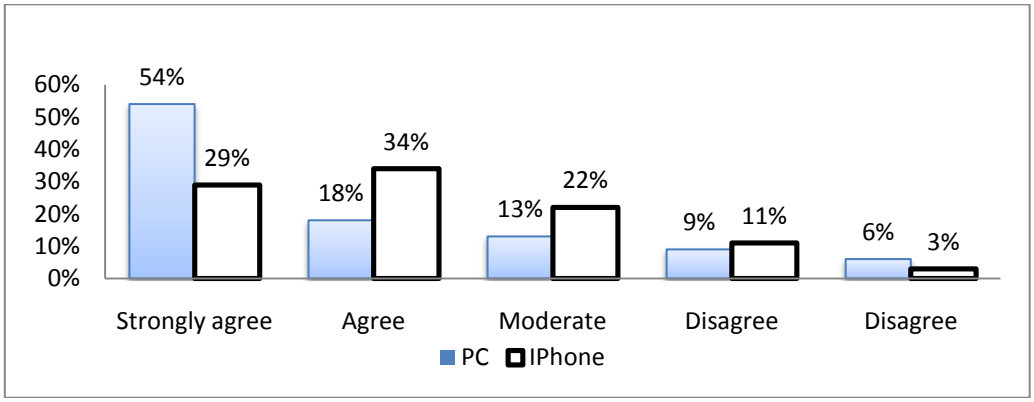
APPENDIX A: QUESTIONNAIRE AND RESPONSE

Sr.	Questions	Strongly Agree	Agree	Moderate	Disagree	Strongly Disagree
		1	2	3	4	5
1	It was easy to go to service provider on PC. e.g. http://www.maps.google.com					
2	It was easy to go to service provider on iPhone. e.g. http://www.maps.google.com					
3	It was easy to find a location using Google Maps on PC.					
4	It was easy to find a location using Google Maps on iPhone.					
5	We can easily search location using PC Google Maps					
6	We can easily search location using iPhone Google Maps					
7	We faced errors while using Google Maps on PC					
8	We faced errors while using Google Maps on PC					
9	We handled number of error occurred while using Google Maps on PC					
10	We handled number of errors occurred while using Google Maps on iPhone					
11	Using Google Maps on PC was more accurate than iPhone					
12	Using Google Maps on iPhone was more accurate than PC					
13	We have successfully completed all the Google Maps tasks on PC					
14	We successfully completed all the Google Maps tasks on iPhone					
15	We have completed all the tasks in first attempt on PC					
16	We have completed all the tasks in first attempt on iPhone					
17	We completed all the tasks in pre-defined time on PC					
18	We completed all the tasks in pre-defined time on iPhone					
19	We learned number of functions in testing Google Maps on PC					
20	We learned number of functions in testing Google map on iPhone					
21	We can use PC anytime from everywhere when we need GIS application e.g. Google Maps					
22	We can use smartphone anytime from anywhere when we need GIS application. e.g. Google Maps					
23	It was more pleasant using Google Maps on PC					
24	It was more pleasant using Google Maps on iPhone					
25	All characters were clearly visible while writing address using Google Maps on PC					

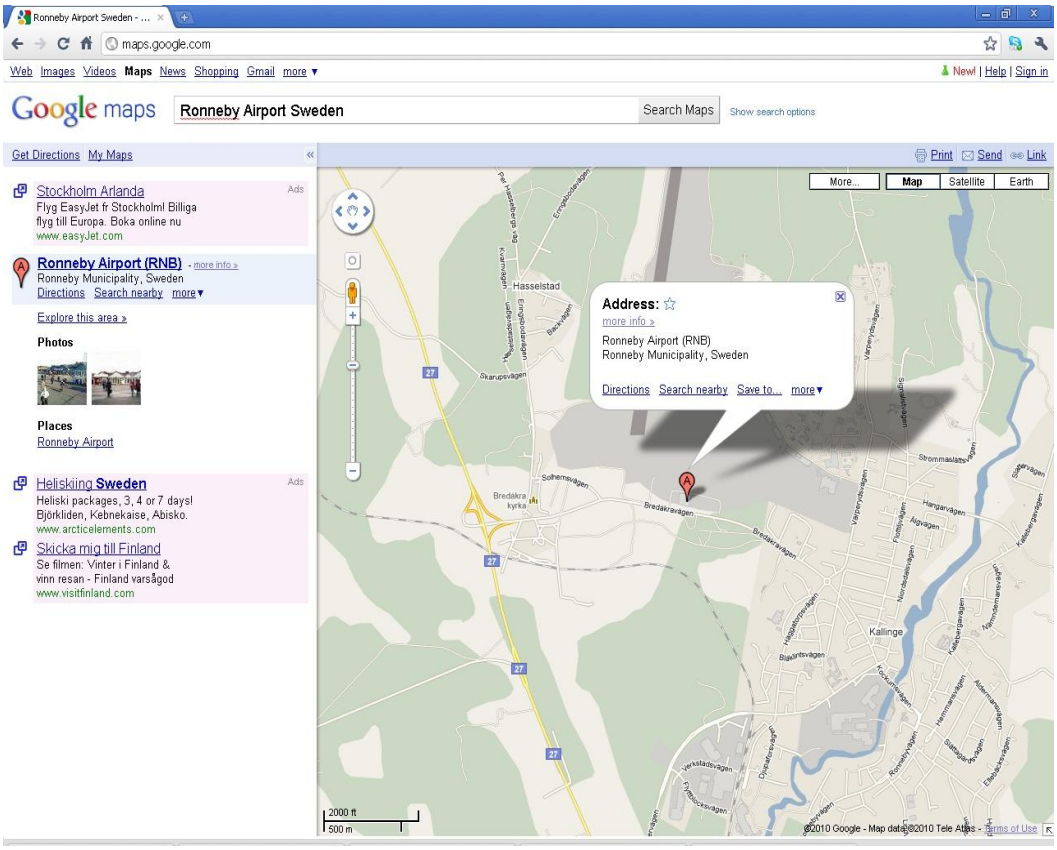
Sr.	Questions	Strongly Agree	Agree	Moderate	Disagree	Strongly Disagree
		1	2	3	4	5
26	All characters were clearly visible while writing address using Google Maps on iPhone					
27	We were bound to use Google Maps on PC					
28	We were bound to use Google Maps on iPhone					
29	Using Google Maps on PC we stopped while performing tasks					
30	Using Google Maps on iPhone we stopped while performing tasks					
31	Using Google Maps on PC we got positive response					
32	Using Google Maps on iPhone we got positive response					
33	Using Google Maps on PC we have enough control to perform task					
34	Using Google Maps on iPhone we have enough control to perform task					
35	It give me result regarding my desired search when using Google Maps on PC					
36	It give me result regarding my desired search when using Google Maps on iPhone					
37	We don't need any guide line while using Google Maps on PC					
38	We don't need any guide line while using Google Maps on iPhone					
39	We find consistency and having no difficulty while using Google Maps on PC					
40	We find consistency and having no difficulty while using Google Maps on iPhone					
41	Using Google Maps on PC we became skillful quickly					
42	Using Google Maps on iPhone we became skillful quickly					
43	We need to learn before using Google Maps on PC					
44	We need to learn before using Google Maps on iPhone					
45	We became satisfied with the use of Google Maps on PC					
46	We became satisfied with the use of Google Maps on iPhone					
47	In future we suggest the use of Google Maps on PC for our colleagues					
48	In future we suggest the use of Google Maps on iPhone for our colleagues					

Occurrences	GOOGLE MAPS ON PC & IPHONE											
	NG1		NG2		EG1		EG2		EG3		EG4	
	PC	iPhone	PC	iPhone	PC	iPhone	PC	iPhone	PC	iPhone	PC	iPhone
St: Agree	17	12	17	5	15	4	5	2	17	5	7	14
Agree	2	8	1	14	1	2	14	7	1	15	7	3
Moderate	3	2	3	2	2	11	3	12	3	2	4	3
Disagree	1	1	3	3	2	6	2	3	3	2	2	1
St: Disagree	1	1	0	0	4	1	0	0	0	0	4	3
TOTAL Q	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**	**24**

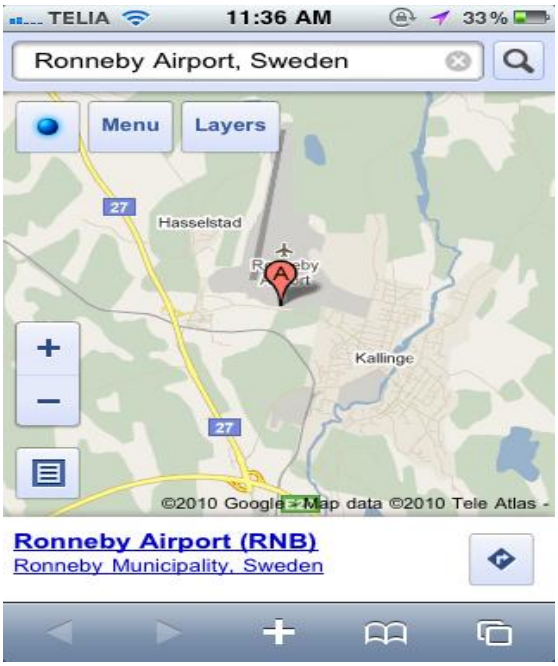
Answers	Google Maps on PC		Google Maps on iPhone	
	No: of occurrences	**Percentage**	**No: of occurrences**	**Percentage**
Strongly Agree	78	54%	42	29%
Agree	26	18%	49	34%
Moderate	18	13%	32	22%
Disagree	13	9%	16	11%
Strongly disagree	9	6%	5	3%
Total	**144**	**100%**	**144**	**100%**



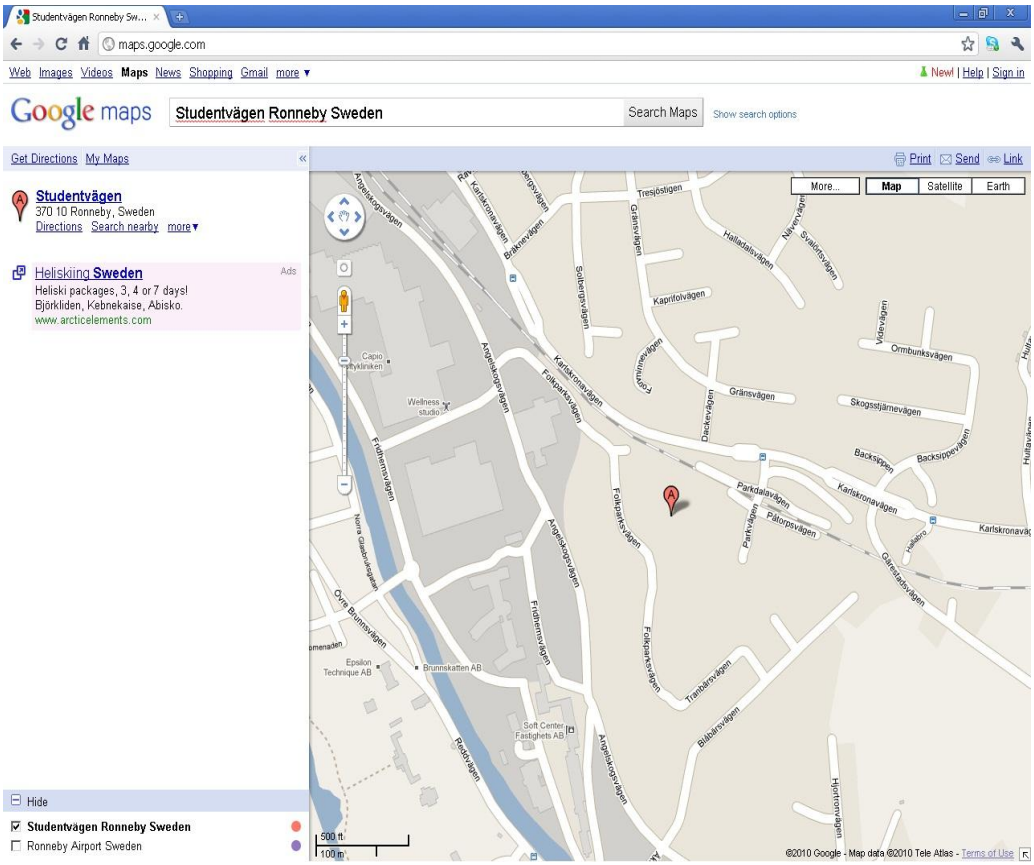
APPENDIX B: SCREENSHOTS OF GOOGLE MAPS ON PC AND IPHONE



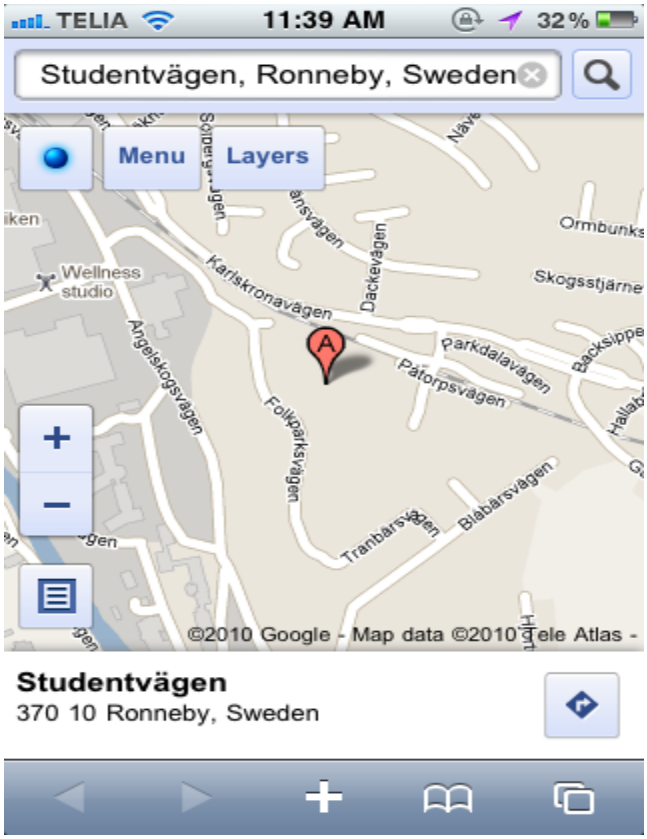
SCREENSHOT 1: SEARCH LOCATION IN PC TASK 1



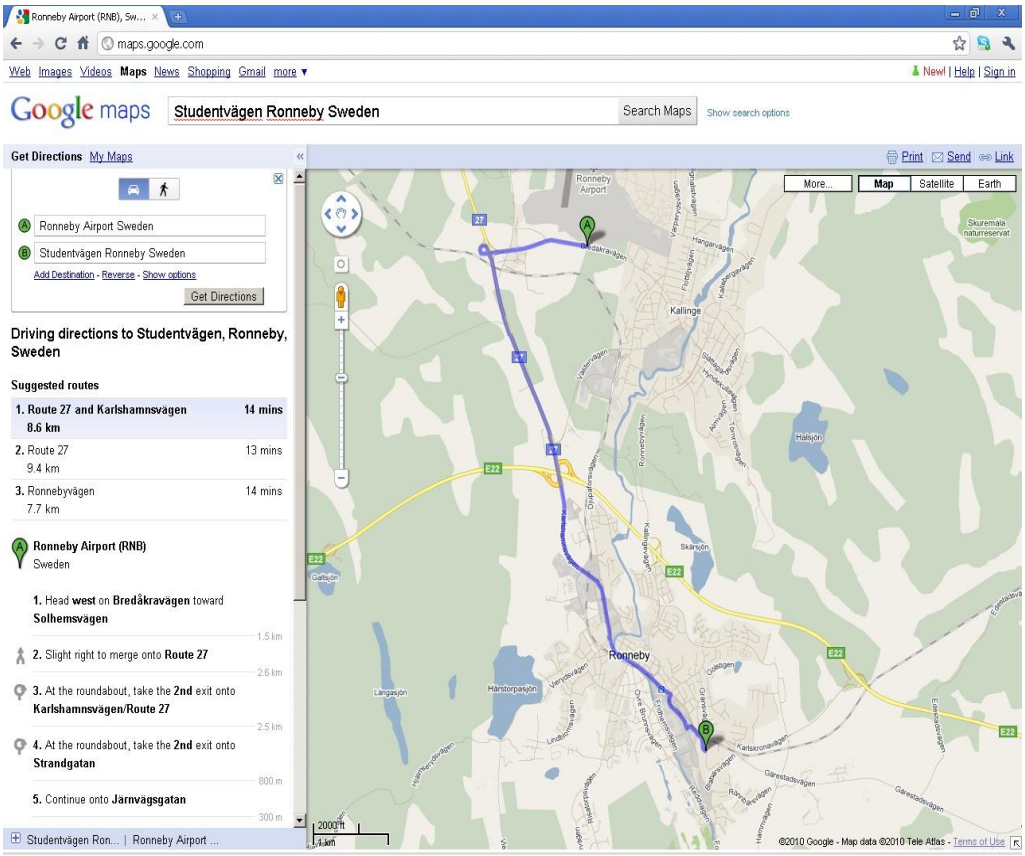
SCREENSHOT 2: SEARCH LOCATION IN IPHONE TASK 1



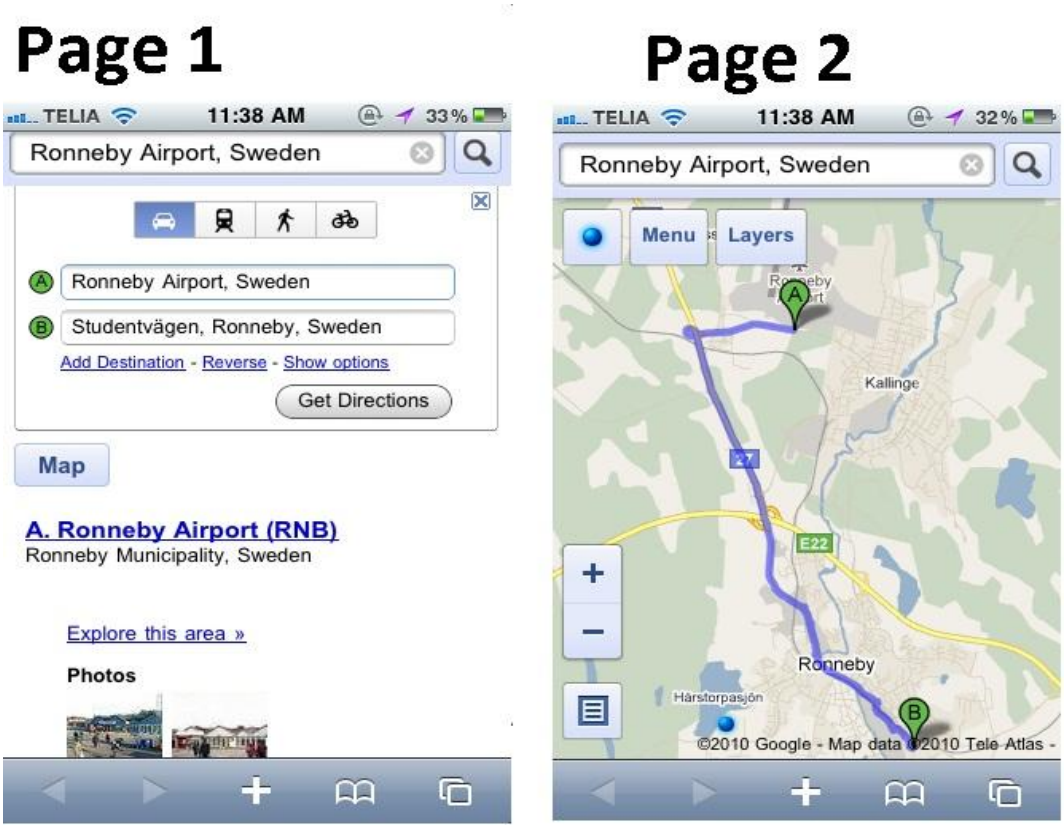
SCREENSHOT 3: SEARCH ADDRESS IN PC TASK 2



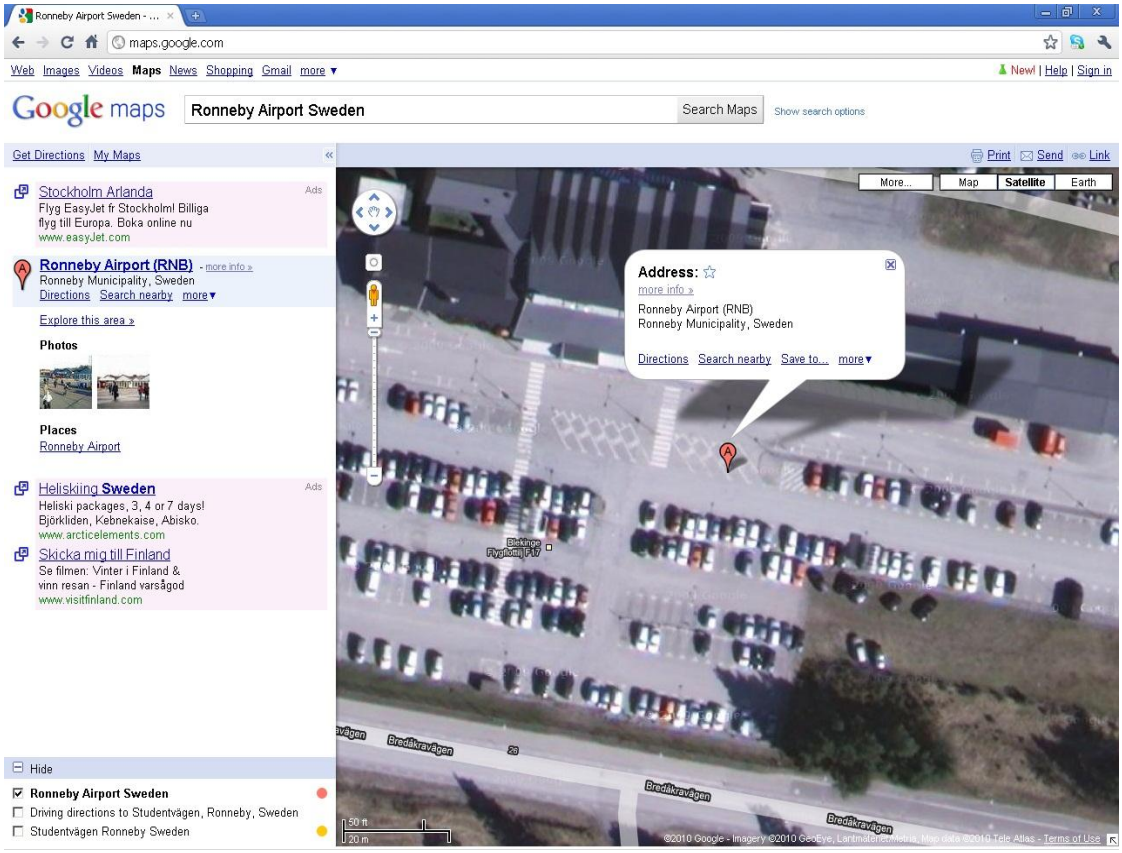
SCREENSHOT 4: SEARCH ADDRESS IN IPHONE TASK 2



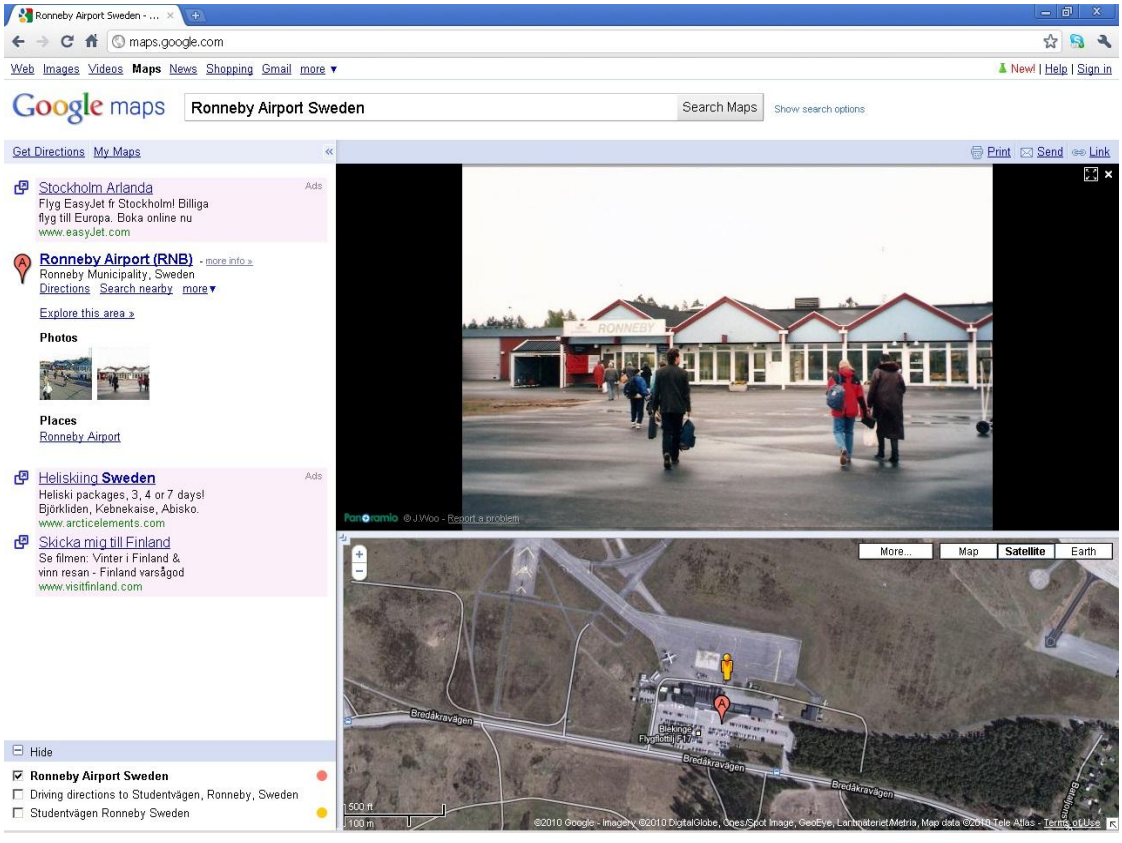
SCREENSHOT 5: GET DIRECTION IN PC TASK 3



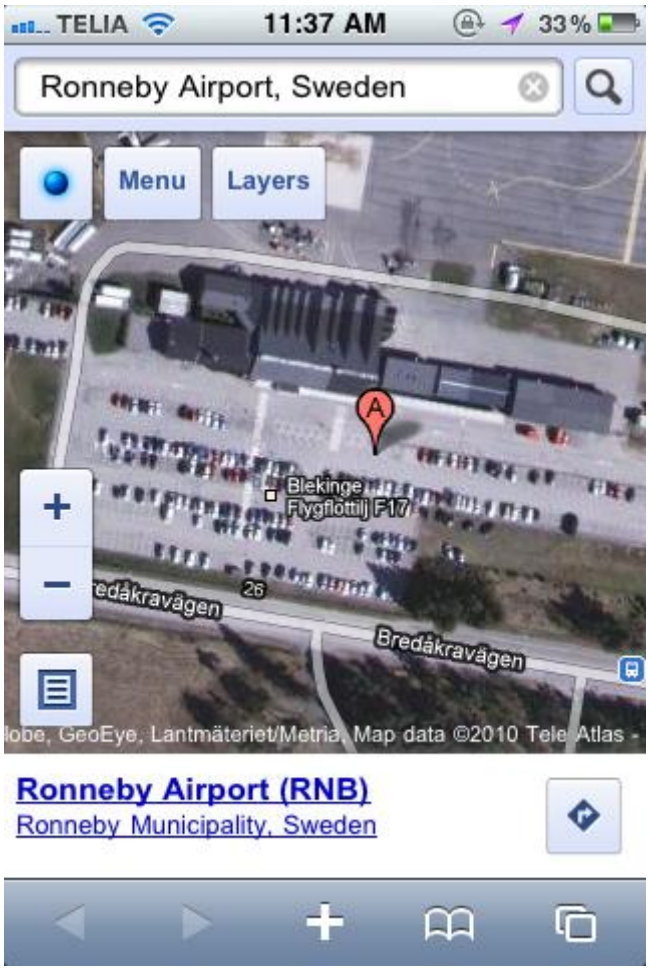
SCREENSHOT 6: GET DIRECTION IN IPHONE TASK 3



SCREENSHOT 7: ZOOMING AND PANNING IN PC TASK 4



SCREENSHOT 8: ZOOMING AND PANNING IN PC TASK 4



SCREENSHOT 9: ZOOMING AND PANNING IN IPHONE TASK 4

APPENDIX C: INTERVIEW CONDUCTED WITH GROUP OF PARTICIPANTS

Group No: NG1	Name P1: Majid Khan	Name P2: Rizwan Bahrawar Khan

Q01. Normally for what purpose you are using GIS application and what are your recommendation for PC and iPhone?
Answer: GIS application may be used for finding maps. We will recommend iPhone, as it is much more portable then PC. We can use PC at our home while we can use iPhone anywhere, may be at home or may be outside.

Q02. Is it helpful when you are using the GIS application?
Answer: Of course it was helpful, because if we are going to some place we can find our location and route with the help of GIS application. In case if we don't have GIS application and we are going to a place, we are asking people for guidance regarding the place where we are going. So it will waste our time and with the use of GIS application, it will be easy for us to not waste the time and find the place easily. Similarly if we are finding a location, it is giving complete information and guidance about the current and desired location, that how we can reach to our destination.

Q03. Is GIS application fulfilling your requirements in daily life?
Answer: We can say that it depends on our use, for example, in case if we are going to a place and we don't know about the place information, then it is fulfilling our requirements. Also it can fulfill our daily requirements, if it gives us information about the train and bus system, if I am finding a direction to Karlskrona, so it should provide me information about the possible transport system with the alternate route. Although GIS application contains the information about the bus but we don't know that from which connected place with the train route we can pick the bus.

Q04. How you experienced GIS usage in performing tests, more efficient on iPhone device or PC?
Answer: As we were using GIS application, so almost all the functions were same for us. But the use of GIS application on iPhone was our first experience and as compared to PC the speed of iPhone was slow, and was not user friendly, we did mistakes regarding typing on mobile. But we recommend that the use of GIS application on iPhone is better. Because we can use GIS application on iPhone while walking, driving which is saving time as compared to PC, in case of PC we have to sit at home first check the place and then go, it is wasting time.

Q05. To use Google Maps which device will be your preferable choice, PC or iPhone?
Answer: We will prefer iPhone for future usage because with the use of GIS application on iPhone when we are finding a location, it not only gives the information about the current address but also the current location that currently where we are. So we think that this is a big benefit of iPhone due to which we are recommending it for future usage.

Q06. Was it easy to use Google Maps on both devices?
Answer: Yes functionally the use of Google Maps was almost easy on both devices for us.

Q07. How many functions did you learn while conducting tests?
Answer: We learned some of the functions like get direction, zooming and panning.

Q08. Did you experience support from Google Maps if your search Query went wrong on PC and iPhone?
Answer: Yes when our query was going wrong on both devices, Google Maps was giving support to us. Like when we were giving any address it was giving some possible options regarding that address and was asking that "did you mean this".

Q09. Are you satisfied with help regarding errors from GIS application of Google Maps?
Answer: We are satisfied with help regarding errors on GIS application on PC. But while using iPhone, when it gave us help regarding error and we clicked it, it took us to wrong address. But from GIS application on PC we are satisfied.

Q10. Was it giving suggestions for correcting search Query?
Answer: Yes it was giving suggestions for correcting search Query

Q11. How did you find visibility of characters/text and labels for both devices iPhone and PC?
Answer: Yes on iPhone it was almost clear but on PC we find that some of the buttons on right top side, like satellite it was not clear, so we (as a novice) think that new users will face problem by it.

Group No: NG2	Name P1: Majid Nasir	Name P2: Abdul Rauf

Q01. Normally for what purpose you are using GIS application and what are your recommendation for PC and iPhone?
Answer: We will use GIS application for finding locations and maps. For feature base PC is better as all the features of GIS application are more clearly on PC. But as portability is much more important so we will recommend iPhone.

Q02. Is it helpful when you are using the GIS application?
Answer: Yes of course it was helpful when we were using GIS application.

Q03. Is GIS application fulfilling your requirements in daily life?
Answer: Yes it is fulfilling our requirements in daily life.

Q04. How you experienced GIS usage in performing tests, more efficient on iPhone device or PC?
Answer: While performing tests, PC was more efficient. Because we were facing a little bit problems with finger touch on iPhone while typing, due to which our function went wrong, but if there is a touch device for iPhone. Then iPhone will be better.

Q05. To use Google Maps which device will be your preferable choice, PC or iPhone?
Answer: We will prefer iPhone for future usage because of its portability.

Q06. Was it easy to use Google Maps on both devices?
Answer: It was easy on PC because everything is more visible on PC.

Q07. How many functions did you learn while conducting tests?
Answer: We have learnt some of the functions like satellite.

Q08. Did you experience support from Google Maps if your search Query went wrong on PC and iPhone?
Answer: Yes it was giving suggestions for correcting search query but mostly it was giving wrong guidance. Due to which one of our query went wrong. We will recommend that it must give the suggestions related to the search query by following each word of the query.

Q09. Are you satisfied with help regarding errors from GIS application of Google Maps?
Answer: Yes we are satisfied with help regarding errors from GIS application of Google Maps.

Q10. Was it giving suggestions for correcting search Query?
Answer: Yes it was giving suggestions for correcting search Query.

Q11. How did you find visibility of characters/text and labels for both devices iPhone and PC?
Answer: We faced a little bit problems on iPhone. But we are satisfied with characters/text and labels of both.

Group No: EG1	Name P1: Nisar Khan	Name P2: Fazal Ullah

Q01. Normally for what purpose you are using GIS application and what are your recommendation for PC and iPhone?
Answer: We are using GIS application for finding a specific location and we would like to recommend PC.

Q02. Is it helpful when you are using the GIS application?
Answer: Yes it is helpful when we are using GIS application.

Q03. Is GIS application fulfilling your requirements in daily life?
Answer: Yes of course GIS application is fulfilling our requirement in daily life.

Q04. How you experienced GIS usage in performing tests, more efficient on iPhone device or PC?
Answer: While using GIS application on iPhone, it was a little bit difficult because of doing some mistake while typing. But as compared to iPhone the typing was easier on PC.

Q05. To use Google Maps which device will be your preferable choice, PC or iPhone?
Answer: We will prefer iPhone for future and further usage, because iPhone is portable as compared to PC.
Q06. Was it easy to use Google Maps on both devices?
Answer: Yes it was easy to use Google Maps on both devices.

Q07. How many functions did you learn while conducting tests?
Answer: While conducting tests we learned some of the functions like, when we are writing a route Query. It is giving a list of suggestions, we can also save the desired addresses, and when we are clicking on the desired route. It gives us all related information about that route.

Q08. Did you experience support from Google Maps if your search Query went wrong on PC and iPhone?
Answer: Yes it was giving suggestions for correcting search query on both iPhone and PC. But on PC the suggestion feedback was quick.

Q09. Was it giving suggestions for correcting search Query?
Answer: We did not do any mistakes but we can say that it was giving suggestion for correction while entering a search query.

Q10. Are you satisfied with help regarding errors from GIS application of Google Maps?
Answer: Yes we are satisfied with help regarding errors from GIS application of Google Maps, as it is giving quick suggestions before the completion of our search query.

Q11. How did you find visibility of characters/text and labels for both devices iPhone and PC?
Answer: As keyboard characters are clearer then iPhone and also we have more practice on keyboard and having high screen resolution PC has high visibility then iPhone.

Group No: EG2	Name P1: Zahid Mehboob	Name P2:Tabassum Riaz

Q01. Normally for what purpose you are using GIS application and what are your recommendation for PC and iPhone?
Answer: We can asses GIS application where ever we are. For example if we are outside of our home, it is difficult for us to carry a laptop with ourselves. But having iPhone, we can assess the desired place with all the required information, maybe we are at home or may be outside. According to our experience the use of GIS application is much better for iPhone.

Q02. Is it helpful when you are using the GIS application?
Answer: Yes we agree that GIS application is helpful in use.

Q03. Is GIS application fulfilling your requirements in daily life?
Answer: Yes of course GIS application is fulfilling our requirements in daily life. For example we can get any desirable query anywhere with the help of GIS application, may be with the use of iPhone or with the use of PC.

Q04. How you experienced GIS usage in performing tests, more efficient on iPhone device or PC?
Answer: While performing test, we have felt satisfied. But we also recommend that there should be high speed internet to access mobile so that a person can get the data very efficiently because GIS application is quite heavy as we think so as text base.

Q05. To use Google Maps which device will be your preferable choice, PC or iPhone?
Answer: We will again repeat our answer that it is much better for iPhone because on iPhone we can access GIS application at home as well as by traveling. But if we have a PC, it is quite difficult to access it.

Q06. Was it easy to use Google Maps on both devices?
Answer: Yes it was easy to use Google Maps on both devices. Only the iPhone has a little bit problems that are when we were writing a query in the search box as compared to PC. But we think that it is not a big problem. As iPhone is fulfilling our need, so we will suggest that iPhone is better.

Q07. How many functions did you learn while conducting tests?
Answer: We learned a lot while conducting tests and it was quite a good experience.

Q08. Did you experience support from Google Maps if your search Query went wrong on PC and iPhone?
Answer: Yes it is giving support. In case when a query goes wrong, GIS application is suggesting us three or four destination in order to correct our query.

Q09. Was it giving suggestions for correcting search Query?
Answer: Yes it is giving suggestions for correcting search query. But in case of iPhone we were facing a little bit problems and that was when we were editing in the search query, we were getting suggestions, which were visible above the search query and because of it; we were facing some difficulty in editing our search query.

Q10. Are you satisfied with help regarding errors from GIS application of Google Maps?
Answer: We are satisfied up to some extent, because if a query is going wrong it is giving us suggestion related to our query.

Q11. How did you find visibility of characters/text and labels for both devices iPhone and PC?
Answer: Again this answer goes to PC. As the PC has high visibility as compared to iPhone, so it was easier on PC. But as iPhone has low visibility, it is giving us many functions and also iPhone has a better portability then PC.

Group No: EG3	Name P1: Asar Jan	Waqas Ahmad

Q01. Normally for what purpose you are using GIS application and what are your recommendation for PC and iPhone?
Answer: We are using GIS application for finding routes, directions and places. We will recommend PC because of its easy use as compared to iPhone.

Q02. Is it helpful when you are using the GIS application?
Answer: Yes of course it is helpful for finding location, finding routes, distance and time consumption.

Q03. Is GIS application fulfilling your requirements in daily life?
Answer: According to one participant it is not fulfilling 100 percent. Because for this purpose he needs a navigator in which he can edit the place name and it can find that place for him and guide him while going on the route by walk. And according to other participant it depends on the use that when they need then it is fulfilling the requirements.

Q04. How you experienced GIS usage in performing tests, more efficient on iPhone device or PC?
Answer: As we are thinking PC is more efficient because of its good response time. When we are giving a query, it is showing all the suggestions clearly and is saving our time. While in iPhone it was not so much clear due to which we took more time. While performing test we experienced about saving map, distance of desired location and alternate route.

Q05. To use Google Maps which device will be your preferable choice, PC or iPhone?
Answer: Because of portability we will prefer iPhone for future and further usage.

Q06. Was it easy to use Google Maps on both devices?
Answer: Yes it was easy on both devices but was more feasible on PC.

Q07. How many functions did you learn while conducting tests?
Answer: We learned functions like saving maps, distance of location and alternate routes.

Q08. Did you experience support from Google Maps if your search Query went wrong on PC and iPhone?
Answer: While searching query on PC, when we did spelling mistake, at that time suggestions became invisible and we came to know that we have done a spelling mistake, while on iPhone it was giving suggestion but it was not detecting spelling mistake.

Q09. Was it giving suggestions for correcting search Query?
Answer: Yes it was giving suggestions for correcting search query.

Q10. Are you satisfied with help regarding errors from GIS application of Google Maps?
Answer: Yes we are satisfied with help regarding errors from GIS application of Google Maps. But in one of a task on iPhone we stuck because of some error but we did not know that what the error was.

Q11. How did you find visibility of characters/text and labels for both devices iPhone and PC?
Answer: For character/text/ and labels, PC was more visible, while on iPhone sometimes we were scrolling for label or characters. But the zooming and panning feature of iPhone was best than that of PC.

Group No: EG4	Name P1: M. Adnan Jalil	Name P2: Ali Raza Fiaz

Q01. Normally for what purpose you are using GIS application and what are your recommendation for PC and iPhone?
Answer: We are using GIS application for information like routes, places and distances etc. we will recommend PC because of its portability and accessibility.

Q02. Is it helpful when you are using the GIS application?
Answer: Yes GIS application is helpful when we are using it.

Q03. Is GIS application fulfilling your requirements in daily life?
Answer: It depends on the use and the need. But we can say that it is fulfilling the requirement whenever we are using it.

Q04. How you experienced GIS usage in performing tests, more efficient on iPhone device or PC?
Answer: We did all tests in right and easy manners. It was more efficient on PC of having high visibility but it is not a big problem. As compared to PC, iPhone having small screen is giving us much more facilities. So our experience was satisfactory while performing test.

Q05. To use Google Maps which device will be your preferable choice, PC or iPhone?
Answer: We will prefer iPhone for future usage because of its portability. It is difficult to carry PC because of its charging issue, large size and weight. The use of iPhone is easy, because we can use it by walk, by drive and anywhere. So having such facilities we will recommend iPhone for future and further usage.

Q06. Was it easy to use Google Maps on both devices?
Answer: Yes of course it was easy on both devices.

Q07. How many functions did you learn while conducting tests?
Answer: Functions like satellite and save maps were new for us. So we learned these two functions and we were familiar with the rest of functions.

Q08. Did you experience support from Google Maps if your search Query went wrong on PC and iPhone?
Answer: Yes it was giving support because when our search query was going wrong, it was giving suggestions. For example in one of a place we did a spelling mistake and it gave us suggestions, but we find it more clearly on PC then iPhone. iPhone was also giving suggestions but sometimes it was not clear.

Q09. Was it giving suggestions for correcting search Query?
Answer: Yes of course it was giving suggestions for correcting search query.

Q10. Are you satisfied with help regarding errors from GIS application of Google Maps?
Answer: Yes we are satisfied with help regarding errors from GIS application of Google Maps. When we were entering the search query, it was giving suggestions for error correction time by time.

Q11. How did you find visibility of characters/text and labels for both devices iPhone and PC?

Answer: The visibility of characters/text and labels were clear on both devices. Because of the large screen it was clearer on PC and was also clear on iPhone, sometimes we were scrolling down the page for some labels like save map on iPhone, but we think that it will not be a big issue, once a person will use it then it will not be a problem. But if such issues will be updated then it will be more easy and helpful for iPhone use.

APPENDIX D: RECOMMENDATIONS

The results of the study cannot be generalized until and unless the process is repeated through several use of context though this thesis provide a basis for future work. The authors' identified some cosmetic issues in PC and iPhone. These issues are:

Hanging of Layer button in iPhone	The authors suggest that system hanging in iPhone "Layer" button issue should be removed. Furthermore, authors suggest that the iPhone should have one main button with the help of which group of participants can move back and front of the page without using the web browser buttons.
Customized map	The authors suggest customized map option on PC, it would work like to search certain locations or places in an area and would like to take a print of the whole located positions as a single map supplemented with directions and optimized routes.
Boundary of the located position	The authors also suggested that it would be better to draw an imaginary line of the whole searched location. In this way a user would have an idea of the area and would be able to locate certain areas without consulting maps or can locate on printed map.
Increase visibility of User interfaces e.g. "Save to My Maps" button position	Thirdly the authors' identified that user interface, e.g. "Save to My Maps" button position on both iPhone and PC is not clearly visible and the user had to either scroll in case of iPhone or had to search for the button in case of PC. It would be better to keep this button on upper left top corner of the map.

APPENDIX E: USABILITY TEST MATERIALS

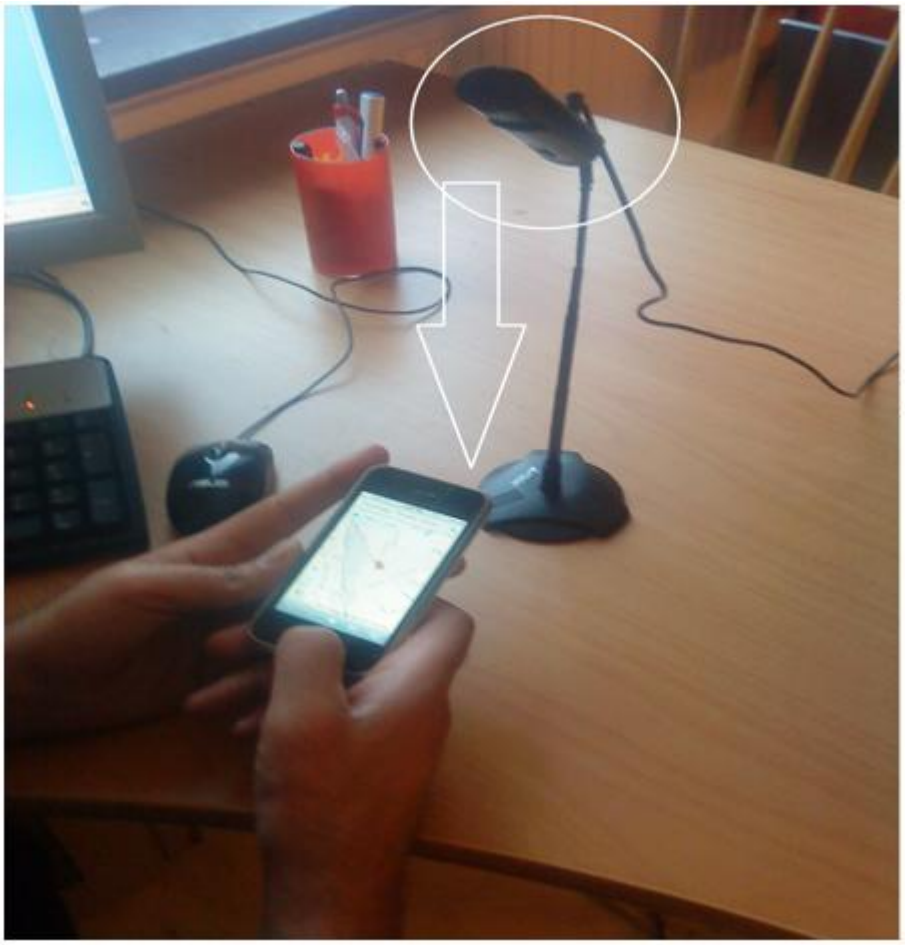
Group No: ____ **Name P1_____** **Name P2 _____** **Date: 2010/11/____**

@-mail: _____ **@-mail: _____**

TASKS	**Effectiveness**				**Efficiency**			
	Tasks Status		***No: of Errors***		***Time Spent on Task***		***No: of Clicks or Tapped***	
	PC	*iPhone*	*PC*	*iPhone*	*PC*	*iPhone*	*PC*	*iPhone*
1								
2								
3								
4								

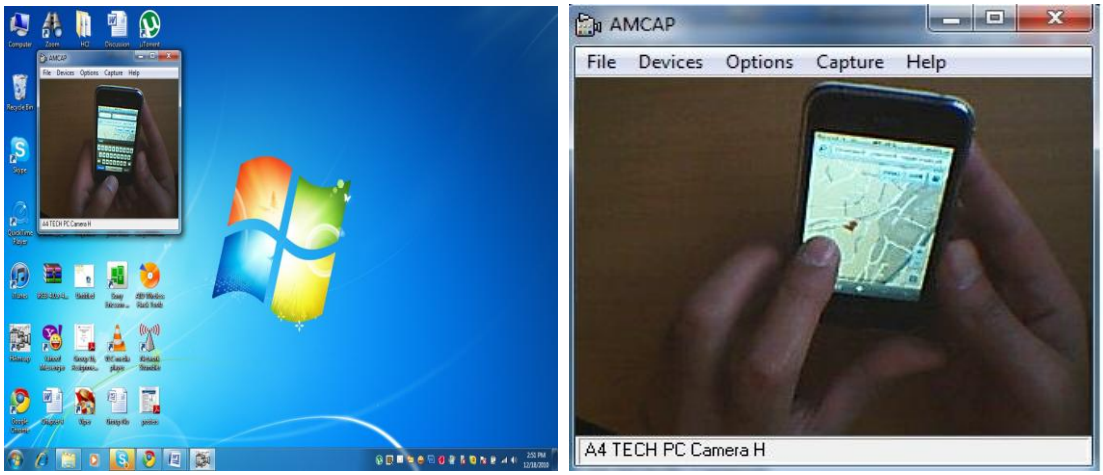
Satisfaction	
PC Comments By Participants	**iPhone Comments By Participant**

Datasheet for note/record observation during the test and after



Web CAM is used during the test of Google maps on iPhone

SCREENSHOT 1 WEBCAM AND DURING INTERACTION WITH IPHONE



SCREENSHOT 2 WEBCAM IPHONE RECORDING BY PC