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Remote Usability Testing - A New Approach Facilitated By Virtual Worlds

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REMOTE USABILITY TESTING - A NEW APPROACH FACILITATED BY VIRTUAL WORLDS

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ABSTRACT

Synchronous remote usability testing, involves a facilitator conducting a usability test in real time, interacting with a participant who is remote. This study proposes a new methodology for conducting these studies using a three-dimensional virtual world, Wonderland, and compares it with two other commonly used synchronous usability test methods: the traditional lab approach and WebEx, a web-based conferencing and screen sharing approach.

The study involved 48 participants in total, 36 test subjects and 12 test facilitators. These 36 were equally divided among the three environments with the 12 test facilitators being paired with one participant in each of the environments. The participants completed 5 tasks on an e-commerce website. The three methodologies were compared with respect to the dependent variables, the time taken to complete the tasks; the usability defects identified; the severity of these usability issues; and the subjective ratings from the NASA-TLX, the presence and post-test subjective questionnaires.

Most importantly, the three methodologies agreed closely in terms of the total number defects identified, number of high severity defects identified and the time taken to complete the tasks. However, there was a significant difference in the workload experienced by the test participants and facilitators, with the traditional lab condition being the least and the Wonderland and the WebEx conditions being almost the same. It was also found that both test participants and test facilitators experienced better involvement and immersive experiences in the Wonderland condition, than the WebEx condition and almost the same for traditional lab condition.

The results of this study suggest that participants were productive and enjoyed the Wonderland condition, indicating the potential of a virtual world based approach as an alternative to the conventional approaches.

DEDICATION

The thesis is dedicated to my beloved parents, Haridasan Chenicheri Veettil and Ramani Chalil Madathil; my brothers Arekh R. Nambiar, Sreenath Chalil Madathil, Anoop R. Nambiar; my sister-in-law Preethi Dhanvi; my uncle Narayanan Chalil Madathil and God Almighty.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER ONE

INTRODUCTION

Usability studies on software interfaces analyzing how users interact with computer applications began in the early 1980’s (Shneiderman, 1980), (Card, Moran, & Newell, 1986). At this time, several usability evaluation methodologies (UEM) evolved, the most common one being laboratory-based testing. This methodology, usually conducted in a lab equipped with audio and video recording capabilities, involves a test facilitator and participant in front of a one-way mirror with the application developers watching and recording the participant’s completion of the tasks assigned. User performance is then evaluated based on parameters such as speed, accuracy and types of errors. These quantitative data are combined with subjective information obtained through verbal protocols (Ericsson & Simon, 1985), critical incident reporting (del Galdo, Williges, Williges, & Wixon, 1986), and user satisfaction surveys (Chin, Diehl, & Norman, 1988). Traditionally, usability evaluation has been conducted during the final stage of the design process, the cost and time requirements associated with it being significant. To address this issue, the early 1990’s witnessed research developing alternative cost-effective UE methods and the inclusion of usability as a product attribute early in the design process. These results led to the development of such methodologies as heuristic evaluation (Nielsen & Molich, 1990), cognitive walk-throughs (Lewis, Polson, Wharton, & Rieman, 1990), usability walk-throughs (Bias, 1991), formal usability inspection (Nielsen, 1994) and heuristic walk-throughs (Sears & Jacko, 1997).

The emergence of high speed internet technologies has resulted in the concept of the global village and next generation products addressing its needs. In such a scenario where usability evaluators, developers and prospective users are wide-spread, across different countries and time zones, conducting a traditional lab usability evaluation creates challenges both from the cost and logistical perspective. These concerns led to research on remote usability evaluation with the user and the evaluators separated over space and time. The development of the internet technology which forms the basis for remote UEM has enabled usability testing to be conducted remotely, resulting in significant cost savings (Hartson, Castillo, Kelso, & Neale, 1996). Remote testing, which facilitates evaluations being done in the context of the user's other tasks and technology can be either synchronous or asynchronous (Scholtz, 2001). The former provides real time one-on-one communication between the evaluator and the user, and the latter involves the evaluator and user working separately (Castillo, 1997). Numerous tools are available to address the needs of both these approaches. For example Microsoft NetMeeting, WebEx, WebQuilt and IBM Lotus Sametime support online screen sharing and collaborative capabilities for synchronous remote UE. Some of the remote asynchronous usability testing tools include auto logging (Millen, 1999), questionnaires (Ericsson & Anders, 1998), user-reported critical incidents (Bruun, Gull, Hofmeister, & Stage, 2009), (Castillo, 1997) unstructured problem reporting, forums and diaries (Bruun et al., 2009). However, remote testing may lack the immediacy and sense of "presence" desired to support a collaborative testing process. Moreover, managing inter-personal dynamics across cultural and linguistic barriers may require approaches sensitive to the cultures involved (Dray & Siegel, 2004). Other disadvantages include having reduced control over the testing environment and the distractions and interruptions experienced by the participants' in their native environment.

The use of three-dimensional (3D) virtual world applications may address some of these concerns. Collaborative engineering was redefined when these worlds integrated high fidelity voice-based communication, immersive audio and data-sharing tools (Erbe & Müller, 2006). In addition, such 3D virtual worlds mirror the collaboration among participants and experts when all are physically present, potentially enabling usability tests to be conducted more effectively when they are located in different places. Virtual world applications are relatively new and as a result have been the focus of limited research. To address this need, this study compared the effectiveness of synchronous usability testing in a 3D virtual meeting room built using Sun Microsystems' Wonderland with traditional lab usability testing and an online meeting tool WebEx. The results of usability tests employing the three methodologies were compared based on qualitative and quantitative measurement of the work performed and the feedback from the participants forming each team to determine which of the three is most effective.

CHAPTER TWO

USABILITY TESTING

Usability testing, developed to learn how prospective customers handle specific products, is a "systematic way of observing actual users trying out a product and collecting information about the specific ways in which the product is easy for them" (Dumas & Redish, 1999). One of the widespread uses of it today is in the design and development of products and services involving human-computer interfaces. According to Nielsen (Nielsen, 1993a; Nielsen, 1994), such interface evaluation can be classified into four categories:

- Formal evaluation
- Informal evaluation
- Empirical evaluation
- Automatic evaluation

Formal evaluation deals with the usage of formulae and models to calculate the usability measures while informal evaluation deals with the general rules of thumb and the general skill and experience of the usability evaluators. Empirical evaluation involves assessing the usability by testing the interface with the real users whereas automatic evaluation involves identifying the usability measures by running a user interface specification through a software program. These evaluation methods can be further grouped into the following categories.

- Usability test methods (UTM) (Nielsen, 1993a)
    - Observation
    - Focus groups
    - Interviews
    - Questionnaires
    - User testing
- Usability inspection methods (UIM) (Nielsen, 1994).
    - Heuristic evaluation
    - Cognitive walk-through
    - Formal usability inspection
    - Pluralistic walk through
    - Feature inspection
    - Consistency inspection
    - Standards inspection

The difference between these two categories is that the former includes real users while the latter does not.

Usability test methods

Usability test methods involve testing a product with the prospective users. Observation, one of the simplest usability methods, involves observing and taking notes unobtrusively while users interact with an interface. Questionnaires, interviews and focus groups provide insight into how users use the interface, including their likes and dislikes. One of the disadvantages of these methodologies is that they do not study the interface itself; rather they elicit the user's opinion of it. The final method, user testing integrates the advantages of such techniques as observation, questionnaires and interviews.

Usability inspection methods

In contrast, usability inspection methods do not involve end users. Heuristic evaluation, one of the most frequently used techniques, involves experienced evaluators inspecting a system and evaluating it against a set of recognized usability principles (Nielsen & Mack L., 1994). These heuristics include using simple and natural dialogue; speaking the user's language; minimizing memory load and providing consistency, feedback, shortcuts, help, documentation, good error messages and error prevention (Nielsen, 1993a; Nielsen & Mack L., 1994). Usually, the heuristic evaluators assess the interface twice, the first iteration focusing on the general scope and navigation structure of the product and the second focusing on the screen layout and interaction structure in relation to pre-defined heuristics. The severity of each usability error is then analyzed individually by the evaluators, and a final report comparing the evaluations of the various evaluators is prepared. In a cognitive walk-through, the interface developers evaluate the interface in the context of core tasks typical users need to accomplish (Lewis et al., 1990; Nielsen, 1994). According to Polson *et al*. (1990), this methodology is best applied early in the design stage as it examines the relationship between the task to be performed and the feedback provided by the interface. Pluralistic walk-throughs include users, developers and human factors experts analyzing the interface step-by-step and providing feedback on each of the dialogues. Feature inspection, which involves identifying the sequence of operations required to perform a task, is most appropriate in identifying long and cumbersome sequences (Nielsen, 1994). A consistency inspection involves designers of the different modules in a project analyzing the interface to ensure that it performs the same set of actions as defined in their existing systems. A standards inspection is conducted by a system expert who evaluates the compliance of the interface with a standard set of requirements.

Usability Measures

The multidimensional nature of usability has resulted in the development of several metrics to measure usability when conducting a usability test (Nielsen & Levy, 1994). These measures assess how actual users use the product in the actual context of use and fall under the broad categories of objective performance measures and subjective user satisfaction measures. The former measures the capability of the user to use the system and the latter, the user experience with the system. The most common factors measured in a usability test include effectiveness, efficiency and satisfaction (U.S. Department of Health & Human Services, 2002). Effectiveness deals with the ability of the users to use a web site successfully to find information and complete the task while efficiency deals with the user’s ability to accomplish the task quickly with ease and without frustration and satisfaction measures how much the user enjoys using the interface. Objective performance measures include successful task completion rates, time on a task, number of pages viewed and analysis of the click stream. Satisfaction questionnaires, user comments and preference ratings are used to capture subjective user satisfaction. Rigorous usability tests tend to rely more on objective performance measures than on subjective satisfaction measures (U.S. Department of Health & Human Services, 2002) .

Traditional lab usability testing methodology

Traditional lab usability testing, a type of formal evaluation where the evaluator and the test participant are in the same place at the same time, is driven by quantitative usability specifications using a predefined set of tasks (Whiteside, Bennett, & Holtzblatt, 1988). This approach involves identifying individual participants representative of the product user base and observing them as they work through tasks designed to demonstrate product functionality. Much research has focused on determining the number of subjects required to find the majority of the usability defects. Virzi's (1992) three studies relating the proportion of the usability defects identified in relation to the number of participants found that the majority of the usability problems were identified using four to five subjects. According to these results, most severe usability problems are identified with the first few subjects, with the additional ones being less likely to identify new usability defects. His findings were supported by studies conducted by Neilsen *et al.* (Nielsen, 2000) (Nielsen & Landauer, 1993) who suggested that the first five users will uncover almost all of the major usability problems and the next few will find almost all of the remaining problems. Spool *et al.* (2001) assert that a large number of users are required with different backgrounds and experiences.

During in-lab usability testing, participants are encouraged to think-aloud during the evaluation. Nielsen (1993b) suggests that this technique "may be the single most valuable usability engineering method." It asks the participants to verbalize their thoughts while interacting with the interface, thereby facilitating identification of their common misconceptions. Since most people will refrain from continuously verbalizing their thoughts (Nielsen, 1992), frequently the facilitator needs to prompt the user with questions like "What are you thinking now?" or "How do you interpret this error message" during the test. A study conducted by Ebling *et al.* (2000) revealed that more than one third of the most severe problems and more than two-thirds of the less severe were identified using a think-aloud protocol. The advantages of this protocol include obtaining an accurate idea of the users' problems including doubts, irritations and other feelings experienced by the participant while interacting with the interface. One of the primary disadvantages of the think-aloud protocol is that time measurements for the task will not be the same as experienced in the real usage environment since the need to communicate reduces the efficiency of the user. To address this, the think-aloud protocol can also be used retrospectively with the user reflecting on the task after completing it.

The traditional lab usability evaluation obtains both qualitative and quantitative data. The quantitative data usually include the time taken to complete a task and the number of usability defects identified. The qualitative data is collected using subjective satisfaction questionnaires (Nielsen & Levy, 1994), as well as through verbal communication both during and after the testing process. Since this mode of testing is considered a *de facto* standard, it is used as a benchmark to compare the efficacies of various usability evaluation methodologies (Landauer, 1996). Though traditional lab usability testing can generate high quality usability problem sets, it possesses inherent drawbacks such as the cost incurred in setting up and bringing people to the lab, lack of availability of prospective users, and the difficulty in building a working environment similar to that of the user (Hartson, Andre, & Williges, 2003).

CHAPTER THREE

REMOTE USABILITY TESTING

Because of the current impact of globalization, companies have begun developing software products and applications for an international market. In a scenario where the prospective users, the usability professionals and product developers are geographically distributed, performing traditional lab usability testing is more difficult due to time, cost and logistical constraints. To address this situation, remote usability testing, with evaluators and users being separated in space and/or time (Castillo, Hartson, & Hix, 1998), has been proposed as a potential solution.

The research conducted by Hammontree *et al.* (1994) on interactive prototypes at Sun Microsystems and Hewlett Packard is one of earliest studies to analyze the potential of remote usability testing. They used window/application sharing, an electronic white board, a computer-based video conferencing tool and a telephone to support the remote usability test. The window/application sharing tool enabled real time sharing of applications between multiple work stations, while the shared white board allowed multiple participants to use a common drawing/writing surface simultaneously. It was also used to provide instructions to the users on the tasks to be performed. Computer-based video conferencing tools provided live video of the user, allowing for the observation of visual cues like gestures and facial expressions. The shared windowing tools and telephone supported the remote think-aloud evaluations. The shared window facilitated the observation of the user interactions remotely. Hammontree *et al.* (1994)

suggest that the video link helped to establish a level of rapport between the participants and observers. Computer supported collaboration technology was in the development phase during their study. The researchers anticipated an improvement in the quality of tools designed to support remote collaborative work.

Remote usability evaluation can either be synchronous or asynchronous (Hartson, 1996). In synchronous remote usability testing, the test facilitator interacts in real time with the participant at a remote location while in asynchronous remote testing, the facilitator and observers do not have access to the data in real-time and do not interact with the participant. Synchronous usability testing methodologies involve video conferencing or employ remote application sharing tools like WebEx. Asynchronous methodologies include automatic collection of user's click streams, user logs of critical incidents that occur while interacting with the application and subjective feedback on the interface by users.

Types of remote evaluation

The different types to remote evaluation (H. R. Hartson et al., 1996; Krauss, 2003; Selvaraj, 2004) are listed below:

- Local evaluation at remote sites
- Remote questionnaires and surveys
- Remote control evaluation
- Video conferencing
- Instrumented remote evaluation

- Semi-instrumented remote evaluation
- Real time design walk-throughs

Local evaluation at remote sites

In general, this mode of evaluation involves contracting out the usability evaluation to a third-party service provider. The network is used only for communication and test material exchange, not for connecting to the remote user. This type of approach, which is used by firms which either lack evaluation expertise or cannot afford appropriate facilities, is remote to the developers but local to the contractor. One of the primary disadvantages of this approach is the impact on quality due to the use of *ad-hoc* methods.

More specifically, remote laboratory testing methodology involves a third-party service provider collecting quantitative and qualitative data as well as recommendations from the users. The data along with the evaluation session video tapes are provided to the development team for further review. Remote inspection involves developers sending the interface design to a third-party contractor who conducts a local evaluation using *ad-hoc* methods. One of the primary disadvantages of this approach is the absence of direct observation of the user, meaning the results of the analysis are solely dependent on the knowledge and skill of the evaluator.

Remote questionnaires and surveys

This methodology incorporates the use of software applications to collect subjective information from the user about the interface. The software prompts for feedback when the user triggers an event or completes a task. One of the primary advantages of this approach is that it enables capturing the user reaction immediately. Since the subjective data are dependent on the questions written by the evaluator, a holistic perspective is not obtained by this approach, resulting in the loss of specific data for identifying usability problems.

Remote control evaluation

In this method the evaluators have control over the remote user's computer through web conferencing software. An audio link is established through the computer or a separate phone line, while the user's interactions are captured through a screen capture program. An advantage of this approach is that the users can participate from their work environment, and it also has the benefit of being synchronous. On the other hand, data capture can alternatively be either a continuous ongoing process or triggered by a particular application. This asynchronous approach allows the evaluators the flexibility of conducting the evaluation at their convenience.

Video Conferencing

Video conferencing allows for increased immediacy through the real-time capture of video and audio information during a remote session. This technology enables collaboration with geographically distributed participants and evaluators using the network and established audio and video links. Though this approach closely resembles traditional lab testing, its inherent disadvantages include limited bandwidth, communication delays and low video frame rates.

Instrumented remote evaluation

Instrumented remote evaluation, an automated usability evaluation, monitors user actions during the task such as click events, program usage, and task times. The application to be evaluated is instrumented by embedding code to capture data related to user interaction for storage as journals or logs. Evaluators employ pattern recognition techniques to analyze these data logs to determine the location and the nature of the usability problems. The primary advantage of this method is its automatic and accurate problem detection capability. In addition, it does not interfere with the user's routine work. Instrumented remote evaluation requires human resources to review and analyze the large quantities of collected data. As a result, it is difficult to evaluate certain usability problems effectively using this technique.

Semi-instrumented remote evaluation/user reported critical incident method

In this asynchronous method, the users and evaluators do not interact in real time. Hartson *et al.* (1998) developed and evaluated this remote usability evaluation approach using a user reported critical incident technique, which involves the self-reporting of critical incidents encountered while performing tasks in native working environments. In the study conducted, participants were given training on identifying and reporting critical events. They were asked to perform six search tasks on a web interface and to file the critical events in an online remote evaluation report. The researchers found that the users were in a position to recognize and report critical incidents effectively with minimal training and the users could even rank the severity of the critical incidents and did not find self-reporting to interfere with getting real work done. Castillo *et al.* (1998) conducted a study analyzing the pros and cons and the effectiveness of the user reported critical incident method to mitigate such issues as reducing the cost of the data capture and collecting real-time fresh data. One of the primary disadvantages of this approach is that the results rely completely on the user's ability to accomplish the task with minimal training.

Real-time design walk-through

This methodology defines a task for the test participant, walks the user through it, and then collects live feedback on the interface. Usually the interface is presented using a presentation tool, and audio communication is established through teleconferencing.

Remote usability testing tools

Though several methods have been developed for conducting a remote usability study, each has disadvantages such as time-consuming data capture, costly data analysis, inapplicability to users in their native work environments and the need to interact effectively with the user during a usability evaluation. In an effort to mitigate these issues, Winckler *et al.* (2000) developed an asynchronous remote usability testing method combining the features of remote questionnaires and automatic gathering of user interactions. This method involved obtaining real-time data from the users while they performed specific tasks remotely. In this proposed method, the evaluator selects a task to evaluate and launches it, inviting users to take part in the test. Data are then collected using log files with the subsequent analysis using visualization tools. The typical process involves assigning a task to the user through a questionnaire and monitoring the navigation performed to accomplish the task. To support the methodology, these researchers developed three tools, a monitor to describe the task to the users and capture their inputs, a test manager to coordinate the parallel run monitors, and a visualization tool to organize the data for further analysis. Though this method did not prove to be as efficient as traditional lab usability testing, the log analysis method provided insight on the process the participants adopted to complete the task assigned.

To widen the range of compatible operating systems and web browsers, Hong *et al.*(Hong & Landay, 2001) built WebQuilt, a tool for enabling easy and fast capture, analysis and visualization of web usage. This tool involves a web designer setting up the tasks and recruiting participants to carry them out through email. The architecture of the tool consists of a proxy logger which logs the communication between the client browser and web server; an action inferencer which takes the log file for the session and converts it into the actions performed by the user; and a graph merger which combines multiple lists of actions, aggregating what multiple people did on a web site into a directed graph where the nodes represent web pages and the edges represent page requests. The graph layout component takes the combined graph of actions and assigns a location to each node while the visualization component takes the results from the graph layout component to provide an interactive display.

To improve the efficiency of the analysis of browser logs, Paganelli *et al.* (Paganelli & Fabio, 2002), developed WebRemUSINE, a tool using the information contained in the task model of the application. If the users perform a task that the model indicates should follow rather precede an action, then the system logs it as a usability error. To use this tool, first a task model of the web interface is created. Then the logged data is collected, and the association between the logged actions and the basic tasks is defined. The second stage is an automatic analysis in which the system examines the logged data with the support of the task model, providing results concerning the performed tasks, the errors and the loading time; finally, the information generated is analyzed to identify usability problems in and improvements required by the interface design.

The majority of these early remote usability testing tools were asynchronous in nature and did not emulate the traditional lab approach. Bartek *et al.* (2003) suggested that the important features for a synchronous remote evaluation tool are the application sharing facility, white board for sketching ideas and online chat capability. They conducted a remote test using Lotus Sametime, a tool providing these features, with encouraging results. Vasnaik *et al*. (2006) expanded this research by developing more tools using more detailed criteria. Specifically, the criteria included features such as cost, the client installation required, the ability of a user to access the application remotely, the colors supported, two-way control, operating system support, session recording features and accessibility through the firewall.

Effectiveness of the different synchronous remote approaches

Numerous studies have been conducted comparing the effectiveness of remote usability testing methodologies. In an early such study, Hartson *et al.* (1996) compared traditional lab usability testing to desktop video conferencing using the Kodak server pages as the interface to be tested. In the remote approach, a telephone connection was used to facilitate voice communication and subjective questionnaires were emailed to the remote users. The results of their study suggest that remote evaluation using video conferencing is feasible, producing similar results to the traditional lab approach.

A similar study was conducted by Tullis *et al.* (2002) in which remote tests were conducted at the participant's work location without real-time observation. The traditional approach involved 8 users and the remote approach 29. In the remote approach, an email was sent, including a link to the website explaining the purpose of study. The participants used two windows, the first one representing the task to be performed and the second the prototype application to be tested. User actions were automatically recorded and analyzed. They were also provided with a subjective questionnaire to rate the difficulty of each task. The data analyzed included successful task completion rates, task completion times, subjective ratings and identified usability issues. The results of the study indicated that the task completion time and task completion rate from the two approaches were similar.

To identify the differences in the qualitative experience from the participant's and facilitator's perspective, Brush *et al*. (2004) compared synchronous remote usability testing with conventional in-lab testing using a plug-in for the integrated software development environment Eclipse as the interface to be tested. Among the 20 participants, eight were asked to perform the task in both scenarios to facilitate a within-group comparison. The remote method was facilitated using a Virtual Network Computing (VNC) based screen sharing program with the audio communication being established through a phone connection. The study revealed that there were no significant differences in the number of usability issues identified, their types and their severities. The participants felt that their contributions to the redesign of the interface were approximately the same in both conditions. The facilitators thought that the effort required to prepare for the remote studies was greater, though the methodology made recruiting subjects easy. During the study, the facilitators indicated that it was easy to observe the issues in the remote condition through screen sharing, while they depended on the change in the tone of the participant's voice to sense frustration.

Thompson *et al.* (2004) compared a traditional and remote approach to identify appropriate tools and methodologies for efficient and effective remote testing environments. In the remote approach, Microsoft NetMeeting and Snag-it were used, with the former providing the screen sharing capability and the latter the screen capture capability. A speaker phone was used to communicate with the remote participants. Both the remote and the traditional lab participants were asked to perform the same five search and shopping functions. The results suggest that there were no significant differences for time on task and number of errors.

Although the results for the two approaches were similar, the disadvantages of the remote studies include loss of control over the participant's test environment, limited visual feedback, session security issues, ease-of-use issues and connection and system performance issues (Bartek & Cheatham, 2003). Dray *et al.* (2004), suggest that "building trust with remote evaluations can be a real challenge", especially in international remote testing, where the interpersonal dynamics of the evaluation must be managed across cultural and linguistic barriers.

CHAPTER FOUR

COLLABORATIVE VIRTUAL ENVIRONMENTS

Technological advances in communication and collaboration technologies have resulted in the development of interactive virtual environments supporting different types of collaboration for a wide range of users. These virtual worlds are three-dimensional simulated environments in which people interact in real-time. Users access these virtual worlds through their avatars, graphical three-dimensional self-incarnations. They are able to engage in rich interactions with one another through text messages and immersive audio, supported by a headset and a microphone.

According to Benford *et al.* (2000), the current research on technology-assisted collaboration focuses on two areas: the work activity, seeking ways to distribute and coordinate it across geographically distributed individuals and the work environment, developing physical settings and computational workspaces to support collaborative work. Research on the capabilities of virtual three dimensional environments has thus far primarily focused on educational applications. In a recent study, De Lucia *et al.* (2008) conducted lectures in a virtual classroom built in Second Life (SL) with students participating through their avatars. They then evaluated the experience in terms of design and context, preparation and material, and execution using the responses to questionnaires on presence, communication, awareness and social awareness, perceived sociability, and comfort. The results of this study indicated that the virtual environment successfully supported synchronous communication and social interaction; in addition, teachers who lectured in SL found their students to be motivated.

Greenstein *et al*. (2007) conducted another study investigating whether virtual environments can be used as a supplement to text-based educational materials. A team of students studied either tsunamis or schizophrenia through an experience in Second Life and then with a handout. The second topic was then taught using the handout alone. Following the learning process, the participants were given an examination on the two topics. The results suggested that the students who were exposed to the SL experience achieved higher exam scores and indicated that the learning experience was more engaging than the students that were exposed to the handout alone. The authors concluded that "virtual worlds are a useful instructional supplement to academic readings."

Similar studies on the effectiveness of virtual worlds for team building and training, suggest that participants found virtual world productive, and enjoyed the virtual world experience (Ranade & Greenstein, 2010). The studies conducted by Ozkan *et al.* (2009) on identifying the potential advantages of using 3D virtual worlds for engineering design teams relative to conventional online meeting tools and traditional meetings, too suggests that virtual worlds could be a medium to communicate and collaborate effectively.

Studies conducted by Traum *et al.* (2007) focusing specifically on the potential use of SL in engineering suggest that the engineers believed SL to be an efficient tool for design. More recently, Kohler *et al.* (2009) proposed a methodology for integrating virtual world residents into an interactive product development process. Their work demonstrates the advantages of product developers working with their prospective customers to create new products by allowing companies to find an audience to test, use, and provide feedback on products they create.

One of the most recent developments in virtual 3D environments is the open-source toolkit for creating virtual worlds from Sun Microsystems called Wonderland. This application offers capabilities like high-fidelity audio communication between avatars, shared applications and support for the conduct of virtual collaborative meetings. Sun's Wonderland is a multi-user environment, robust in security, scalability, reliability and functionality that organizations can rely on as a place to conduct business (Sun Microsystems, 2008). This tool kit is relatively new and limited research has been conducted on it. Its integration of office tools, applications and collaborative browsers appear to make it particularly suitable for the conduct of remote usability tests.

CHAPTER FIVE

RESEARCH QUESTIONS AND HYPOTHESES

Two usability test methodologies were compared to a usability test methodology using Wonderland (WL):

1) Traditional lab usability testing (TL)
2) Remote usability testing using WebEx

   WebEx, one of the most popular online meeting tools supporting collaboration, is marketed by Cisco Systems for collaboration in business. It supports audio and text-based communication. Using WebEx, people can meet together online and share their desktop and software applications.

To compare the effectiveness of the online usability testing technologies WebEx and Wonderland with traditional lab usability testing, the following research hypotheses were tested.

Hypothesis 1:

To address the question of whether the number and severity of usability defects identified vary in the three environments, the following null hypothesis was tested:

There will be no significant differences in the number and severity of usability defects identified in the three environments.

Hypothesis 2:

To address the question of whether the time taken to complete a usability test varies in the three environments, the following null hypothesis was tested:

There will be no significant differences in the time taken to complete usability test tasks in the three environments.

Hypothesis 3:

To address the question of whether the experience of the usability test participant varies among the three environments, the following null hypothesis was tested:

There will be no significant differences in the participants' comfort level for collecting usability test data using the three usability test methodologies.

Hypothesis 4:

To address the research question of whether the experience of the usability test facilitator varies among the three environments, the following null hypothesis was tested:

There will be no significant differences in the preference of facilitators for the three usability test methodologies.

The synchronous usability testing process involves extensive interaction between the test facilitator and the test participant, as the participant performs the tasks and thinks aloud. In Wonderland, the facilitator and participant can see one another's avatars as they interact with the in-world applications, perhaps enhancing their sense of interpersonal interaction. Moreover, the need to upload and download documents is minimal, thus enabling the participant to focus on his/her task, perhaps thereby increasing their satisfaction. De Lucia *et al*. (2008) found that participants who are comfortable in a 3D virtual world are motivated to perform well.

CHAPTER SIX

METHOD

Participants

Forty-eight students from Clemson University familiar with Internet applications were recruited. They were screened for their academic experience with usability testing and familiarity with the Internet. The 12 test facilitators, 10 males and 2 females, between the ages of 24 and 40, were required to have taken courses in usability engineering while the remaining 36, consisting of 22 males and 14 females, between the ages of 23 and 35, served as usability test participants. These 36 were equally divided among the three environments, 12 in a traditional lab usability test, 12 in a remote usability study using WebEx and the remaining 12 using Wonderland. The 12 test facilitators were paired with one participant in each of the environments. Thus, each test facilitator monitored three sessions, one in a traditional lab, one in WebEx and one in Wonderland, as shown in Figure 6.1:

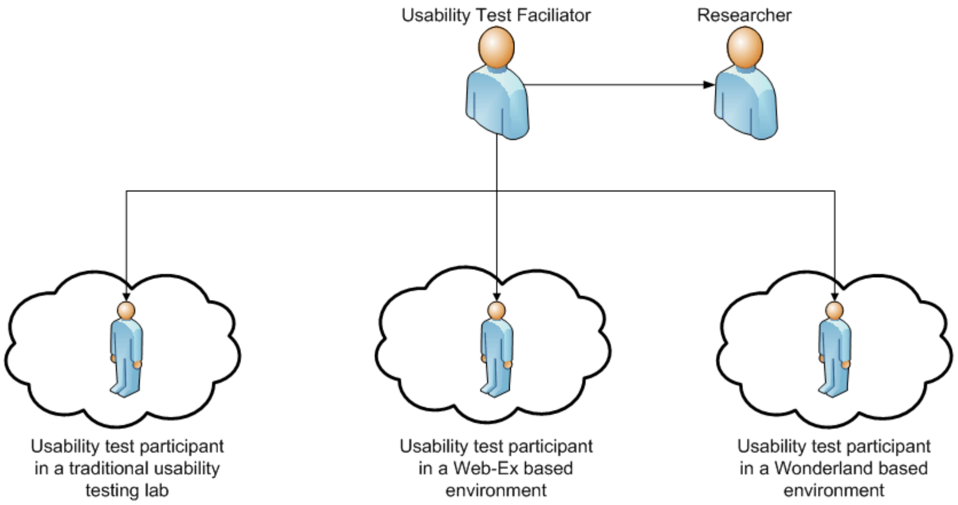

Usability Test Faciliator
Researcher
Usability test participant in a traditional usability testing lab
Usability test participant in a Web-Ex based environment
Usability test participant in a Wonderland based environment

Figure 6.1: Test Methodology

Testing Environments

The independent variable of this study was the usability test methodology, examined at three levels: the traditional lab usability laboratory, the web-based meeting tool WebEx and the 3D virtual world Wonderland. The traditional lab usability environment consisted of a participant and a test facilitator physically located together in a lab to perform the usability test, as shown in Figure 6.2. The traditional lab usability test environment included a table, two chairs, one computer, and other supplemental materials, such as pens and paper.

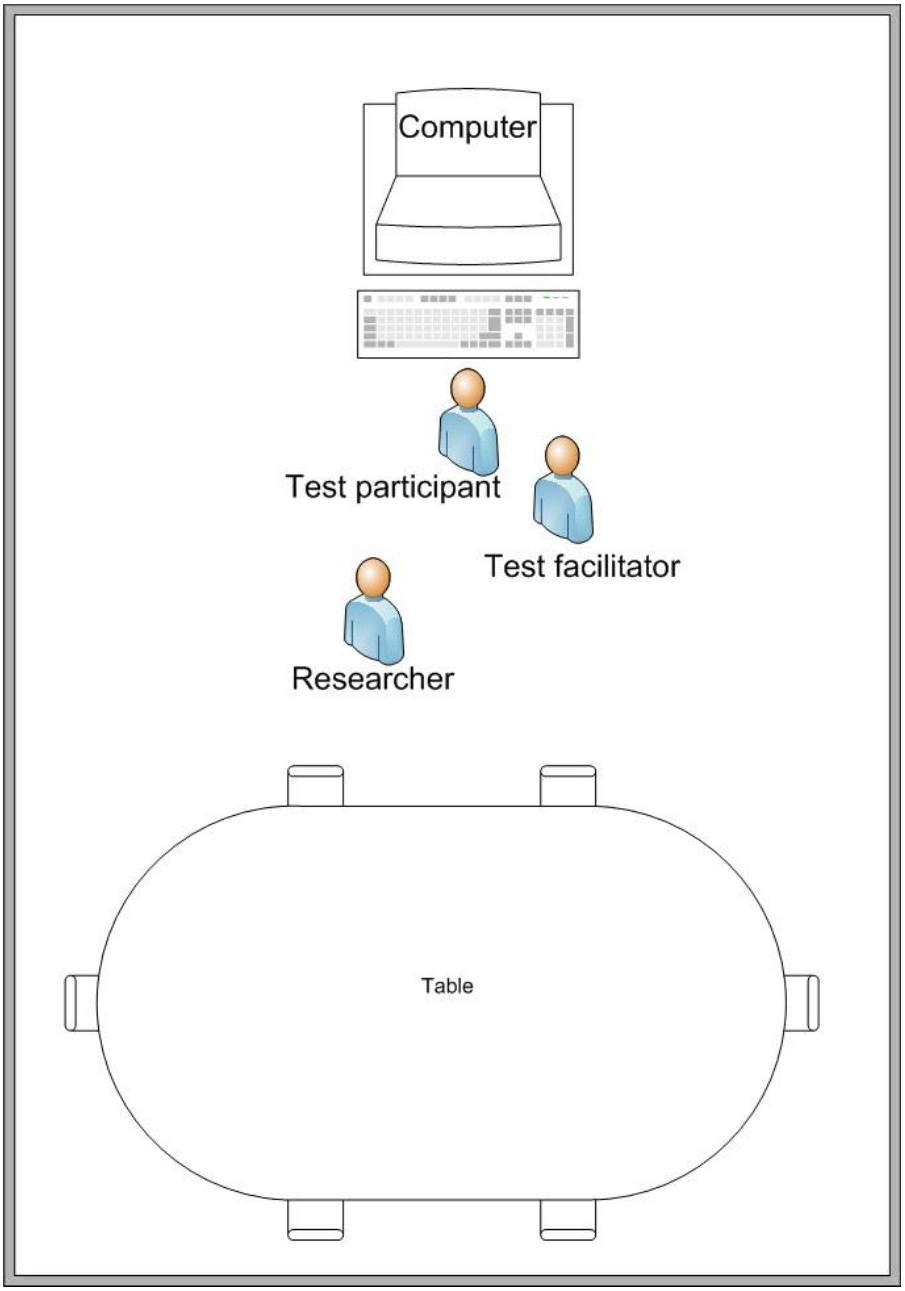


Figure 6.2: Traditional lab setup

The second test methodology employed WebEx, using the setup shown in Figure 6.3. The

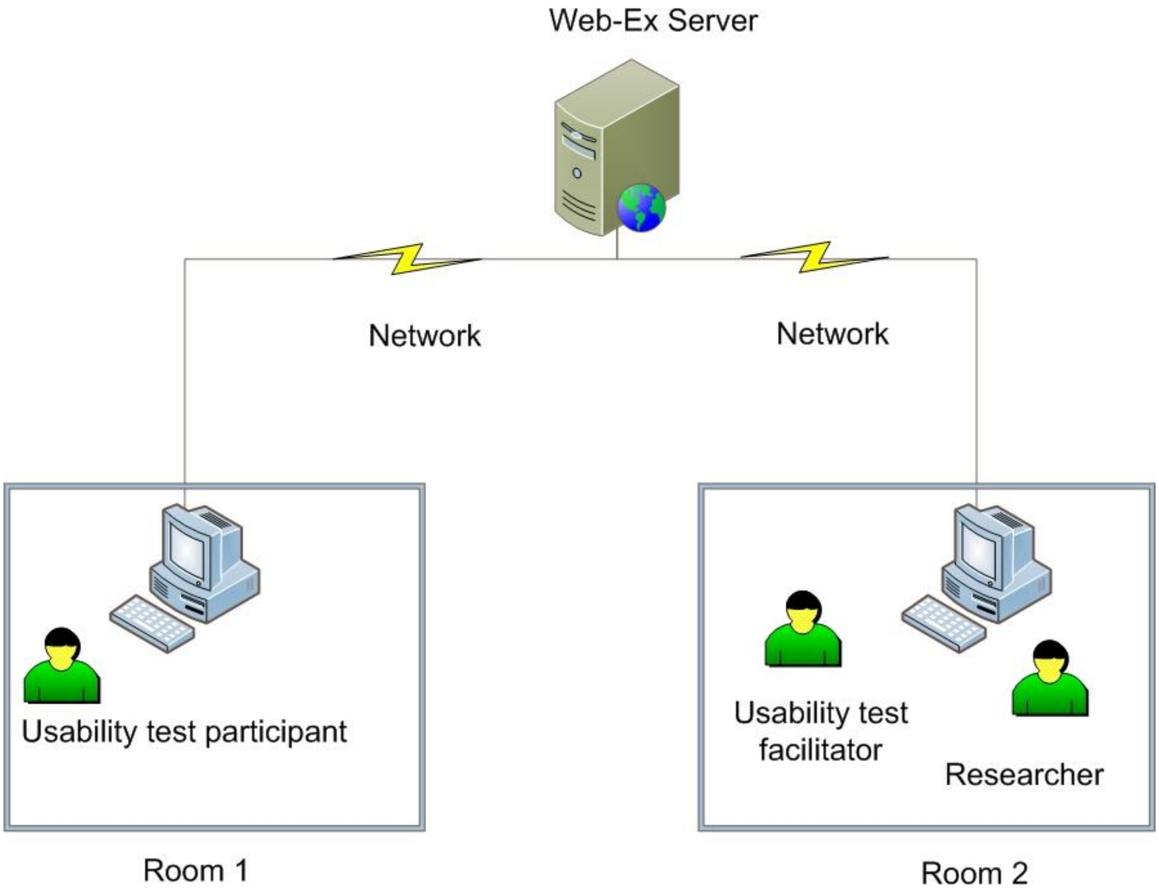
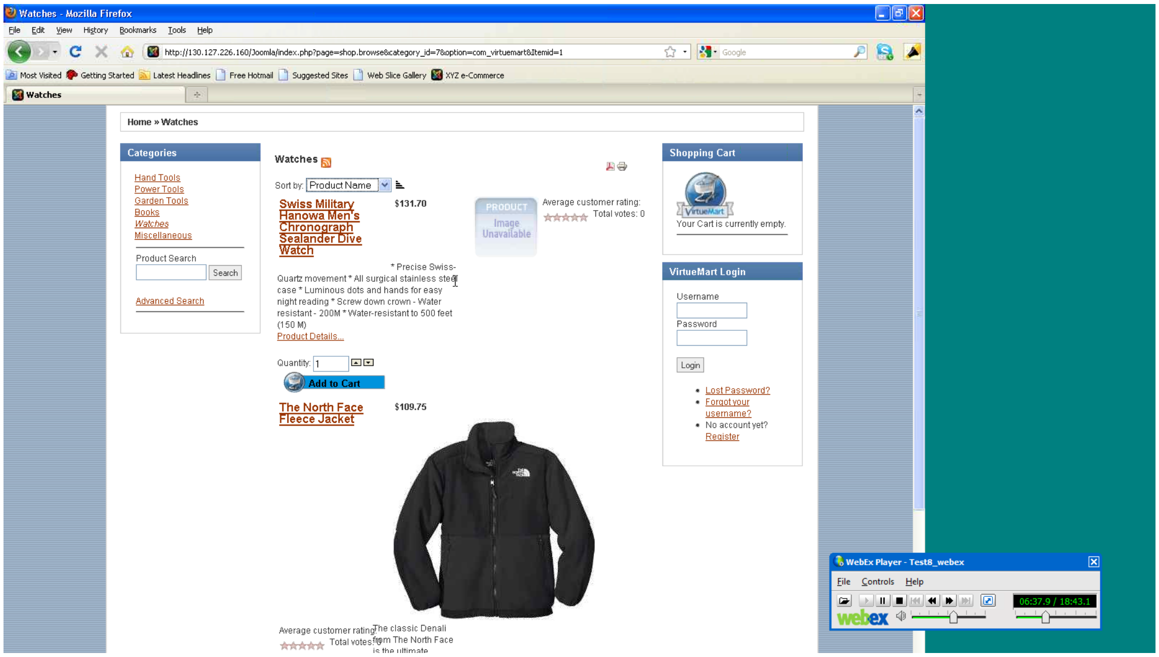


Figure 6.3 : WebEx test setup

WebEx environment provides a web browser for the participant and facilitator to share, as shown in Figure 6.4. Two computers were provided, one for the usability test participant and the other for the test facilitator. The participant and facilitator were physically separated in different rooms.



http://130.127.226.160/Joomla/index.php?page=shop.browse&category_id=7&option=com_virtuemart&Itemid=1

Home » Watches

Sort by: Product Name

Swiss Military Hanowa Men's Chronograph Sealander Dive Watch	$131.70
The North Face Fleece Jacket	$109.75

Average customer rating: Total votes: 0

* Precise Swiss-Quartz movement * All surgical stainless steel case * Luminous dots and hands for easy night reading * Screw down crown - Water resistant - 200M * Water-resistant to 500 feet (150 M)

Quantity: 1

Average customer rating: Total votes: 0

The classic Denali from The North Face is the ultimate

Your Cart is currently empty.

No account yet?

06:37.9 / 18:43.1

Figure 6.4: WebEx environment

The third test methodology employed was Wonderland. Its setup is shown in Figure 6.5:

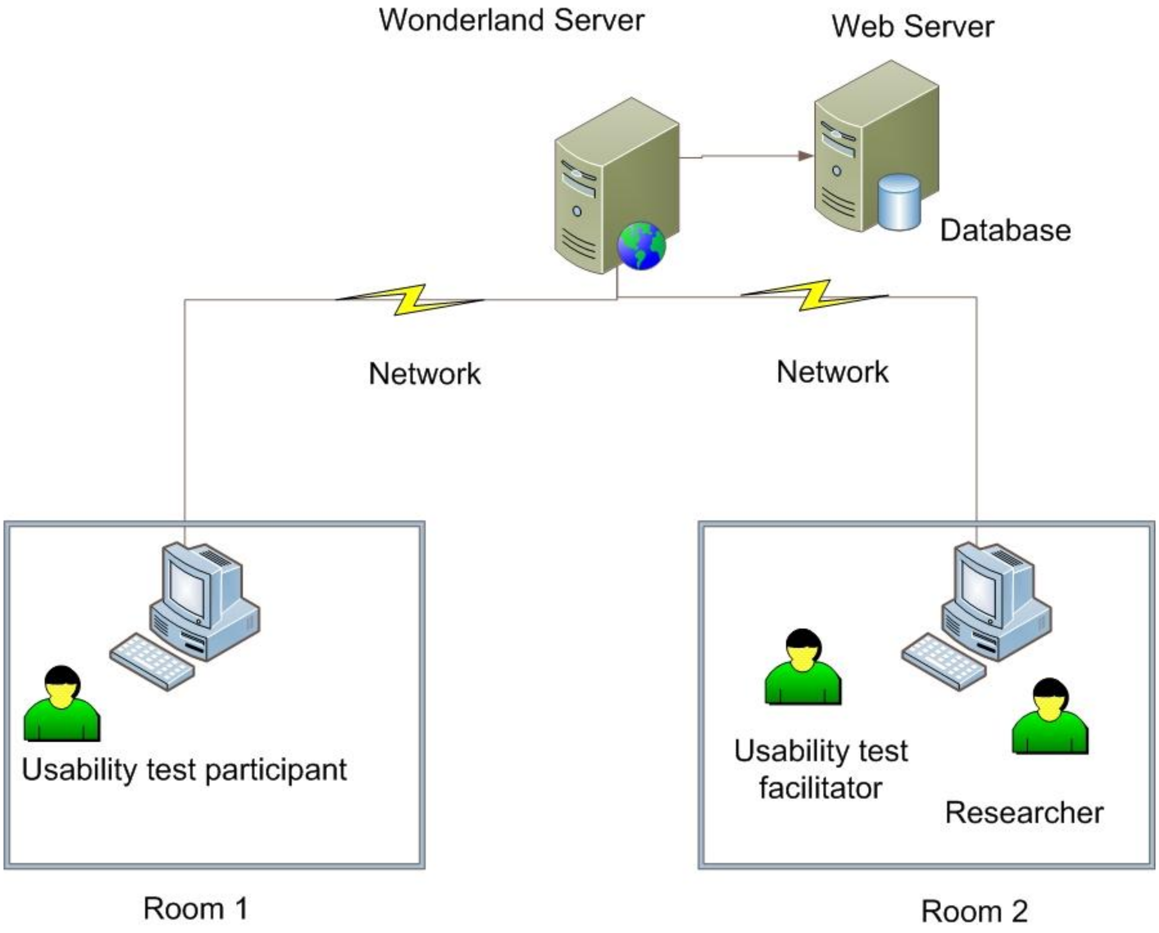
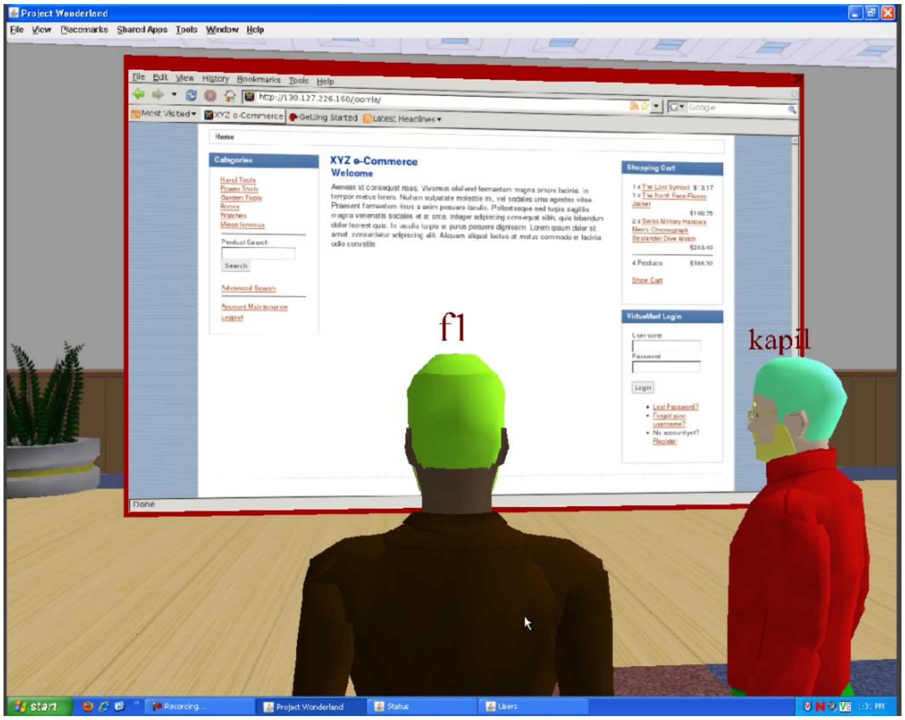


Figure 6.5 : Wonderland setup

The Wonderland environment consisted of a virtual usability testing laboratory equipped with an integrated web browser and a white board, both of which can be shared, as shown in Figure 6.6. Using these tools, the participants and facilitators can interact with a web application and record their concerns with the design of its interface. In addition, the team members can use text and audio chat tools to communicate through their avatars. Two computers were provided, one for the usability test participant and the other for the test facilitator. The participants and facilitators were physically separated in different rooms.



XYZ e-Commerce
Welcome

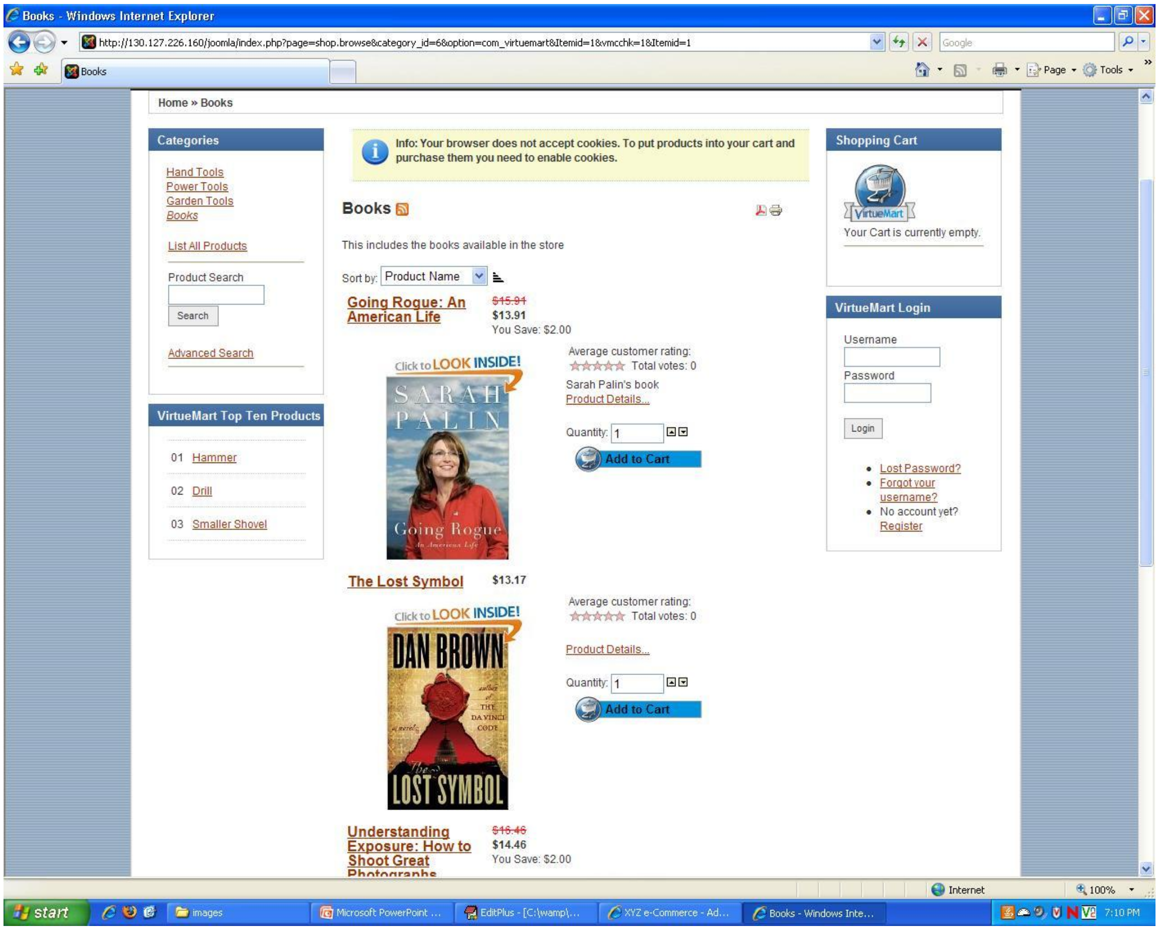
Aenean ut consequat risus. Vivamus eleifend fermentum magna ornare lacinia. In tempor metus lorem. Nullam vulputate molestie mi, vel sodales urna egestas vitae. Praesent fermentum risus a enim posuere iaculis. Pellentesque sed turpis sagittis magna venenatis sodales et ac arcu. Integer adipiscing consequat nibh, quis bibendum dolor laoreet quis. In iaculis turpis et purus posuere dignissim. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Aliquam aliquet luctus at metus commodo ac lacinia odio convallis

Figure 6.6: Wonderland environment

Tasks

An E-commerce web application modeled after Amazon was developed with usability flaws deliberately embedded. A screen shot of the application is presented in Figure 6.7. This application was developed using php and deployed on an Apache Tomcat web server running the Windows XP operating system with a MySQL database providing the data tier. All test participants, regardless of the test environment, performed the following tasks on the website:

1) Your watch is not working, and you want to buy a new Swiss watch. After checking the price, add the watch to your cart.
2) Winter is over, and you heard that there are good deals on North Face Jackets. Look for a North face jacket and add two to the cart.
3) One of your friends is a fan of Dan Brown's novels. Find Dan Brown's latest novel the *Lost Symbol* and add it to the cart.
4) Look in the shopping cart and change the quantity of Swiss watches to two.
5) Check out.



http://130.127.226.160/joomla/index.php?page=shop.browse&category_id=6&option=com_virtuemart&Itemid=1&vmcchk=1&Itemid=1

Info: Your browser does not accept cookies. To put products into your cart and purchase them you need to enable cookies.

This includes the books available in the store

Sort by: Product Name

Sarah Palin's book

Quantity: 1

Your Cart is currently empty.

Figure 6.7: E-commerce web application

After the completion of each task, the participant was asked to return to the e-commerce site’s home page.

Experimental Design

The study used a mixed experimental design, with the test facilitators observing the test participants’ interactions with the web interface in a within subjects design and the test participants experiencing the test environment in a between-subjects design. The within subject experimental design involves collecting data from the test facilitators who facilitates tests in each of the three environments. The between-subjects experimental design involves collecting data from test participants in one test environment and comparing this data with those from the participants in the other environments, with the constraint that data from an individual participant is collected in only one test environment. The experiment was counter-balanced using a Latin-square design, such that two test facilitators conducted the usability test session first with the traditional lab method, then with WebEx and finally with Wonderland and two test facilitators conducted the usability test sessions in each of five remaining possible orders.

Procedure

Irrespective of the usability testing environment, the facilitators and test participants followed the same procedure. Initially all the usability test facilitators were trained on how to conduct the usability test. Steve Krug’s usability test demonstration video was used for this purpose as well as to refresh the facilitators’ memories on the material in the usability engineering class that they had taken (Krug, 2009). At the beginning of each test session, the researcher greeted the test facilitator and the participant in a classroom and gave them a brief overview of the study. Then, the test facilitators were asked to read and sign the consent form found in Appendix A and to complete the pre-test questionnaire, asking for their basic demographic information, as seen in Appendix B. The test participant was asked to read and sign the consent form found in Appendix C and to complete the pre-test questionnaire in Appendix D to obtain their basic demographic information and their experience with relevant Internet technologies. Next, the facilitators were provided a list of tasks to be performed; including instructions on the scenarios the participant would experience using the web interface.

The facilitator and participant were then taken to their respective usability testing rooms and given a brief training session of approximately ten minutes to acquaint them with the environment. The test facilitator then gave the participant a sample task to familiarize him/her with the nature of the web application to be used during the test session. Next, the facilitator interacted with the participant as in a typical usability test session, asking him/her to complete the individual tasks. The researcher was co-located with the facilitator and recorded the time taken for each task using a stop watch. After each task, the test participant was asked to detail his/her concerns while interacting with the interface in a retrospective think-aloud session. The researcher recorded the concerns raised and Camtasia, the screen capture software, was used to record all screen and audio activity during both the task and the think-aloud session.

Upon completing the final task and think-aloud session, the participant and test facilitator completed the NASA-TLX test and the presence questionnaire (Witmer, 1998), found in Appendix E. The test participants also completed a post-test subjective questionnaire comprised of three sections concerning their satisfaction with the usability testing methodology, as seen in Appendix 7. The section on the effect of the environment assessed the quality of the test environment. The user satisfaction portion evaluated the perceived ease-of-use while performing the tasks, including how comfortable and confident participants felt in conducting the usability task and detecting the usability defects. The section on the quality of the collaborative usability test methodology assessed the perceived level of presence and co-presence in the test environment. The participants ranked each metric using a 7-point Likert scale, ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). Finally, the questionnaire contained a section for written comments. Then the participants were de-briefed by the researcher. The time taken for each session was approximately one hour. Once the test facilitators completed the three sessions in the three environments, they completed a post-test questionnaire assessing their satisfaction with the three usability testing methodologies shown in Appendix 8 and they were de-briefed.

Then, a heuristic evaluation was individually conducted by three people, the investigator, and two usability test experts, who are graduate students in the Human Factors program and had experience conducting usability evaluations. During this analysis, the severities of the problems were also rated to ensure consistency. Nielsen's severity rating scale (Nielsen, 2005) was used as the basis for this rating. This scale ranges from 0 to 4, with 4 indicating a catastrophic defect. The severity rating scale is presented in Table 1.

Severity Rating	Severity Description
0	I don't agree that this is a usability problem at all
1	Cosmetic problem. Need not be fixed unless extra time is available on project
2	Minor usability problem: fixing this should be given low priority

3	Major usability problem: important to fix, so should be given high priority
4	Usability catastrophe: imperative to fix this before product can be released

Table 6.1: Severity ratings and descriptions (Nielsen, 2005)

The three evaluators then combined their individual lists consisting of the problem descriptions and their respective severities. In case of disagreement on the problem and its severity, the web interface and the original data were further analyzed until an agreement was reached. The combined problem list was then compared with the list of problems identified by the users to ensure that all the problems were given a severity rating. The issues not identified during the heuristic evaluation were evaluated again until consensus was reached on their severity.

Objective and Subjective Measures Analyses

The three usability test methodologies were compared using objective and subjective measures. The objective measures consisted of the task completion time, the number of defects identified and the defects' severity, while the subjective measures consisted of the subjective data from the post-test and the NASA-TLX questionnaires completed by both the test participants and test facilitators. The data for the number of defects identified were obtained from the observations of the usability test facilitator and analysis of the Camtasia recording of the test session. The severity of each defect was obtained from the heuristic evaluation data provided by the usability experts. Task completion time was the time taken to complete each task.

The data collected were classified into the following two sets:

1. Dataset of test participants, which consisted of 36 datasets, 12 for each condition
2. Dataset of test facilitators, which consisted of 12 datasets.

Each usability test participant dataset was given a unique identifier and evaluated individually. The evaluation of each dataset was conducted by performing a thorough walkthrough of the videos and analyzing the pre-test, the NASA-TLX and the post-test subjective questionnaires. During the video analysis, the problems raised by the users were carefully evaluated and tabulated. The usability test facilitator datasets, which were also given unique identifiers, were analyzed based on the data from the pre-test and post-test questionnaires.

SPSS 17.0 was used to analyze the data. Initially, a normality test was conducted to determine whether the data followed a normal distribution. The subjective and objective data more or less followed a normal distribution. Hence, they were analyzed using a one-way ANOVA with a 95% confidence interval to determine the presence of significant differences, if any, among the test environments. If the null hypothesis of an ANOVA was rejected, the results were then subjected to a post-hoc least significance difference (LSD) test to determine the locus of the significant differences.

CHAPTER SEVEN

RESULTS

In this section, the three usability testing environments are compared with respect to the time taken to complete the tasks; the usability issues identified; the severity of these usability issues; and the subjective ratings from the NASA-TLX, the presence and post-test subjective questionnaires.

Time taken to complete the task

The time taken to complete the task was measured from the time the task was given to the participants to the time when they completed it by clicking the appropriate task completion button. The descriptive statistics for this metric are provided in Table 7.1. The task completion times are plotted in Figure 7.1.

		N	Mean	Std. Deviation	F value	Significance
Task1	TL	12	.9683	.80741	0.226	0.779
	WebEx	12	.9750	.72294		
	WL	12	1.1400	.57874		
	Total	36	1.0278	.69347		
Task 2	TL	12	.9233	.41849	1.171	0.323
	WebEx	12	1.0758	.47270		
	WL	12	1.1950	.41410		
	Total	36	1.0647	.43804		
Task3	TL	12	1.0333	.69712	0.330	0.772
	WebEx	12	1.0550	.91266		
	WL	12	1.2717	.76039		
	Total	36	1.1200	.77984		
Task4	TL	12	.7458	.39798	0.267	0.767
	WebEx	12	.8250	.59934		
	WL	12	.6767	.47400		
	Total	36	.7492	.48689		
Task5	TL	12	6.6367	1.69204	0.254	0.777
	WebEx	12	6.6833	1.92363		
	WL	12	6.2483	1.23463		
	Total	36	6.5228	1.60653		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.1: Descriptive statistics of the time taken for individual tasks

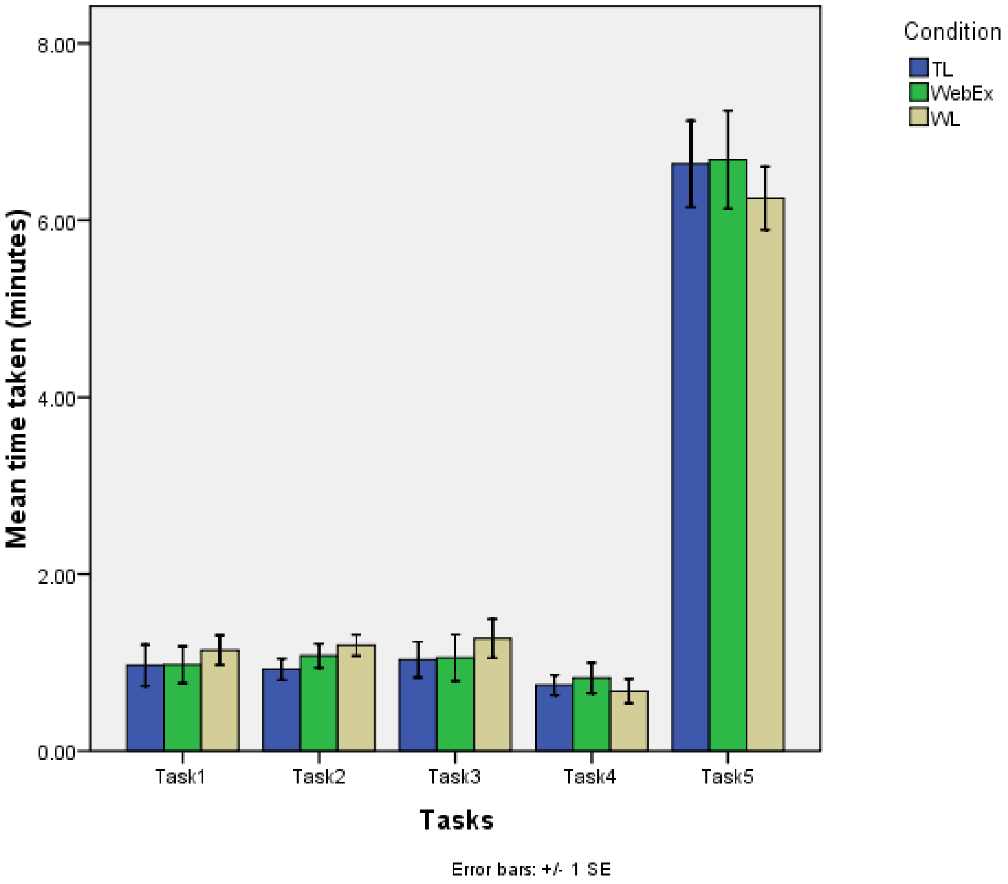


Figure 7.1: Mean time taken to complete the tasks

Though significant differences were not observed, it was found that for Tasks 1, 2 and 3, the mean time taken under the Wonderland condition was the longest of the other three conditions, whereas for Tasks 4 and 5, the mean time was shortest for Wonderland, as shown in Figure 7.1.

Number of usability problems identified

The effect of usability test environment on the total number of usability defects identified, was not significant, *F* (2, 33) = 1.406, *p*=0.260. The descriptive statistics for the total number of defects identified, number of Severity 1 defects, number of Severity 2 defects, number of Severity 3 defects and number of Severity 4 defects are provided in Table 7.2. The mean numbers of defects are plotted in Figure 7.2.

		N	Mean	Std. Deviation	F value	Significance
SEV-1	TL	12	2.0000	1.04447	2.509	0.097
	WebEx	12	1.2500	1.28806		
	WL	12	2.4167	1.50504		
	Total	36	1.8889	1.34754		
SEV-2	TL	12	2.7500	1.76455	3.222	0.050
	WebEx	12	3.3333	1.92275		
	WL	12	4.5833	1.72986		
	Total	36	3.5556	1.91899		
SEV-3	TL	12	1.3333	.65134	1.216	0.309
	WebEx	12	1.2500	.86603		
	WL	12	.9167	.51493		
	Total	36	1.1667	.69693		
SEV-4	TL	12	4.1667	1.11464	0.184	0.833
	WebEx	12	4.2500	1.60255		
	WL	12	3.9167	1.44338		
	Total	36	4.1111	1.36858		
TOTAL Defects	TL	12	10.2500	2.00567	1.406	0.260
	WebEx	12	10.0833	3.14667		
	WL	12	11.8333	3.15748		
	Total	36	10.7222	2.85468		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.2: Descriptive statistics of the defects identified in each condition

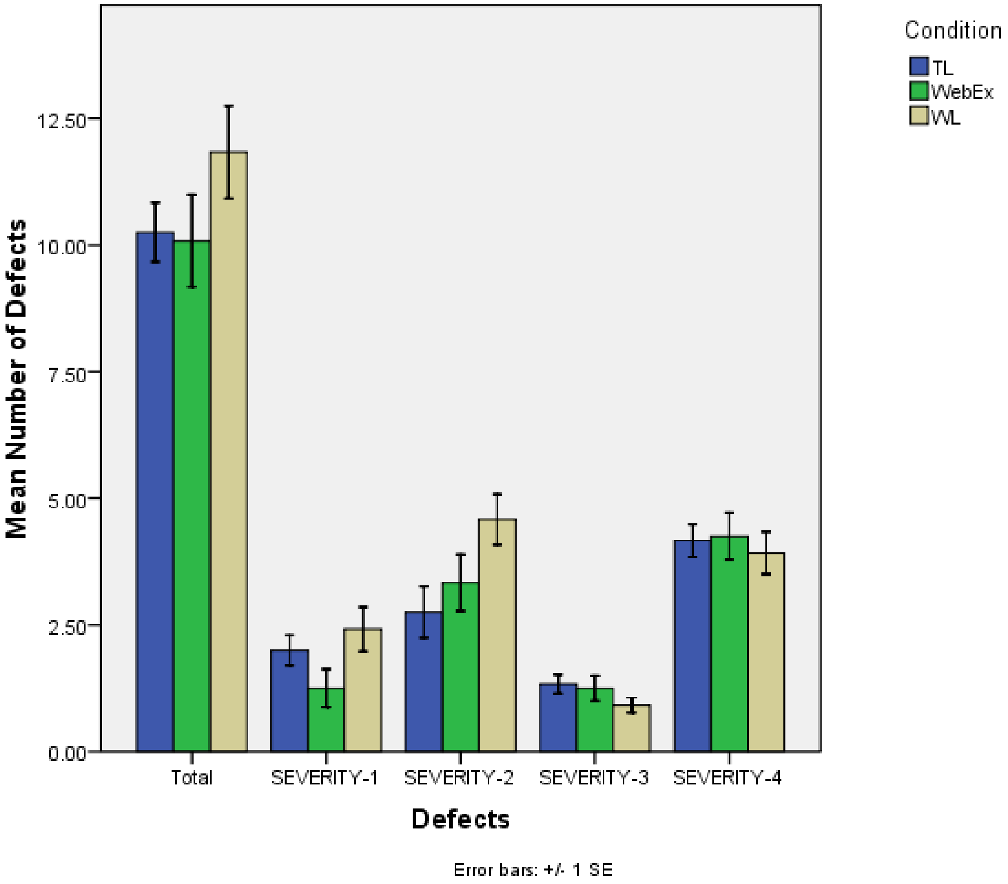


Figure 7.2: Defects identified in each condition

Severity 1 defects identified. A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the number of Severity 1 defects identified under the traditional lab, WebEx and Wonderland conditions. The effect of test environment on the number of Severity 1 defects identified, approached significance, *F* (2, 33) = 2.509, *p* = 0.097. Subsequent post-hoc analysis suggests that this effect is due to differences between the WebEx and Wonderland conditions (*p* = 0.034). Overall, these results suggest that a higher number of Severity 1 defects were identified in the Wonderland condition than in the WebEx condition.

Severity 2 defects identified. A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the number of Severity 2 defects identified under traditional lab, WebEx and Wonderland conditions. The effect of test environment on the number of Severity 2 issues identified approached significance, F (2, 33) = 3.222, p=0.050. Subsequent post-hoc analysis reveals that there is a significant difference in the number of Severity 2 defects identified for the traditional lab and Wonderland condition (p = 0.018). A higher number of severity 2 defects were identified in the Wonderland condition than in the traditional lab condition.

Severity 3 defects identified. A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the number of Severity 3 defects identified under traditional lab, WebEx and Wonderland conditions. The effect was not significant, F (2, 33) = 1.216, p=0.309.

Severity 4 defects identified. A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the number of severity 4 defects identified under traditional lab, WebEx and Wonderland conditions. The effect was not significant, F (2, 33) = 1.406, p=0.260.

Test participants’ experience

NASA-TLX Workload Indices:

The NASA-TLX is a subjective workload assessment instrument, which derives the total workload based on the weighted average ratings of the six subscales of mental demand, physical demand, temporal demand, effort, performance and frustration. The description of each subscale is provided in Table 7.3. The descriptive statistics for the NASA-TLX metrics are shown in Table 7.4. The mean values for the workload indices are plotted in Figure 7.3.

Title	Endpoints	Descriptions
Mental Demand	*Low/High*	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical Demand	*Low/High*	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Temporal Demand	*Low/High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Effort	*Low/High*	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Performance	*Good/Poor*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Frustration Level	*Low/High*	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Table 7.3: NASA-TLX rating scale definitions (Hart, 2002)

		N	Mean	Std. Deviation	F Value	Significance
Workload	TL	12	19.6101	10.46474	4.00	0.028
	WebEx	12	38.4156	18.88981		
	WL	12	33.3040	19.60892		
	Total	36	30.4432	18.22753		
Mental Demand	TL	12	6.1111	2.63363	1.482	0.242
	WebEx	12	8.7500	7.76175		
	WL	12	5.5278	2.10559		
	Total	36	6.7963	4.95265		
Physical Demand	TL	12	.9722	1.12329	1.640	0.209
	WebEx	12	2.5000	3.56044		
	WL	12	4.1944	6.56354		
	Total	36	2.5556	4.43865		
Temporal Demand	TL	12	2.0833	2.98524	0.778	0.468
	WebEx	12	3.3611	3.94010		
	WL	12	4.5000	6.57590		
	Total	36	3.3148	4.71939		
Effort	TL	12	4.1667	5.69867	0.510	0.605
	WebEx	12	6.2222	6.35059		
	WL	12	4.2778	4.63808		
	Total	36	4.8889	5.52800		
Performance	TL	12	3.0833	1.86475	4.317	0.022
	WebEx	12	9.0278	8.56874		
	WL	12	4.0278	2.86200		
	Total	36	5.3796	5.80867		
Frustration level	TL	12	3.1944	4.40720	2.557	0.093
	WebEx	12	8.5556	9.41450		
	WL	12	10.7778	10.29202		
	Total	36	7.5093	8.81322		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.4: Descriptive statistics of the NASA-TLX metrics for test participants

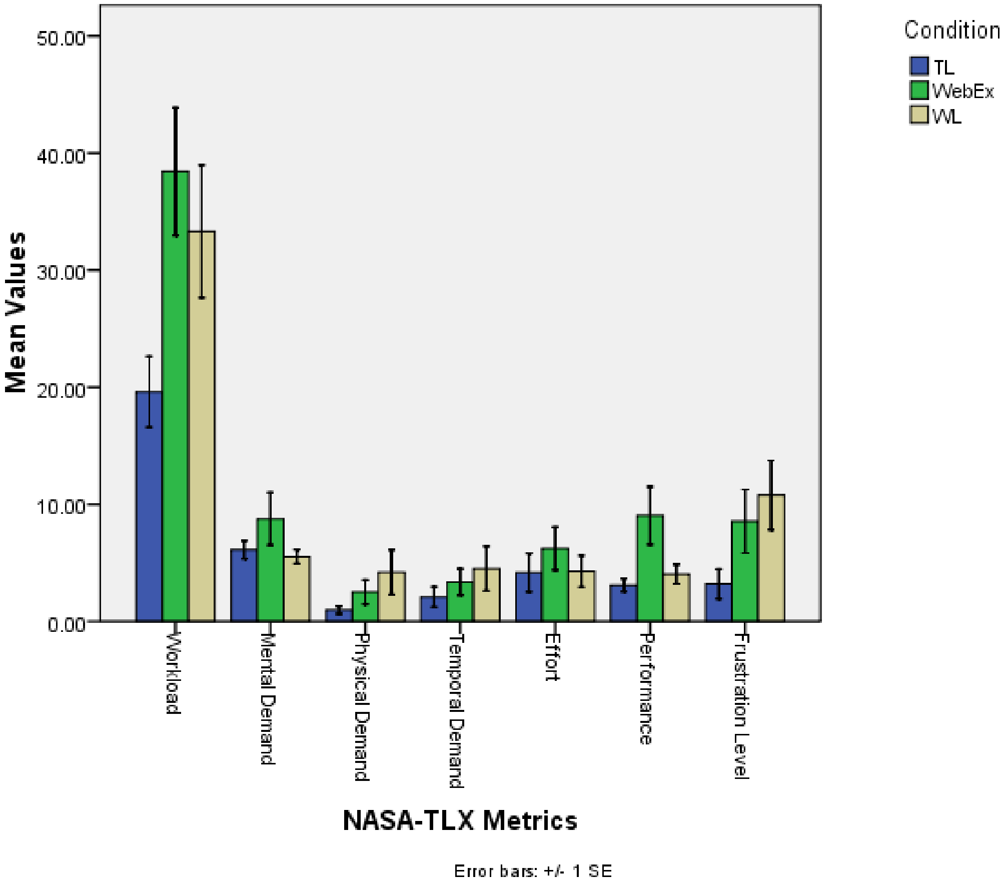


Figure 7.3: NASA-TLX workload indices for the test participants

Total Workload: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition experienced by the test participants. The effect of test environment was significant, *F* (2, 33) = 4.00, *p*=0.028. Subsequent post-hoc analysis reveals that the total workload experienced in the traditional lab testing environment is lower than that experienced in WebEx (p = 0.010) and Wonderland (p = 0.055) conditions.

Mental Demand: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the mental demand experienced by the participants. The effect was not significant, F (2,33) = 1.482, p = 0.242.

Physical Demand: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the physical demand experienced by the participants. The effect was not significant, F (2, 33) = 1.640, p = 0.209.

Temporal Demand: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the temporal demand experienced by the participants. The effect was not significant, F (2, 33) = 0.778, p = 0.468.

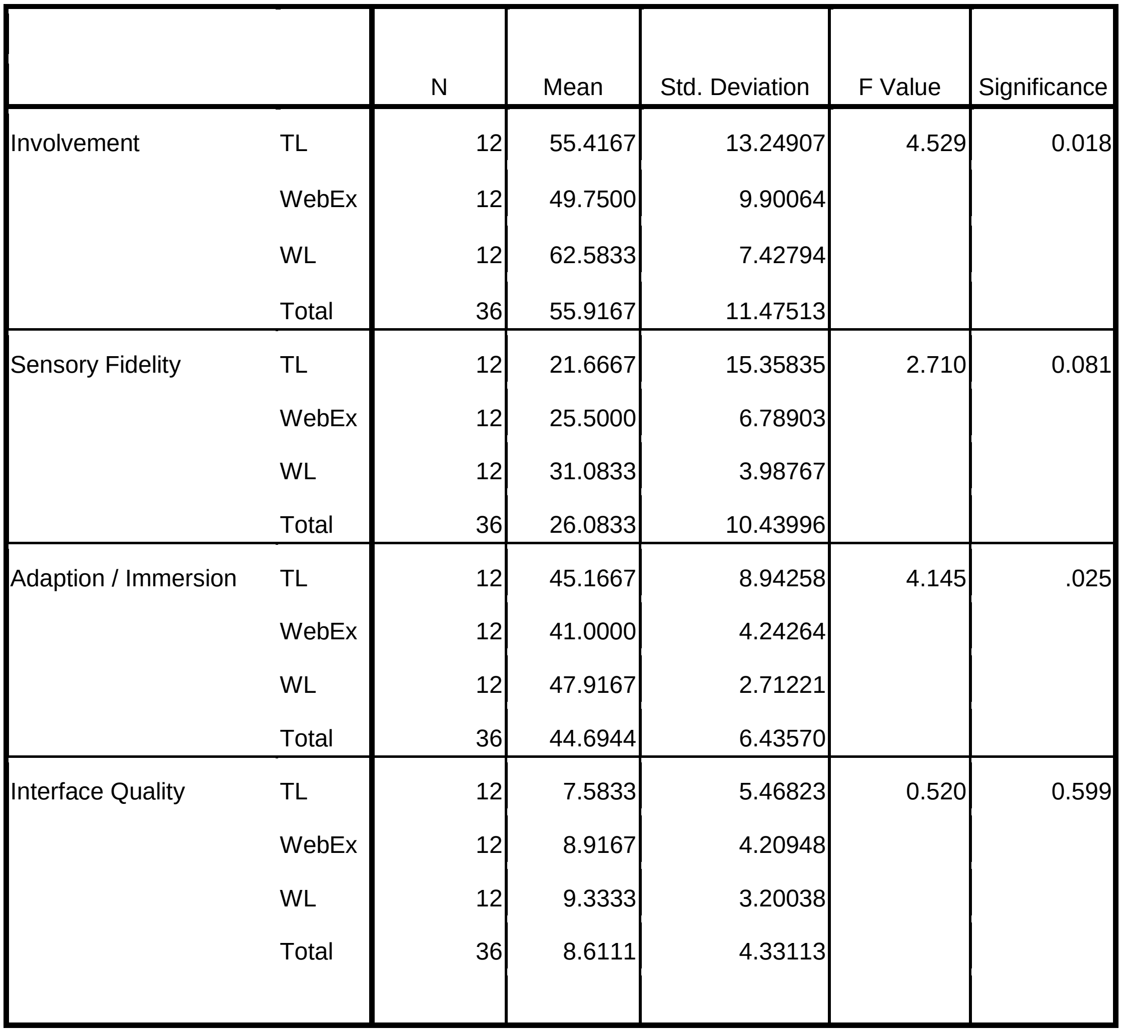
Effort: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the effort required by the participants. The effect was not significant, F (2,33) = 0.510, p = 0.605.

Performance: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the performance component of the NASA-TLX workload index. The effect of test environment on the performance component was significant, F (2,33) = 4.317, p=0.022. Subsequent post-hoc analysis reveals that the performance component of workload was higher in the WebEx test environment than in either the traditional lab (p=0.010) or the Wonderland (p=0.028) test environments.

Frustration: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on the frustration experienced by the participants. The effect of test environment on frustration level approached significance, F (2,33) = 2.557, p=0.093. Subsequent post-hoc analysis suggests that this effect is due to differences between the traditional lab testing and Wonderland-based testing environments (p = 0.035). These results suggest that frustration was lower for the traditional lab condition than for the Wonderland testing condition.

Presence Questionnaire

The effectiveness of a virtual environment is to some extent dependent on the sense of presence experienced by its users (Witmer *et al.*, 1998). The presence questionnaire categorized the overall usability testing experience into subscales of involvement, sensory fidelity, adaption/ immersion and interface quality. The descriptive statistics for these presence metrics are shown in Table 7.5. Mean values of these metrics are plotted in Figure 7.4.



		N	Mean	Std. Deviation	F Value	Significance
Involvement	TL	12	55.4167	13.24907	4.529	0.018
	WebEx	12	49.7500	9.90064		
	WL	12	62.5833	7.42794		
	Total	36	55.9167	11.47513		
Sensory Fidelity	TL	12	21.6667	15.35835	2.710	0.081
	WebEx	12	25.5000	6.78903		
	WL	12	31.0833	3.98767		
	Total	36	26.0833	10.43996		
Adaption / Immersion	TL	12	45.1667	8.94258	4.145	.025
	WebEx	12	41.0000	4.24264		
	WL	12	47.9167	2.71221		
	Total	36	44.6944	6.43570		
Interface Quality	TL	12	7.5833	5.46823	0.520	0.599
	WebEx	12	8.9167	4.20948		
	WL	12	9.3333	3.20038		
	Total	36	8.6111	4.33113		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.5: Presence metrics for the usability test participants

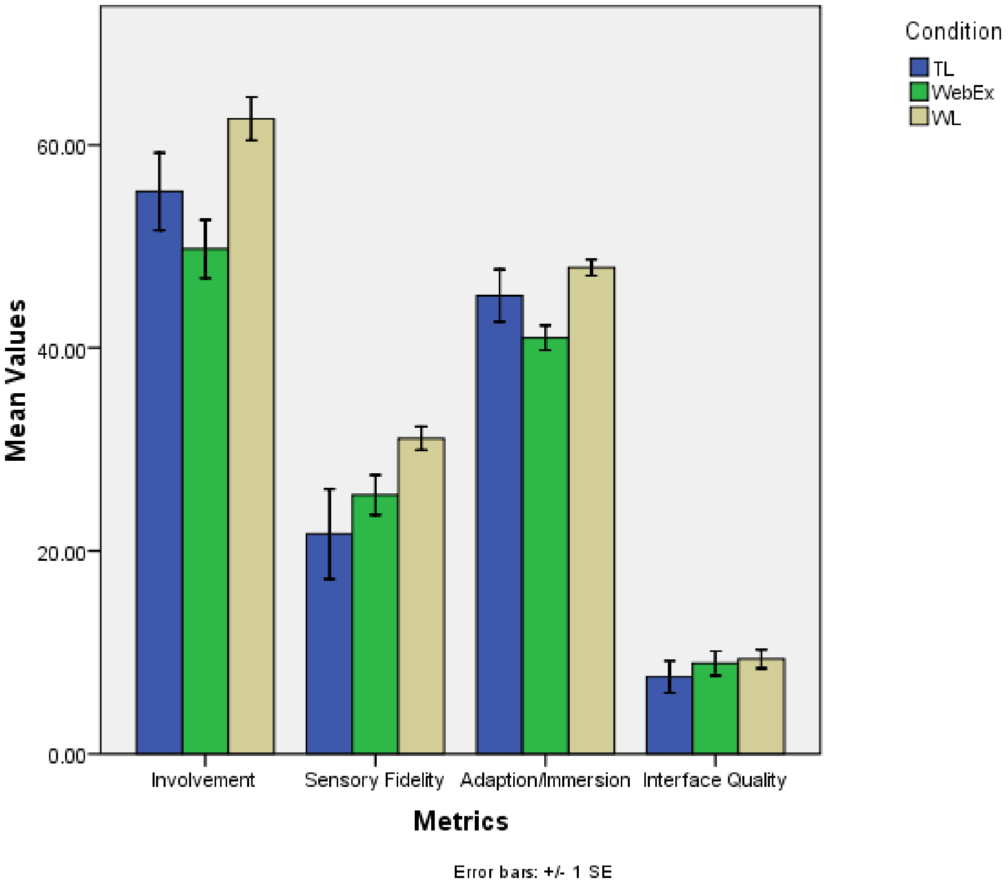


Figure 7.4: Presence metrics for the usability test participants

Involvement: A one-way between subjects ANOVA was conducted to test the effect of usability test environment on this metric. The effect of test environment on involvement was significant, *F* (2, 33) = 4.529, *p* = 0.018. Subsequent post-hoc analysis reveals that there is a significant difference between the WebEx and Wonderland testing conditions (*p* = 0.005). Test participants experienced a lower level of involvement in the WebEx condition than in the Wonderland condition.

Sensory Fidelity: A one-way between subjects ANOVA was conducted to test the effect of the usability test environment on the sensory fidelity experienced by the usability test participants. The effect of test environment on sensory fidelity was not significant, *F* (2, 33) = 2.710, *p* = 0.081.

Adaption/ Immersion: A one-way between subjects ANOVA was conducted to test the effect of the usability test environment on this metric. The effect was significant, *F* (2,33) = 4.145 *p*=0.025. Subsequent post-hoc analysis reveals that there is a significant difference in adaption/immersion for the WebEx and Wonderland (*p*=0.007) testing conditions. Participants achieved a higher level of immersion in the Wonderland environment than in the WebEx environment.

Interface Quality: A one-way between subjects ANOVA was conducted to test the effect of the usability test environment on the participants' perception of the quality of the interface. The effect was not significant, *F* (2, 33) = 0.520, *p*=0.599.

Post-test subjective questionnaire

The subjective rating questionnaire totalled 15 questions, 4 asking about the naturalness of the environment, 5 asking about the satisfaction with and ease-of-use of the usability testing methodology and 6 questions on the quality of the usability test methodology, as shown in Table 7.6. The mean value was calculated for each of these categories. The descriptive statistics for each category are shown in Table 7.7. Mean values are plotted in Figure 7.5.

Category	Statements
Naturalness of the environment	1. I had a sense of being in a meeting room. 2. I felt like I was in a usability testing environment. 3. The usability testing laboratory environment seemed natural. 4. I was confused in this usability testing environment
User satisfaction and ease-of-use	1. I would like to participate in usability tests using this meeting environment 2. The usability testing methodology was user-friendly. 3. Learning to participate in the usability test in this environment was easy for me. 4. I found this meeting environment to be more useful for a usability test. 5. Overall, I felt comfortable participating in the usability test.
Quality of usability test methodology	1. It was easy to identify usability defects in the website. 2. I feel confident that I identified the websites' most serious defects. 3. I had a strong sense of being with the usability expert within the environment. 4. I feel that I worked well with the usability expert to complete the usability test. 5. I feel that the environment facilitated and supported collaboration with the test administrator. 6. I feel that the environment facilitated seamless communication with the test facilitator.

Table 7.6: Statements in the subjective rating questionnaire

		N	Mean	Std. Deviation	F Value	Significance
Naturalness of the environment	TL	12	4.2708	.85585	0.202	0.818
	WebEx	12	4.0625	.82658		
	WL	12	4.1875	.73951		
	Total	36	4.1736	.79016		
User satisfaction and ease of use	TL	12	6.3500	.54689	3.715	0.035
	WebEx	12	5.6667	.71010		
	WL	12	5.5167	1.05299		
	Total	36	5.8444	.85805		
Quality of the usability test methodology	TL	12	5.5833	.63365	0.881	0.424
	WebEx	12	5.2500	.96006		
	WL	12	5.7222	1.04043		
	Total	36	5.5185	.89245		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.7: Descriptive statistics of the subjective ratings by the test participants

Naturalness of the environment: A one-way between subjects ANOVA was conducted to test the effect of the usability test environment on naturalness. The effect was not significant, $F(2,33) = 0.202$, $p=0.818$.

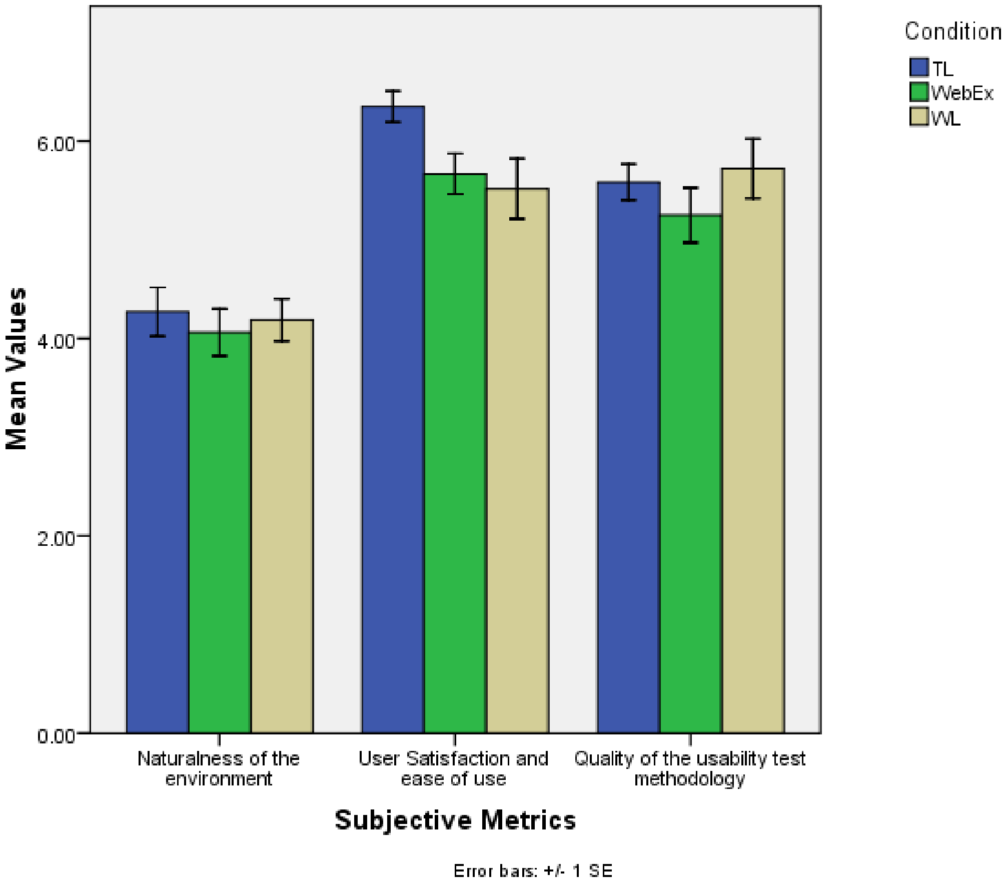


Figure 7.5. Subjective ratings by the test participants

User satisfaction and ease-of-use: A one-way between subjects ANOVA was conducted to test the effect of the usability test condition on this metric. The effect of test environment on user satisfaction and ease-of-use was significant, F (2,33) = 3.715 p=0.035. Subsequent post-hoc analysis revealed that the traditional lab test environment scored higher in user satisfaction and ease-of-use than WebEx (p=0.044) and Wonderland (p=0.015) test environments.

Quality of the usability testing methodology: A one-way between subjects ANOVA was conducted to test the effect of the usability test environment on this metric. The effect was not significant, *F* (2, 33) = 0.881, *p*=0.424.

Test facilitator's experience

The following section summarizes the results for the NASA-TLX, presence and post-test subjective questionnaires answered by the 12 test facilitators who experienced each of the three conditions. Descriptive statistics for the metrics are shown in Table 7.8. The mean values for the metrics are plotted in Figure 7.6.

		N	Mean	Std. Deviation	F Value	Significance
Workload	TL	12	30.33	6.07	5.843	0.021
	WebEx	12	39.91	12.46		
	WL	12	41.85	9.95		
Mental Demand	TL	12	10.68	2.78	1.639	0.242
	WebEx	12	11.08	5.40		
	WL	12	13.55	5.37		
Physical Demand	TL	12	5.75	2.93	5.306	0.027
	WebEx	12	8.74	4.02		
	WL	12	8.80	5.20		
Temporal Demand	TL	12	1.25	3.81	1.625	0.245
	WebEx	12	0.49	1.36		
	WL	12	0.80	1.69		
Effort	TL	12	3.73	2.16	6.241	0.017
	WebEx	12	6.86	4.73		
	WL	12	5.22	2.80		
Performance	TL	12	5.77	2.97	0.913	0.432
	WebEx	12	6.97	3.16		
	WL	12	6.58	3.95		
Frustration level	TL	12	2.91	2.42	6.660	0.014
	WebEx	12	5.75	3.20		
	WL	12	6.58	2.84		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.8: Descriptive statistics of the NASA-TLX metrics for test facilitators

Workload: A one-way within subjects, or repeated measures, ANOVA was conducted to test the effect of usability test condition on this metric. The effect of test environment on the total workload experienced was significant, Wilks' Lambda =0.461, *F* (2, 10) = 5.843, *p*=0.021. Subsequent post-hoc analysis reveals that the total workload experienced in the traditional lab condition is lower than that experienced in WebEx (*p*=0.015) and Wonderland conditions (*p*=0.007).

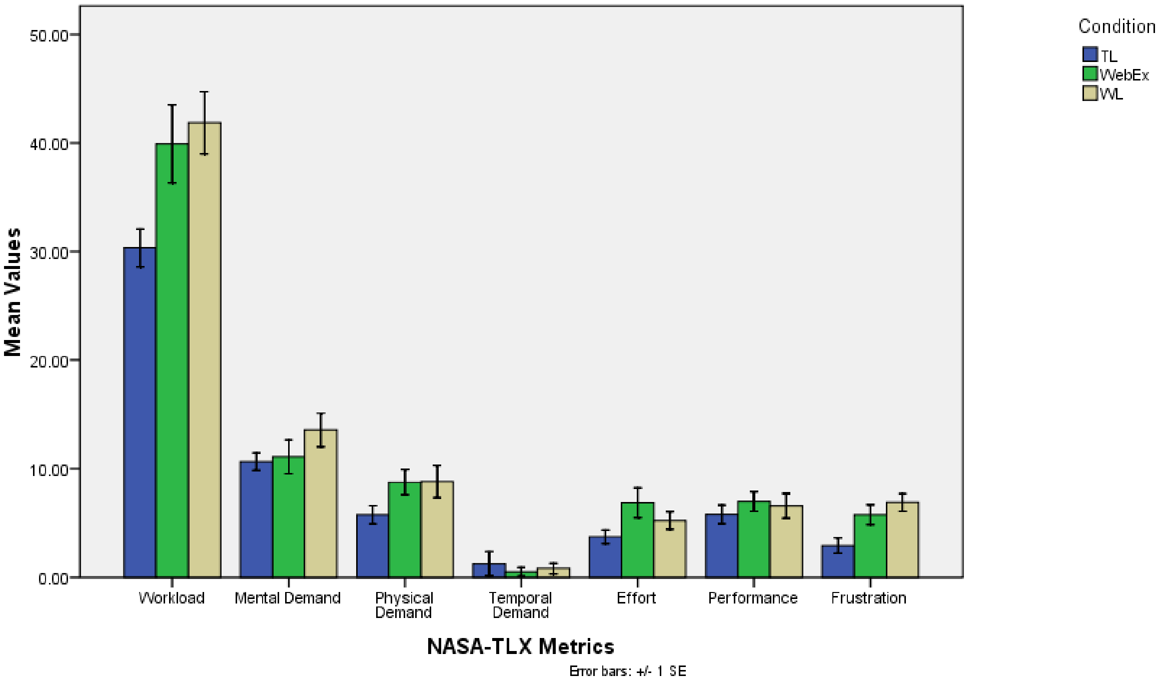


Figure 7.6: NASA-TLX metrics of the test facilitators

Mental Demand: A one-way within subjects ANOVA was conducted to test the effect of test environment on this metric. The effect was not significant, Wilks' Lambda =0.753, *F* (2, 10) = 1.639, *p*=0.242.

Physical Demand: A one-way within subjects ANOVA was conducted to test the effect of usability test condition on this metric. The effect of test environment on physical demand was significant, Wilks' Lambda =0.485, *F* (2, 10) = 5.306, *p*=0.027. Subsequent post-hoc analysis reveals that the physical demand experienced in the traditional lab testing environment is lower than that experienced in WebEx (*p*=0.008) and Wonderland (*p* = 0.023) conditions.

Temporal Demand: A one-way within subjects ANOVA was conducted to test the effect of the usability test condition on this metric. The effect was not significant, Wilks' Lambda =0.755, *F* (2, 10) = 1.625, *p*=0.245.

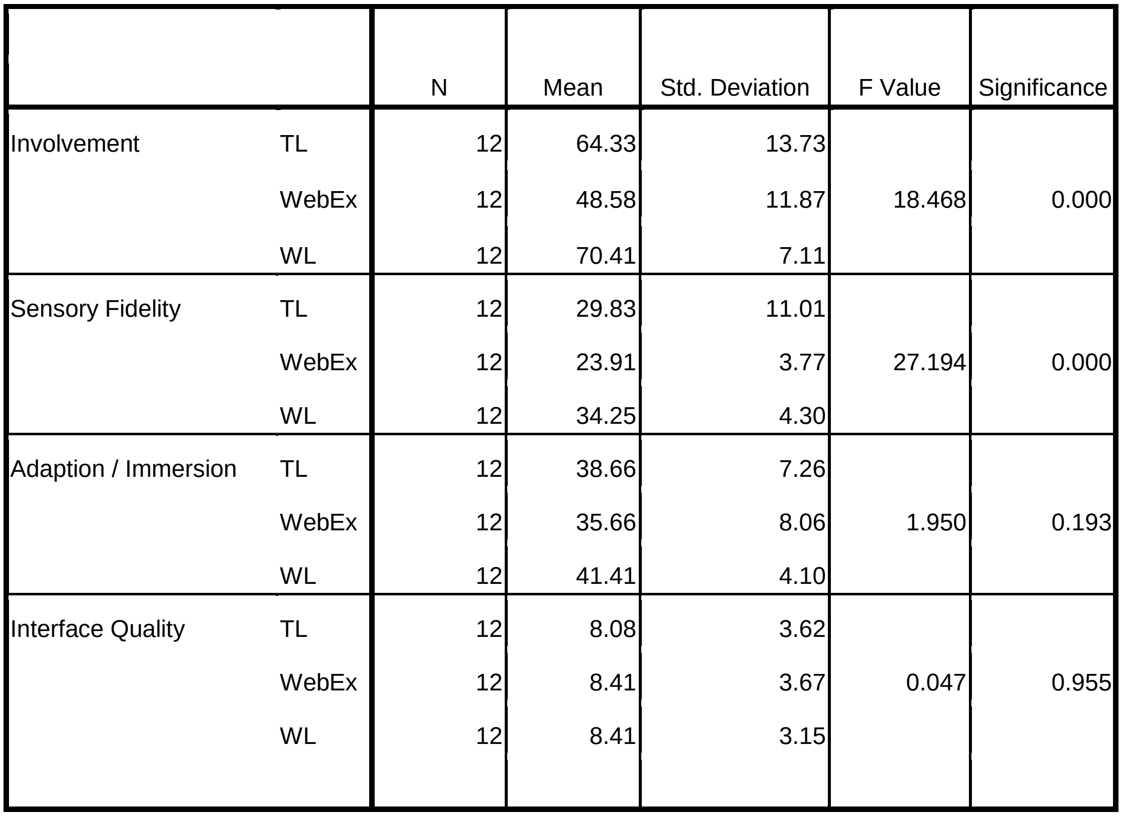
Effort: A one-way within subjects ANOVA was conducted to test the effect of usability test condition on this metric. The effect of test environment was significant, Wilks' Lambda =0.445, *F* (2, 10) = 6.241, *p*=0.017. Subsequent post-hoc analysis reveals that facilitators exerted less effort in traditional lab testing environment than in WebEx (*p*=0.026) and Wonderland conditions (*p*=0.050).

Performance: A one-way within subjects ANOVA was conducted to test the effect of usability test condition on this metric. The effect was not significant, Wilks' Lambda =0.846, *F* (2, 10) = 0.913, *p*=0.432.

Frustration: A one-way within subjects ANOVA was conducted to test the effect of usability condition on this metric. The effect of test environment on frustration was significant, Wilks' Lambda =0.429, *F* (2, 10) = 6.6, *p*=0.014. Subsequent post-hoc analysis reveals that facilitators experienced less frustration in the traditional lab testing environment than in WebEx (*p*=0.035) and Wonderland (*p*=0.003) conditions.

Presence Questionnaire

The sense of presence was analyzed by administering the presence questionnaire, which categorized the overall experience into subscales of involvement, sensory fidelity, adaption/ immersion and interface quality. The descriptive statistics for these metrics are shown in Table 7.9. Mean values for the metrics are plotted in Figure 7.7.



		N	Mean	Std. Deviation	F Value	Significance
Involvement	TL	12	64.33	13.73		
	WebEx	12	48.58	11.87	18.468	0.000
	WL	12	70.41	7.11		
Sensory Fidelity	TL	12	29.83	11.01		
	WebEx	12	23.91	3.77	27.194	0.000
	WL	12	34.25	4.30		
Adaption / Immersion	TL	12	38.66	7.26		
	WebEx	12	35.66	8.06	1.950	0.193
	WL	12	41.41	4.10		
Interface Quality	TL	12	8.08	3.62		
	WebEx	12	8.41	3.67	0.047	0.955
	WL	12	8.41	3.15		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.9: Descriptive statistics of the presence metrics for test facilitators

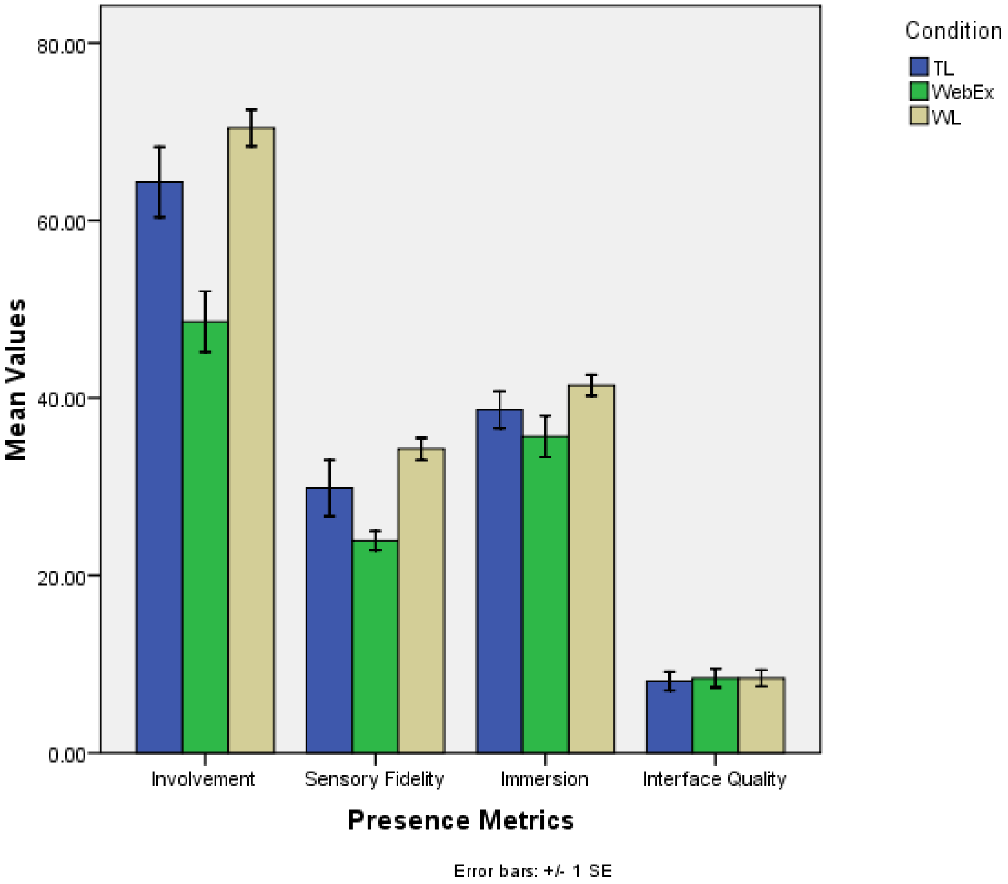


Figure 7.7: Presence metrics for the usability test facilitators.

Involvement: A one-way within subjects ANOVA was conducted to test the effect of usability test environment on this metric. The effect was significant, Wilks' Lambda =0.213, *F* (2, 10) = 18.468, *p*=0.000. Subsequent post-hoc analysis reveals that facilitators experienced a lower level of involvement in the WebEx condition than they did in the traditional lab (*p*=0.004) and Wonderland (p=0.000) testing environments.

Sensory Fidelity: A one-way within subjects ANOVA was conducted to compare the effect of this metric for the traditional lab, WebEx and Wonderland conditions. There was a significant effect in the sensory fidelity experienced under the three conditions, Wilks' Lambda =0.155, *F* (2, 10) = 27.194, *p*=0.000 as shown in Figure 12. Subsequent post-hoc analysis suggests that the experience of sensory fidelity was lower for the WebEx condition than it was for Wonderland (*p*=0.000) condition.

Adaption/ Immersion: A one-way within subjects ANOVA was conducted to test the effect of this metric for the traditional lab, WebEx and Wonderland conditions. The effect was not significant, Wilks' Lambda =0.719, *F* (2, 10) = 1.950, *p*=0.193.

Interface Quality: A one-way within subjects ANOVA was conducted to compare the effect of this metric for the traditional lab, WebEx and Wonderland conditions. The effect was not significant, Wilks' Lambda =0.991, *F* (2, 10) = 0.047, *p*=0.955.

Post-test subjective questionnaire

The descriptive statistics for each of the categories addressed by the post-test subjective questionnaire are shown in Table 7.10. The mean values are plotted in Figure 7.8.

		N	Mean	Std. Deviation	F Value	Significance
Ease-of-use	TL	12	6.66	0.651	25.78	0.000
	WebEx	12	5.50	1.08		
	WL	12	5.50	1.00		
Seamless communication	TL	12	6.33	1.49	2.43	0.137
	WebEx	12	5.91	0.90		
	WL	12	6.25	0.75		
Sense of presence	TL	12	6.91	0.28	23.10	0.000
	WebEx	12	4.66	1.30		
	WL	12	5.91	1.16		
Confidence	TL	12	6.16	1.40	1.93	0.196
	WebEx	12	5.25	1.13		
	WL	12	5.50	0.67		
Efficiency	TL	12	6.00	1.70	0.58	0.575
	WebEx	12	5.41	1.08		
	WL	12	5.58	0.79		
Analyze user interaction	TL	12	6.75	0.62	17.66	0.001
	WebEx	12	5.75	0.75		
	WL	12	4.66	1.07		
Comfort level	TL	12	6.08	1.37	3.64	0.065
	WebEx	12	5.58	1.16		
	WL	12	6.08	0.79		
Likeability	TL	12	6.16	1.02	0.99	0.964
	WebEx	12	6.08	0.66		
	WL	12	6.08	0.66		

TL - Traditional lab methodology; WL - Wonderland methodology

Table 7.10: Descriptive statistics of the subjective satisfaction for the test facilitators

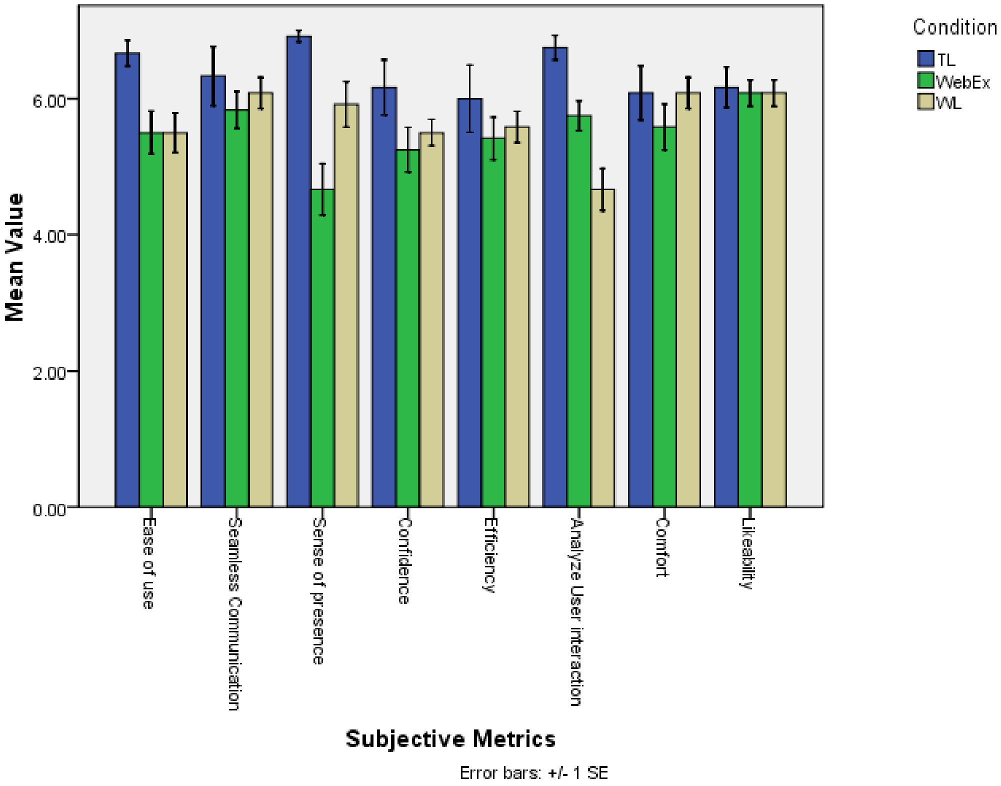


Figure 7.8: Subjective satisfaction metrics for the test facilitators

Ease of use: The effect of usability test environment on ease of use was significant, Wilks' Lambda =0.162, *F* (2, 10) = 25.78, *p*=0.000. Subsequent post-hoc analysis reveals that facilitators found the traditional lab test environment easier to use than the WebEx (*p* =0.006) and Wonderland (*p*= 0.001) environments.

Seamless communication with test participant during the think-aloud process: The effect of test environment on communication with the test participant during the think-aloud process was not significant, Wilks' Lambda =0.672, *F* (2, 10) = 2.43, *p*=0.137.

A strong sense of presence with the test participant: The effect of usability test environment on the facilitators' sense of presence was significant, Wilks' Lambda =0.178, *F* (2, 10) = 23.10, *p*=0.000. Subsequent post-hoc analysis reveals that the facilitators' sense of presence with the test participant was higher in the traditional lab than in the WebEx (*p*=0.000) environment.

Confidence in conducting the usability test. The effect of test environment on the facilitators' confidence in conducting the usability test was not significant, Wilks' Lambda =0.722, *F* (2, 10) = 1.93, *p*=0.196.

Efficiency. The effect of test environment on the facilitators' perception if test efficiency was not significant, Wilks' Lambda =0.895, *F* (2, 10) = 0.58, *p*=0.575.

Ability to analyze user interaction with the web interface. The effect of usability test environment on the facilitators' ability to analyze user interaction with the web interface was significant, Wilks' Lambda =0.221, *F* (2, 10) = 17.66, *p*=0.001. Subsequent post-hoc analysis reveals that facilitators felt they were best able to analyze the user interaction with the new interface in the traditional lab environment. They felt that they were least able to analyze user interaction with web interface in the Wonderland environment. The WebEx environment was rated more highly on this metric than the Wonderland environment, but less highly than the traditional lab environment.

Comfort level: The effect of test environment on the facilitators' comfort level was not significant, Wilks' Lambda =0.578, *F* (2, 10) = 3.64, *p*=0.065.

Likeability: There were no significant differences among the test environments in terms of how much the facilitators liked them, Wilks' Lambda =0.993, *F* (2, 10) = 0.036, *p*=0.964.

CHAPTER EIGHT

DISCUSSION

One of the initial research questions was to identify whether there were any differences in the effectiveness of the three evaluation approaches, the traditional lab approach, the WebEx approach, and the Wonderland approach, in collecting usability data. Though no significant differences were identified for the time taken to complete the tasks, the mean time for the first three tasks in Wonderland was slightly higher, perhaps because of the learning process the participants experienced while transitioning into a virtual environment. No differences were identified for the total number of defects identified and the number of Severity 3 and Severity 4 defects identified for the three environments. These results are consistent with those found by Hartson *et al.* (1996) for conducting a synchronous usability test in different settings. Similarly, in the studies conducted by Brush *et al.* (2004) found no significant differences between the traditional lab condition and the remote synchronous testing condition in terms of the number, types and severities of usability problems.

In the comparative analysis of objective measures, the effect of test environment on the number of Severity 1 defects identified approached significance. The effect of test environment on the number of Severity 2 defects was significant. More Severity 1 defects were identified in the Wonderland condition than in the WebEx condition. More Severity 2 defects were identified in the Wonderland condition than in the traditional lab condition. It is not clear why the participants in the Wonderland condition identified more minor usability defects than the participants in the other conditions. Perhaps the novelty of the Wonderland condition increased the motivation of the participants to detect and mention even minor usability issues. This difference may be explained by the interface layout. The Wonderland system had a browser, bordered clearly with a green band, helping the participants to focus on the website. This conclusion is supported by participant responses. These factors may have contributed to the identification of a slightly higher number of Severity 1 and Severity 2 issues in the Wonderland system. Another explanation for this result could be the inherent variability in the identification of defects by the participants, since the think-aloud protocol was a new experience for many of the participants. The studies conducted by Molich *et al.* (1998) also suggest that different participant-facilitator groups could yield a different type and number of results, even though they test the same interface.

Significant qualitative differences were observed for the three conditions. The NASA-TLX scales, used to determine the total perceived workload indicate that the participants experienced the least workload in the traditional lab condition. This result could have been due to the co-location of the test facilitator with the test participant during the preparatory stages as well as during the test. In the case of the WebEx-based approach, test participants experienced some difficulty during the preparatory session figuring out how to operate the system. In addition, there was a time delay while the remote session loaded. Though this delay was short, participants complained that they did not know what was happening other than that there was a white screen display explaining that "the session is loading." For the Wonderland-based testing, participants clicked on a button to launch the session and soon were transitioned to the virtual world. For both of the remote testing environments, the participants were required to perform a series of button clicks on an interface supporting the remote infrastructure to begin the session.

The NASA-TLX subscales of mental demand, physical demand, temporal demand and effort did not reveal any significant differences. However, significant differences were found for the performance and frustration subscales. The test participants felt their performance was poorer in the WebEx environment than in the traditional lab and Wonderland environments. They experienced more frustration with the Wonderland environment than with the traditional lab environment. The participants using the Wonderland environment appeared to be frustrated primarily by its slow response to the inputs of the test participants and test facilitators. Nonetheless, a number of test participants using the Wonderland environment commented that they enjoyed moving around inside the virtual usability testing laboratory and interacting with the shared web browser using their avatars.

The NASA-TLX workload indices suggest that the total workload experienced by facilitators was also lower in the traditional lab environment than in the two remote testing environments. No significant differences were observed for for the test facilitators on the mental demand, temporal demand, and performance subscales. However, significant differences were observed for physical demand, effort and frustration subscales. Test facilitators felt that physical demands, effort, and frustration were higher for the two remote testing environments than for the traditional lab environment. This may be due to the lower initial setup required for the traditional lab condition. It took time for the test facilitators to become acquainted with the remote testing environments. In addition, the high level of physical demand in the WebEx and Wonderland conditions might also be due to the higher level of interaction with the computer required in these environments during the study. The relatively slow response times of the web browser to user inputs in the remote testing environments may also have led to increased levels of frustration for the test facilitators.

For the test participants, significant differences were observed for involvement and immersion on the presence questionnaire. Involvement was higher in the Wonderland environment than in the WebEx environment. For the test facilitators, involvement was higher in the Wonderland and traditional lab conditions than in the WebEx condition. The level of immersion experienced by the participants was also higher in the Wonderland condition than in the WebEx condition. These results may be due to the multisensory immersive experience produced by the Wonderland virtual world, characterized by avatars, and simultaneous visual and auditory feedback.

The subjective ratings provided by the test participants in the final subjective rating questionnaire revealed significant differences in terms of user satisfaction and ease of use. The user satisfaction and ease of use were higher for the traditional lab methodology than for the remote testing environments. The test facilitators also rated the ease of use of the traditional lab environment higher than that of the remote test environments. Interestingly, however, some of the test participants in the traditional lab environment commented that they felt some pressure to avoid making mistakes while being observed by a test facilitator. None of the participants in the remote testing environments expressed this concern.

Test facilitators felt that they were best able to analyze the user interaction with the web interface in the traditional lab environment. They felt they were least able to analyze the user interaction in the Wonderland environment. The low rating of the Wonderland environment on this metric was probably the result of a technical problem with the display of the web browser in this environment. Mouse movements within a browser made by the test participant were not visible to the test facilitator in the Wonderland environment.

The effect of the test environment on the comfort level of the test facilitators approached significance. The test facilitators appeared to be somewhat more comfortable with the traditional lab than with the Wonderland and WebEx environments. Test facilitators were, on average, equally comfortable with the WebEx and Wonderland environments.

One of the challenges of remote usability testing is the recruitment of security-conscious participants. These participants, or the organizations employing them, may consider allowing others to access their computers to be a security risk (Vasnaik *et al.,* 2006). Remote testing using Wonderland requires only that participants interact with their web browser. The test facilitator cannot view any information on their computers that is not displayed within the browser. WebEx addresses this concern by allowing its users to selectively share applications on their computers. Another difficulty encountered in remote usability testing is the need for installing a client application to enable screen sharing and chat functionalities (Vasnaik *et al*., 2006). WebEx requires that users install either an ActiveX control or a Java applet on the computer at each end of the conference to enable screen sharing. Wonderland relies on Java applets to achieve these functionalities. Moreover, the applet used by Wonderland employs the Java Web Start technology. As a result,there is no need for the users to install a program to enable these functionalities. In addition, remote usability testing with Wonderland and WebEx retains the inherent advantages of synchronous usability testing, including significant savings in travel time and cost, reduced turn-around time for user-centered iterative product development, recruitment of geographically dispersed participants and the ability for geographically distributed product development teams to participate in a real time study. Table 8.11 compares the traditional lab, WebEx-based and Wonderland-based approaches in terms of several technical and financial selection criteria.

Criteria	**Traditional lab**	**WebEx**	**Wonderland**
Cost	Laboratory facilities are expensive. Incurs additional cost due to the logistics involved in bringing the participants to the lab.	$49/month/host.	Initial investment is high. Need to buy a server class machine and almost 48 man hours to develop the virtual usability lab.
Client installation	None	ActiveX plugin or Java Applet	Java Applet
Two-way interaction	Yes	Yes	Yes
Operating system support	PC, Mac, Linux, Unix and Solaris systems	PC, Mac, Linux, Unix and Solaris systems.	PC, Mac, Linux, Unix and Solaris systems
Ability to record the session	Yes, using screen capture software, such as Camtasia Studio	Yes. But the WebEx player, which plays the recorded session only works on Windows and the MacOS	Streams as an audio video interleave (AVI) file, compatible with all operating systems.
Accessibility through firewall	Not applicable	Yes	Yes
Workload	Low	High	High
Time taken to build the remote testing infrastructure	Low	Low	High

Table 8.11: Summary of the three approaches based on selected criteria

CHAPTER NINE

CONCLUSION

This study proposed a new methodology for conducting a synchronous remote usability test using a three-dimensional virtual world, Wonderland, and empirically compared it with WebEx, a web-based two-dimensional screen sharing and conferencing tool, and the traditional lab method. One of the most important findings of this study is that the Wonderland is as effective as the traditional lab and WebEx-based methods in terms of the time taken by the test participants to complete the tasks and the number of higher severity defects identified. Interestingly, participants appeared to identify a slightly larger number of lower severity defects in the Wonderland environment than in the traditional lab and WebEx environments.

Test participants and facilitators alike experienced lower overall workload in the traditional lab environment than in either of the remote testing environments. The findings indicate that both the test participants and test facilitators experienced a higher level of involvement in the Wonderland condition than in WebEx condition. Wonderland offers a remote testing infrastructure without any software installation required by the usability test participants and facilitators. It supports recruitment of geographically distributed, diverse participants who can remain in their native work environments. Given that it generates usability test results compared to those of traditional lab testing, remote usability testing in virtual world appears to be a viable alternative to the conventional lab testing approach. The two primary disadvantages of testing in the Wonderland environment were the delay the participants experienced while interacting with the interface and the inability of test facilitators to monitor the mouse movements of test participants as they interacted with the interface prototype being tested.

The study presented here is only an initial step; below are listed suggestions for future studies.

- Studies involving professional test facilitators to address the potential bias of the university students used here.
- Studies involving more participants to ensure the validity and reliability of the results.
- Studies using geographically dispersed participants in a real time environment, to measure the level of trust between the facilitator and the participants.
- Studies using participants and facilitators with less technology experience, to determine their comfort level with the methodology.

APPENDICES

Appendix A

Consent Form for Participation in a Research Study
Clemson University

An investigation of usability testing methodologies

Description of the research and your participation

You are invited to participate in a research study conducted by Dr. Joel S. Greenstein and Kapil Chalil Madathil. The purpose of this study is to compare different usability testing methodologies.

The study will compare the effectiveness of three different meeting space environments for usability testing. The procedure involves a representative user interacting with a web site and a usability expert monitoring the user's interaction with the site. The first environment will be a traditional meeting room where the subjects will sit and interact with a web interface displayed on a computer monitor. The second environment will employ an online meeting tool (WebEx™) which facilitates data sharing and communication support. The third environment will be a three-dimensional (3D) virtual world, in which the user will interact with the web interface. Each meeting will include a user and a usability expert. As the usability expert, you will monitor a usability test in all three meeting spaces. Each user will experience only one of the three meeting spaces.

You will be asked to fill out a brief questionnaire about you and your knowledge of computers and the internet. The experimenter will guide you to the usability-testing laboratory and you will be asked to monitor three usability sessions with users in three different environments. While you are in the process of performing these tasks, you will ask the user to perform tasks on the web page and talk about his reactions to the website. The think-aloud protocol will be used during each usability session. The test session will be recorded using a screen capture software application. The video and the audio data of the session will be used to analyze the difficulties the user experiences with the website. After you have completed each session, you will be asked to complete two questionnaires asking about your experience while conducting the usability test. The amount of time required for your participation will be approximately 60 minutes for each session (3 hours in total). Once you have completed monitoring three usability sessions in three different environments, you will be asked to fill out a final questionnaire in which you provide a subjective rating for each of the three environments.

Please understand that we are not testing your personal performance. We are testing the effectiveness of usability testing in three different types of meeting space.

Risks and discomforts
There are no known risks associated with participation in this study.

Potential benefits
There are no known benefits to you that would result from your participation in this research. This research may help us to understand how to develop more effective usability tests.

Protection of confidentiality
We will do everything we can do to protect your privacy. The audio and video data captured will be stored on a password-protected computer in the Human Computer Systems Laboratory (Freeman Hall 147). The survey questionnaires will be kept in a locked cabinet. The documents will be accessible only to the principal investigator and the co-investigator. Your identity will not be revealed in any publication that might result from this study.

In rare cases, a research study will be evaluated by an oversight agency, such as the Clemson University Institutional Review Board or the federal Office for Human Research Protections that would require that we share the information we collect from you. If this happens, the information would only be used to determine if we conducted this study properly and adequately protected your rights as a participant.

Voluntary participation

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

Contact information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Joel S. Greenstein at Clemson University at 864-656-5649. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board at 864-656-6460.

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant’s signature: ______________________________ Date: _____________

A copy of this consent form should be given to you.

Appendix B

PRE-TEST QUESTIONNAIRE - USABILITY TEST FACILITATOR

GENERAL

Meeting space: ______________________ (*This will be filled out by the test administrator*)

Age: ______________________

Gender: □ Male □ Female

EDUCATION

1. Please check your academic level below

□ Undergraduate student
□ Graduate student (*Masters or Ph.D.*)
□ Other
(Please specify ______________________)

2. List your major area of study: __________________________

EXPERIENCE WITH USABILITY TESTING

3. Have you taken IE 802 or PSYCH 840 or ENGL 834?

□ Yes □ No (*If **No**, please contact test administrator*)

4. Are you aware of the think-aloud protocol?

□ Yes □ No (*If **No**, please contact test administrator*)

5. Have you ever participated in an online web meeting?
(*Example: A conversation on Skype*)

□ Yes □ No

6. Do you have any experience working in three-dimensional virtual worlds?
(*Example: Playing 3D games like World of Warcraft or visiting virtual worlds like Second Life*)

□ Yes □ No

7. Have you ever conducted a usability test?

□ Yes □ No

6. Do you ever use the internet to buy or sell items online?
(*Example: Purchasing items from Amazon.com*)

□ Yes □ No

7. If **YES**, how often?

□ Very Frequently □Sometimes □Rarely □Never

8. Have you ever participated in a usability test **as a usability test subject**?

□ Yes □ No

Appendix C

Consent Form for Participation in a Research Study
Clemson University

An investigation of usability testing methodologies

Description of the research and your participation

You are invited to participate in a research study conducted by Dr. Joel S. Greenstein and Kapil Chalil Madathil. The purpose of this study is to compare different usability testing methodologies.

You will be asked to fill out a brief questionnaire about you and your knowledge of computers and the internet. The test facilitator will guide you to the usability-testing laboratory and you will be asked to complete a set of tasks using a website. While you are in the process of performing these tasks, you will be asked to think aloud and talk about your reactions to website. Feel free to tell us about any of the inconveniences you experience while navigating through the website. The test session will be recorded using a screen capture software application. The video and the audio data of the session will be used to analyze the difficulties you experience with the website. Once you have completed your task, you will be asked to complete three subjective questionnaires asking about your experience of using the usability test methodology.

The amount of time required for your participation will be approximately 60 minutes. Please understand that we are not testing your personal performance. We are testing the effectiveness of usability testing in three different types of usability test methodologies.

Risks and discomforts

There are no known risks associated with participation in this study.

Potential benefits

There are no known benefits to you that would result from your participation in this research. This research may help us to understand how to develop more effective usability tests.

Protection of confidentiality

We will do everything we can do to protect your privacy. The audio and video data captured will be stored on a password-protected computer in the Human Computer Systems Laboratory (Freeman Hall 147). The survey questionnaires will be kept in a locked cabinet. The documents will be accessible only to the principal investigator and the co-investigator. Your identity will not be revealed in any publication that might result from this study.

In rare cases, a research study will be evaluated by an oversight agency, such as the Clemson University Institutional Review Board or the Federal Office for Human Research Protections that would require that we share the information we collect from you. If this happens, the information would only be used to determine if we conducted this study properly and adequately protected your rights as a participant.

Voluntary participation

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

Contact information

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Joel S. Greenstein at Clemson University at 864-656-5649. If you have any questions or concerns about your rights as a research participant, please contact the Clemson University Institutional Review Board at 864-656-6460.

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant’s signature: ________________________________ Date: ______________

A copy of this consent form should be given to you.

Appendix D

PRE-TEST QUESTIONNAIRE - USABILITY TEST PARTICIPANTS

GENERAL

Meeting space: ______________________ (*This will be filled out by the test administrator*)

Age: ________________________

Gender: □ Male □ Female

EDUCATION

1. Please check your academic level below

□ Undergraduate student
□ Graduate student (Masters or Ph.D.)
□ Other
(Please specify ________________________)

2. List your major area of study: ___________________________

EXPERIENCE WITH INTERNET

3. How long have you been using computers?

□ Less than a year □ 1- 3 years □ 3- 5 years □ More than 5 years

4. List the Internet browsers you are familiar with.

□ Internet Explorer
□ Mozilla Firefox
□ Safari
□ Opera
□ Google Chrome
□ Other
(Please specify ________________________)

5. How would you rate your experience with Internet browsing?

□ Very experienced □ Moderate □ Minimal None □

6. Do you ever use the internet to buy or sell items online?
(Example: Purchasing items from Amazon.com)

□ Yes □ No

7. If **YES**, how often?

□ Very Frequently □ Sometimes □ Rarely □ Never

9. How often have you felt that you were not able to perform a task efficiently on a website?
(Example: "Website is very hard to understand")

□ Very Frequently □ Sometimes □ Rarely □ Never

10. Have you ever participated in an online web meeting?
(Example: A conversation on Skype)

□ Yes □ No

11. Do you have any experience working in three-dimensional virtual worlds?
(Example: Playing 3D games like World of Warcraft or visiting virtual worlds like Second Life)

□ Yes □ No

12. Have you taken any courses on Human Computer Interaction or Usability evaluation?

□ Yes □ No

If **YES**, please list them.

□ IE 802
□ PSYCH 840
□ ENGL 834
□ Other (*Please Specify*) (______________________)

13. Have you ever participated in a usability test?

□ Yes □ No

Appendix E
An investigation of usability testing methodologies
Presence Questionnaire (Witmer *et al.*, 2005)

Characterize your experience in the environment, by marking an "X" in the appropriate box of the 7-point scale, in accordance with the question content and descriptive labels. Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer. Answer in relation to when you were in the usability test session.

1. How much were you able to control events?

|________|________|________|________|________|________|________|
NOT AT ALL SOMEWHAT COMPLETELY

2. How responsive was the environment to actions that you initiated (or performed)?

|________|________|________|________|________|________|________|
NOT RESPONSIVE MODERATELY RESPONSIVE COMPLETELY RESPONSIVE

3. How natural did your interactions with the environment seem?

|________|________|________|________|________|________|________|
EXTREMELY ARTIFICIAL BORDERLINE COMPLETELY NATURAL

4. How much did the visual aspects of the environment involve you?

|________|________|________|________|________|________|________|
NOT AT ALL SOMEWHAT COMPLETELY

5. How much did the auditory aspects of the environment involve you?

|________|________|________|________|________|________|________|
NOT AT ALL SOMEWHAT COMPLETELY

6. How natural was the mechanism which controlled movement through the environment?

|________|________|________|________|________|________|________|
EXTREMELY ARTIFICIAL BORDERLINE COMPLETELY NATURAL

7. How compelling was your sense of objects moving through space?

|________|________|________|________|________|________|________|

NOT AT ALL MODERATELY COMPELLING VERY COMPELLING

8. How much did your experiences in the test environment seem consistent with your real world experiences?

|________|________|________|________|________|________|________|

NOT CONSISTENT MODERATELY CONSISTENT VERY CONSISTENT

9. Were you able to anticipate what would happen next in response to the actions that you performed?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

10. How completely were you able to actively survey or search the environment using vision?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

11. How well could you identify sounds?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

12. How well could you localize sounds?

|________|________|________|________|________|________|________|

NOT AT ALL SOMEWHAT COMPLETELY

13. How well could you actively survey or search the test environment using touch?

|________|________|________|________|________|________|________|

NOT AT ALL   SOMEWHAT   COMPLETELY

14. How compelling was your sense of moving around inside the test environment?

|________|________|________|________|________|________|________|

NOT COMPELLING   MODERATELY COMPELLING   VERY COMPELLING

15. How closely were you able to examine objects?

|________|________|________|________|________|________|________|

NOT AT ALL   PRETTY CLOSELY   VERY CLOSELY

16. How well could you examine objects from multiple viewpoints?

|________|________|________|________|________|________|________|

NOT AT ALL   SOMEWHAT   EXTENSIVELY

17. How well could you move or manipulate objects in the test environment?

|________|________|________|________|________|________|________|

NOT AT ALL   SOMEWHAT   EXTENSIVELY

18. How involved were you in the test environment experience?

|________|________|________|________|________|________|________|

NOT INVOLVED   MILDLY INVOLVED   COMPLETELY ENGROSSED

19. How much delay did you experience between your actions and expected outcomes?

|________|________|________|________|________|________|________|

NOT DELAYS   MODERATE DELAYS   LONG DELAYS

20. How quickly did you adjust to the test environment experience?

|________|________|________|________|________|________|________|

NOT AT ALL	SLOWLY	LESS THAN A MINUTE

21. How proficient in moving and interacting with the test environment did you feel at the end of the experience?

|________|________|________|________|________|________|________|

NOT PROFICIENT	MODERATELY PROFICIENT	VERY PROFICIENT

22. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

|________|________|________|________|________|________|________|

NOT AT ALL	MODERATELY INTERFERED	PREVENTED TASK PERFORMANCE

23. How much did the control devices interfere with the performance of assigned tasks or with other activities?

|________|________|________|________|________|________|________|

NOT AT ALL	MODERATELY INTERFERED	INTEREFERED GREATLY

24. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

|________|________|________|________|________|________|________|

NOT AT ALL	SOMEWHAT	EXTENSIVELY

25. How completely were your senses engaged in this experience?

|________|________|________|________|________|________|________|

NOT ENGAGED	MILDLY ENGAGED	COMPLETELY ENGAGED

29. How easy was it to identify objects through physical interaction; like touching an object, walking over a surface, or bumping into a wall or object?

|________|________|________|________|________|________|________|

IMPOSSIBLE MODERATELY DIFFICULT VERY EASY

30. Were there moments during the test environment experience when you felt completely focused on the task or environment?

|________|________|________|________|________|________|________|

NONE OCCASIONALLY FREQUENTLY

31. How easily did you adjust to the control devices used to interact with the test environment?

|________|________|________|________|________|________|________|

DIFFICULT MODERATE VERY EASY

32. Was the information provided through different senses in the test environment (e.g., vision, hearing, touch) consistent?

|________|________|________|________|________|________|________|

NOT CONSISTENT MODERATELY CONSISTENT VERY CONSISTENT

There are 4 subscales:
Involvement – 1, 2, 3, 4, 6, 7, 8, 10, 14, 17, 18, 29
Sensory Fidelity – 5, 11, 12, 13, 15, 16
Adaptation/Immersion – 9, 20, 21, 24, 25, 30, 31, 32
Interface Quality – 19, 22, 23

Note: The numbering of the above items is consistent with version 3.0 of the Presence Questionnaire. However, the items themselves are from version 4.0.

Witmer, B., Jerome, C.J., & Singer, M.J. (2005). The factor structure of the presence questionnaire. *Presence, 14*(3), 298-312.

Appendix F

Usability Subject: Subjective Questionnaire

Meeting space: ______________________ (*This will be filled out by the test administrator*)

(Please provide the following information)

Naturalness of the Environment:

1. I had a sense of being in a meeting room.

0 1 2 3 4 5 6 7

Strongly Disagree ... Strongly Agree

2. I felt like I was in a usability testing laboratory environment.

0 1 2 3 4 5 6 7

Strongly Disagree ... Strongly Agree

3. The usability testing laboratory environment seemed natural.

0 1 2 3 4 5 6 7

Strongly Disagree ... Strongly Agree

4. I was confused in this usability testing laboratory environment.

0 1 2 3 4 5 6 7

Strongly Disagree ... Strongly Agree

User Satisfaction and Ease of use of the usability testing methodology:

5. I would like to participate in usability tests using this meeting environment.

0	1	2	3	4	5	6	7
Strongly Disagree							Strongly Agree

6. This usability testing methodology was user friendly.

0	1	2	3	4	5	6	7
Strongly Disagree							Strongly Agree

7. Learning to participate in the usability test in this environment was easy for me.

0	1	2	3	4	5	6	7
Strongly Disagree							Strongly Agree

8. I found this meeting environment to be useful for a usability test.

0	1	2	3	4	5	6	7
Strongly Disagree							Strongly Agree

9. Overall, I felt comfortable participating in the usability test.

0	1	2	3	4	5	6	7
Strongly Disagree							Strongly Agree

<u>Quality of the usability test methodology</u>

10. It was easy to identify usability defects in the website.

0 1 2 3 4 5 6 7

Strongly Disagree — Strongly Agree

11. I feel confident that I identified the website’s most serious defects.

0 1 2 3 4 5 6 7

Strongly Disagree — Strongly Agree

12. I had a strong sense of being with the usability expert within the environment.

0 1 2 3 4 5 6 7

Strongly Disagree — Strongly Agree

13. I feel that I worked well with usability expert to complete the usability test.

0 1 2 3 4 5 6 7

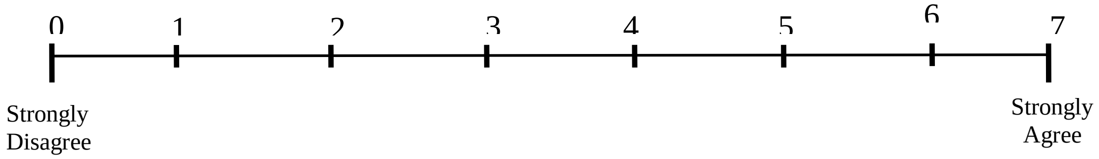
Strongly Disagree — Strongly Agree

14. I feel that the environment facilitated and supported collaboration with the test administrator.

0 1 2 3 4 5 6 7

Strongly Disagree — Strongly Agree

15. I feel that the environment facilitated seamless communication (auditory and visual) with the test administrator.



16. List the most **POSITIVE** aspect of this meeting space for usability testing

17. List the most **NEGATIVE** aspect of this meeting space for usability testing

Appendix G

Usability test facilitator: Subjective Questionnaire

Please provide the following information based on your experience with the

- Traditional in-lab usability test
- Remote usability test using WebEx™
- Remote Usability test using Wonderland.

Please provide subjective ratings for each of the usability testing environments with respect to the feature.

1) Ease of use.

In-lab Usability test

0 1 2 3 4 5 6 7

Very Difficult — Very Easy

WebEx™ based test

0 1 2 3 4 5 6 7

Very Difficult — Very Easy

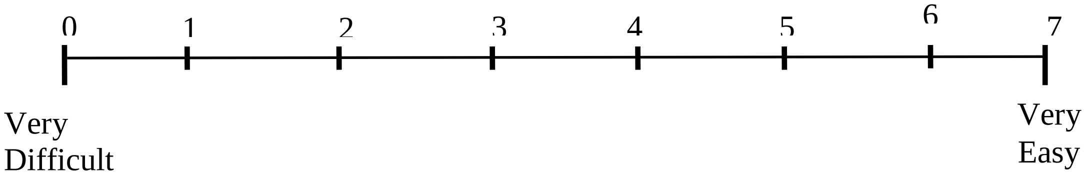
Usability test in **Wonderland**

0 1 2 3 4 5 6 7

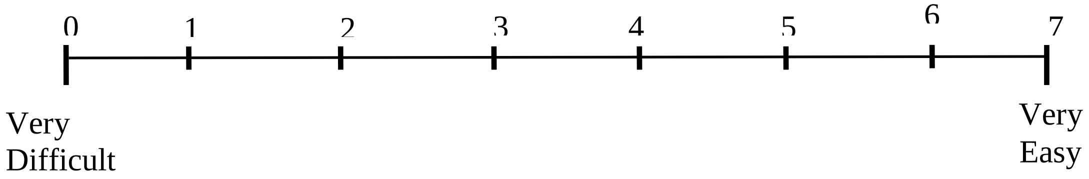
Very Difficult — Very Easy

2) Seamless communication with the usability participant during the think-aloud process.

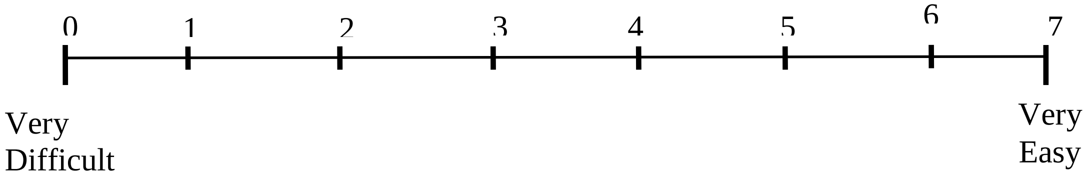
In-lab Usability test



WebEx™ based test



Usability test in **Wonderland**



3) A strong sense of presence with the usability participant.

In-lab Usability test

0 1 2 3 4 5 6 7

Never Always

WebEx™ based test

0 1 2 3 4 5 6 7

Never Always

Usability test in **Wonderland**

0 1 2 3 4 5 6 7

Never Always

4) Confidence in conducting the usability test.

In-lab Usability test

0	1	2	3	4	5	6	7
Not at all confident							Very confident

WebEx™ based test

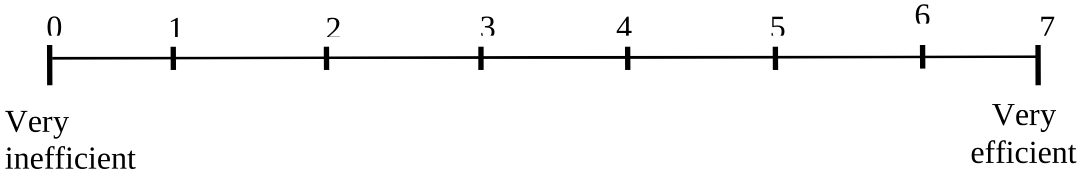
0	1	2	3	4	5	6	7
Not at all confident							Very confident

Usability test in **Wonderland**

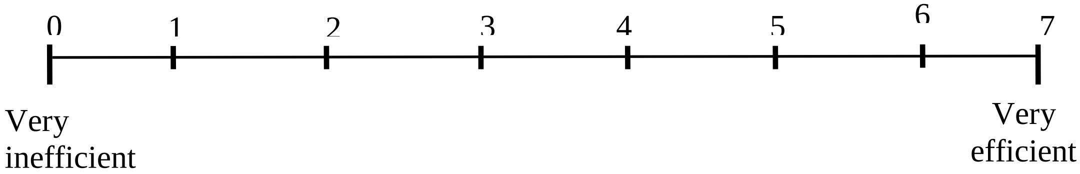
0	1	2	3	4	5	6	7
Not at all confident							Very confident

5) Efficiency.

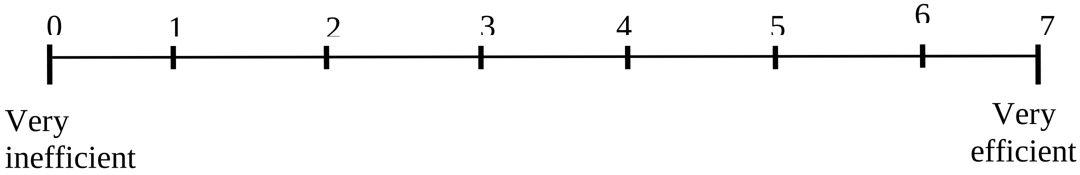
In-lab Usability test



WebEx™ based test

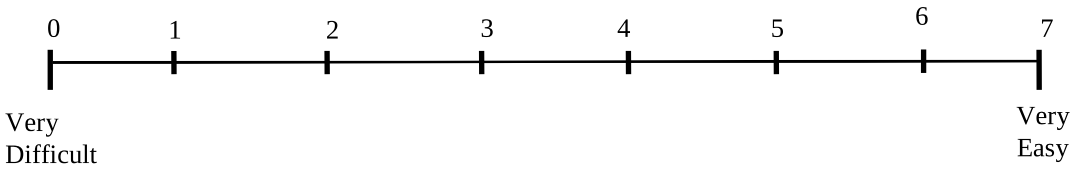


Usability test in **Wonderland**

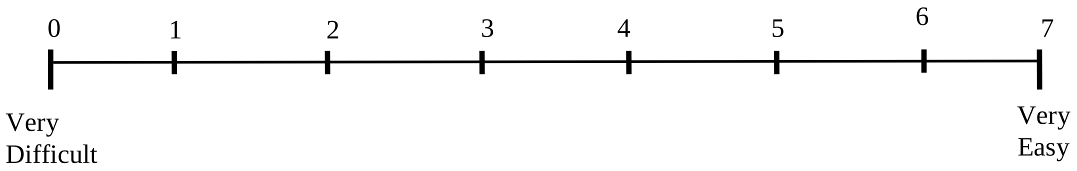


6) Ability to analyze user interaction with the web interface.

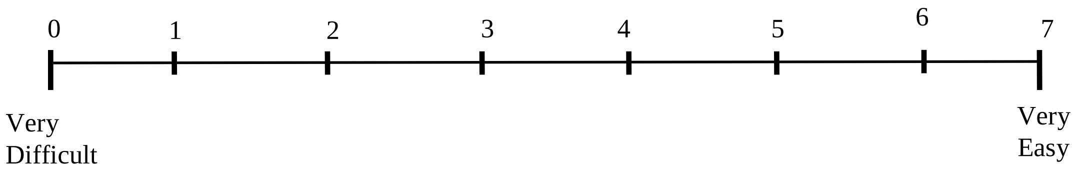
In-lab Usability test



WebEx™ based test

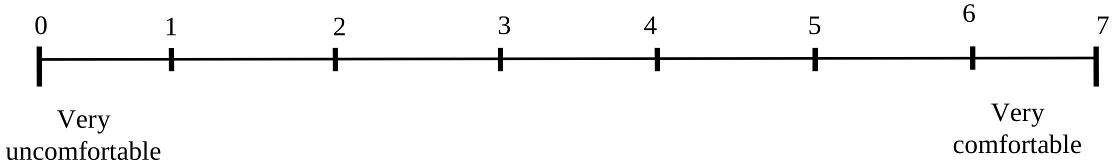


Usability test in **Wonderland**

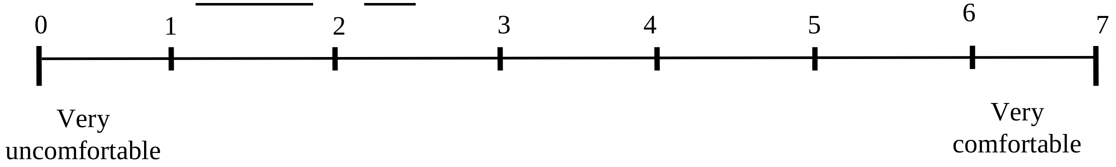


7) Comfort.

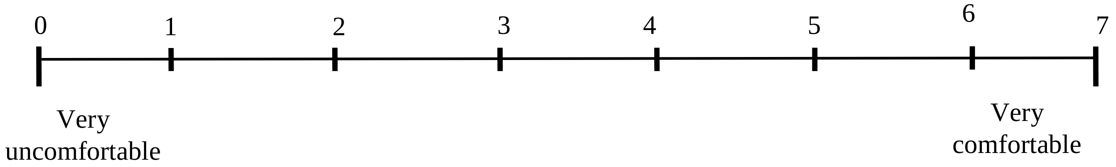
In-lab Usability test



WebEx™ based test



Usability test in **Wonderland**



8) As usability test administrator, how much would you like to use these approaches?

In-lab Usability test

0 1 2 3 4 5 6 7

Never Use — Frequently use

WebEx™ based test

0 1 2 3 4 5 6 7

Never Use — Frequently use

Usability test in **Wonderland**

0 1 2 3 4 5 6 7

Never Use — Frequently use

Thank you for your participation!

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