

THE DESIGN AND EVALUATION OF A COMPUTER-BASED TOOL TO SUPPORT
THE CONSTRUCTION AND WIZARD-OF-OZ TESTING OF LOW FIDELITY
PROTOTYPES

By

STEPHEN JAMES TRENT

A thesis submitted in partial fulfillment of
the requirements for the degree of

Master of Science in Computer Science

WASHINGTON STATE UNIVERSITY
Department of Electrical Engineering and Computer Science

MAY 2009

To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of
STEPHEN JAMES TRENT find it satisfactory and recommend that it be
accepted.

Christopher D. Hundhausen, Ph.D., Chair

Robert Patterson, Ph.D.

Robert R. Lewis, Ph.D.

ACKNOWLEDGMENTS

There are many wonderful individuals that have assisted and encouraged my pursuit of an advanced degree in computer sciences. To my wonderful wife Tai I express the greatest appreciation and gratitude. Since the beginning of our life together, she has always been supportive of my efforts, and has taken on additional family responsibilities over the years to allow me the time to complete my coursework and thesis. My ever-patient children, Samuel, Lauren, and Emily have been wonderful and supportive of their father. They have often asked, “What are you working on now?” With the completion of my thesis, I can finally say, “I’m done.” My initial inspiration to “step out of my comfort zone” and pursue an advanced degree I owe to extended family members Jim Wooldridge and Ero Brown, both of whom I deeply admire and consider my “brothers.” To Anzor Balkar and Mohamed Nuur, two hard-working and bright computer science undergraduates, I owe much of the basis for my thesis. Their dedication to designing and programming the WOZ PRO software was a key ingredient to the successful completion of my research.

I greatly appreciate my past and current employers, Fluor Hanford Inc. and CH2M-Hill Plateau Remediation Company, who have provided financial support for the majority of my coursework. I am indebted to Dr. Carl Connell, my work group manager for many years at Fluor Hanford, who supported me and allowed for flexible work hours so that I could complete my coursework.

I am exceedingly grateful for the opportunity to have worked with my thesis advisor Dr. Chris Hundhausen. His enthusiasm for human-computer interaction drew me to this field of study. He has patiently endured my long-distance, part-time graduate student situation, and has gone well out of his way to help me conduct my research and complete this thesis.

Finally, I wish to thank the Hewlett-Packard Corporation for their support of this research through their “Technology for Teaching” Grant.

THE DESIGN AND EVALUATION OF A COMPUTER-BASED TOOL TO SUPPORT THE CONSTRUCTION AND WIZARD-OF-OZ TESTING OF LOW FIDELITY PROTOTYPES

Abstract

by Stephen James Trent
Washington State University
May 2009

Chair: Christopher D. Hundhausen

In software development, the creation and testing of low-fidelity user interface (UI) prototypes is a common practice. Our informal analysis of current technologies used for low-fidelity prototype development indicates that they do not optimally support the two key, complementary tasks of (a) prototype creation and (b) wizard-of-oz testing. To address this problem, we have developed WOZ PRO (Wizard Of OZ Prototyper), a pen-based software environment for the quick and easy creation and testing of low-fidelity UI prototypes. WOZ PRO supports the creation and presentation of low-fidelity UI prototypes that take the form of a network of sketch-based UI screens that can be stored, modified, displayed, and manipulated on a tablet PC.

An experimental comparison of WOZ PRO and a conventional art supplies (pen and paper) prototyping environment is the central work of this thesis. The results of this experiment shows that while WOZ PRO provides an excellent sketching medium for generation of website low-fidelity prototype UI screens, more thought and work is needed to develop a scalable UI screen navigation model. The state transition network paradigm, upon which the UI screen navigation model is based, was found to be cumbersome and difficult for study participants to effectively use in their organization and mapping of valid UI screen transitions. Observation of prototypes developed by

study participants using art supplies provides us with insight on how the WOZ PRO UI screen navigation model could be improved through modeling and implementing the organizing and “piling” of UI screens into discreet task sequences. Our work also shows that there is significant potential for improving and expanding the usefulness of WOZ PRO. Generalizing WOZ PRO to facilitate prototyping of other types UI interfaces beyond that of websites is a recommended improvement. In addition, establishment of a “dual interface” scheme based on two networked tablet PCs running WOZ PRO may provide a richer and more realistic wizard-of-oz testing environment.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	iii
Abstract.....	v
LIST OF TABLES	x
LIST OF FIGURES	xi
CHAPTER	
1. INTRODUCTION	1
Research Problem	1
Rapid Creation and Modification of a Prototype.....	2
Conducting Wizard-of-Oz Studies.....	2
A Possible Solution: WOZ PRO	3
Research Questions.....	5
Thesis Outline	6
2. RELATED WORK.....	7
The Fidelity of Prototypes	7
Graphic Design Software for Low-Fidelity Prototyping	10
SILK and DENIM Low-Fidelity Prototyping Environments	11
Other Environments	13
Observations	15
3. DESIGN AND IMPLEMENTATION OF WOZ PRO.....	17
WOZ PRO 1.0 Requirements.....	18
Design Screens Mode	19

Screen Transition Mode.....	21
Run Screens Mode	24
Discussion and Summary.....	25
4. EXPERIMENTAL STUDY.....	28
Experiment Design.....	28
Study Participants	29
Materials and Tasks	30
Procedure	36
Measuring Dependent Variables.....	39
Results	43
Dependent Variable 1 - Time to construct prototype.....	43
Dependent Variable 2 - Average time delay between screen transitions.....	44
Dependent Variable 3 – Screen Transition Errors	45
Dependent Variable 4 – Usability Problem Detection.....	45
Overall Effectiveness of the Prototyping Environments	46
Dependent Variable 1 – Discussion.....	49
Dependent Variable 2 – Discussion.....	52
Dependent Variable 3 – Discussion.....	54
Dependent Variable 4 – Discussion.....	55
Overall Effectiveness of the Prototyping Environments – Discussion.....	56
Limited User Testing of WOZ.....	57
STN design paradigm	59

5. CONCLUSIONS AND FUTURE WORK	60
Future Work	61
Generalization of WOZ PRO	62
Implementation of two interfaces: user and wizard	62
Collaborative Environment	64
Transition speed vs. transition flexibility and creativity	64
BIBLIOGRAPHY	66
APPENDIX	
A. RESEARCH DATA COMPILATION	69
B. DIRECTIONS AND PROCEDURES FOR EXPERIMENTAL STUDY	89
C. TUTORIAL AND EXPERIMENTAL STUDY WEBSITE PAGES	120

LIST OF TABLES

	Page
1. Tasks simulated by participants in the wizard-of-oz demonstration	35
2. Study questionnaire rated elements.	41
3. Start and stop criteria for determining time durations	41
4. Usability Heuristics from Nielsen [14].	42
5. Shapiro-Wilk normality test results for dependent variable 1.	43
6. Results of ANOVA statistical tests for Dependent Variable 1.	44
7. Shapiro-Wilk normality test results for dependent variable 2.	44
8. Results Kruskal-Wallis statistical test for Dependent Variable 2.	44
9. Shapiro-Wilk normality test results for dependent variable 3.	45
10. Results Kruskal-Wallis statistical test for Dependent Variable 3.	45
11. Shapiro-Wilk normality test results for dependent variable 4.	46
12. One-way ANOVA Statistical Test Results for Dependent Variable 4.	46
13. Shapiro-Wilk normality test results for questionnaire rated elements.	47
14. Analysis of variance for questionnaire rated elements.	48

LIST OF FIGURES

	Page
1. WOZ PRO Interface.....	4
2. The WOZ PRO Design Screens mode interface.	19
3. The WOZ PRO Propagate Changes interface.....	21
4. The WOZ PRO Screen Transitions mode interface. No transitions are defined yet....	22
5. The WOZ PRO Screen Transitions mode interface. Transition diagram defined.	23
6. The WOZ PRO Run Screens mode interface.....	25
7. Sample UI screen from the tutorial segment.....	31
8. Study Website site map.....	32
9. Work area configuration for both experimental conditions.	34
10. An example of the "piling" strategy employed by ART condition.....	50
11. Screen capture from Edit Screens Transition mode.....	52
12. Screen capture of a "Run Screens" mode session	53
13. Conceptualization of a wizard-of-oz prototyping environment.....	63

CHAPTER 1

INTRODUCTION

Prototyping is a design technique used by product designers to examine and test design ideas and concepts. In software development, creating prototypes of user interfaces can be an important step in the development process. User interface prototypes of various levels of “fidelity” can be used to solicit critical design input from software users, which can aid in the identification of user interface design issues prior to implementing the user interface in software [1]. Here, fidelity is defined as a qualitative measure of how well the prototype reflects the functionality, completeness, and “polish” of the final product.

Low-fidelity prototyping is advantageous for many reasons. It provides a low cost mechanism for testing multiple design concepts and screen layouts early on in the development cycle [1]. In addition, low fidelity prototypes can stimulate and enhance design-oriented communication and dialog between designers and end users [1, 2]. Most importantly, good low-fidelity prototypes can help identify usability issues early in the design cycle, thus avoiding costly late-term user interface redesign and implementation efforts [1, 3].

Research Problem

Low-fidelity prototypes are typically produced using art supplies such as pens, paper, whiteboards, “post-it” notes and other similar materials. More recently, software such as Microsoft PowerPoint, DENIM [4], SILK [5] and simple web browsers have

been used to facilitate the production of low-fidelity prototypes [6, 7]. Informal analyses of these prototyping environments show that they are not optimized to support the two key tasks associated with low-fidelity prototyping; 1) rapid creation and modification of user interface (UI) screens, and 2) wizard-of-oz testing, where a human simulates the user interface prototype as test users interact with it [8].

Rapid Creation and Modification of a Prototype. The early stages of UI design can benefit greatly from multiple iterations of testing and prototype modification. Multiple prototype design iterations often result in value-added refinements to the final UI design. However, multiple iterations could be overwhelming to a designer who utilizes an arts supply prototyping environment. For example certain UI changes may cascade through multiple UI screens. For large projects, this may present an odious task to fix all the affected UI screens. Designers might be reluctant to iteratively refine the prototype if the hand sketching updates become too costly in terms of time, budget, and possibly patience of the designer. Current computer-based low-fidelity prototyping environments are somewhat better. For example, Microsoft PowerPoint® supports the concept of a “Master Slide,” which, if modified, propagates a change through all associated slides. This capability is considered limited because it does not provide the flexibility a designer might need to update only a subset of UI screens. Custom software such as SILK and DENIM are designed specifically to support low-fidelity prototyping, but they require a significant upfront implementation effort to create a demonstrable prototype [8].

Conducting Wizard-of-Oz Studies. When developing a new user interface, designers typically run wizard-of-oz studies on prototypes with dozens, and sometimes

hundreds of screens. As a result, the wizard incurs a high cognitive load in manipulating the prototype in response to user input [8]. The consequences of this situation include potential errors and significant time lags in manipulation of the prototype during wizard-of-oz studies. Software such as SILK and DENIM are designed specifically to support low-fidelity prototyping but they do not technically support wizard-of-oz studies. Art supplies, along with software tools like PowerPoint® and SMART® Notebook, do not support features specifically geared toward assisting wizards in navigating from screen to screen.

A Possible Solution: WOZ PRO

Within the context of the development of a new studio-based curriculum for an undergraduate course on human-computer interaction design at Washington State University [9], this thesis aims to address the problems cited above through the development and empirical evaluation of a computer-based wizard-of-oz prototyping tool called WOZ PRO (Wizard of OZ Prototyper). WOZ PRO supports the creation and presentation of a low fidelity user interface prototypes that take the form of a network of sketch-based user interface screens that can be stored, modified, displayed, and manipulated on a tablet PC (Figure 1).

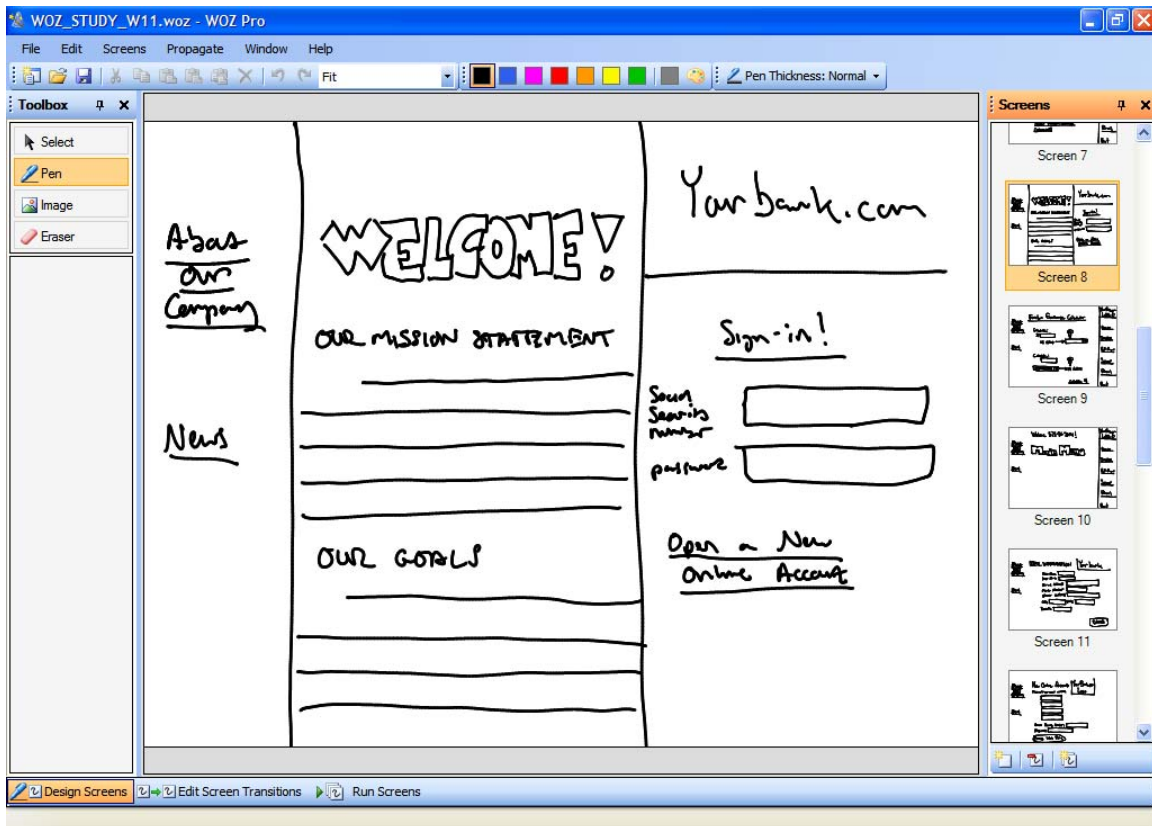


Figure 1. WOZ PRO Interface

WOZ PRO's design emerged through an iterative, user-centered design process in which we, ourselves, ran wizard-of-oz studies on early paper prototypes of WOZ PRO. Because it required us to run wizard-of-oz studies within wizard-of-oz studies, the user-centered development of WOZ PRO raised several research issues whose resolution, along with the design of WOZ PRO itself, constitutes a key contribution of this thesis. Yet, our development of WOZ PRO led to broader questions regarding the effectiveness of low fidelity prototyping tools in the user interface design and testing process. We now turn to these questions.

Research Questions

A key motivation for developing the WOZ PRO software was that we thought it would exhibit several potential advantages over conventional prototyping environments. These advantages are associated with the accuracy of prototype production and the execution of wizard-of-oz studies. To evaluate these potential advantages, we ran an experimental study in which we had alternative treatment groups undertake prototype construction activities in either WOZ PRO (the experimental treatment) or an arts supply (the control treatment) prototyping environment. The arts supply environment was chosen over other prototyping environments because it is considered the easiest prototyping environment to work in, and is commonly used in industry and academia for software UI design and teaching [3, 10]. Within the context of a WOZ PRO and Arts Supply experimental study, the following research questions were addressed:

RQ1: Will WOZ PRO support faster and more accurate prototype construction, and faster and more accurate prototype execution in a wizard-of-oz study, compared to art supplies?

Another key attribute of a low-fidelity prototyping environment is the ability to detect and isolate usability problems with the form and function of the UI [11]. This potential benefit led to a second research question regarding the performance of the WOZ PRO environment relative to the arts supply environment:

RQ2: Will WOZ PRO support increased detection of usability problems, as compared to art supplies?

This thesis documents the experimental design, data collection, analysis, and conclusions associated with the experimental comparison of WOZ PRO and art supply environments. The experimental study will show that while WOZ PRO provides an excellent sketching medium for generation of low-fidelity prototype UI screens, more work is needed on defining a scalable UI screen navigation model.

Thesis Outline

The remaining contents of this thesis are organized in the following manner. Chapter 2 summarizes the body of work relevant to low-fidelity prototyping and the purpose of this thesis. Chapter 3 documents the user-centered design and implementation of the WOZ Pro low-fidelity prototyping environment. Chapter 4 provides a detailed description of the experimental design, data collection efforts, and analysis of the data. Chapter 5 presents conclusions of this study and recommendations for future research work.

CHAPTER 2

RELATED WORK

Over the last several years considerable effort has been expended on developing computer-based prototyping environments that incorporate the “free-form” attributes of the conventional arts supply prototyping environment. The emphasis of this body of work has been to harness the speed, flexibility, and design memory offered by a computer-based system with the high provisionality characteristics of the arts supply prototyping environment. In addition, support of wizard-of-oz study techniques, beautification of sketched objects, and conversion of sketched objects to graphic objects that can be coded are design goals for much of the more recent work. A description of the salient development efforts follow.

The Fidelity of Prototypes

For several years the user interface design community has focused a good deal of discussion and research on evaluating the relative advantages and disadvantages of prototype development using different levels of fidelity. Virzi et al. [12] argued that prototype fidelity represents a continuum rather than two mutually exclusive categories of “low” and “high”. They proposed that four basic dimensions characterize the relative fidelity of prototypes. These dimensions include: 1) breadth of features, 2) degree of functionality, 3) similarity of interaction, 4) and aesthetic refinement. Virzi et al. [12] stated a prototype that compromises in an obvious way any of these four dimensions should be considered “a low-fidelity prototype.”

Virzi et al. [12] also explored the impact of prototype fidelity on a designer's ability to detect usability problems throughout the software development cycle. They conducted two experiments where they created low- and high-fidelity prototypes to determine if usability issues were more detectable in one or the other. The first experiment involved low- and high- fidelity prototypes of an electronic encyclopedia system. The high-fidelity prototype was developed using a portable electronic book reader running an abridged encyclopedia. This prototype allowed the test subject to enter commands via a limited QWERTY keyboard configured with some dedicated function keys. The low-fidelity prototype counterpart was developed using art supplies. The hardware interface and UI screens for the low-fidelity prototype were simulated using index cards which had the various UI states and the hardware interface printed on them. Based on the test subject's actions with the paper hardware interface, the experimenter would present the test subject with an index card showing the appropriate UI screen. The experiment required test subjects to complete a number of tasks using these prototypes. During execution of the tasks, experimenters tracked three types of problems encountered by test subjects: 1) errors made during completion of tasks, 2) test subject confusion with the interface, and 3) an obvious misunderstanding of the interface, even if no error is made. The second experiment followed a similar test protocol, but prototypes were developed for an interactive voice response telecommunications system. The low-fidelity prototype was created using an experimenter to simulate a computer, and a standard touch tone telephone with no network connection as the physical interface to the system. The test subjects entered commands on the telephone and the experimenter would verbally respond back to the test subject, simulating the interactive computer response.

The high-fidelity prototype was created using an Apple Macintosh computer and TLFX telephony software. The system was designed to provide a limited number of pre-recorded responses, depending on test subject input from a standard touch tone telephone. Results from both experiments showed that low- and high- fidelity prototypes supported effective identification of usability issues. Virzi et al. [12] contended that well-constructed low-fidelity prototypes are effective throughout the software development cycle for detection of usability issues.

Rudd et al. [1] discussed the relative advantages and disadvantages associated with low- and high-fidelity prototypes. In their discussion they presented various criteria by which a low- or high- fidelity prototype might be more appropriate over the other. They concluded there were many factors that need to be considered in deciding to use low- or high-fidelity prototyping and that both have a place in the UI design process. Arguments contending that one form of prototyping is better than the other are not relevant as both have a place in UI design, according to Rudd et al. [1].

A study of the impact of prototype fidelity and development medium on website usability testing was conducted by Walker et al. [13]. These researchers experimented with low- and high-fidelity prototypes of a website developed in both computer and paper mediums to determine if one type of prototype and medium supported better detection of website usability problems. Four types of prototypes were developed; 1) paper-based low-fidelity prototype, 2) paper-based high-fidelity prototype, 3) computer-based low-fidelity prototype, and 4) computer-based high-fidelity prototype. The low-fidelity prototypes consisted of hand-sketched pages representing various states of the website with associated navigation and function buttons, and data entry points. For the computer-

based version, these hand-sketched pages were electronically scanned and used as background images in HTML and JavaScript pages that were presented in a web browser. Website page navigation and functionality was simulated by building hyperlink hotspots over navigation and function buttons, and data entry points. The high-fidelity prototype was developed directly in HTML using standard HTML navigation and function buttons, and text boxes for data entry points. For the paper-based version of the high-fidelity prototype, the web pages of all possible states of the website were printed onto paper for use during prototype testing. All prototypes were seeded with a number of usability problems based on the usability heuristics developed by Nielsen [14].

Walker et al. [13] found no significant difference in the types and number of usability problems detected in any of the four prototypes tested. While the computer-based prototypes seemed to elicit more general comments, they did not make detection of usability issues any easier. They concluded that their findings support the use of low-fidelity prototypes in either a computer or paper-based medium as a cost-effective mechanism for conducting rapid, multiple iterations of software user-testing and design. They noted that prototyping on paper supports a more participatory and dynamic design process, while computer-based prototypes provides tools for recording of user-tests, can be distributed electronically, and help document the design process.

Graphic Design Software for Low-Fidelity Prototyping

Wong [15] was an early proponent of using graphic design techniques and associated software for producing interactive computer based low-fidelity prototypes. Wong [15] argued that the early stages of UI design should use low-resolution

representations of UI components that are then animated to illustrate the general functionality of a UI. Low-resolution representations are initially hand-sketched drawings that are digitized or scanned into electronic images. The images are then animated using a program such as Macromedia Director to create the sense of program flow and operation of the UI. Wong [15] found that the use of the “low-resolution” graphics helped to avoid premature commitment to a particular design and stimulated discussion on alternative UI design and program flow.

SILK and DENIM Low-Fidelity Prototyping Environments

Landay was the first to fully investigate the utility, design and implementation of computer-based prototyping environments that support the development of computer-based low-fidelity interface prototypes [18]. Landay and his various colleagues carried out extensive studies of low-fidelity and high-fidelity prototyping techniques beginning in the early 1990s. Landay’s early work resulted in the first computer-based low-fidelity prototyping environment that integrated an electronic sketching interface using a computer stylus and screen [5, 19]. This environment, called SketChing InterFaces Like Krazy (SILK) allows UI designers to use a computer stylus to quickly sketch UI screens and test the general functionality of the hand-drawn widgets and other primitive components associated with the screen. SILK also supports creation of storyboards for specifying the transitions between screens. Hand-drawn widgets are interpreted by SILK using a “widget recognition engine” that infers and assigns functionality to the sketched component. For example, if a designer sketches a button-like widget, SILK will attempt to assign the widget as a button control. If SILK cannot recognize the sketched object,

then the designer can make his or her own assignment of functionality. SILK also supports direct editing of the sketched objects, and incorporation of sketched static objects that have no assigned functionality. Once the UI screens have been sketched, the designer can create a storyboard of UI screens. Storyboard transitions are created by placing the sketched UI screens in the storyboard screen of SILK. The SILK storyboard screen has a tool for drawing transition arrows between UI widgets and anchoring them to related UI screens. The transition arrows indicate to SILK which UI screen will be presented to a UI tester once a widget has been activated. Following the completion of a storyboard, the designer can iterate through many UI design changes and refinements by running the prototype in the storyboard mode with test users. SILK supports transformation of the low-fidelity prototype into the actual UI once the prototype has been refined to a point where implementation is feasible. Since SILK understands the widgets and controls that have been sketched, it simply replaces these sketched items with the real widgets and graphical controls. These controls can then be coded to function in accordance with the requirements and specifications of the prototyped UI.

Related to SILK is the Design Environment for Navigation and Information Models (DENIM) low-fidelity prototyping environment [5]. DENIM was designed and built with similar design goals to SILK [4]. Although the primary objective for DENIM is to support early prototyping of websites, the concepts of rapid prototyping, sketching, maintenance of design memory, and progressive refinement of prototype details drive the form and function of DENIM. A significant difference between SILK and DENIM is that current versions of DENIM do not support transformation of sketched widgets and controls to their graphical counterparts.

Both SILK and DENIM are not optimized for wizard-of-oz studies. While both support storyboarding functions, they do not appear to permit a wizard to dynamically navigate an interface in response to a test user's actions; rather, they require a test user to interact *directly* with the interface. Moreover, these environments, in our experience, can prove difficult for designers to use. SILK and DENIM require a user interface designer to become familiar with the specialized gesture language. In addition, interfaces in SILK and DENIM must be specified at a level of detail that permits their translation to computer widgets. Specifying an interface at this level of detail may be more than some interface designers are willing to do, especially in the early stages of design.

Other Environments

The "Ozlab" prototyping environment [16] is a formal implementation of Wong's [15] concept of using graphic design software for low-fidelity prototyping. The Ozlab environment is designed specifically to support wizard-of-oz studies of software that employ speech recognition as an input domain. Ozlab is a system composed of supporting software and two networked computers. One computer is used to display the UI screen to the test user while the second computer is used by the wizard to manipulate the UI screen in response to test user input. The Ozlab software is developed in Macromedia Director for generation of the UI screens, which allows for support of both low- and high-fidelity prototyping as required by the design cycle of the software being developed [17]. Ozlab does not support prototyping of UI screen transition or navigation, however. Rather, it focuses on prototyping user interactivity with single UI screens.

SILK and DENIM appear to have inspired other similar computer-based prototyping environments. Plimmer and Apperly [20,21] developed a low-fidelity prototype sketching environment called “FreeForm” that uses a digital whiteboard as the sketching medium. The FreeForm environment allows designers to work as a group at a large digital whiteboard. Similar to SILK, FreeForm attempts to take sketched text, widgets, and other components and transform them into the appropriate graphical objects for direct generation of Microsoft Visual Basic forms. Unlike either SILK or DENIM, FreeForm does not support storyboarding UI screens. Like SILK and DENIM, FreeForm does not support wizard-of-oz studies.

Chung and others [22] recently introduced “InkKit”, a tablet PC-based low-fidelity prototyping environment. InkKit allows a designer to sketch UI screens and content using the tablet PC stylus. A storyboard mode allows the designer to delineate transitions to UI screens by associating sketched controls with transitions to other UI screens. Like SILK, InkKit implements a graphical transformation engine that “beautifies” text, widgets, and other components sketched on the UI screen. Similar to FreeForm, InkKit attempts to generate Microsoft Visual Basic forms from the sketches to support coding of the prototype. As in SILK and DENIM, the storyboard functionality would likely be insufficient to support a wizard-of-oz study.

The “Sketch Wizard” prototyping environment was recently developed by Davis et al. [23], who were students of Landay. Sketch Wizard is specifically catered for the prototyping and testing of pen-based UIs that support handwriting and gesture recognition. Like Ozlab, Sketch Wizard is designed to support wizard-of-oz studies via two networked computers. One computer displays the UI screen to a test user, while the

other is covertly operated by the wizard who controls the UI screens presented to the test user. Sketch Wizard captures the interaction of the test user with the UI screen and transmits the interaction to the wizard's computer, allowing the wizard to respond to the user input. Sketch Wizard supports the transformation of sketched objects to higher fidelity objects. The transformation is controlled by the wizard and used to simulate recognition behavior that pen based software might exhibit. Sketch Wizard includes a module for capturing and replaying wizard-of-oz sessions. While it is geared toward the simulation of pen-based UIs that support gesture and handwriting interaction, Sketch Wizard does not address storyboarding navigation or techniques for allowing the wizard to simulate transitions between UI screens.

Observations

Based on the above examination of the body of work in the area of computer-based low-fidelity prototyping environments, no general purpose low-fidelity prototyping and testing environment for tablet PCs appears to be available. SILK, the most relevant of the environments described above, focuses on the transformation of the prototype into higher-fidelity prototypes as the design process proceeds. We believe this focus is an unnecessary complication that distracts from the goal of replacing arts supply prototyping with an efficient computer-based environment. Other environments described above do not fit the definition of a general purpose low-fidelity prototyping environment because they specialize in prototyping a particular type of software, or they focus on the transitioning from low- to high-fidelity prototypes and beyond. In contrast, the WOZ PRO environment presented here is aimed at providing a general purpose low-fidelity

prototyping environment that is at least as easy to use as paper and pen with the added benefits of a built-in design memory, ability to easily propagate changes throughout the prototype, and support for efficient and effective wizard-of-oz studies.

CHAPTER 3

DESIGN AND IMPLEMENTATION OF WOZ PRO

Implemented for tablet PCs in C# using the Microsoft .NET 2.0 API and the Microsoft Tablet PC software development kit version 1.7, WOZ PRO software supports both the creation of low-fidelity prototypes and the subsequent execution of wizard-of-oz tests involving those prototypes. We¹ developed WOZ PRO through an iterative, user-centered design process (see, e.g., Norman & Draper [23]). We developed the specifications and functional requirements for WOZ PRO during the summer of 2006, when the first round of low-fidelity prototype tests were conducted. Further iterative design and usability testing of both low- and high-fidelity prototypes continued from September of 2006 through March of 2007. The process culminated in the completion of WOZ PRO 1.0, the version of the software used in the experimental study to be described in Chapter 4.

In this chapter, we first describe the requirements upon which the design of WOZ PRO is based. We then walk through a detailed example in which we create an actual prototype with the system. This example illustrates the features and functionality of the software. We conclude with a discussion of the design and implementation challenges we faced, along with our plans for further developing WOZ PRO.

¹ It is important to identify what is meant by “we” in this chapter, as that meaning differs from other chapters. While I was the primary contributor to the design and actual execution of the empirical evaluation of WOZ Pro described in this thesis, I played only a peripheral role in the software design and implementation efforts described in this chapter. With funding from a Hewlett Packard “Technology for Teaching Grant,” WOZ Pro was designed by WSU undergraduate students Anzor Balkar and Mohamed Nuur, along with my faculty advisor, Chris Hundhausen. I provided critical input into this design process, especially toward the end, when the version to be used in the experimental study was being finalized. However, Anzor Balkar and Mohamed Nuur were solely responsible for implementing the WOZ Pro software.

WOZ PRO 1.0 Requirements

The WOZ PRO software was designed to support two key activities in the user-centered development process:

- Creating a low-fidelity interface prototype that consists of a network of UI screen sketches; and
- Running wizard-of-oz studies in which a human demonstrates the interface to test users.

Four general functional requirements were developed to address these two key activities:

1. Designers must be able to create functional low-fidelity prototypes of websites. Test users must be able to interact with the prototype to complete specific tasks.
2. Designers must be able to specify (in plain English) to the system each task that their low-fidelity prototype will support. That task description can then be used by test users as they complete tasks with the low-fidelity prototype.
3. Designers must be able to specify to the system the manner in which each task would be ideally completed.
4. Designers must be able to run prototype tests with the system in which:
 - test users are presented with tasks.
 - test users complete the tasks with the low-fidelity prototype.

To this end, WOZ PRO defines three general modes of operation: 1) design screens mode, 2) edit screens transition mode, and 3) run screens mode. We describe these below.

Design Screens Mode

The design screens mode is the default startup mode for WOZ PRO. Figure 2 illustrates the major elements of the WOZ PRO UI in the design screens mode. The work area of WOZ PRO in this mode consists of a sketching tool palette, a sketching region, and a side bar for displaying thumbnail images of sketched UI screens. The operating mode of WOZ PRO is changed via control tabs located at the bottom left-hand corner of the application UI, with the current mode of operation indicated by the highlighted tab.

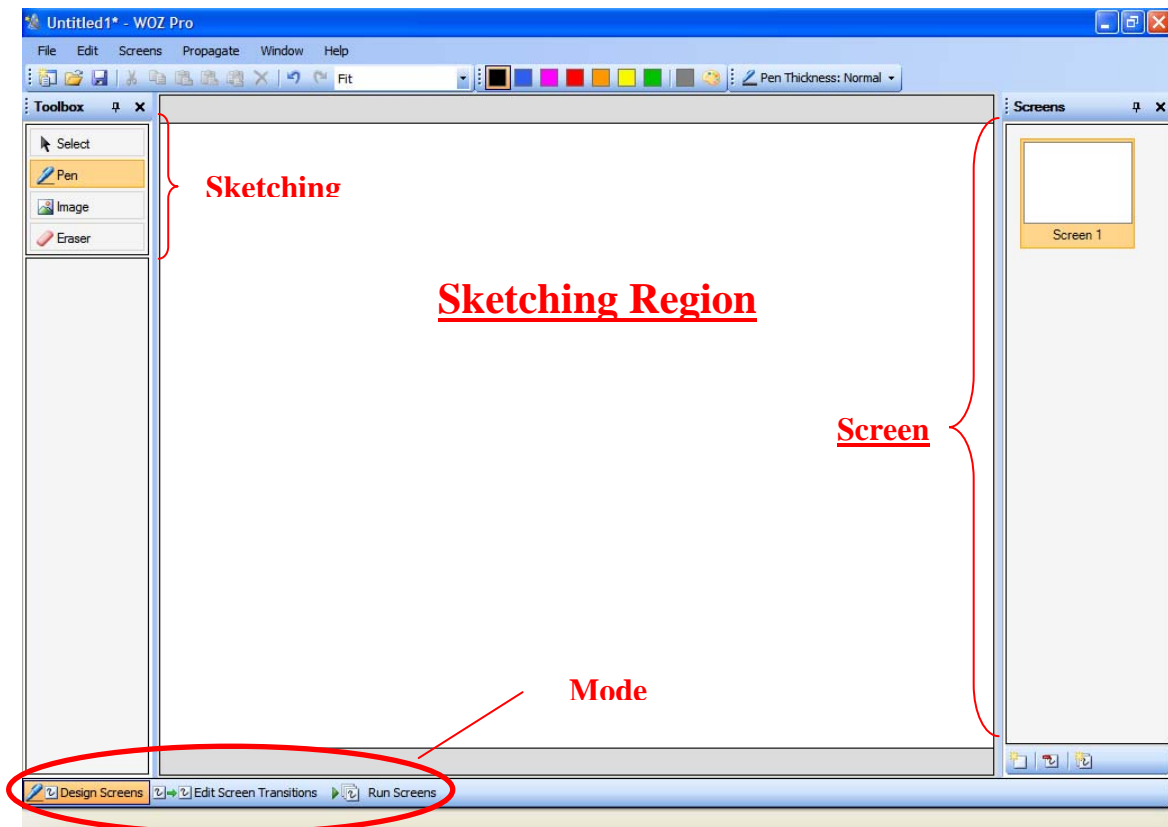


Figure 2. The WOZ PRO Design Screens mode interface.

The sketching region is a canvas on which the user can create free-hand drawings of individual UI screens using the tablet PC stylus. This mode also supports the display

of screen “thumbnails” or reduced size graphics of the drawn UI screens. These thumbnails are displayed on a split screen that easily allows the designer to pick a thumbnail and make it the current graphic in the canvas area. In addition, thumbnails can be reordered, copied, and deleted. The drawing toolbox includes selection, pen, image, and eraser tools. Drawing is performed using the pen tool. The pen tool can be adjusted for line thickness and color using the pen thickness and color palette found on the menu. The selection tool is used to select all or portions of a drawing for resizing, repositioning, copying, cutting, and pasting. The image tool is used for importing image files into the prototype. Finally, the eraser tool provides a convenient alternative to inverting the drawing stylus to erase all or portions of a drawing. Once a screen is complete, the designer can create a new UI screen by picking the “Screens” menu item and choosing the “Add New Screen” option. If the designer is not happy with the current screen, the current UI screen may be completely removed by choosing the “Remove Current Screen” option.

Design screens mode includes two productivity-enhancing functions: screen cloning and change propagation. “Clone Current Screen” is a menu choice found under the “Screens” menu item. Screen cloning allows a designer to pick a thumbnail screen and create a complete copy of that screen in the drawing canvas area. Designers can use the cloning function to produce one or more templates for creating large numbers of similar UI screens, or as a simple way to copy a UI screen to replicate reoccurring screen elements.

The propagate changes function is associated with the “Propagate” menu item (Figure 3). This function allows a designer to make changes to a UI screen and cascade

the changes to a chosen list of UI screens. WOZ PRO stores the pen stroke metadata for each UI screen. In the propagate changes function, the designer is presented with a list of pen strokes that compose the current UI screen. The designer picks which pen strokes will be deleted or added to a list of UI screens. Deletions only affect screens that have been cloned from the current UI screen, while additions can be cascaded to all chosen screens.



Figure 3. The WOZ PRO Propagate Changes interface

Screen Transition Mode

The Edit Screens Transition mode supports the networking or linking of UI screens to simulate the navigation from an interface screen to others, based on the software functionality that is being prototyped. UI screen navigation is modeled as a

state transition network (STN), with the idea that every UI screen represents a new state in the STN and that at least one transition must be specified for each UI screen in the prototype. Figure 4 shows the initial state of the Edit Screens Transition mode following completion of UI screens produced in the design screens mode. Designers begin defining screen transitions by dragging and dropping the screen thumbnails into the UI screen navigation region of the WOZ PRO Edit Screens Transition mode interface.

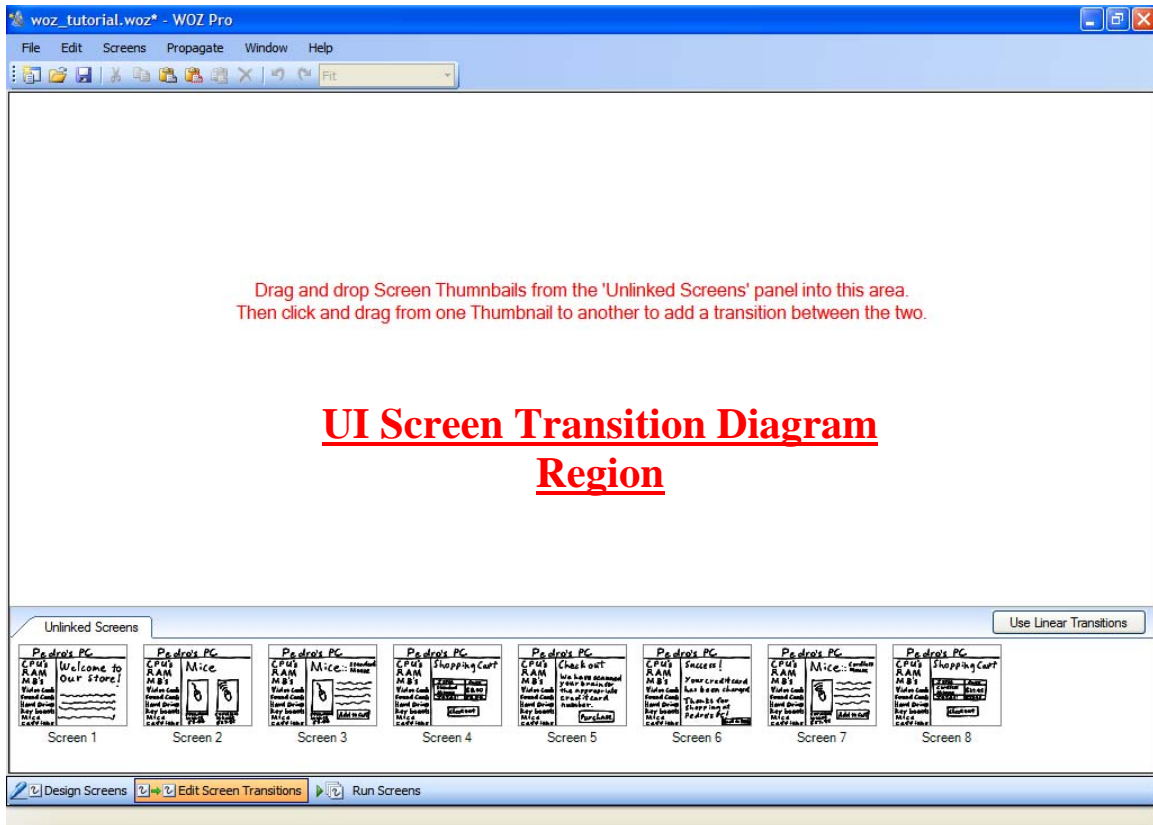


Figure 4. The WOZ PRO Screen Transitions mode interface. No transitions are defined yet.

Using the UI screen thumbnails, designers graphically link the UI screens with arrows drawn from one UI screen thumbnail to another creating a transition diagram for the prototype. The screen transition arrows represent the intended flow and function of

the prototyped software (Figure 5). Designers also define the software entry point (i.e., the first screen to be presented in the prototype) in this mode.

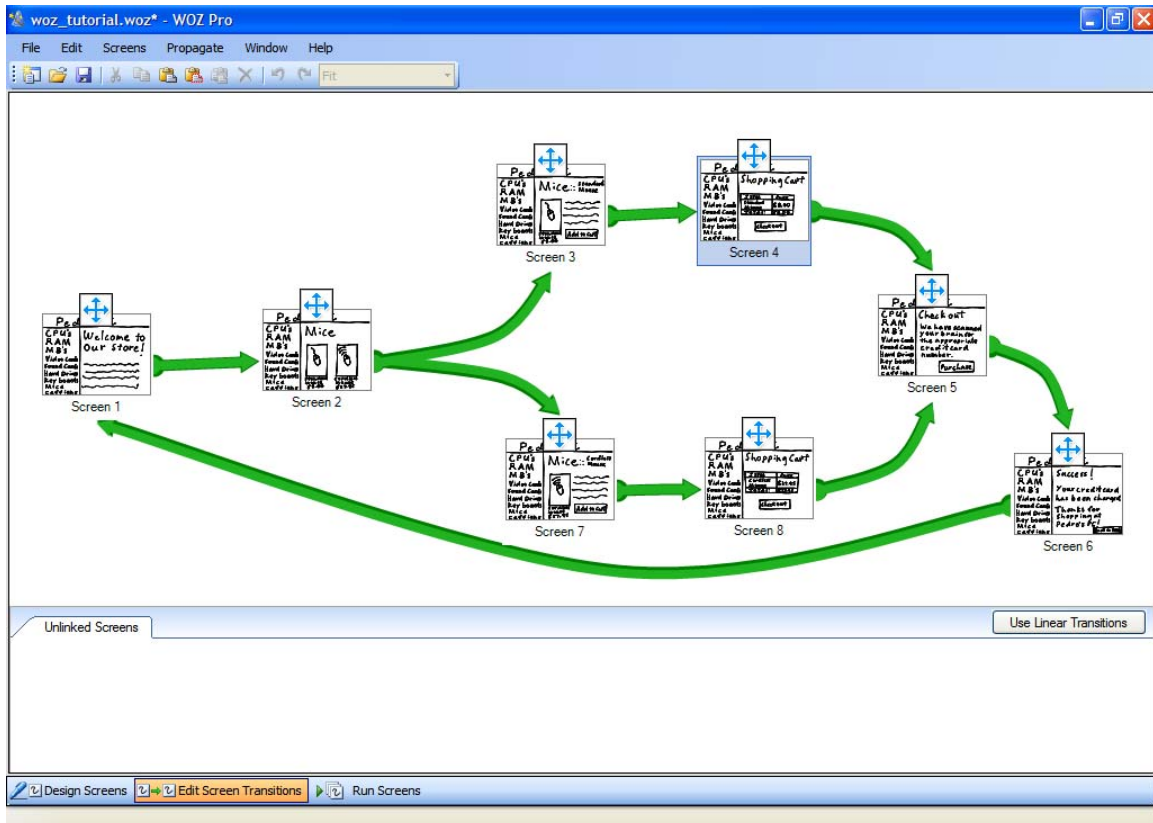


Figure 5. The WOZ PRO Screen Transitions mode interface. Transition diagram defined.

The screen transition arrows can be repositioned or removed entirely by dragging them away from the screen thumbnails and redrawing them as needed. If a screen thumbnail requires modification, a designer can “double-click” on a UI screen thumbnail to bring WOZ PRO back into the Design Screens mode where changes to the subject UI screen may be completed as well as changes to any other UI screen. UI screen transition diagrams may extend beyond the visible UI screen navigation region. Areas of the transition diagram outside the current view of the navigation region are accessible by

vertical and horizontal scroll bars that become available when the transition diagram is larger than the navigation region.

Run Screens Mode

Once the navigation of the prototype has been specified in the Screens Transition mode, the designer can demonstrate his prototype to a test user. The demonstration of the prototype is performed in the Run Screens mode of WOZ PRO as illustrated in Figure 6. The Run Screens mode provides a tool for conducting wizard-of-oz prototype studies, with WOZ PRO providing the UI screen navigation functionality for the “man behind the curtain.” The Run Screens mode provides a full-screen preview of the current UI screen. Navigation controls found in the bottom left-hand corner of the interface allow a wizard to control which UI screen is previewed through “forward” and “Previous” buttons. The choice of UI screens is constrained by the transition diagram established in the Screen Transitions mode of WOZ PRO. If navigation can result in more than one screen choice, then a thumbnail of the UI screen choices is presented to the Wizard just above the controls for reference. If the wizard needs to correct a navigation step, he or she can stop the wizard-of-oz session with the “stop” button, which drops them back into the Screens Transition mode were changes to the transition diagram can be made.

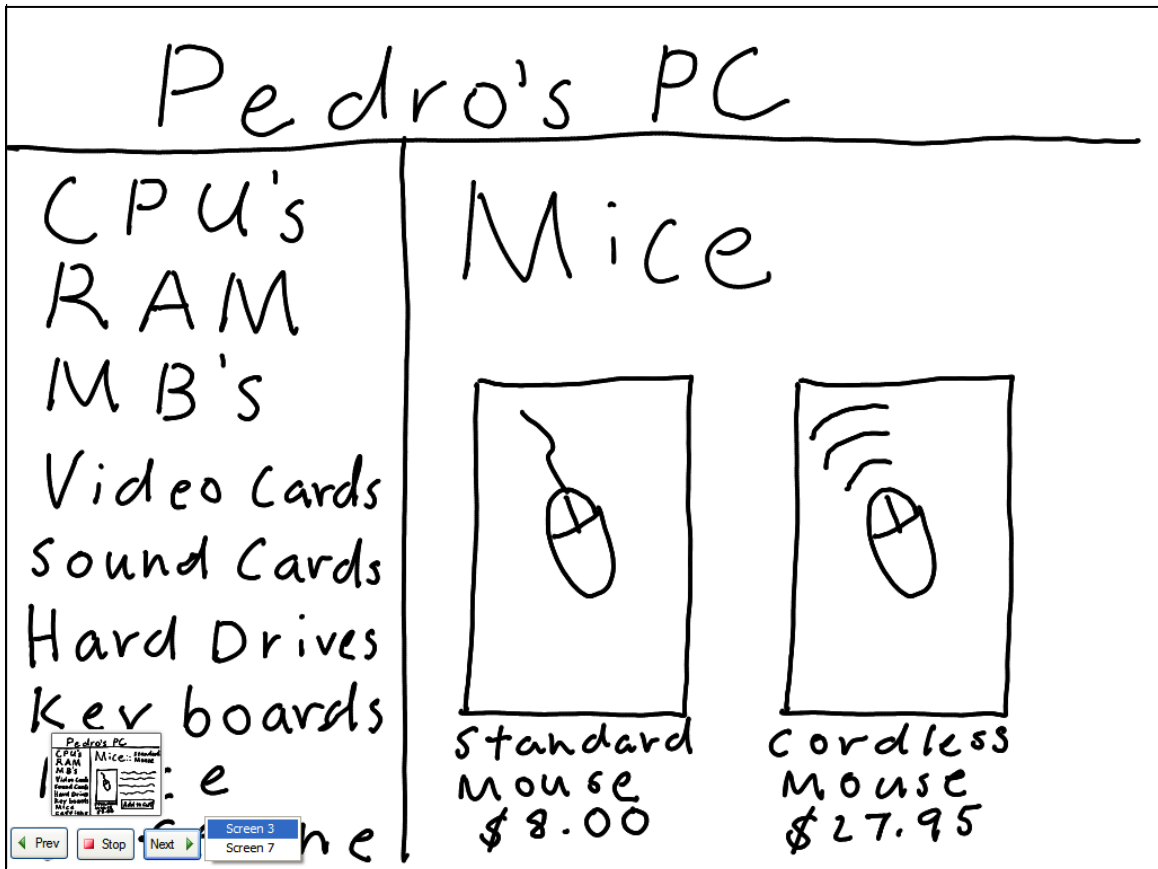


Figure 6. The WOZ PRO Run Screens mode interface.

Discussion and Summary

WOZ PRO presented unique challenges to our software design team. Initially the design team struggled with how to best simulate the work flow of a “paper and pen” low-fidelity prototyping environment that would also support a wizard-of-oz demonstration capability on the tablet PC. While the tablet PC readily lent itself to hand sketching of UI screens, efficient mass production and illustration of modifiable UI screens proved to be a non-trivial effort. In addition, conceiving and implementing a simple and effective UI screen navigation model to support wizard-of-oz studies was more difficult than originally thought, and remains a major design issue for WOZ PRO developers to address. Our screen navigation model, which is based on a STN paradigm, required prototype

developers to specify every possible screen transition. This model was adequate for simple prototype development and wizard-of-oz demonstrations. However, its shortcomings were evident when applied to more complex prototypes. Ultimately we found the STN model did not support faster or more accurate prototype execution during wizard-of-oz studies. Chapter 4 discusses this problem in detail and outlines an alternative screen navigation model for future research.

Designing, creating, and user testing the WOZ PRO interface presented a host of interesting problems. During our design process, we created low-fidelity prototypes of WOZ PRO using the SMART® Notebook whiteboarding software and a SMARTBoard® electronic whiteboard. We then iterated through two rounds of wizard-of-oz testing, each involving three participants. In these tests, participants were tasked with (a) designing a low fidelity prototype of a website according to specifications we provided, and then (b) running a wizard-of-oz study on the prototype. Running wizard-of-oz studies in which participants themselves ran wizard-of-oz studies posed two notable challenges. First, participants were initially confused about which tool to use to develop and test their prototypes—SMART® Notebook, or our low fidelity prototype developed in SMART® Notebook. To resolve this issue, we resorted to draping a towel over all interface components of the SMART® Notebook software, leaving in view only the screens that composed our prototype. Second, when it came time for participants to run a wizard-of-oz study on their prototypes, they initially became confused about their role as wizard—a role that we (as the researchers) had been playing for the first part of the study. We therefore had to take care, in our instructions, to explain that their job in the second part

of the study was to run a study on their prototype with us (the researchers) as test users. Once we refined our explanation of this, participants caught on quickly.

For this thesis study, nearly the entire designed functionality of WOZ PRO 1.0 was available to the researchers. The only functionality not available was the “propagate screen changes” function. This did not prove to be a limiting factor in conducting the study, however.

CHAPTER 4

EXPERIMENTAL STUDY

As described in Chapter 2, simple art supplies (pen, paper, and the like) are commonly used to construct low fidelity prototypes. They are generally seen as the “gold standard” for low fidelity prototyping, due to their naturalness and ease of use as a prototyping medium. Therefore, they are an appropriate baseline against which to measure the effectiveness of the WOZ PRO tool described in the previous chapter. Indeed, WOZ PRO was designed to be as easy to use as art supplies, but to afford key advantages over art supplies, including (a) the ability to quickly clone existing screens, (b) the ability to quickly propagate design changes, and (c) the ability to run wizard-of-oz studies quickly and easily.

In this chapter, we put the design of WOZ PRO to the test by presenting an experimental evaluation that compares WOZ PRO to art supplies.

Experiment Design

Two hypotheses were explored in the experiment:

H1: WOZ PRO will promote faster, more accurate construction of user interface prototypes than art supplies.

H2: In wizard of oz prototype studies, WOZ PRO will promote more efficient screen transitions and fewer screen transition errors than art supplies.

The experiment was designed as a between-subjects study with two treatments: 1) WOZ PRO (WOZ) and 2) Arts Supplies (ART). To gauge the effectiveness of the prototyping

environments being compared, the experiment defined the following four dependent measures:

1. Time to construct prototype
2. Average time delay between screen transitions
3. Number of screen transition errors
4. Number of usability problems identified by designer.

In addition, each study participant completed an exit questionnaire in which they documented their experience using the low-fidelity prototyping tools. The responses to the questionnaire were also used to evaluate the overall effectiveness of the prototyping environments based on user feedback.

Study Participants

Twenty-four computer science students and recent graduates participated in the study (20 males, 4 females). Sixteen of these participants were recruited from the Spring, 2007 offering of CptS 443/580, “Human-Computer Interaction” (HCI) at Washington State University, and received course credit for their participation. Eight additional participants who had completed the CptS 443/580 course at Washington State University during the previous two years were recruited from the local area. These individuals were given a \$25.00 honorarium for their participation. All study participants had a basic understanding of low-fidelity prototyping and wizard-of-oz studies due to their past or present enrollment in the CptS 443/580 course. Of the 24 study participants, 5 took part in pilot studies. Of the 19 remaining study participants, 9 were assigned to ART condition, and 10 were assigned to the WOZ condition.

Materials and Tasks

Study participants were required to create and test, in wizard-of-oz fashion, two target websites—one in the tutorial segment of the session, and another in the study segment of the session. For the tutorial segment of the session, participants in both conditions were provided with a web browser running a simple low-fidelity (sketched) version of a computer peripherals purchasing website (see Figure 7 for a sample screen), along with informationally-equivalent sets of instructions for constructing and testing prototypes with their respective tools (art supplies or WOZ PRO). They were required to use their respective tools to construct and test the website per a set of instructions that were identical to those that they would use in the main part of the study (see below). For the main part of the study, participants were given a web browser running a more complex website of a fictitious bank. This website, henceforth referred to as the “study website,” was based on an online banking website developed by Walker et al. [13] for their experimental study of paper versus computer prototyping techniques. Walker et al. [13] embedded usability problems in the website based on the usability heuristics developed by Nielsen [14]. Through pilot studies, we adapted the website of Walker et al. [13] by reducing its complexity such that our study participants could create and test the website within the allotted time of each experimental session; however, most of the usability problems of the site were retained. Our study website consisted of 21 screens and 157 possible transitions, and was seeded with 14 known usability problems. Figure 8 shows a site map of the final study website; screen shots of the study website web pages are contained in Appendix C.

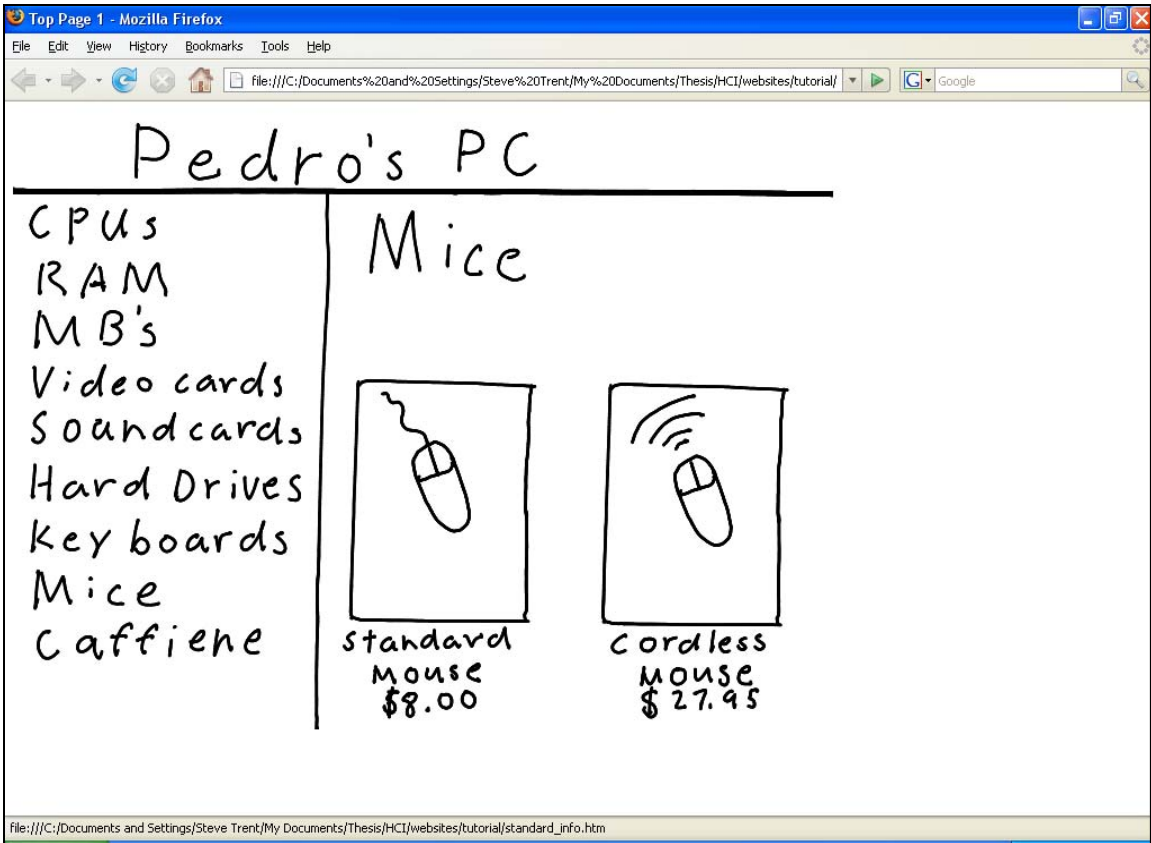


Figure 7. Sample UI screen from the tutorial segment.

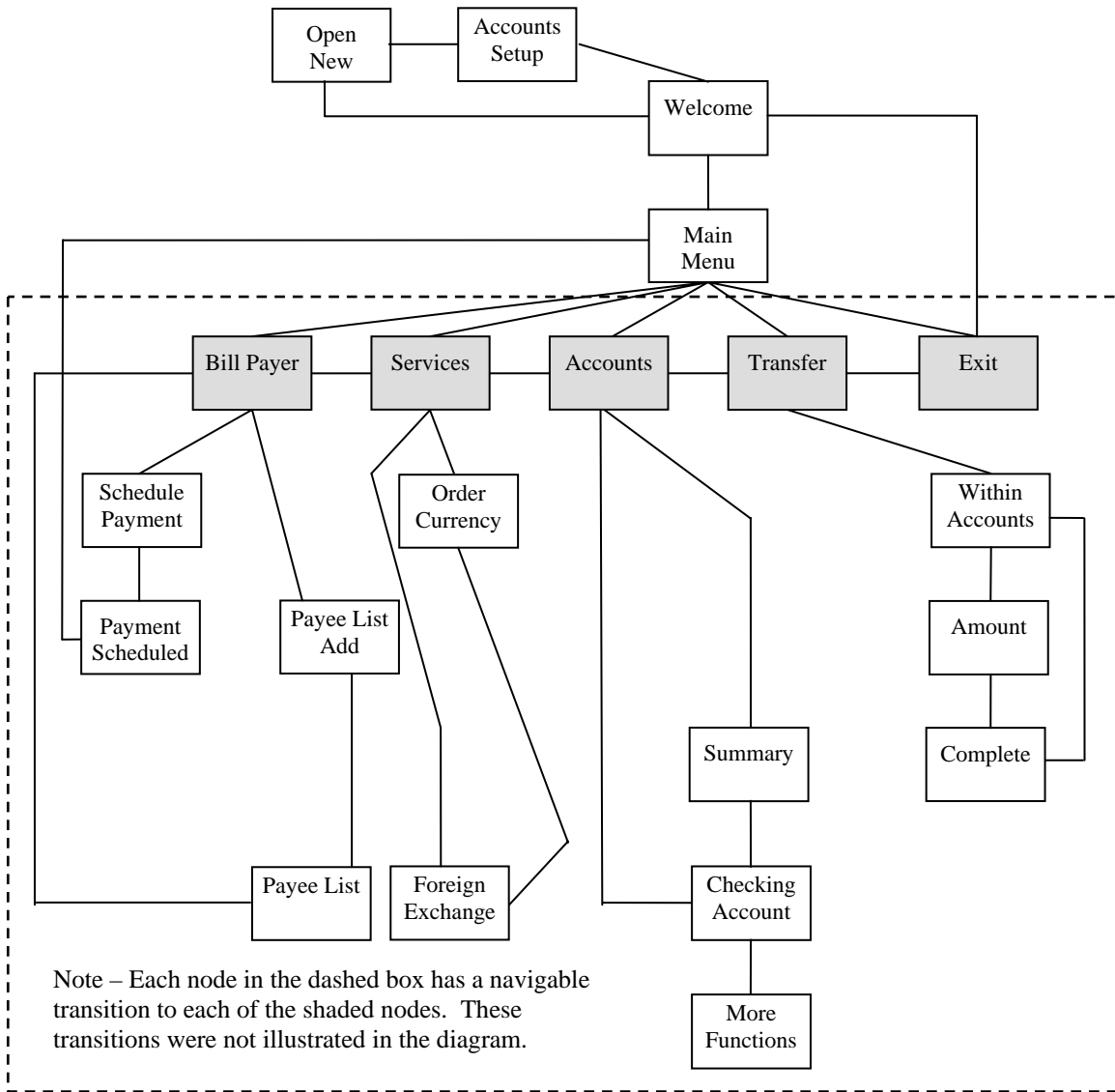


Figure 8. Study Website site map.

Two types of tasks were completed by study participants during the main part of each experimental session: (a) prototype creation tasks, and (b) wizard-of-oz demonstration tasks. Prototype creation tasks included sketching screens, defining transitions between screens (screen transition diagram), and organizing screens for presentation to a test user. For the wizard-of-oz demonstration, the experimenter entered the room and role-played a test user as each participant simulated the website he/she had constructed for a set of five tasks (see Table 1).

In the ART condition, participants were provided with sheets of standard 8½ x 11-inch paper for creating and presenting their website prototypes. Sketching was performed with black dual-tip (fine and standard tips) permanent markers. White out pens and correction tape were provided for correcting errors. In contrast, in the WOZ condition, participants used the WOZ PRO software (see previous section) to create and present their website prototypes. Participants worked with WOZ PRO on a Hewlett-Packard Compaq tc4200 tablet PC with a 14" screen, 512 MB of RAM and an Intel Centrino 2.0 GHz processor. For both tasks, participants accessed the target websites they were to create and test through a web browser running on a Hewlett-Packard Compaq tc4200 tablet PC with a 14" screen, 512 MB of RAM and an Intel Centrino 2.0 GHz processor. They performed their work in an area directly adjacent to that PC, as illustrated in Figure 9. The Tablet PC at the bottom of the figure (but at the top of the work area, with respect to participants) ran the target website that participants were to create and simulate within the study. Participants in the ART condition were requested to keep their drawing activities (which involved 8½" x 11" sheets of paper, black markers, and whiteout) within the area delineated by the black tape. Likewise, the WOZ PRO

participants were asked to keep the tablet PC running WOZ PRO within the area delineated by the black tape.



Figure 9. Work area configuration for both experimental conditions.

Demonstration Tasks	Total transitions	Correct screen transition	Transition
Task 1: Open a new online account	3	newaccount1.html	1-1
		newaccount2.html	1-2
		mainwelcome.html	1-3
Task 2: E-mail a checking account statement to a user	6	mainmenu.html	2-1
		mainaccounts3.html	2-2
		accountssummary.html	2-3
		accountstatment-unfiltered.html	2-4
		accountstatment-unfilterread-morefunc3.html	2-5
		mainaccounts3.html	2-6
Task 3: Set up automatic bill payments	7	mainbillpayer.html	3-1
		billpay-payee1.html	3-2
		billpay-payee2frameset.html	3-3
		mainbillpayer2.html (same as mainbillpayer.html)	3-4
		billpay-scheduled-cingular4.html	3-5
		billpaysuccess.html	3-6
		mainmenu.html	3-7
Task 4: Find the value of foreign currency	4	mainservices.html	4-1
		foreignexchange1b.html	4-2
		foreignexchange2.html	4-3
		mainmenu.html	4-4
Task 5: Transfer money between accounts	5	maintransfers.html	5-1
		Transfers-within-account1d.html	5-2
		Transfers-within-account2.html	5-3
		Transfers-confirmation.html	5-4
		maintransfers.html	5-5

Table 1. Tasks simulated by participants in the wizard-of-oz demonstration portion of the main study.

We used the TechSmith Morae® Recorder to create high-quality recordings of participants' work sessions. In particular, we created both (a) lossless recordings of the target screens participants viewed as they constructed their websites, and (b) the screens that participants actually created and presented (either with art supplies or WOZ PRO). The picture-in-picture feature of Morae Recorder was used to synchronize participants' work with the target screens that they viewed. By viewing these recordings, we were able to gather our dependent measures.

Procedure

In order to guard against the possibility that individual differences in sketching speed might confound the results, we had participants complete a sketching pretest prior to the experimental sessions. We then assigned participants to the two conditions such that the mean pre-test performances of the two conditions were optimally matched.

The experiment was conducted over a two week period during which participants completed experimental session individually. Each experimental session was approximately two hours in duration, and consisted of a tutorial (30 minutes), the main study (75 minutes), and an exit questionnaire (15 minutes). In the tutorial segment, participants were given a brief introduction to the prototyping tool they were to use (art supplies or WOZ PRO), and practiced creating the screens. Following that, they were required to use that tool to create a low-fidelity prototype of a simple website for purchasing computer peripherals, and then to use their prototype to conduct a wizard-of-oz demonstration with a test user. The purpose for the tutorial segment was to familiarize

study participants with the low-fidelity prototyping tools and wizard-of-oz prototyping techniques.

Following completion of the tutorial and training activities, study participants were presented with written instructions for completing the study segment of the experimental session. Study participants were asked to read all instructions aloud and announce when they had started or completed a task. In addition, study participants were requested to “think aloud” [24]. Any thoughts that they felt were pertinent to the experimental study, such as problems using the WOZ PRO software, comments on the tasks they were performing, etc.

The first task study participants were required to complete was to review and sketch the UI screens for the prototype. Study participants were presented with a series of low-fidelity UI screen images of the study website pages via a web browser on a tablet PC, and were requested to sketch each UI screen as quickly but as accurately as possible. UI screen images were presented to all study participants in the same linear order.

After completing the sketching task, study participants were presented with a navigable low-fidelity version of the study website in a web browser, and requested to create a screen transition diagram of possible navigation paths through the website. Participants in the ART condition sketched their navigation maps on paper, whereas participants in the WOZ condition created their maps in the screens transition mode of the WOZ PRO software.

Once the mapping task was completed, study participants were asked to organize their prototype so that they could conduct a wizard-of-oz demonstration with a test user. For participants in the ART condition, the organization task consisted mainly of

organizing their hand-sketched papers in a manner that would allow them easy access to the hand sketches during the wizard-of-oz demonstration. In the WOZ condition, study participants reviewed their prototypes in the “run screens” mode of WOZ PRO to ensure that transitions had been appropriately defined in the “screens transitions” mode.

Upon completion of the organization task, study participants invited the test user to participate in a wizard-of-oz demonstration. In all experimental sessions, the test user was played by the same experimenter. During the wizard-of-oz demonstration, the test user attempted to complete the same five study tasks using the participant’s prototype. Each task required the study participant to present a specific UI screen based upon the input from the test user. Test user input took the form of pencil tap on a portion of the current UI screen that would initiate the next screen transition. Each task consisted of specific number of transitions with a specific sequence of screens. Table 1 provides a description of the demonstration tasks, the number of transitions per task, and the correct screen transitions for each task.

Following the completion of the study session, study participants were asked to fill out an exit questionnaire where they documented their experience using the low-fidelity prototyping tools, and any usability issues associated with their prototypes. The questionnaire required each study participant to rate (ranging from 1 to 10) their experience in developing and using their particular prototyping environment. Five areas of concern relative to the study participants’ experience are addressed in the questionnaire; 1) Difficulty using the prototyping environment, 2) confidence in using the prototyping tools, 3) ease of learning to use the prototyping tool, 4) effectiveness of the

prototyping tool, and 5) satisfaction with use of the prototyping tool. Table 2 lists the specific elements of these areas that were rated by the study participants.

Measuring Dependent Variables

Measurement of dependent variables involved reviewing the video recordings. Measuring the prototype construction time was accomplished by determining the time required by each study participant to complete the three prototype construction subtasks—sketching, mapping, and organizing (Dependent Variable 1). In particular, using the time-marking functions of the TechSmith Morae® software, we identified the start and stop times that corresponded to the beginning and end of all tasks to determine the time duration for each task.

In a similar fashion, the time delay incurred for screen transitions during wizard-of-oz demonstrations was determined by marking the start and stop times for each correct screen transition (Dependent Variable 2). If an uncorrected screen transition error was made, or if no transition was defined by the study participant, then no time delay was calculated for the screen transition. Table 3 shows the specific criteria used to measure the duration of the tasks performed in this study.

The recordings were also used to identify and tabulate the errors made by study participants during the wizard-of-oz demonstration of their prototypes (Dependent Variable 3). Two types of screen transition errors were coded in the recordings. The first type of error was defined as presentation of an incorrect screen during the wizard-of-oz demonstration. Incorrect screen transitions were counted as errors regardless of whether the study participant recognized the error and corrected the screen presented to the test

user. The second type of error was missed transitions. If a study participant failed to complete all transitions in a transition sequence, each missed screen was counted as an error. In addition to counting errors, corrected screen transitions were also tabulated. A corrected screen transition occurred when the study participant recognized that an incorrect transition had been made, and attempted to find the appropriate transition and associated screen.

Measurement of dependent variable 4 was accomplished by evaluating a questionnaire completed by study participants immediately following each experimental session. In the questionnaire, each study participant was asked to identify usability problems they observed in the study website. Their responses were categorized with respect to the usability heuristics described in Nielsen [14] as shown in Table 4.

Area of Concern	Rated Element
Difficulty	Sketching website screens
	Fixing errors made to website screens
	Creating duplicate website screens
	Creating screen transitions
	Navigating website screens in response to test user actions
Confidence	Correctness of the study website
	Correctness of the screen transitions made in response to test user actions
Learning	How easy to learning to use prototyping environment
Effectiveness	How effective is the prototyping tool
Satisfaction	Level of frustration in using the prototyping tool

Table 2. Study questionnaire rated elements.

Task Type	Task	Start Criteria	Stop Criteria
Prototype Creation	Sketching	First drawing gesture put on paper or WOZ PRO drawing region after reading of the task description.	Last drawing gesture put on paper or WOZ PRO drawing region.
	Mapping	Opening of navigable study website on tablet PC.	Announcement by study participant that they had completed the mapping task.
	Organizing	First observable effort to organize hand-sketched screens or run WOZ PRO in “run screens” mode after reading of the task description.	Announcement by study participant that they had completed the mapping task.
WOZ demonstration	See Table 1.	Audible or visible gesture made by test user on the current screen to initiate a screen transition.	Point at which the old screen had been replaced with a new current screen, and was viewable.

Table 3. Start and stop criteria for determining time durations of various study session tasks.

Usability Heuristic	Description
Visibility of system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
Match between system and the real world	The system should speak the users language, with words, phrases, and concepts familiar to the user, rather than system oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
User control and freedom	Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
Consistency and standards	Users could not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
Error prevention	Even better than good error messages is a careful design which prevents a problem from occurring in the first place.
Recognition rather than recall	Make objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
Flexibility and efficiency of use	Accelerators - unseen by the novice user - may often speed up the interaction for the expert user to such an extent that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
Aesthetic and minimalist design	Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
Help users recognize, diagnose, and recover from errors	Error messages should be expressed in a plain language (no code), precisely indicate the problem, and constructively suggest a solution.
Help and documentation	Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the users task, list concrete steps to be carried out, and not be too large.

Table 4. Usability Heuristics from Nielsen [14].

Results

Data were subjected to statistical analysis to determine if significant differences existed between the WOZ and ART conditions for all four dependent variables and the exit questionnaire ratings. We used two statistical tests: the one-way analysis of variance (ANOVA) statistical test, and the Kruskal-Wallis statistical test, a non-parametric equivalent of the ANOVA test. Data sets approximating a normal distribution were analyzed using the ANOVA test, while non-normal data sets were analyzed using the Kruskal-Wallis test. Determination of a normal data distribution was facilitated using a Shapiro-Wilk test for normality on each data set.

Dependent Variable 1 - Time to construct prototype

Analysis of the time to construct a prototype was conducted using an ANOVA statistical test on each task associated with prototype creation. The ANOVA test was deemed the appropriate statistical test based on the results of the Shapiro-Wilk normality testing on each data set. Results of the Shapiro-Wilk normality tests are shown in table 5, while the ANOVA test results are shown in Table 6. Of the three tasks, only the mapping task demonstrates a significant difference between the ART and WOZ conditions. The sketching time and organizing tasks showed no significant difference between the WOZ and ART conditions.

Distribution	n	Mean (Minutes)	Std. Deviation (Minutes)	p value
Sketching	19	44.982	7.7541	0.8418
Mapping	19	22.919	9.7229	0.5789
Organizing	19	5.0932	2.8651	0.6724

Table 5. Shapiro-Wilk normality test results for dependent variable 1.

Condition	n	Mean (Minutes)	Std. Deviation (Minutes)	Statistic	p value
Sketching Task					
ART	9	46.048	7.231	ANOVA	0.5846
WOZ	10	44.023	8.463		
Mapping Task					
ART	9	16.059	5.201	ANOVA	<u>0.0014</u>
WOZ	10	28.903	8.843		
Organizing Task					
ART	9	4.517	2.385	ANOVA	0.4204
WOZ	10	5.613	3.275		

Table 6. Results of ANOVA statistical tests for Dependent Variable 1.

Dependent Variable 2 - Average time delay between screen transitions

Analysis of the average time delay between screen transitions was conducted using a Kruskal-Wallis statistical test. The Kruskal-Wallis test was deemed the appropriate statistical test based on the results of the Shapiro-Wilk normality test on the data set, which indicated the data were not normally distributed. Results of the Shapiro-Wilk normality tests are shown in table 7, while the Kruskal-Wallis test results are shown in Table 8. The results of the statistical test shows no significant difference between the average screen transition delay times for the WOZ and ART conditions.

Distribution	n	Mean (Seconds)	Std. Deviation (Seconds)	p value
Average Delay	19	6.9474	2.1467	<u>0.0178</u>

Table 7. Shapiro-Wilk normality test results for dependent variable 2.

Condition	n	Mean (Seconds)	Std. Deviation (Seconds)	Statistic	p value
Dependent Variable 2 - Average time delay between screen transitions					
ART	9	7.333	1.323	Kruskal-Wallis	0.5846
WOZ	10	6.600	2.716		

Table 8. Results Kruskal-Wallis statistical test for Dependent Variable 2.

Dependent Variable 3 – Screen Transition Errors

Dependent variable 3 was evaluated using data sets representing the number of screen transition errors made and number of screen transition errors corrected. Analysis of the number of screen transition errors and transition errors corrected was conducted using a Kruskal-Wallis statistical test. The Kruskal-Wallis test was deemed the appropriate statistical test based on the results of the Shapiro-Wilk normality testing on each data set, which indicated the data are not normally distributed. Results of the Shapiro-Wilk normality tests are shown in Table 9, while the Kruskal-Wallis test results are shown in Table 10. Results of the statistical test show a significant difference between the number of screen transition errors fixed for the WOZ and ART conditions while the total transition errors committed for both conditions was not significantly different.

Distribution	n	Mean	Std. Deviation	p value
Total Transition Errors	19	3.0536	1.9853	<u>0.0051</u>
Transition Errors Fixed	19	0.0789	0.1535	<u><0.0001</u>

Table 9. Shapiro-Wilk normality test results for dependent variable 3.

Condition	n	Mean	Std. Deviation	Statistic	p value
Dependent Variable 3 – Total Transition Errors					
ART	9	2.666	1.0	Kruskal-Wallis	0.9666
WOZ	10	3.4	2.591		
Dependent Variable 3 - Transition Errors Fixed					
ART	9	0	0	Kruskal-Wallis	<u>0.0178</u>
WOZ	10	0.15	0.188		

Table 10. Results Kruskal-Wallis statistical test for Dependent Variable 3.

Dependent Variable 4 – Usability Problem Detection

Usability problems were tabulated relative to the categories shown in Table 4, and then summed for each study participant. Based on the Shapiro-Wilk normality test

indicating a normal data distribution, the one-way ANOVA statistical test was used to analyze the usability problem detection data set. Results of the Shapiro-Wilk normality tests are shown in Table 11, while the ANOVA test results are shown in Table 12. The ANOVA test indicated no significant difference between the WOZ and ART conditions with respect to usability problem detection.

Distribution	n	Mean	Std. Deviation	p value
Usability Problems Detected	19	2.000	1.291	0.0756

Table 11. Shapiro-Wilk normality test results for dependent variable 4.

Condition	n	Mean	Std. Deviation	Statistic	p value
Dependent Variable 4 - Usability Problem Detection					
ART	9	2.444	1.130	ANOVA	0.1602
WOZ	10	1.600	1.350		

Table 12. One-way ANOVA Statistical Test Results for Dependent Variable 4.

Overall Effectiveness of the Prototyping Environments

The study participant ratings in the exit questionnaire were statistically analyzed using either the one-way ANOVA analysis of variance for normally distributed data sets, or the Kruskal-Wallis non-parametric test for data sets not meeting the normality requirement of the ANOVA test. Data set normality was determined using the Shapiro-Wilk normality test (see Table 13). Results of the analysis of variance tests are shown in Table 14. Of the ten rated elements in the questionnaire, the “Creating Duplicate Website Screens” was the only element to exhibit a significant difference between the WOZ and ART conditions.

Distribution	n	Mean	Std. Deviation	p value
Sketching website screens	19	2.000	1.291	<u>0.0296</u>
Fixing errors made to website screens	19	3.737	1.996	0.2707
Creating duplicate website screens	19	2.842	2.911	<u><0.001</u>
Creating screen transitions	19	5.526	2.342	0.9603
Navigating website screens in response to test user actions	19	4.789	2.200	0.2131
Correctness of the study website	19	7.263	2.156	<u>0.0049</u>
Correctness of the screen transitions made in response to test user actions	19	6.895	2.536	0.0960
How easy to learning to use prototyping environment	19	8.368	2.565	<u><0.001</u>
How effective is the prototyping tool	19	7.121	2.124	0.0891
Level of frustration in using the prototyping tool	19	4.947	2.953	<u>0.0049</u>

Table 13. Shapiro-Wilk normality test results for questionnaire rated elements.

Condition	n	Mean	Std. Deviation	Statistic	p value
Sketching website screens					
ART	9	3.778	2.386	Kruskal-Wallis	0.4552
WOZ	10	3.0	2.309		
Fixing errors made to website screens					
ART	9	4.667	1.936	ANOVA	0.0508
WOZ	10	2.9	1.729		
Creating duplicate website screens					
ART	9	4.5556	3.432	Kruskal-Wallis	<u>0.0108</u>
WOZ	10	1.3	0.949		
Creating screen transitions					
ART	9	5.333	1.732	ANOVA	0.7438
WOZ	10	5.7	2.869		
Navigating website screens in response to test user actions					
ART	9	5.111	2.571	ANOVA	0.5607
WOZ	10	4.5	1.900		
Correctness of the study website					
ART	9	7.0	2.550	Kruskal-Wallis	0.8671
WOZ	10	7.5	1.841		
Correctness of the screen transitions made in response to test user actions					
ART	9	7.667	0.831	ANOVA	0.2175
WOZ	10	6.200	0.788		
How easy to learning to use prototyping environment					
ART	9	9.333	0.866	Kruskal-Wallis	0.1436
WOZ	10	7.5	3.274		
How effective is the prototyping tool					
ART	9	6.556	2.404	ANOVA	0.2110
WOZ	10	7.8	1.751		
Level of frustration in using the prototyping tool					
ART	9	4.889	3.14	Kruskal-Wallis	0.9000
WOZ	10	5.0	2.944		

Table 14. Analysis of variance for questionnaire rated elements.

Dependent Variable 1 – Discussion

Results for dependent variable 1 do not support our hypothesis that WOZ PRO promotes faster prototype construction. In fact, analysis of data from the Mapping task indicates that WOZ PRO provides a less efficient prototyping environment with respect to the time needed to create a prototype.

Contrary to our initial thinking, the study shows for the sketching task that there is no statistical difference between the two conditions at the 95% confidence interval.

WOZ condition study participants took an average of 44 minutes to sketch their UI screens, whereas ART condition study participants took an average of 46 minutes. The WOZ PRO sketching functions did not appear to increase the efficiency of creating UI screens. Functions such as the clone screen function, copy function, select and move function, and erase function did not have much, if any effect on decreasing the time to create the sketches. Observations of WOZ condition study participants creating the UI screens showed that study participants may not have taken full advantage of the sketching functions in WOZ PRO. For example, the cloning screens function was not routinely used by all WOZ condition study participants. Although all participants completed the tutorial, their lack of familiarity with the functionality of the software seemed to impede effective use of all the sketching functions available in WOZ PRO.

Similar to the Sketching task, the Organizing task did not show a statistical difference between study participants in the WOZ or ART conditions at the 95% confidence interval. WOZ condition study participants took an average of 2.4 minutes to organize their UI screens, whereas ART condition study participants took an average of 3.3 minutes. Organization of the UI screens was a fundamentally different activity for

the two conditions. In the ART condition, most study participants spent the majority of the time shuffling screens and placing them in “piles” on the desk next to the work area (see Figure 10). The purpose of the piling was to place related UI screens in logical sequences that allowed the study participant to easily access them during the prototype demonstration sessions. The Organizing task for the WOZ condition study participants involved reviewing their UI screen transitions created during the Mapping task. Most of the WOZ condition study participants changed to the WOZ PRO “run screens” mode and reviewed their transitions as part of the Organizing task. No similar activity was performed by ART condition study participants. Conversely, no activity similar to the “piling” of UI screens was performed by the WOZ condition study participants.

The Mapping task was the only task that showed a significant difference between conditions at the 95% confidence interval. The average mapping task time



Figure 10. An example of the "piling" strategy employed by ART condition study participants during the Organizing task.

for the ART condition was 16 minutes compared to a significantly longer average mapping task time of almost 29 minutes for the WOZ condition. In the ART condition, the study participants hand sketched simple state transition diagrams showing the relationship and navigation between various UI screens. In the WOZ condition, the study participants switched the WOZ PRO software into the “edit screens transition” mode, and defined the state transition diagrams using the UI screens thumbnail linking/unlinking functions.

Several problems with the WOZ PRO implementation of the screen transition mode impacted the ability of the WOZ condition study participants to complete a usable state transition diagram in a timely fashion. On several occasions, the software crashed, interrupting the study participant’s completion of the task. These software crashes were likely due to competition for tablet PC system resources between WOZ PRO and the TechSmith Morae® screen capture software. While the time to recover from the software crash was not included in the final compilation of time duration, the interruption probably affected the study participants’ ability to concentrate on the task. Another problem was UI screen thumbnails being placed in locations where the study participant could not relocate them at a later time. This problem occurred when thumbnails were placed along the top margin of the UI screen transition diagram region just below the menu bar (see Figure 11). If a thumbnail was placed with its top border beyond the bottom of the menu bar, the study participant was unable to grab the thumbnail to relocate it. If the thumbnail was more than three-fourths hidden by the menu bar, then transitions could not be made or redefined for these thumbnails.

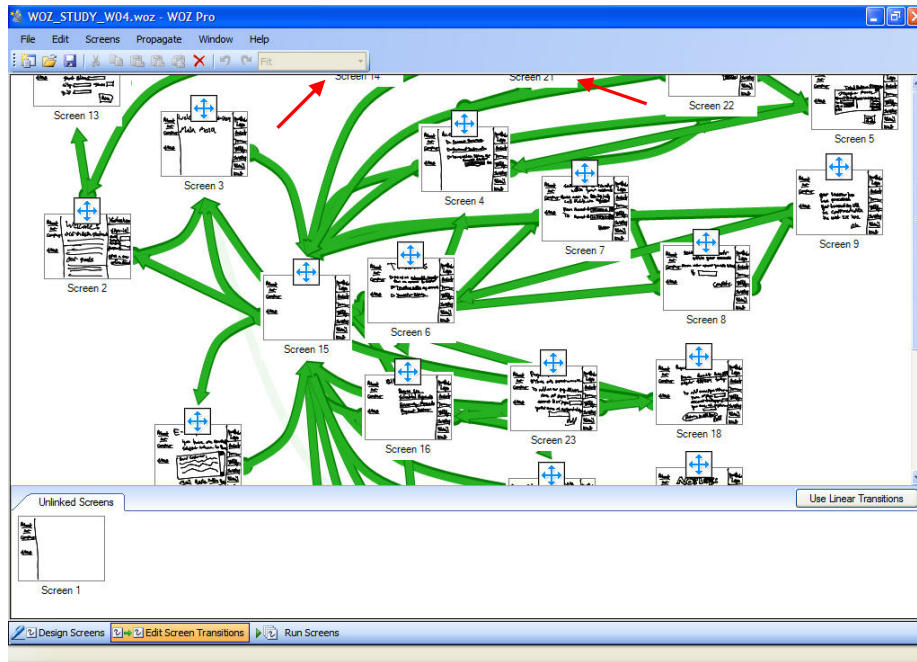


Figure 11. Screen capture from Edit Screens Transition mode in a WOZ PRO session where the study participant was unable to relocate UI screen thumbnails (see red arrows).

Dependent Variable 2 – Discussion

Results for dependent variable 2 do not support our hypothesis that WOZ PRO promotes faster, more efficient screen transitions during a wizard-of-oz prototype demonstration, as no statistically significant difference was found between the average screen transition times for the two conditions. Wizard-of-oz prototype demonstrations are supported in WOZ PRO through the “Run Screens” mode of the software. The “Run Screens” mode allows the designer to navigate to the next appropriate UI screen using the “run” button. If there is more than one possible UI screen to navigate to from the current UI screen, the designer is presented with a choice of these screens in thumbnail format (see Figure 12).

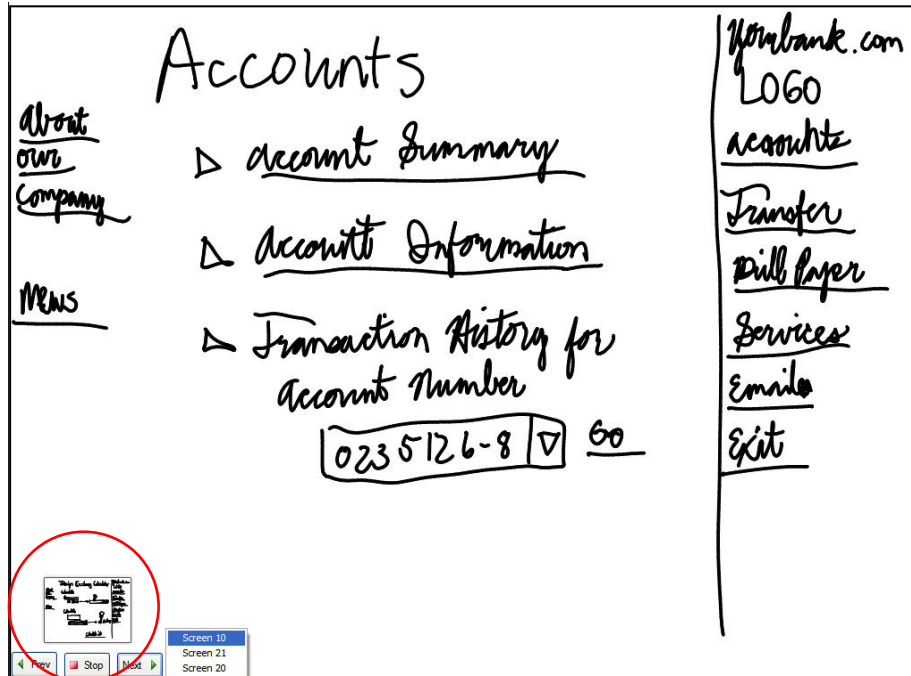


Figure 12. Screen capture of a "Run Screens" mode session where navigation to the next screen is facilitated by review of the thumbnails (circled) associated with possible screen transitions.

WOZ PRO's support for wizard-of-oz demonstrations was impacted by the inability of the study participants to quickly and consistently identify the next thumbnail screen to navigate to while in the "Run Screens" mode. Figure 12 illustrates this problem. In the "Run Screens" mode, the study participant must visually identify the correct screen to navigate to, based on a visual identification of the screen from the thumbnails provided. Many study participants struggled with positively identifying the correct screen transition because they could not visually distinguish the thumbnails from each other. The visual identification problem was the result of the small size of the thumbnail provided. The small size of the thumbnails (approximate dimension of 2.5 cm by 1.9 cm on the tablet PC screen) masked the screen details that the study participants used as visual queues to determine the next screen navigation. When there were multiple screen navigation choices, most study participants struggled at some point during the

wizard-of-oz demonstration to identify the next screen to navigate to, resulting in delayed screen transitions.

Screen transitions time in the ART condition was related to the ability of the study participant to locate the correct “pile” of UI screens (see discussion on “piling” in the dependent variable 1 discussion) and mechanically place the correct screen in the work area. This methodology produced much more consistent screen transition times, relative to the method used in WOZ PRO. A comparison of the standard deviation of average transition times of the ART and WOZ conditions (± 1.3 seconds and ± 2.7 seconds, respectively) supports this contention. As a result, it appears that the WOZ condition study participants had a more difficult time finding the correct UI screen for the test user to view.

Dependent Variable 3 – Discussion

Results for dependent variable 3 indicate that the WOZ and ART conditions were significantly different with respect to the overall accuracy of screen transitions during wizard-of-oz demonstrations. Unlike arts supplies, WOZ PRO provides a prototyping environment that increases the accuracy of screen transitions. While the total number of transition errors did not statistically differ between the two conditions, WOZ PRO provided a feedback mechanism that helped identify transition errors, and motivated WOZ PRO users to correct those errors before they could proceed with their demonstrations. The feedback mechanism is a direct result of the WOZ PRO requirement to explicitly map and define all screen transitions. When WOZ PRO users cannot make a particular screen transition in the “Run Screens” mode because the transition was not

mapped, they are forced to reexamine their screen transition diagram and redefine the transitions in order to allow the correct UI screen to be displayed. Conversely, those using the art supply prototypes have no built-in constraints on their transitions. While their screen transition diagrams may be correct, there is no mechanism that ensures that they follow the transition diagram logic (outside of their own memory) during a wizard-of-oz demonstration. Further, there is no process or tool that prompts them when they make screen transitions that do not meet the specification of their screen transition diagram.

The result of the feedback mechanism in WOZ PRO means that wizard-of-oz screen transition errors are more easily identified and rectified, as compared to wizard-of-oz demonstrations using arts supplies. In this study, an average of 15% of screen transition errors made during WOZ PRO wizard-of-oz demonstrations were identified and corrected by the study participants. In stark contrast, no screen transition errors were identified and corrected during wizard-of-oz demonstrations using prototypes constructed with art supplies.

Dependent Variable 4 – Discussion

As part of constructing more accurate prototypes, we thought that WOZ PRO would help designers more easily identify software usability problems. The results of the study do not support this argument. No significant difference was found between the numbers of usability problems identified by the two experimental conditions. This outcome appears to support the conclusions of Walker et al. [13], who found that neither

the prototype medium nor the prototype fidelity seemed to affect the number of usability problems identified during testing of their various prototypes.

While the identification of usability problems did not appear to differ between the two experimental conditions, it should be noted that our experimental design may not have been adequate for evaluating the two experimental conditions for this variable. Review of the study participants' responses to identifying usability issues show that they gave differing levels of detail and attention to this part of the study. Some participants noted that they were too busy with the other study tasks to adequately capture usability issues. Others noted broad categories of usability issues (i.e., "page navigation is generally inconsistent"). Still others gave very detailed descriptions of particular usability problems (i.e., "navigation from page X to page Y was inconsistent with other similar page navigation"). Because of the differences in responses, it was difficult to consistently tabulate the responses into the various usability problem heuristics given in Table 4.

Overall Effectiveness of the Prototyping Environments – Discussion

With one exception, results of the exit questionnaire showed study participants had little preference for one prototyping environment over the other with respect to the five key areas of overall effectiveness: difficulty, confidence, ease of learning, effectiveness, and satisfaction. The exception involved creating duplicate UI screens, which is a measure of difficulty using the prototyping environment. The WOZ condition study participants gave WOZ PRO a significantly more favorable rating for ease in producing duplicate UI screens relative to ART condition study participants. The ability

to clone UI screens in WOZ PRO was identified as a key design feature early on in the development of WOZ PRO. Obviously some WOZ PRO users found this feature helpful. It is curious, however, that several of the WOZ condition participants failed to use the clone screens tool effectively, as noted in the discussion on dependent variable 1.

The fact that WOZ PRO was unable to distinguish itself from the art supply prototyping environment in other areas of concern is associated with two primary factors: limited user testing of the WOZ PRO software prior to this study, and the underlying STN design paradigm used for the edit screens transition mode.

Limited User Testing of WOZ PRO. Although WOZ PRO underwent user testing prior to this study, it was evident during the study that not all the bugs and implementation issues had been successfully identified and dealt with in WOZ PRO version 1.0. This study revealed critical and non-critical bugs and implementation problems that affected the usability of WOZ PRO. Study participant experiences with these bugs and implementation issues negatively influenced their ratings of WOZ PRO as a prototyping environment relative to the Art Supplies prototyping environment. Addressing these problems in future revisions to WOZ PRO would likely result in a more favorable set of ratings for WOZ PRO.

One of the most serious problems with WOZ PRO involved UI screen thumbnails becoming immovable and inaccessible for creating and modifying screen transitions. This problem occurred when study participants positioned the UI screen thumbnails so that the top of the thumbnail extended beyond the top menu bar in the “edit screens transition” mode work area (see figure 11 for an example). UI screen thumbnails too far beyond the top menu bar essentially became “stranded” and could no longer be grabbed

and moved with the mouse pointer. In addition, transitions involving these thumbnails could not be created or easily modified. As a result, a few WOZ condition study participants were not able to efficiently organize their transition diagrams. This bug also introduced transition errors into their prototypes that may have been avoidable if the thumbnails could have been repositioned for better transition diagram organization, viewing, and establishment of, or corrections to screen transitions.

A significant implementation problem was experienced by study participants using the navigation functions in the “Run Screens” mode. Where more than one UI screen was available for navigation within their prototypes, study participants relied on the visual differences between UI screen thumbnails to guide their navigation choices. Many study participants complained they were not able to visually distinguish between the different UI screen thumbnails because of their small size. Figure 12 illustrates the visibility problem of the small UI screen thumbnails when using the navigation controls. This problem was a contributing factor to incorrect screen navigations and increased transition time during wizard-of-oz demonstrations.

The stability of WOZ PRO on the tablet PC was a minor but frustrating problem for some study participants. On two occasions WOZ PRO exhibited erratic behavior during file saves. Study participants would attempt to save their work, and WOZ PRO would not complete the file save operation. On another occasion the screen redraws in the design screens mode became erratic. In all cases, halting WOZ PRO and restarting the application seemed to resolve the issues. In cases where WOZ PRO stability affected the completion of study tasks, the time required to solve the WOZ PRO stability problems was not included in the task completion time duration.

STN design paradigm. The second factor impacting overall effectiveness of WOZ PRO is the STN screen navigation model we used for establishing and mapping the legal screen transition choices in WOZ PRO. The STN design paradigm requires WOZ PRO users to specify every possible screen transition that can be made in a prototype. Requiring explicit definition of all screen transitions did not scale well for prototypes with a large number of UI screens and potential transitions. As a result, many study participants complained that explicit mapping of all possible screen transitions in WOZ PRO was too difficult and confusing. A large number of UI screen thumbnails combined with many possible transitions led to unmanageable screen “clutter” (see Figure 11), which in turn made completing an accurate STN very difficult for most study participants.

Another problem with the STN model is it did not always help reduce the cognitive load on the study participants during wizard-of-oz demonstrations conducted using the run screens mode of WOZ PRO. While explicit mapping of all screen transitions did limit the number of “legal” navigation choices available from any particular UI screen, study participants still had to recall from memory which screen to select when more than one possible UI screen navigation choice was available. In cases where more than one screen was available, study participants used visual cues from the UI screen thumbnails to help decide which screen to navigate to next. However, at times even this help was insufficient, especially if the UI screen thumbnails could not be visually resolved because of their small size.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

We have presented an experimental study that evaluated WOZ Pro as a low-fidelity prototyping environment. In addition to testing our hypotheses, the study has explored the design space of wizard-of-oz prototyping tools. We've realized that the current version of WOZ PRO has some serious shortcomings that will need to be addressed in the future. We have found that WOZ PRO only partially satisfies our goal of a new prototyping environment that 1) permits faster and more accurate prototyping and wizard-of-oz demonstrations, and 2) detects more usability problems, relative to conventional prototyping tools. When compared to an art supply prototyping environment, WOZ PRO did not lead to significantly improved performance in most of the areas of prototype construction, and execution of wizard-of-oz studies. Screen cloning and screen editing, key features of WOZ PRO, did not appear to have the intended affect of improving the speed of prototype production. Likewise, the STN design paradigm upon which the WOZ PRO screen transition mode is based introduced unintended complexity to the prototype construction effort. The task of defining all possible screen transitions was overwhelming for most users of the software. In addition, wizard-of-oz demonstrators still had to memorize and subsequently recall the correct transitions when more than one transition choice was available while demonstrating a prototype. Finally, it is not evident from our data that WOZ PRO helps identify usability problems any better than paper prototyping.

One advantage of WOZ PRO and the STN paradigm for defining screen transitions was an increase in the accuracy of prototypes. Explicitly defining all screen transitions as required by WOZ PRO helped prototype demonstrators (wizards) more easily identify incorrect or missing transitions. Typically, WOZ PRO wizards would correct these errors “on the fly” as they demonstrated their prototypes. Art Supply wizards did not recognize when they had committed transition errors because either their hand-drawn STNs were not detailed enough for them to follow explicitly or they would not routinely refer back to their STNs for the proper transitions.

Future Work

The approach that WOZ Pro takes is to require users to completely specify all screen transitions in edit screens transition mode. This leads to large, cluttered STNs. WOZ Pro users quickly lose a global perspective of their STNs, and have trouble finding their way around the STNs of a large and complex user interface.

We gained insight into how to remedy this situation by observing the Art Supply study participants in action. After they constructed their STNs, Art Supply participants placed the screens related to each area of the website into separate piles (see Figure 10). Then, when they were asked to perform that task, they simply reached for the pile corresponding to the task. Notably, most study participants did not specify, in this organization, every single transition. Rather, they relied upon the context of interaction to generate the next screen. While this strategy sometimes led to screen transition errors, it appeared to be natural and easy. A similar paradigm could be designed into WOZ PRO to supplement or perhaps replace the current STN paradigm upon which screen

transitions in WOZ PRO are based. We could support the concept of a "task pile" or a "task sequence:" a container into which users could drag-and-drop screens that are related by task. They could also specify a "main" screen that would navigate to the first screen in each task sequence. From any given screen, the main screen, together with the first screen of each task sequence, would be available by default, thus obviating the need to define these transitions explicitly. Finally, the organization and layout of task sequences could be aided by implementing an automated layout function in the "edit screens transition" mode of WOZ PRO. This function would assist designers in optimally placing their screen thumbnails, task sequences, and associated transitions in positions that reduce the visual clutter and confusion that result from prototypes with complex STNs.

Generalization of WOZ PRO. It is evident that the current WOZ PRO is tailored for website wizard-of-oz prototypes, as opposed to prototypes of general interfaces. WOZ PRO does not support such common items as drop-down menus and dialog boxes. To support this additional functionality, we would need to expand WOZ PRO's interface. For example, we could support "an interface widget" pile that could be associated with each screen. The wizard could select widgets to display in response to user actions. The idea would be to leverage the "paper prototyping" metaphor: make it as easy as, or even easier than, paper prototyping, yet offer several advantages over paper prototyping by virtue of being digital.

Implementation of two interfaces: user and wizard. Our observations of the wizard-of-oz demonstrations from this study indicate that WOZ PRO is not optimally tailored to support rigorous wizard-of-oz studies. During wizard-of-oz demonstrations, the test user had to lean over the shoulder of the wizard and point to various portions of

the screen to initiate transitions. It was also strange that the test user got to see the menu of next screen choices. Clearly, this menu should be hidden from the test user.

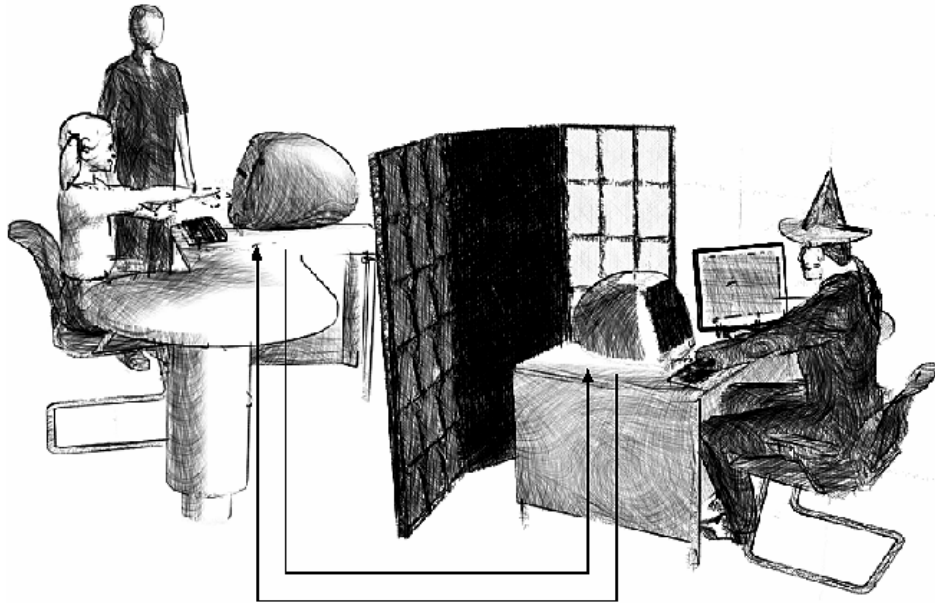


Figure 13. Conceptualization of a wizard-of-oz prototyping environment that utilizes networked client-server architecture (from Pettersson [17]).

It is apparent that if we really want to support wizard-of-oz studies, we actually need to support two, networked interfaces: one that the test user sees and manipulates, and one that the wizard sees and manipulates. Through client-server architecture, these two interfaces would be synchronized via a network. Both OZLab [17] and SketchWizard [23] employ this architecture for testing out speech and gesture recognition interfaces, respectively.

Under this dual-interface scheme, we could support true wizard-of-oz studies in which the wizard could be positioned next to the tester, or even in a separate room. The wizard could see what the user is doing through the wizard interface. At the same time, the wizard would be presented with a special interface for making the next screen happen

(see Figure 13 for an illustrated example). This interface would support both (a) on-the-fly construction of screens, as is common in wizard-of-oz studies, (b) presentation of pre-constructed screens, (c) on-the-fly augmentation of pre-constructed screens, and (d) presentation of user interface widgets on a given screen. The interface may have the feel of a digital editing room, with the screen currently displayed on the user's screen on the left, and the next screen to be displayed on the right. To prepare the next screen, the wizard could (a) drag and drop predefined elements or sketch new ones onto a blank screen or select from constrained menus of predefined screens and/or widgets.

Collaborative Environment. Software development benefits from collaborative work environments where design and development team members coordinate their efforts [26]. Implementing the client-server architecture as described above for the user and wizard interfaces may be easily extended to create a collaborative prototype development environment in WOZ PRO. We envision an environment where a limited set of configuration control tools are available for managing multiple versions of a prototype. In addition, the environment would permit multiple designers to work independently on portions of the prototype while maintaining its overall integrity and consistency.

Transition speed vs. transition flexibility and creativity. In our study, we were interested in transition speed: how quickly participants could put up the next screen in response to user actions. However, in wizard-of-oz studies, that is not always the emphasis. Indeed, a key goal of a wizard-of-oz study is to explore and test the feasibility of user interface designs. This means that wizards sometimes need the freedom and flexibility to spontaneously generate new screens in response to user actions. Transition

speed does not always matter, because the test user is already being asked to suspend disbelief by participating in a study with a non-implemented prototype.

This observation brings into question the ecological validity of our "transition speed" measure. In practice, it may not really matter which tool supports faster transition speeds. What may matter more are (a) how much time the wizard spends constructing the prototype and preparing for the simulation, (b) the wizard's perceived effort during the study—how easy the wizard finds it to generate new screens in response to user actions, and (c) the wizard's perceived flexibility and creativity—can the wizard spontaneously generate new screens in response to unanticipated actions?

Future studies might take these observations into consideration. To our knowledge, no HCI practitioners have actually studied wizard-of-oz prototyping in this depth, nor have they seriously considered how one might support this process through tablet PC technology. The work we have presented constitutes but an initial step in this direction.

BIBLIOGRAPHY

- [1] Rudd, J., Stern, K., and Isensee, S. 1996. Low vs. high-fidelity prototyping debate. *interactions* 3, 1 (Jan. 1996), pp 76-85.
- [2] Hundhausen, C. D., 2005. Using end-user visualization environments to mediate conversations: a ‘Communicative Dimensions’ framework. *Journal of Visual Languages and Computing* 16 (2005), pp 153–185.
- [3] Frank, C. E., Naugler, D., and Traina, M. 2005. Teaching user interface prototyping. *J. Comput. Small Coll.* 20, 6 (Jun. 2005), pp 66-73.
- [4] Lin, J., Newman, M. W., Hong, J. I., and Landay, J. A. 2000. DENIM: finding a tighter fit between tools and practice for Web site design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (The Hague, The Netherlands, April 01 - 06, 2000)*. CHI '00. ACM Press, New York, NY, pp 510-517.
- [5] Landay, J. A. and Myers, B. A. 1995. Interactive sketching for the early stages of user interface design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Denver, Colorado, United States, May 07 - 11, 1995)*. I. R. Katz, R. Mack, L. Marks, M. B. Rosson, and J. Nielsen, Eds. *Conference on Human Factors in Computing Systems*. ACM Press/Addison-Wesley Publishing Co., New York, NY, pp 43-50.
- [6] McCurdy, M., Connors, C., Pyrzak, G., Kanefsky, B., and Vera, A. 2006. Breaking the fidelity barrier: an examination of our current characterization of prototypes and an example of a mixed-fidelity success. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Montréal, Québec, Canada, April 22 - 27, 2006)*. R. Grinter, T. Rodden, P. Aoki, E. Cutrell, R. Jeffries, and G. Olson, Eds. CHI '06. ACM Press, New York, NY, pp 1233-1242.
- [7] Vaidyanathan, J., Robbins, J. E., and Redmiles, D. F. 1999. Using HTML to create early prototypes. In *CHI '99 Extended Abstracts on Human Factors in Computing Systems (Pittsburgh, Pennsylvania, May 15 - 20, 1999)*. CHI '99. ACM Press, New York, NY, pp 232-233.
- [8] Hundhausen, C. D., Balkar, A., Nuur, M., and Trent, S. 2007. WOZ PRO: a pen-based low fidelity prototyping environment to support wizard-of-oz studies. In *CHI '07 Extended Abstracts on Human Factors in Computing Systems (San Jose, CA, USA, April 28 - May 03, 2007)*. CHI '07. ACM Press, New York, NY, pp 2453-2458.

- [9] Hundhausen, C. D. 2006. Using HP Mobile Technology to Support a Human-Computer Interaction Design Studio. Hewlett Packard Grant Proposal <http://eecs.wsu.edu/~veupl/pub/HP-Proposal.pdf>
- [10] Rauch, Thyra L., Dana L. Gillihan, and Paul Leone. 1997. Low-fidelity prototyping for technical communicators. Society for Technical Communication 44th Annual Conference 1997 Proceedings. Arlington, VA: Society for Technical Communication.
- [11] Nielsen, J. 1992. Finding usability problems through heuristic evaluation. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Monterey, California, United States, May 03 - 07, 1992). P. Bauersfeld, J. Bennett, and G. Lynch, Eds. CHI '92. ACM Press, New York, NY, pp 373-380.
- [12] Virzi, R.A., Sokolov, J.L. and Karis, D. Usability problem identification using both low- and high-fidelity prototypes. In Proc.SIGCHI 1996, ACM Press, (1996), pp 236-243.
- [13] Walker, M., Takayama, L. and Landay, J.A. High-fidelity or low-fidelity, paper or computer medium?" In Proc. Human Factors and Ergonomics Society 46th Annual Meeting, Human Factors and Ergonomics Society, (2002), pp 661-665.
- [14] Nielsen, J. (1994) Usability Engineering. San Francisco: Morgan Kaufmann. Ericsson, K. A., & Simon, H. A. (1984). Protocol Analysis: Verbal Reports as Data. Cambridge, MA: MIT Press)
- [15] Wong, Y. Y. 1992. Rough and ready prototypes: lessons from graphic design. In Posters and Short Talks of the 1992 SIGCHI Conference on Human Factors in Computing Systems (Monterey, California, May 03 - 07, 1992). CHI '92. ACM Press, New York, NY, pp 83-84.
- [16] Pettersson, J. S. and Siponen, J. 2002. Ozlab: a simple demonstration tool for prototyping interactivity. In Proceedings of the Second Nordic Conference on Human-Computer interaction (Aarhus, Denmark, October 19 - 23, 2002). NordiCHI '02, vol. 31. ACM Press, New York, NY, pp 295-296.
- [17] Pettersson, J.S. 2003. Ozlab – a system overview with an account of two years of experiences. In HumanIT 2003. Karlstad University Studies 2003:26, ed. J.S. Pettersson. Karlstad University, pp 159-185.
- [18] Landay, J. A., 1996a. Interactive Sketching for the Early Stages of User Interface Design. PhD Thesis, Carnegie Mellon University, School of Computer Science, Pittsburg, PA, 262 pp.

- [19] Landay, J. A. 1996b. SILK: sketching interfaces like crazy. In Conference Companion on Human Factors in Computing Systems: Common Ground (Vancouver, British Columbia, Canada, April 13 - 18, 1996). M. J. Tauber, Ed. CHI '96. ACM Press, New York, NY, pp 398-399.
- [20] Plimmer, B. and Apperley, M. 2002. Computer-aided sketching to capture preliminary design. In Proceedings of the Third Australasian Conference on User interfaces - Volume 7 (Melbourne, Victoria, Australia). ACM International Conference Proceeding Series, vol. 20. Australian Computer Society, Darlinghurst, Australia, pp 9-12.
- [21] Plimmer, B.E. and M. Apperley. 2003. Software to Sketch Interface Designs. In Human-Computer Interaction – INTERACT'03 M. Rauterberg et al. (Eds.). Published by IOS Press, © IFIP, pp 73-80.
- [22] Chung, R., Mirica, P., and Plimmer, B. 2005. InkKit: a generic design tool for the tablet PC. In Proceedings of the 6th ACM SIGCHI New Zealand Chapter's international Conference on Computer-Human interaction: Making CHI Natural (Auckland, New Zealand, July 07 - 08, 2005). CHINZ '05, vol. 94. ACM Press, New York, NY, pp 29-30.
- [23] Richard C. Davis, T. Scott Saponas, Michael Shilman, and James A. Landay. 2007. "SketchWizard: Wizard of Oz Prototyping of Pen-based User Interfaces." To appear in Proceedings UIST 2007: ACM Symposium on User Interface Software and Technology, Newport, RI, Oct 2007.
- [24] Norman, D. A. and Draper, S. W., (eds), 1986. User Centered System Design - New Perspectives on Human-Computer Interaction. University of California, San Diego, Lawrence Erlbaum Associates. 526 pp.
- [25] Ericsson, K. A. & Simon, H. A. 1984. Protocol analysis: Verbal reports as data. Cambridge, MA: [The MIT Press](#).
- [26] Whitehead, J. 2007. Collaboration in Software Engineering: A Roadmap. FOSE '07: 2007 Future of Software Engineering. IEEE Computer Society, Washington, DC, pp 214-225.

RESEARCH DATA COMPILATION

WOZ Study Data

Condition	P Code	Pre-test Time	Map Task Start	Map Task End	Map Task Duration	MAP DUR MIN	Sketch Task Start	Sketch Task End	Sketch Task Duration	SKETCH DUR MIN	Organize Task Start	Organize Task End
ART	A04	0:06:11	0:01:08	0:20:03	0:18:55	18.92	0:21:28	1:11:08	0:49:40	49.67	1:15:13	1:18:36
ART	A05	0:05:25	0:01:16	0:20:30	0:19:14	19.23	0:20:52	1:09:15	0:48:23	48.38	1:09:55	1:15:26
ART	A06	0:04:00	0:00:58	0:12:00	0:11:02	11.03	0:13:10	0:58:36	0:45:26	45.43	1:01:03	1:03:29
ART	A07	0:04:10	0:01:04	0:09:21	0:08:17	8.28	0:10:14	0:43:09	0:33:53	33.88	0:45:22	0:46:23
ART	A08	0:05:30	0:56:25	1:11:57	0:15:32	15.53	0:01:20	0:54:17	0:52:56	52.93	1:13:20	1:21:52
ART	A09	0:04:34	0:47:01	0:59:57	0:12:56	12.93	0:01:36	0:16:20	0:41:34	41.57	1:01:13	1:06:38
ART	A10	0:04:55	0:59:04	1:12:17	0:13:13	13.22	0:02:25	0:56:52	0:54:27	54.45	1:14:08	1:18:09
ART	A11	6:48:00	0:55:27	1:16:22	0:20:55	20.92	0:02:04	0:53:23	0:51:19	51.32	1:17:52	1:25:13
ART	A12	0:03:48	0:42:18	1:06:46	0:24:28	24.47	0:03:21	0:40:09	0:36:48	36.80	1:06:46	1:08:06
WOZ	W03	0:03:04	0:46:38	1:30:07	0:43:29	43.48	0:01:02	0:44:51	0:43:49	43.82	1:30:18	1:31:53
WOZ	W04	0:06:50	1:00:32	1:29:53	0:29:21	29.35	0:02:40	0:58:22	0:51:12	51.20	1:31:12	1:38:39
WOZ	W05	0:06:12	0:37:57	1:08:52	0:30:55	30.92	0:01:22	0:34:24	0:33:02	33.03	1:03:10	1:08:52
WOZ	W06	0:04:26	0:40:52	1:19:34	0:38:42	38.70	0:01:08	0:39:52	0:38:44	38.73	1:19:55	1:24:14
WOZ	W07	0:03:57	0:46:27	1:02:23	0:15:56	15.93	0:01:24	0:44:32	0:43:08	43.13	1:03:42	1:11:27
WOZ	W08	0:04:28	0:34:54	0:57:34	0:22:40	22.67	0:01:25	0:32:56	0:31:31	31.52	0:58:33	0:59:18
WOZ	W09	0:03:49	0:50:02	1:09:14	0:18:14	18.23	0:01:30	0:47:57	0:47:25	47.42	1:10:00	1:19:00
WOZ	W10	0:04:39	0:45:33	1:10:33	0:25:01	25.02	0:01:26	0:43:38	0:42:12	42.20	1:10:44	1:17:09
WOZ	W11	0:03:15	1:02:23	1:30:48	0:28:26	28.43	0:01:34	1:01:06	0:59:32	59.53	1:32:26	1:34:57
WOZ	W12	0:05:05	0:54:08	1:30:26	0:36:18	36.30	0:01:45	0:51:24	0:49:39	49.65	1:32:05	1:42:44

WOZ Study Data

Condition	P Code	Organize Task Duration	ORGANIZE DUR MIN	1st User Task Start	Transition 1 Start	Transition 1 End	Transition 1-1 Duration	TRANS 1-1 DUR	Transition 1-2 Start	Transition 1-2 End
ART	A04	0:03:23	3.38	1:20:29	1:20:29	1:20:33	0:00:04	4	1:20:45	1:20:47
ART	A05	0:05:32	5.53	1:17:59	1:17:59	1:18:04	0:00:05	5	1:18:15	1:18:19
ART	A06	0:02:26	2.43	1:05:46	1:05:46	1:05:49	0:00:03	3	1:06:01	1:06:06
ART	A07	0:02:39	2.65	0:53:36	0:53:36	0:53:40	0:00:04	4	0:53:50	0:53:53
ART	A08	0:08:32	8.53	1:23:21	1:23:21	1:23:29	0:00:08	8	1:23:41	1:23:44
ART	A09	0:05:25	5.42	1:07:30	1:07:30	1:07:37	0:00:07	7	1:07:54	1:07:56
ART	A10	0:04:01	4.02	1:20:52	1:20:52	1:21:04	0:00:12	12	1:21:12	1:21:15
ART	A11	0:07:21	7.35	1:27:49	1:27:49	1:27:56	0:00:07	7	1:28:02	1:28:04
ART	A12	0:01:20	1.33	1:10:10	1:10:10	1:10:25	0:00:15	15	1:10:31	1:10:39
WOZ	W03	0:01:35	1.58	1:33:15	1:33:15	1:33:20	0:00:05	5	1:33:31	1:33:33
WOZ	W04	0:07:26	7.43	1:40:17	1:40:17	1:40:20	0:00:03	3		
WOZ	W05	0:05:42	5.70	1:10:32	1:10:32	1:10:36	0:00:04	4	1:10:47	1:10:49
WOZ	W06	0:04:19	4.32	1:25:18	1:25:18	1:25:21	0:00:03	3	1:25:30	1:25:32
WOZ	W07	0:07:45	7.75	1:13:01	1:13:01	1:13:05	0:00:05	5	1:13:15	1:13:16
WOZ	W08	0:00:45	0.75	1:00:35	1:00:35	1:00:40	0:00:05	5	1:00:47	1:00:50
WOZ	W09	0:09:00	9.00	1:20:42	1:20:42	1:20:44	0:00:02	2	1:20:54	1:20:56
WOZ	W10	0:06:26	6.43	1:18:52	1:18:52	1:18:56	0:00:04	4	1:19:02	1:19:04
WOZ	W11	0:02:31	2.52	1:35:40	1:35:40	1:35:44	0:00:04	4	1:35:56	1:35:58
WOZ	W12	0:10:39	10.65	1:43:58	1:43:58	1:44:05	0:00:07	7	1:44:12	1:44:14

WOZ Study Data

Condition	P Code	Transition 1-2 Duration	TRANS 1-2 DUR	Transition 1- 3 Start	Transition 1-3 End	Transition 1-3 Duration	TRANS 1-3 DUR	1st User Task End	Errors	1st User Task Duration
ART	A04	0:00:03	3	1:21:03	1:21:08	0:00:05	5	1:21:08	0	0:00:40
ART	A05	0:00:04	4	1:18:36	1:18:42	0:00:07	7	1:18:42	0	0:00:43
ART	A06	0:00:05	5	1:06:18	1:06:28	0:00:09	9	1:06:28	0	0:00:42
ART	A07	0:00:03	3	0:54:06	0:54:15	0:00:09	9	0:54:15	0	0:00:25
ART	A08	0:00:03	3	1:23:57	1:24:06	0:00:09	9	1:24:06	0	0:00:45
ART	A09	0:00:03	3	1:08:08	1:08:17	0:00:09	9	1:08:17	0	0:00:47
ART	A10	0:00:03	3	1:21:23	1:21:30	0:00:06	6	1:21:30	0	0:00:37
ART	A11	0:00:03	3	1:28:14	1:28:23	0:00:08	8	1:28:23	0	0:00:34
ART	A12	0:00:08	8	1:10:45	1:10:54	0:00:09	9	1:10:54	0	0:00:44
WOZ	W03	0:00:02	2	1:33:43	1:33:43	0:00:01	1	1:33:43	0	0:00:29
WOZ	W04									
WOZ	W05	0:00:02	2	1:11:00	1:11:03	0:00:02	2	1:11:03	0	0:00:31
WOZ	W06	0:00:02	2	1:25:43	1:25:44	0:00:02	2	1:25:44	0	0:00:26
WOZ	W07	0:00:01	1	1:13:24	1:13:27	0:00:02	2	1:13:27	0	0:00:26
WOZ	W08	0:00:03	3	1:00:58	1:01:00	0:00:01	1	1:01:00	0	0:00:25
WOZ	W09	0:00:02	2	1:21:07	1:21:09	0:00:02	2	1:21:09	0	0:00:27
WOZ	W10	0:00:02	2	1:19:12	1:19:15	0:00:02	2	1:19:15	0	0:00:23
WOZ	W11	0:00:02	2	1:36:05	1:36:07	0:00:02	2	1:36:07	0	0:00:27
WOZ	W12	0:00:02	2	1:44:22	1:44:24	0:00:02	2	1:44:24	0	0:00:26

WOZ Study Data

Condition	P Code	TRANS 1 TOTAL DUR	2nd User Task Start	Transition 2-1 Start	Transition 2-1 End	Transition 2-1 Duration	TRANS 2-1 DUR	Transition 2-2 Start	Transition 2-2 End
ART	A04	12	1:21:32	1:21:32	1:21:37	0:00:05	5	1:21:52	1:21:58
ART	A05	16	1:19:02	1:19:02	1:19:04	0:00:03	3	1:19:17	1:19:23
ART	A06	17	1:06:43	1:06:43	1:06:49	0:00:07	7	1:06:56	1:07:05
ART	A07	16	0:54:32	0:54:32	0:54:34	0:00:02	2	0:54:43	0:54:50
ART	A08	20	1:24:24	1:24:24	1:24:31	0:00:06	6	1:24:37	1:24:44
ART	A09	19	1:08:34	1:08:34	1:08:40	0:00:06	6	1:08:45	1:08:53
ART	A10	21	1:21:42	1:21:42	1:21:47	0:00:04	4	1:21:53	1:22:01
ART	A11	18	1:28:35	1:28:35	1:28:41	0:00:06	6	1:28:46	1:28:52
ART	A12	32	1:11:09	1:11:09	1:11:22	0:00:13	13	1:11:28	1:11:41
WOZ	W03	8	1:34:00	1:34:00	1:34:03	0:00:04	4	1:34:15	1:34:23
WOZ	W04		1:41:08	1:41:08	1:41:11	0:00:03	3	1:41:17	1:41:22
WOZ	W05	8	1:11:22	1:11:22	1:11:23	0:00:01	1	1:11:31	1:11:36
WOZ	W06	7	1:25:58	1:25:58	1:26:01	0:00:03	3	1:26:11	1:26:14
WOZ	W07	8	1:13:39	1:13:39	1:13:44	0:00:05	5	1:13:49	1:13:54
WOZ	W08	9	1:01:15	1:01:15	1:01:18	0:00:02	2	1:01:23	1:01:28
WOZ	W09	6	1:21:25	1:21:25	1:21:28	0:00:02	2	1:21:34	1:21:37
WOZ	W10	8	1:19:29	1:19:29	1:19:31	0:00:03	3	1:19:36	1:19:41
WOZ	W11	8	1:36:22	1:36:22	1:36:27	0:00:06	6	1:36:32	1:36:37
WOZ	W12	11	1:44:38	1:44:38	1:44:43	0:00:05	5	1:44:50	1:44:55

WOZ Study Data

Condition	P Code	Transition 2-2 Duration	TRANS 2-2 DUR	Transition 2-3 Start	Transition 2-3 End	Transition 2-3 Duration	TRANS 2-3 DUR	Transition 2-4 Start	Transition 2-4 End
ART	A04	0:00:06	6					1:22:10	1:22:16
ART	A05	0:00:07	7	1:19:30	1:19:34	0:00:04	4	1:19:44	1:19:49
ART	A06	0:00:09	9	1:07:08	1:07:17	0:00:09	9		
ART	A07	0:00:07	7					0:54:59	0:55:38
ART	A08	0:00:07	7	1:24:50	1:24:59	0:00:09	9		
ART	A09	0:00:07	7	1:08:57	1:09:01	0:00:04	4	1:09:08	1:09:16
ART	A10	0:00:08	8	1:22:05	1:22:20	0:00:15	15	1:22:26	1:22:32
ART	A11	0:00:06	6	1:28:57	1:29:01	0:00:04	4	1:29:06	1:29:15
ART	A12	0:00:13	13	1:11:42	1:11:52	0:00:10	10	1:11:57	1:12:07
WOZ	W03	0:00:08	8	1:34:31	1:34:37	0:00:07	7	1:34:43	1:34:57
WOZ	W04	0:00:05	5					1:41:28	1:41:32
WOZ	W05	0:00:05	5	1:11:40	1:11:47	0:00:07	7	1:11:54	1:13:41
WOZ	W06	0:00:03	3	1:26:21	1:26:23	0:00:03	3	1:26:29	1:26:31
WOZ	W07	0:00:05	5	1:14:04	1:14:09	0:00:05	5	1:14:14	
WOZ	W08	0:00:05	5	1:01:33	1:01:40	0:00:07	7	1:01:47	1:01:58
WOZ	W09	0:00:03	3	1:21:42	1:21:48	0:00:06	6		
WOZ	W10	0:00:05	5	1:19:47	1:19:49	0:00:02	2	1:19:54	1:19:55
WOZ	W11	0:00:05	5	1:36:41	1:36:45	0:00:04	4	1:36:50	1:38:35
WOZ	W12	0:00:04	4	1:44:58	1:45:06	0:00:08	8	1:45:12	1:45:24

WOZ Study Data

Condition	P Code	Transition 2-4 Duration	Transition 2-4 Error Recog Time	Trans 2-4 Fix Time	TRANS 2-4 DUR	Transition 2-5 Start	Transition 2-5 End	Transition 2-5 Duration	TRANS 2-5 DUR	Transition 2-6 Start
ART	A04	0:00:06			6	1:22:25	1:22:30	0:00:05	5	1:22:47
ART	A05	0:00:05			5	1:20:02	1:20:04	0:00:03	3	1:20:21
ART	A06									
ART	A07	0:00:39			39	0:55:45	0:55:49	0:00:05	5	0:55:59
ART	A08									
ART	A09	0:00:08			8					
ART	A10	0:00:06			6	1:22:37	1:22:49	0:00:12	12	
ART	A11	0:00:09			9	1:29:19	1:29:24	0:00:05	5	1:29:32
ART	A12	0:00:09			9	1:12:16	1:12:25	0:00:09	9	1:12:31
WOZ	W03	0:00:15			15	1:35:04	1:35:11	0:00:08	8	1:35:21
WOZ	W04	0:00:03			3	1:41:43	1:41:47	0:00:04	4	1:41:54
WOZ	W05	0:00:24	1:11:58	1:13:21	24	1:13:48	1:13:55	0:00:06	6	1:14:01
WOZ	W06	0:00:02			2	1:26:37	1:26:40	0:00:03	3	1:26:47
WOZ	W07									
WOZ	W08	0:00:11			11	1:02:06	1:02:11	0:00:05	5	1:02:19
WOZ	W09									1:22:01
WOZ	W10	0:00:02			2	1:20:01	1:20:02	0:00:02	2	1:20:08
WOZ	W11	0:00:24	1:36:58	1:38:19	24	1:38:39	1:38:54	0:00:15	15	1:38:59
WOZ	W12	0:00:11			11	1:45:30	1:45:37	0:00:07	7	1:45:43

WOZ Study Data

Condition	P Code	Transition 2-6 End	Transition 2-6 Duration	Transition 2-6 Error Recog Time	Trans 2-6 Fix Time	TRANS 2-6 DUR	2nd User Task End	Errors	2nd User Task Duration	TRANS 2 TOTAL DUR
ART	A04	1:23:08	0:00:20			20	1:23:08	1	0:01:36	
ART	A05	1:20:37	0:00:16			16	1:20:37	0	0:01:35	38
ART	A06						1:07:17	3	0:00:34	
ART	A07	0:56:17	0:00:18			18	0:56:17	2	0:01:46	71
ART	A08						1:25:04	3	0:00:40	
ART	A09						1:09:16	2	0:00:42	
ART	A10						1:22:49	2	0:01:07	
ART	A11	1:29:39	0:00:07			7	1:29:39	1	0:01:03	37
ART	A12	1:12:46	0:00:16			16	1:12:46	1	0:01:38	70
WOZ	W03	1:35:28	0:00:06			6	1:35:28	1	0:01:28	48
WOZ	W04	1:42:22	0:00:28			28	1:42:22	1	0:01:13	
WOZ	W05	1:15:05	0:00:39	1:14:06	1:14:31	39	1:15:05	2	0:03:43	82
WOZ	W06	1:26:54	0:00:07			7	1:26:54	0	0:00:56	21
WOZ	W07							3		
WOZ	W08	1:03:06	0:00:47			47	1:03:06	0	0:01:50	77
WOZ	W09	1:22:15	0:00:14			14	1:22:15	3	0:00:50	
WOZ	W10	1:20:24	0:00:16			16	1:20:24	1	0:00:56	30
WOZ	W11	1:39:04	0:00:05			5	1:39:04	2	0:02:43	59
WOZ	W12	1:46:25	0:00:42			42	1:46:25	1	0:01:46	77

WOZ Study Data

Condition	P Code	3rd User Task Start	Transition 3-1 Start	Transition 3-1 End	Transition 3-1 Duration	Transition 3-1 Error Recog Time	Trans 3-1 Fix Time	TRANS 3-1 DUR	Transition 3-2 Start	Transition 3-2 End
ART	A04	1:23:43	1:23:43	1:23:49	0:00:06			6	1:24:04	1:24:09
ART	A05	1:20:50	1:20:50	1:20:57	0:00:07			7	1:21:06	1:21:11
ART	A06	1:07:52	1:07:52	1:08:02	0:00:09			9	1:08:06	1:08:15
ART	A07	0:56:57	0:56:57	0:57:00	0:00:03			3	0:57:06	0:57:13
ART	A08	1:25:45	1:25:45	1:25:52	0:00:08			8	1:25:58	1:26:05
ART	A09	1:10:11	1:10:11	1:10:17	0:00:06			6	1:10:20	1:10:25
ART	A10	1:23:18	1:23:18	1:23:23	0:00:05			5	1:23:25	1:23:35
ART	A11	1:29:49	1:29:49	1:29:56	0:00:07			7	1:30:01	1:30:06
ART	A12	1:12:53	1:12:53	1:13:02	0:00:09			9	1:13:06	1:13:15
WOZ	W03	1:35:45	1:35:45	1:36:42	0:00:39	1:36:10	1:36:28	39	1:36:46	1:36:55
WOZ	W04	1:42:40	1:42:40	1:42:47	0:00:07			7	1:42:55	1:42:58
WOZ	W05	1:15:17	1:15:17	1:15:36	0:00:19			19	1:15:39	1:15:43
WOZ	W06	1:27:08	1:27:08	1:27:11	0:00:03			3	1:27:14	1:27:17
WOZ	W07	1:15:01	1:15:01	1:15:09	0:00:08			8	1:15:14	1:15:17
WOZ	W08	1:03:19	1:03:19	1:03:23	0:00:04			4	1:03:28	1:03:36
WOZ	W09	1:22:32	1:22:32	1:22:35	0:00:03			3	1:22:39	1:23:44
WOZ	W10	1:20:36	1:20:36	1:20:39	0:00:03			3	1:20:44	1:20:46
WOZ	W11	1:39:15	1:39:15	1:39:20	0:00:04			4	1:39:24	1:39:32
WOZ	W12	1:46:49	1:46:49	1:46:53	0:00:04			4	1:46:56	1:47:05

WOZ Study Data

Condition	P Code	Transition 3-2 Duration	Transition 3-2 Error Recog Time	Trans 3-2 Fix Time	TRANS 3-2 DUR	Transition 3-3 Start	Transition 3-3 End	Transition 3-3 Duration	TRANS 3-3 DUR
ART	A04	0:00:05			5	1:24:23	1:24:30	0:00:07	7
ART	A05	0:00:05			5				
ART	A06	0:00:09			9	1:08:29	1:08:38	0:00:09	9
ART	A07	0:00:07			7	0:57:27	0:57:33	0:00:06	6
ART	A08	0:00:07			7	1:26:23	1:26:28	0:00:06	6
ART	A09	0:00:05			5	1:10:35	1:10:41	0:00:06	6
ART	A10	0:00:09			9	1:23:40	1:23:46	0:00:05	5
ART	A11	0:00:06			6	1:30:15	1:30:20	0:00:05	5
ART	A12	0:00:09			9	1:13:24	1:13:35	0:00:10	10
WOZ	W03	0:00:09			9				
WOZ	W04	0:00:03			3	1:43:11	1:43:16	0:00:06	6
WOZ	W05	0:00:03			3	1:15:51	1:15:53	0:00:02	2
WOZ	W06	0:00:02			2	1:27:27	1:27:30	0:00:03	3
WOZ	W07	0:00:03			3	1:15:26	1:15:30	0:00:04	4
WOZ	W08	0:00:08			8	1:03:46	1:03:50	0:00:04	4
WOZ	W09	0:00:45	1:23:14	1:23:33	45	1:23:53	1:24:06	0:00:13	13
WOZ	W10	0:00:03			3	1:20:55	1:20:57	0:00:02	2
WOZ	W11	0:00:08			8	1:39:38	1:39:43	0:00:05	5
WOZ	W12	0:00:09			9	1:47:12	1:47:18	0:00:06	6

WOZ Study Data

Condition	P Code	Transition 3-4 Start	Transition 3-4 End	Transition 3-4 Duration	TRANS 3-4 DUR	Transition 3-5 Start	Transition 3-5 End	Transition 3-5 Duration	TRANS 3-5 DUR	Transition 3-6 Start
ART	A04	1:24:36	1:24:43	0:00:07	7	1:24:48	1:24:51	0:00:03	3	1:25:08
ART	A05									1:21:38
ART	A06	1:08:42	1:08:50	0:00:08	8	1:08:55	1:09:04	0:00:09	9	1:09:14
ART	A07	0:57:37	0:57:44	0:00:07	7	0:57:52	0:57:55	0:00:03	3	0:58:09
ART	A08	1:26:35	1:26:39	0:00:04	4	1:26:46	1:26:52	0:00:06	6	1:27:03
ART	A09	1:10:44	1:10:47	0:00:03	3	1:10:52	1:10:58	0:00:06	6	1:11:11
ART	A10	1:23:52	1:24:00	0:00:07	7	1:24:01	1:24:07	0:00:06	6	1:24:18
ART	A11	1:30:26	1:30:34	0:00:08	8	1:30:39	1:30:43	0:00:04	4	1:30:55
ART	A12	1:13:39	1:13:53	0:00:14	14	1:13:56	1:14:05	0:00:09	9	1:14:16
WOZ	W03									
WOZ	W04	1:43:21	1:43:31	0:00:10	10	1:43:37	1:43:43	0:00:06	6	1:43:58
WOZ	W05	1:16:01	1:16:03	0:00:02	2	1:16:07	1:16:11	0:00:04	4	1:16:22
WOZ	W06	1:27:36	1:27:38	0:00:02	2	1:27:41	1:27:44	0:00:03	3	1:27:59
WOZ	W07	1:15:35	1:15:37	0:00:02	2	1:15:41	1:15:46	0:00:05	5	1:15:57
WOZ	W08	1:03:55	1:04:00	0:00:06	6	1:04:04	1:04:09	0:00:06	6	1:04:19
WOZ	W09					1:24:10	1:24:13	0:00:03	3	1:24:21
WOZ	W10	1:21:02	1:21:04	0:00:02	2	1:21:11	1:21:13	0:00:03	3	1:21:24
WOZ	W11	1:39:49	1:39:51	0:00:02	2	1:39:55	1:40:02	0:00:07	7	
WOZ	W12	1:47:23	1:47:28	0:00:05	5	1:47:31	1:47:36	0:00:06	6	1:47:48

WOZ Study Data

Condition	P Code	Transition 3-6 End	Transition 3-6 Duration	TRANS 3 6 DUR	Transition 3-7 Start	Transition 3 7 End	Transition 3-7 Duration	TRANS 3 7 DUR	3rd User Task End	Errors
ART	A04	1:25:12	0:00:03	3	1:25:16	1:25:24	0:00:08	8	1:25:24	1
ART	A05	1:21:41	0:00:03	3	1:21:46	1:22:03	0:00:17	17	1:22:03	3
ART	A06	1:09:21	0:00:07	7	1:09:25	1:09:35	0:00:10	10	1:09:35	0
ART	A07	0:58:11	0:00:03	3	0:58:17	0:58:22	0:00:05	5	0:58:22	0
ART	A08	1:27:08	0:00:05	5	1:27:12	1:27:19	0:00:07	7	1:27:19	0
ART	A09	1:11:17	0:00:06	6	1:11:21	1:11:34	0:00:13	13	1:11:34	0
ART	A10	1:24:25	0:00:07	7					1:24:25	2
ART	A11	1:30:58	0:00:03	3	1:31:02	1:31:14	0:00:12	12	1:31:14	0
ART	A12	1:14:28	0:00:13	13	1:14:31	1:14:42	0:00:11	11	1:14:42	0
WOZ	W03									5
WOZ	W04	1:44:01	0:00:03	3	1:44:01	1:44:17	0:00:15	15	1:44:17	0
WOZ	W05	1:16:24	0:00:02	2	1:16:28	1:16:28	0:00:01	1	1:16:28	2
WOZ	W06	1:28:01	0:00:03	3	1:28:05	1:28:07	0:00:02	2	1:28:07	0
WOZ	W07	1:16:00	0:00:03	3	1:16:03	1:16:06	0:00:03	3	1:16:06	0
WOZ	W08	1:04:33	0:00:15	15	1:04:38	1:05:32	0:00:53	53	1:05:32	1
WOZ	W09	1:24:25	0:00:04	4	1:24:28	1:24:33	0:00:05	5	1:24:33	3
WOZ	W10	1:21:25	0:00:01	1	1:21:29	1:21:31	0:00:02	2	1:21:31	0
WOZ	W11								1:40:02	2
WOZ	W12	1:47:53	0:00:05	5	1:47:57	1:48:03	0:00:07	7	1:48:03	0

WOZ Study Data

Condition	P Code	3rd User Task Duration	TRANS 3 TOTAL DUR	4th User Task Start	Transition 4-1 Start	Transition 4-1 End	Transition 4-1 Duration	TRANS 4-1 DUR	Transition 4-2 Start	Transition 4-2 End
ART	A04	0:01:41	39	1:25:46	1:25:46	1:25:50	0:00:04	4	1:26:02	1:26:08
ART	A05	0:01:13		1:22:21	1:22:21	1:22:38	0:00:17	17	1:22:47	1:22:51
ART	A06	0:01:43	61	1:09:47	1:09:47	1:09:51	0:00:04	4	1:09:58	1:10:04
ART	A07	0:01:26	34	0:58:33	0:58:33	0:58:40	0:00:06	6	0:58:49	0:58:54
ART	A08	0:01:34	43	1:27:34	1:27:34	1:27:41	0:00:07	7	1:27:49	1:27:55
ART	A09	0:01:24	45	1:11:47	1:11:47	1:11:58	0:00:10	10	1:12:06	1:12:13
ART	A10		39	1:24:40	1:24:40	1:24:46	0:00:06	6	1:24:56	1:25:01
ART	A11	0:01:26	45	1:31:26	1:31:26	1:31:31	0:00:05	5	1:31:38	1:31:45
ART	A12	0:01:49	75	1:14:51	1:14:51	1:15:02	0:00:11	11	1:15:05	1:15:09
WOZ	W03			1:37:45	1:37:45	1:37:51	0:00:06	6	1:37:57	1:38:58
WOZ	W04	0:01:36	50	1:44:27	1:44:27	1:44:33	0:00:06	6	1:44:44	1:44:47
WOZ	W05	0:01:12	33	1:16:45	1:16:45	1:16:53	0:00:08	8	1:17:03	1:17:08
WOZ	W06	0:00:59	18	1:28:26	1:28:26	1:28:29	0:00:03	3	1:28:37	1:28:41
WOZ	W07	0:01:05	28	1:16:18	1:16:18	1:16:25	0:00:07	7	1:16:31	1:16:34
WOZ	W08	0:02:12	96	1:05:44	1:05:44	1:05:50	0:00:06	6	1:05:56	1:05:59
WOZ	W09			1:24:45	1:24:45	1:24:52	0:00:07	7	1:25:01	1:25:02
WOZ	W10	0:00:55	16	1:21:43	1:21:43	1:21:46	0:00:02	2	1:21:54	1:21:55
WOZ	W11			1:41:04	1:41:04	1:41:09	0:00:06	6	1:41:18	1:41:24
WOZ	W12	0:01:15	42	1:48:12	1:48:12	1:48:20	0:00:08	8	1:48:26	1:48:30

WOZ Study Data

Condition	P Code	Transition 4-2 Duration	Transition 4-2 Error Recog Time	Trans 4-2 Fix Time	TRANS 4 2 DUR	Transition 4-3 Start	Transition 4-3 End	Transition 4-3 Duration	TRANS 4 3 DUR
ART	A04	0:00:06			6	1:26:25	1:26:29	0:00:04	4
ART	A05	0:00:04			4	1:23:13	1:23:17	0:00:04	4
ART	A06	0:00:06			6	1:10:26	1:10:33	0:00:07	7
ART	A07	0:00:06			6	0:59:08	0:59:13	0:00:05	5
ART	A08	0:00:06			6	1:28:07	1:28:16	0:00:09	9
ART	A09	0:00:07			7	1:12:22	1:12:29	0:00:07	7
ART	A10	0:00:05			5	1:25:09	1:25:16	0:00:06	6
ART	A11	0:00:07			7	1:31:58	1:32:02	0:00:03	3
ART	A12	0:00:05			5	1:15:18	1:15:23	0:00:06	6
WOZ	W03	0:00:42	1:38:10	1:38:30	42	1:39:06	1:39:12	0:00:07	7
WOZ	W04	0:00:03			3	1:44:57	1:45:00	0:00:03	3
WOZ	W05	0:00:05			5	1:17:35	1:17:37	0:00:02	2
WOZ	W06	0:00:03			3	1:28:52	1:28:56	0:00:03	3
WOZ	W07	0:00:02			2	1:16:44	1:16:48	0:00:04	4
WOZ	W08	0:00:03			3	1:06:10	1:06:15	0:00:05	5
WOZ	W09	0:00:02			2	1:25:10	1:25:14	0:00:03	3
WOZ	W10	0:00:02			2	1:22:06	1:22:09	0:00:02	2
WOZ	W11	0:00:06			6	1:41:30	1:41:37	0:00:07	7
WOZ	W12	0:00:04			4	1:48:37	1:48:41	0:00:04	4

WOZ Study Data

Condition	P Code	Transition 4-4 Start	Transition 4-4 End	Transition 4-4 Duration	TRANS 4-4 DUR	4th User Task End	Errors	4th User Task Duration	TRANS 4 TOTAL DUR	5th User Task Start
ART	A04	1:26:36	1:26:48	0:00:12	12	1:26:48	0	0:01:03	26	1:27:03
ART	A05	1:23:21	1:23:25	0:00:04	4	1:23:25	0	0:01:04	29	1:23:37
ART	A06	1:10:37	1:11:12	0:00:35	35	1:11:12	0	0:01:25	52	1:11:19
ART	A07	0:59:18	0:59:21	0:00:03	3	0:59:21	0	0:00:47	20	0:59:30
ART	A08	1:28:20	1:28:27	0:00:08	8	1:28:27	0	0:00:53	30	1:28:34
ART	A09	1:12:33	1:12:43	0:00:11	11	1:12:43	0	0:00:56	35	1:12:50
ART	A10	1:25:19	1:25:27	0:00:07	7	1:25:27	0	0:00:47	24	1:25:36
ART	A11	1:32:07	1:32:20	0:00:13	13	1:32:20	0	0:00:54	28	1:32:25
ART	A12	1:15:27	1:15:36	0:00:10	10	1:15:36	0	0:00:46	32	1:15:45
WOZ	W03	1:39:16	1:39:35	0:00:19	19	1:39:35	1	0:01:50	74	1:39:41
WOZ	W04	1:45:10	1:45:14	0:00:04	4	1:45:14	0	0:00:47	16	1:45:25
WOZ	W05	1:17:41	1:17:43	0:00:01	1	1:17:43	1	0:00:57	16	1:17:56
WOZ	W06	1:29:01	1:29:03	0:00:02	2	1:29:03	0	0:00:37	11	1:29:12
WOZ	W07	1:16:53	1:17:05	0:00:12	12	1:17:05	0	0:00:47	25	1:17:11
WOZ	W08	1:06:19	1:06:31	0:00:11	11	1:06:31	0	0:00:47	25	1:06:41
WOZ	W09	1:25:19	1:25:24	0:00:06	6	1:25:24	1	0:00:39	18	1:25:32
WOZ	W10	1:22:14	1:22:16	0:00:01	1	1:22:16	0	0:00:32	7	1:22:25
WOZ	W11	1:41:41	1:41:50	0:00:09	9	1:41:50	0	0:00:46	28	1:41:57
WOZ	W12	1:48:45	1:48:49	0:00:04	4	1:48:49	0	0:00:37	20	1:48:56

WOZ Study Data

Condition	P Code	Transition 5-1 Start	Transition 5-1 End	Transition 5-1 Duration	TRANS 5-1 DUR	Transition 5-2 Start	Transition 5-2 End	Transition 5-2 Duration	TRANS 5-2 DUR	Transition 5-3 Start
ART	A04	1:27:02	1:27:08	0:00:06	6	1:27:15	1:27:21	0:00:06	6	1:27:32
ART	A05	1:23:37	1:23:44	0:00:07	7	1:23:53	1:23:57	0:00:04	4	1:24:06
ART	A06	1:11:19	1:11:25	0:00:05	5	1:11:29	1:11:36	0:00:07	7	1:11:43
ART	A07	0:59:30	0:59:33	0:00:04	4	0:59:40	0:59:45	0:00:06	6	0:59:58
ART	A08	1:28:34	1:28:42	0:00:08	8	1:28:48	1:28:56	0:00:08	8	1:29:03
ART	A09	1:12:50	1:12:57	0:00:07	7	1:13:03	1:13:08	0:00:05	5	1:13:15
ART	A10	1:25:36	1:25:42	0:00:06	6	1:25:49	1:25:55	0:00:06	6	1:26:02
ART	A11	1:32:25	1:32:32	0:00:07	7	1:32:36	1:32:41	0:00:05	5	1:32:46
ART	A12	1:15:45	1:15:56	0:00:11	11	1:16:00	1:16:08	0:00:08	8	1:16:20
WOZ	W03	1:39:41	1:39:44	0:00:03	3	1:39:52	1:40:00	0:00:09	9	1:40:06
WOZ	W04	1:45:25	1:45:29	0:00:04	4	1:45:33	1:45:36	0:00:03	3	1:45:42
WOZ	W05	1:17:56	1:17:59	0:00:03	3	1:18:04	1:18:06	0:00:02	2	1:18:16
WOZ	W06	1:29:12	1:29:14	0:00:02	2	1:29:20	1:29:23	0:00:03	3	1:29:29
WOZ	W07	1:17:11	1:17:14	0:00:03	3	1:17:19	1:18:20	0:01:01	61	1:18:24
WOZ	W08	1:06:41	1:06:45	0:00:04	4	1:06:53	1:07:02	0:00:09	9	1:07:08
WOZ	W09	1:25:32	1:25:36	0:00:04	4	1:25:41	1:25:43	0:00:03	3	1:25:50
WOZ	W10	1:22:25	1:22:28	0:00:04	4	1:22:37	1:22:38	0:00:01	1	1:22:44
WOZ	W11	1:41:57	1:42:01	0:00:04	4	1:42:05	1:42:12	0:00:07	7	1:42:18
WOZ	W12	1:48:56	1:49:01	0:00:05	5	1:49:05	1:49:12	0:00:07	7	1:49:19

WOZ Study Data

Condition	P Code	Transition 5-3 End	Transition 5-3 Duration	TRANS 5-3 DUR	Transition 5-4 Start	Transition 5-4 End	Transition 5-4 Duration	Transition 5-4 Error Recog Time	Trans 5-4 Fix Time
ART	A04	1:27:37	0:00:05	5	1:27:44	1:27:47	0:00:03		
ART	A05	1:24:09	0:00:03	3	1:24:15	1:24:18	0:00:03		
ART	A06	1:11:52	0:00:10	10	1:12:00	1:12:09	0:00:09		
ART	A07	1:00:02	0:00:05	5	1:00:08	1:00:12	0:00:05		
ART	A08	1:29:10	0:00:08	8	1:29:14	1:29:21	0:00:07		
ART	A09	1:13:22	0:00:07	7	1:13:25	1:13:32	0:00:07		
ART	A10	1:26:09	0:00:07	7	1:26:19	1:26:25	0:00:05		
ART	A11	1:32:52	0:00:06	6	1:32:55	1:33:02	0:00:07		
ART	A12	1:16:31	0:00:11	11	1:16:34	1:16:41	0:00:07		
WOZ	W03	1:40:18	0:00:11	11	1:40:24	1:40:32	0:00:08		
WOZ	W04	1:45:45	0:00:03	3	1:45:48	1:45:50	0:00:02		
WOZ	W05	1:18:18	0:00:02	2	1:18:22	1:18:23	0:00:01		
WOZ	W06	1:29:32	0:00:03	3	1:29:35	1:29:37	0:00:02		
WOZ	W07	1:18:28	0:00:04	4	1:18:31	1:18:34	0:00:02		
WOZ	W08	1:07:14	0:00:06	6	1:07:18	1:08:45	0:00:38	1:07:33	1:08:22
WOZ	W09	1:25:53	0:00:03	3	1:25:59	1:26:01	0:00:02		
WOZ	W10	1:22:45	0:00:01	1	1:22:52	1:22:54	0:00:02		
WOZ	W11	1:42:25	0:00:07	7					
WOZ	W12	1:49:24	0:00:06	6	1:49:29	1:49:32	0:00:04		

WOZ Study Data

Condition	P Code	TRANS 5-4 DUR	Transition 5-5 Start	Transition 5-5 End	Transition 5-5 Duration	TRANS 5-5 DUR	5th User Task End	Errors	5th User Task Duration	TRANS 5 TOTAL DUR
ART	A04	3	1:27:54	1:28:03	0:00:08	8	1:28:03	0	0:00:59	28
ART	A05	3	1:24:22	1:24:29	0:00:07	7	1:24:29	0	0:00:52	24
ART	A06	9	1:12:13	1:12:21	0:00:09	9	1:12:21	0	0:01:02	40
ART	A07	5	1:00:15	1:00:29	0:00:14	14	1:00:29	0	0:00:59	34
ART	A08	7	1:29:27	1:29:33	0:00:06	6	1:29:33	0	0:00:59	37
ART	A09	7	1:13:37	1:13:43	0:00:06	6	1:13:43	0	0:00:53	32
ART	A10	5	1:26:28	1:26:34	0:00:06	6	1:26:34	1	0:00:58	30
ART	A11	7	1:33:05	1:33:16	0:00:12	12	1:33:16	1	0:00:51	37
ART	A12	7	1:16:46	1:16:57	0:00:11	11	1:16:57	1	0:01:12	48
WOZ	W03	8	1:40:35	1:40:44	0:00:08	8	1:40:44	0	0:01:03	39
WOZ	W04	2	1:45:52	1:45:55	0:00:03	3	1:45:55	0	0:00:30	15
WOZ	W05	1	1:18:25	1:18:26	0:00:01	1	1:18:26	0	0:00:30	9
WOZ	W06	2	1:29:40	1:29:43	0:00:02	2	1:29:43	1	0:00:31	12
WOZ	W07	2	1:18:36	1:18:38	0:00:02	2	1:18:38	0	0:01:26	72
WOZ	W08	38	1:08:48	1:08:57	0:00:09	9	1:08:57	1	0:02:16	66
WOZ	W09	2	1:26:06	1:26:08	0:00:02	2	1:26:08	0	0:00:36	14
WOZ	W10	2	1:22:57	1:22:58	0:00:01	1	1:22:58	0	0:00:33	9
WOZ	W11	4	1:42:28	1:42:31	0:00:03	3	1:42:31	2		
WOZ	W12	4	1:49:35	1:49:45	0:00:10	10	1:49:45	0	0:00:49	32

WOZ Study Data

Condition	P Code	TOTAL TRANSITION ERRORS	NUM TRANSITION ERRORS FIXED	% TRANSITION ERRORS FIXED	AVERAGE TRANSITION TIME
ART	A04	2	0	0.00%	6
ART	A05	3	0	0.00%	6
ART	A06	3	0	0.00%	9
ART	A07	2	0	0.00%	7
ART	A08	3	0	0.00%	7
ART	A09	2	0	0.00%	7
ART	A10	5	0	0.00%	7
ART	A11	2	0	0.00%	7
ART	A12	2	0	0.00%	10
WOZ	W03	7	2	28.57%	11
WOZ	W04	1	0	0.00%	6
WOZ	W05	5	2	40.00%	6
WOZ	W06	1	0	0.00%	3
WOZ	W07	3	0	0.00%	7
WOZ	W08	2	1	50.00%	11
WOZ	W09	7	1	14.29%	6
WOZ	W10	1	0	0.00%	3
WOZ	W11	6	1	16.67%	6
WOZ	W12	1	0	0.00%	7

Results of Exit Questionnaire

WOZPro											
Participant	Sketching Web Site Screens Difficulty	Fixing Errors Made To Web Site Screens Difficulty	Creating Duplicate Web Site Screens Difficulty	Creating Screen Transitions Difficulty	Navigating Web Site Screens in Response to Test User Actions Difficulty	Correctness of the Study Web Site Confidence	Correctness of the Screen Transitions Made in Response to Test Users Actions Confidence	How Easy it Was to Learn WOZPro	Effectiveness of WOZPro	Level of Frustration Using WOZPro	
W01	7	2	2	4	4	4	3	9	8	6	
W02	3	3	1	2	5	8	7	9	9	7	
W03	2	2	1	3	2	7	7	9	8	8	
W04	9	3	1	3	3	8	8	10	10	4	
W05	1	3	1	10	7	3	1	9	9	1	
W06	1	3	1	5	3	10	9	10	8	2	
W07	3	1	4	1	2	9	7	9	8	6	
W08	4	7	1	8	7	8	3	7	4	2	
W09	2	4	1	5	5	8	7	9	9	8	
W10	3	2	1	6	5	7	7	2	9	9	
W11	2	1	1	7	5	7	10	1	7	7	
W12	3	3	1	9	6	8	3	9	6	3	
Art Supplies											
Participant	Sketching Web Site Screens Difficulty	Fixing Errors Made To Web Site Screens Difficulty	Creating Duplicate Web Site Screens Difficulty	Creating Screen Transitions Difficulty	Navigating Web Site Screens in Response to Test User Actions Difficulty	Correctness of the Study Web Site Confidence	Correctness of the Screen Transitions Made in Response to Test Users Actions Confidence	How Easy it Was to Learn Art Supplies	Effectiveness of Arts Supplies	Level of Frustration Using Arts Supplies	
A01											
A02	3	4	5	6	8	9	9	10	7	5	
A03	2	3	3	2	2	8	9	9	9	8	
A04	6	6	5	4	5	8	8	10	7	2	
A05	5	5	8	6	8	9	9	9	2	2	
A06	3	4	3	7	7	3	5	8	7	5	
A07	1	2	1	2	4	8	8	10	9	8	
A08	6	8	8	7	8	6	10	10	7	8	
A09	7	5	10	4	2	3	5	10	4	1	
A10	1	4	1	6	7	7	6	8	6	2	
A11	1	2	1	7	1	10	10	9	10	8	
A12	4	6	4	5	4	9	8	10	7	8	

DIRECTIONS AND PROCEDURES FOR EXPERIMENTAL STUDY

(ARTS SUPPLIES INSTRUCTIONS)

Spring, 2007

Low Fidelity Prototyping Study

Instruction Booklet

Version A.7

Study Participant A_____

Please open this booklet only when instructed to do so.

General Instructions for the Low Fidelity Prototyping Study

(Please follow along as these instructions are read aloud.)

In the early stages of designing user interfaces, designers often construct “low fidelity” prototypes. Such prototypes typically consist of a series of screen sketches on pieces of paper—one screen per page. Using such a prototype, designers can simulate how the user interface works with test users. As test users complete tasks, they can use a finger as a mouse pointer, and can verbally state what they would do to accomplish the task. In response to the test users’ actions, designers can present test users with the next screen in the prototype.

In this study, you will be constructing and user testing two low fidelity prototypes of websites. You will construct the first website prototype as part of a tutorial that will acquaint you with the process of constructing and testing a low fidelity prototype. You will then construct and test a second low fidelity website prototype. Following that, you will complete a brief exit questionnaire that asks you to reflect on your experiences. The entire session will last two hours or less.

Before you begin today’s lab session, please note the following:

- We greatly appreciate your participation in this study, which could ultimately help to improve the CptS 443 “Human Computer Interaction” course at WSU. If, at the end of the study, you have any questions about what you have done, please ask us.
- We will be measuring how quickly the low fidelity prototyping tool you use allows you to complete tasks. Therefore, please try to complete the prototype construction and evaluation tasks as quickly as you can without sacrificing accuracy.
- You are free to take a break at any time, but preferably *between* tasks.
- Please do not write on this document. Please use the scratch paper provided.
- Remember that you are participating in a scientific study. In order to help us ensure that the results are scientifically valid, **please do not discuss what you do today with others, especially others enrolled in CptS 443, until Spring Break. Thank you!**

Before continuing, do you have any questions?

Tutorial

(Please follow along as the experimenter reads these instructions aloud.)

Using pencil and paper, you can construct a “low fidelity” prototype of a website—that is, a collection of screen sketches that represent the web site. This involves not only sketching out the screens on pieces of paper, but also defining possible transitions between screens. Once you have defined a website in this way, you can run a “wizard of oz” test in which a test user attempts tasks with the website as you simulate its behavior. In such a test, you have the test user interact with the screen sketches. Based on the test user’s interactions, you navigate to subsequent website screens.

During this tutorial you will learn how to use pencil and paper to construct and run “wizard of oz” tests. You will do this by constructing and testing a simple prototype of a website for selling computer equipment. You will be provided with a version of the tutorial website in a web browser. Your job is to replicate this website using pencil and paper, and then to simulate the user interface while a test user completes a set of tasks with the website.

You will have **30** minutes to complete this tutorial, which includes four steps. Before completing a given step in the tutorial, please read that step aloud. You should plan on approximately 25 minutes to replicate the website, and approximately 5 minutes to demonstrate the prototype to a test user. You will be informed when time is up. Do not work on anything besides this tutorial until you are asked to do so.

Before continuing, do you have any questions?

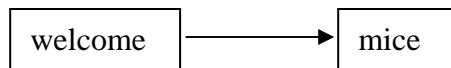
Step 1: Launch, Review, and Map Out Tutorial Website

(Remember to read these instructions aloud before proceeding.)

On the laptop computer, launch the “Tutorial Website” shortcut on the desktop. This is the website that you are to replicate using pencil and paper.

To help you replicate this website, use the pencil and scratch paper provided to sketch out a *state-transition diagram* of the site as you explore the site. Your state-transition diagram should include a node for each web page in the site, and links that connect each web page to those web pages that are reachable from it. **Your state transition diagram should only include those web pages that have been implemented.**

For example, the “mice” page is reachable from the “welcome” page. Hence, in your state-transition network, you would draw a link from the “welcome” page to the “mice” page:



When you are done with this step of the tutorial, please turn the page.

Step 2: Sketch Interface Screens

Using a pencil, **copy each web page that has actually been implemented** in the tutorial website. Copy each screen verbatim to a separate sheet of paper, making sure that all text is in your own handwriting, and that the layout of each screen accurately reflects the page you are copying.

Important guidelines:

- Remember that you will ultimately demonstrate this website to someone else. Therefore, copy each **screen using your own handwriting, making sure that the writing can be read by someone else.**
- Since you will be testing the usability of this website, make sure that the layout of the text and lines accurately reflects the general layout of the web page screen you are portraying.
- We are not interested in your artistic capabilities. Therefore, do not waste time making each of your screen sketches exactly match the corresponding screen in the website!

When you are done with this step of the tutorial, please turn the page.

Step 3: Organize Web Page Sketches So that You Can Demonstrate Website

In this step, organize your web page sketches so that you can quickly and easily navigate between them in a manner that is consistent with the state-transition diagram you developed in Step 1 of this tutorial.

Before you simulate the website for a test user, navigate the possible screen sequences through the website. Make sure that you are able to simulate the website correctly. That is, make sure that your screen transitions accurately reflect the architecture of the tutorial website.

When you feel you are ready to simulate the website for a test user, please verbally inform the experimenter.

When you are done with this step of the tutorial, please turn the page.

Step 4: Test the Website with a Test User

In this final step of the tutorial, the experimenter will come in the room and serve as a test user for your site. The test user will attempt to perform the two tasks, which he will clearly state as he attempts to perform them. Your job is to act as the “wizard of oz” by navigating the web site in response to the test user’s actions.

Once this test is complete, are finished with this tutorial.

PLEASE TURN TO THE NEXT PAGE ONLY WHEN YOU ARE ASKED TO DO SO.

STUDY TASK

(Please follow along as the experimenter reads these instructions aloud.)

You will now create and test a different website prototype. This task is nearly identical to the task you completed in the tutorial, except that you will be creating and testing a more complicated website prototype. Therefore, the steps you completed in the tutorial provide excellent guidance for this task.

You have up to **90 minutes** to complete this task in its entirety. You will be given up to **75 minutes** create the website prototype, and up to **15 minutes** to test the website prototype with a test user. **Please complete the following tasks as quickly as possible, without sacrificing accuracy.**

Step 1: Explore and map out the study website

On the laptop computer, launch the “Study Website” by double-clicking on the desktop icon. This is the website that you are to replicate using pencil and paper. As with the “Tutorial Website” you just explored, not all areas of this website have been implemented. Do not concern yourself with the unimplemented areas of the site. Moreover, note that there are several usability problems with this website. Your job is not to fix these problems, but rather to map out the website accurately.

When you are done with this task, please inform the experimenter and turn the page.

Step 2: Create the screens of the study website

1. Sketch out the screens for the website using the same techniques that you learned in the tutorial. Do this as quickly as you can, without sacrificing accuracy.

Note: Sketch the screens as quickly as you can, making sure that your screens (a) are legible (in your own handwriting) and (b) reflect the general layout of the corresponding screens of the study website. Please do not waste time making the screen text styles and layouts exactly match those of the study website screens, or sketching the interim states of pull-down text boxes! We are not measuring your artistic abilities or your ability to exactly replicate the study website screens.

When you are done with this task, please inform the experimenter and turn the page.

Step 3: Organize study website screens

Organize your web page screens so that you can quickly and easily navigate between them in a manner that is consistent with the state-transition diagram you developed in Step 1. Then navigate your website to ensure that you can perform the screen transitions that accurately reflect the architecture of the study website. Once again, do this step as quickly as you can, without sacrificing accuracy.

When you are done with this task, please inform the experimenter and turn the page.

Step 4: Simulate study website with test user

When you are confident that you are able to simulate the study website correctly, please verbally inform the experimenter, who will then enter the room and serve as a test user as you simulate the website. Remember to try to simulate the website as efficiently and accurately as you can.

When you are done with this task, turn the page.

Finishing Up the Study

Congratulations on finishing the low fidelity prototyping study! We would now like you to reflect on your experiences in this lab by taking a few minutes to fill out the exit questionnaire that you will find in the folder next to your computer. Once you have completed this exit questionnaire, you are free to leave.

One last reminder: **In order to ensure the scientific validity of our research study, please remember *not* to discuss what you did today with anyone in class until Spring Break. Thanks!**

PLEASE FILL OUT THE EXIT QUESTIONNAIRE NOW. THANKS!

(WOZ PRO INSTRUCTIONS)

Spring, 2007

Low Fidelity Prototyping Study

Instruction Booklet

Version W

Please open this booklet only when instructed to do so.

General Instructions for the Low Fidelity Prototyping Study

(Please follow along as these instructions are read aloud.)

In the early stages of designing user interfaces, designers often construct “low fidelity” prototypes. Such prototypes typically consist of a series of screen sketches on pieces of paper—one screen per page. Using such a prototype, designers can simulate how the user interface works with test users. As test users complete tasks, they can use a finger as a mouse pointer, and can verbally state what they would do to accomplish the task. In response to the test users’ actions, designers can present test users with the next screen in the prototype.

In this study, you will be constructing and user testing two low fidelity prototypes of websites. You will construct the first website prototype as part of a tutorial that will acquaint you with the process of constructing and testing a low fidelity prototype. You will then construct and test a second low fidelity website prototype. Following that, you will complete a brief exit questionnaire that asks you to reflect on your experiences. The entire session will last two hours or less.

Before you begin today’s lab session, please note the following:

- We greatly appreciate your participation in this study, which could ultimately help to improve the CptS 443 “Human Computer Interaction” course at WSU. If, at the end of the study, you have any questions about what you have done, please ask us.
- We will be measuring how quickly the low fidelity prototyping tool you use allows you to complete tasks. Therefore, please try to complete the prototype construction and evaluation tasks as quickly as you can without sacrificing accuracy.
- You are free to take a break at any time, but preferably *between* tasks.
- Please do not write on this document. Please use the scratch paper provided.
- Remember that you are participating in a scientific study. In order to help us ensure that the results are scientifically valid, **please do not discuss what you do today with others, especially others enrolled in CptS 443, until Spring Break. Thank you!**

Before continuing, do you have any questions?

Tutorial

(Please follow along as the experimenter reads these instructions aloud.)

WOZ Pro (“Wizard of OZ PROtyper) is a new pen-based software environment for the tablet PC. WOZ Pro enables you to construct a “low fidelity” prototype of a website—that is, a collection of screen sketches that represent the website. This involves not only sketching out the screens, but also defining the possible transitions between screens. Once you have defined a website in this way, you can use WOZ Pro to run a “wizard of oz” test in which a test user attempts tasks with the website as you simulate its behavior. In such a test, you have the test user interact with the screen sketches. Based on the test user’s interactions, you navigate to subsequent website screens.

In this tutorial, you will learn how to use the WOZ Pro software to construct and run “wizard of oz” tests. You will do this by constructing and testing a simple website for selling computer equipment. You will be provided with a version of the target website in a web browser. Your job is to replicate this website using WOZ Pro, and then to simulate the interface while a test user completes a set of tasks with the website.

You will have **30** minutes to complete this tutorial, which includes seven steps. Before completing a given step in the tutorial, please read that step aloud. You should plan on approximately 25 minutes to replicate the website in WOZ Pro, and approximately 5 minutes to demonstrate the prototype to a test user. You will be informed when time is up. Do not work on anything besides this tutorial until you are asked to do so.

Before continuing, do you have any questions?

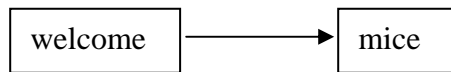
Step 1: Launch, Review, and Map Out Target Website

(Remember to read these instructions aloud before proceeding.)

On the left-hand laptop computer, launch the “Tutorial Website” shortcut on the desktop. This is the website that you are to replicate in WOZ Pro.

To help you replicate this website, use the pencil and scratch paper provided to sketch out a *state-transition diagram* of the site as you explore the site. Your state-transition diagram should include a node for each web page in the site, and links that connect each web page to those web pages that are reachable from it.

For example, the “mice” page is reachable from the “welcome” page. Hence, in your state-transition network, you would draw a link from the “welcome” page to the “mice” page:

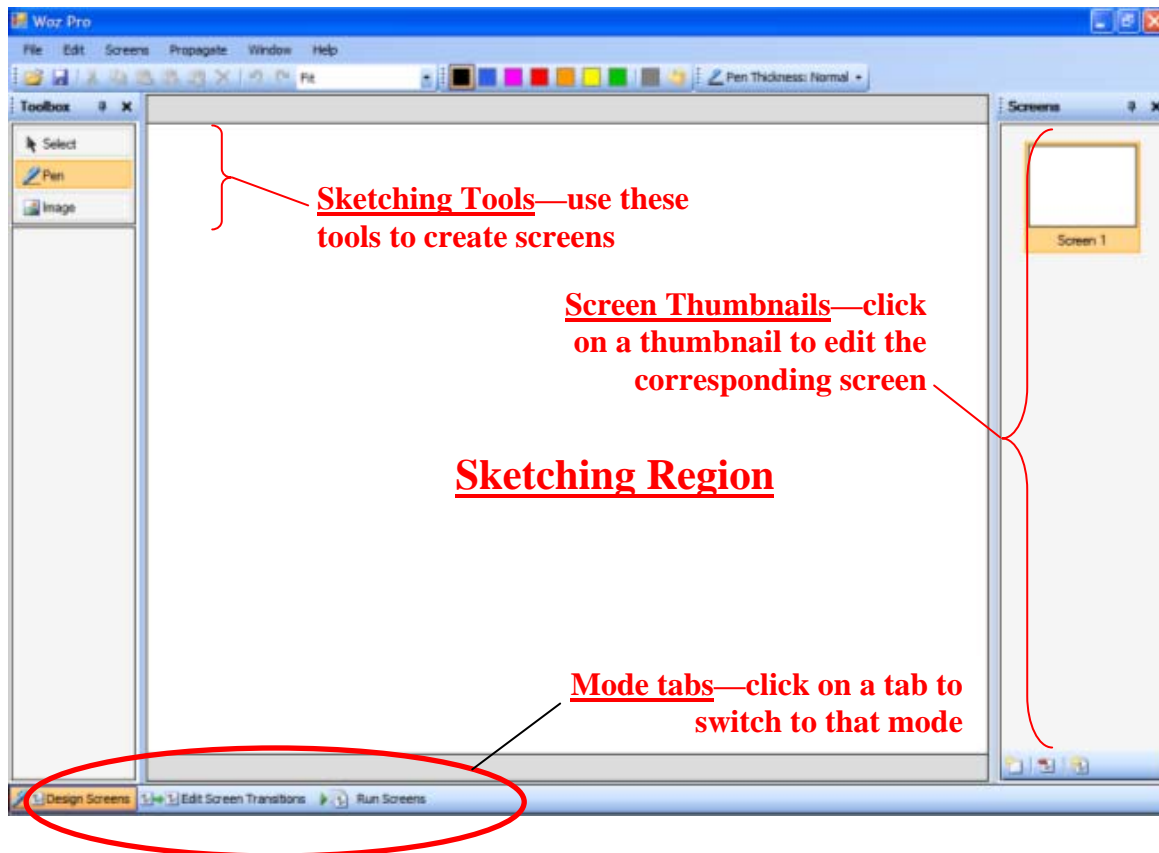


When you are done with this step of the tutorial, please turn the page.

Step 2: Launch WOZ Pro and Sketch Initial Website Screen

Launch the WOZ Pro software by clicking on the WOZ Pro desktop shortcut on the right-hand laptop computer. Please be patient; the startup of WOZ Pro may take some time to load.

WOZ Pro will present you with an interface that looks something like this:



Note that WOZ Pro starts in the Design Screens Mode. The current mode of operation is indicated by the highlighted tab at the bottom of the application (see red oval in previous screenshot).

In Design Screens mode, you sketch out each screen in the large sketching region at the center of the screen. The left-hand pane is a tool box of sketching tools. In this study, you will need only to use the “pen” tool (to sketch), the “eraser” tool (to erase sketch marks), and the “select” tool (to select, move, and delete sketch marks). The right-hand pane shows a list of thumbnails of the screens you have created. Clicking on any thumbnail will display the corresponding screen in the sketching region for editing.

Now grab the stylus and begin sketching the first screen in the target website. **Draw each screen so that it is legible, and so that it accurately reflects the general layout of**

the target screen you are portraying; however, do not waste time making the screen exactly match the target screen! Indeed, we are not interested in your artistic capabilities!

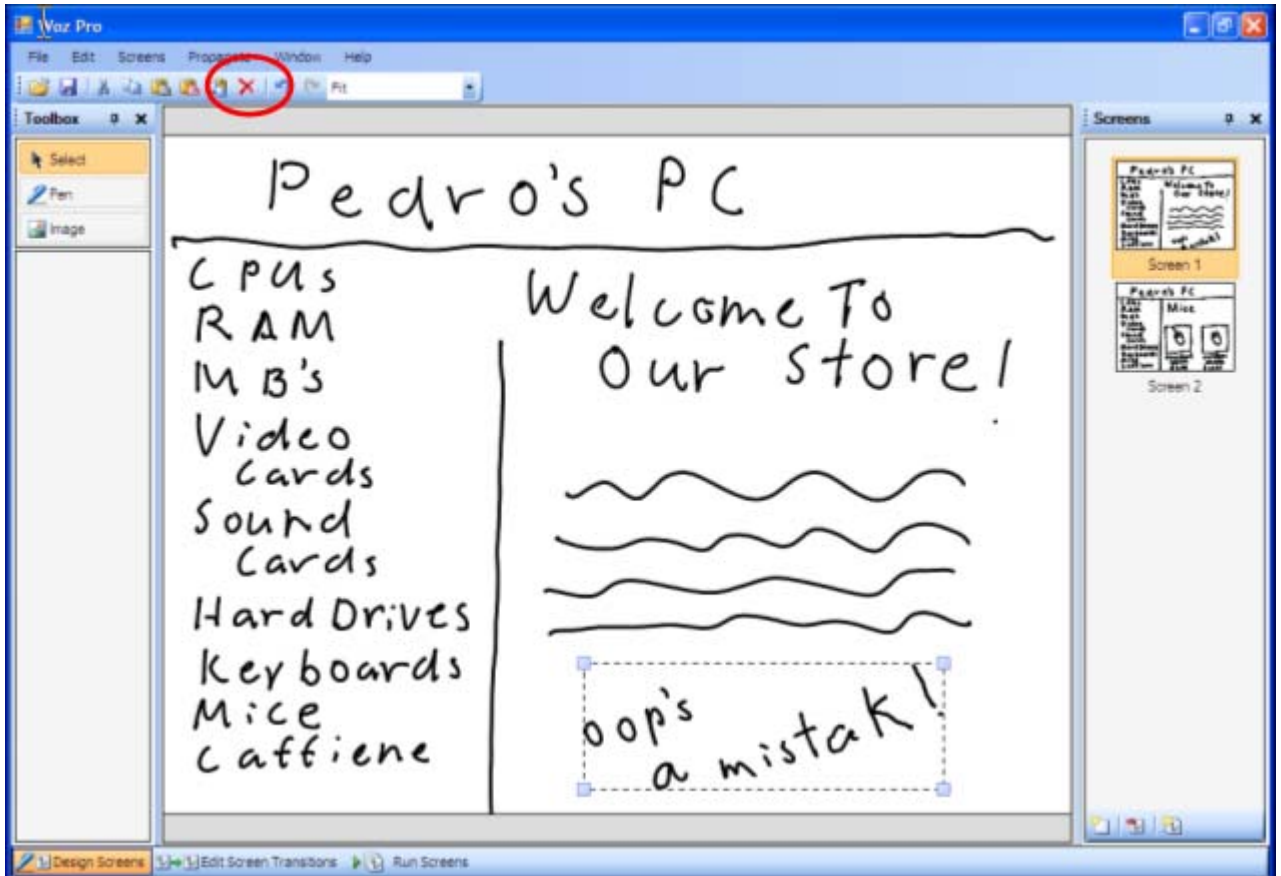
When you are done drawing the first screen, please turn the page.

After drawing your first interface screen you should have something like this:



Note that in this screen, we have made a mistake in the text and in the placement of the vertical line. In Woz Pro, you can fix a mistake in two ways. Pen strokes can be removed either by (a) flipping the pen and erasing the stroke, just as you would do with a pencil, or (b) changing the stylus tool from “pen” to “select,” drawing a selection box around the pen strokes, and choosing delete, as illustrated below (see red oval for location of delete button):

When you are done reading this page, please turn the page.



Once the interface sketch screen is to your liking, save the project. We recommend that you save each time you complete an interface screen. The project can be saved by choosing the “File” menu item and then selecting the “Save Project” drop down menu item. Alternatively, you can use the shortcut key combination of Ctrl-S to bring up the project save dialog box. Please name your WOZ Pro tutorial project file as follows:

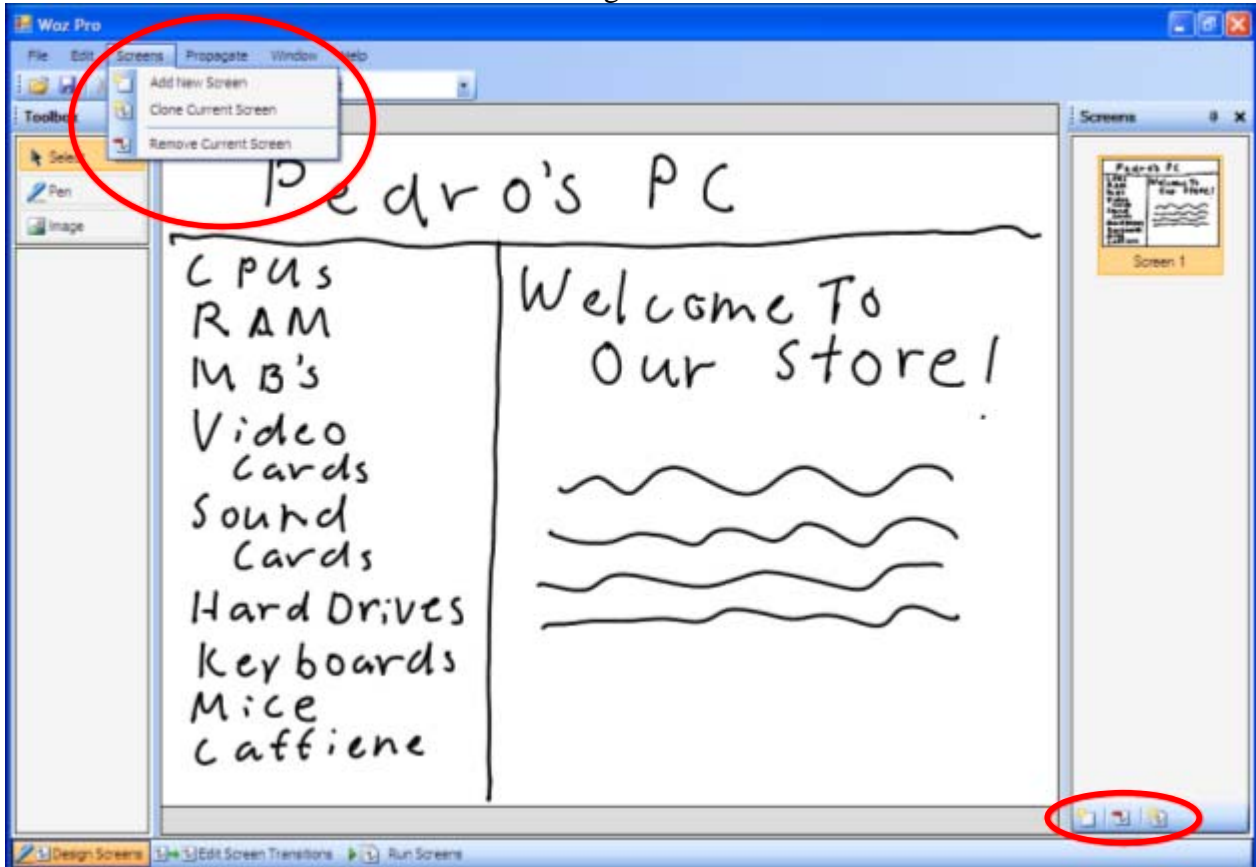
WOZ_tutorial_xxx

Where “xxx” is your participant code which appears on your instruction booklet. Subsequent saves should be made using the same file name.

When you have completed the instructions on this page, please turn the page.

Step 3: Sketch the Second Website Screen by Cloning the First

Adding a new screen is accomplished by selecting items on the “Screens” menu item, or by clicking on one of the small buttons at the bottom of the screen thumbnails pane. Both of these items are circled in red in the following screenshot:



Notice that there are three choices: “Add New Screen,” “Clone New Screen,” and “Remove Current Screen.”

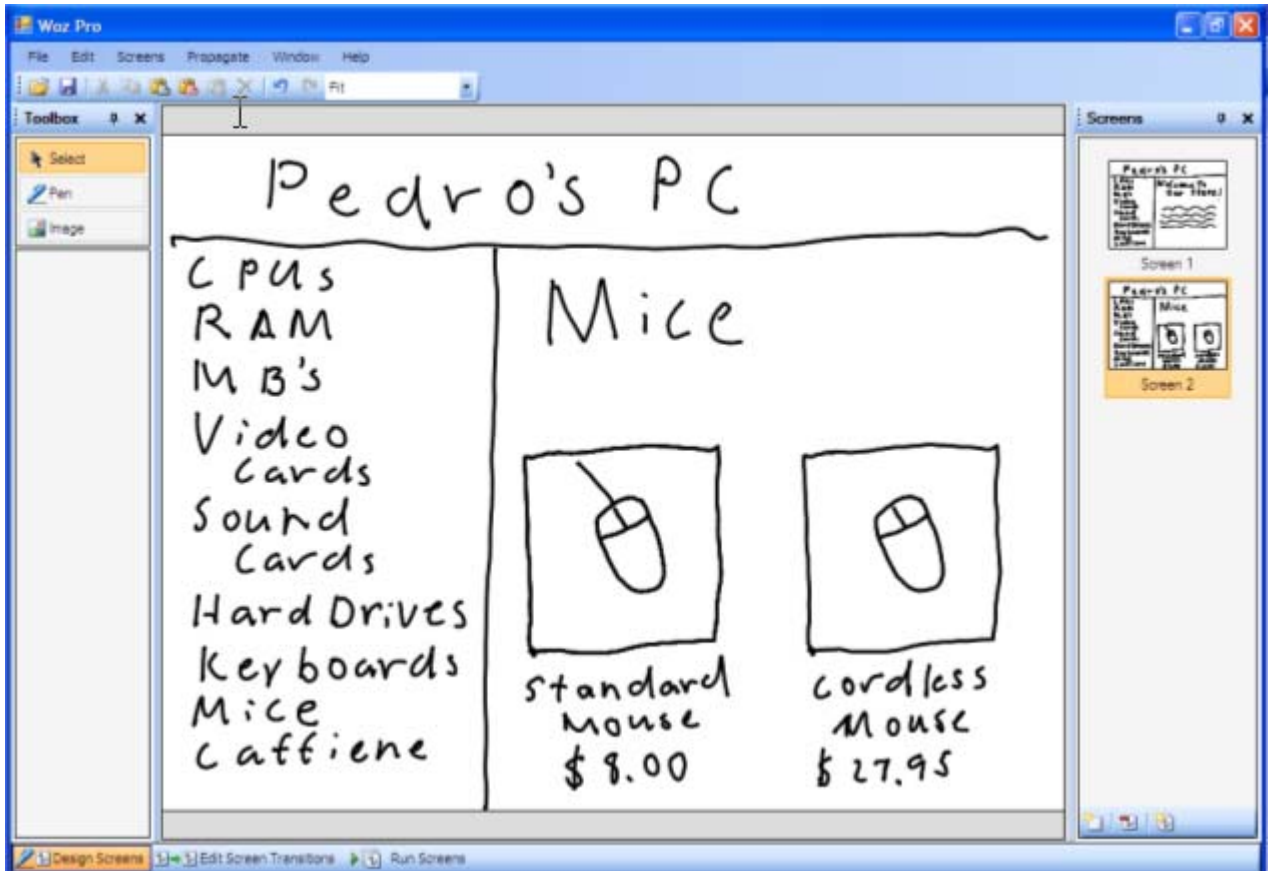
Since all target web pages have the same title and left-hand frame menu items, this is a good opportunity to use the “Clone New Screen” feature, which creates a new screen that is a clone of the current screen.

To clone the current screen, either choose the “Clone Current Screen” menu item, or click on the left-most button at the bottom of the screen thumbnails pane. This will create a second screen that is identical to the screen you just created. This cloned screen then becomes the current screen (“Screen 2” in the screen thumbnails pane).

Now that you have a copy of the first interface screen you can modify as needed. Let’s first work on the “Mice” screen:

1. Select all graphical elements that are not needed for this screen and delete them using the procedures you learned previously.
2. Using the stylus, sketch the text and graphics that will allow the user to navigate to next set of web pages to purchase cordless or standard mice.

Your second screen should look something like the screenshot that follows:



Make sure you save your project after generating new interface screens.

When you are done creating your second screen, please turn the page.


Step 4: Sketch the Remaining Screens

Using the techniques described in the previous steps (sketching, deleting sketches, and cloning screens), create the remaining screens in the target website. Be sure to save the project when you are done.

When you are done with this step of the tutorial, please turn the page.

Step 5: Define Screen Transitions

Now that you have created all of the screens on the Pedro's PC website, you can define the valid transitions between screens. To do this, follow these steps:

1. Switch to the "Edit Screen Transitions" mode by clicking on the "Edit Screen Transitions" tab at the bottom-left of the screen.
2. You will see a state-transition diagram in which each screen (displayed as a thumbnail) is linked to the screen that you created immediately after that screen. Your job is to redefine the links to reflect the actual architecture of the Pedro's PC site. The transitions to be defined are as follows:
 - a. The "welcome" screen links to the "mice" screen and the "keyboards" screen.
 - b. The "mice" screen links to the "standard mouse" and the "cordless mouse" screens.
 - c. The "standard mouse" screen links to the "standard mouse shopping cart" screen.
 - d. The "cordless mouse" screen links to the "cordless mouse shopping cart" screen.
 - e. Both the "standard mouse shopping cart" and the "cordless mouse shopping cart" screens link to the "checkout screen."
 - f. The "checkout" screen links to the "success" screen.
3. To delete a link, simply click on the link to select it, and then hit the "delete" button .
4. To create a new link between two screens, simply click two screen thumbnails in succession, or click and drag from one screen to another.
5. To make the state-transition diagram more readable, you will need to move screen thumbnails around. To move a screen thumbnail, simply press the mouse button down and drag. You can move screen thumbnails around. This allows you to define the interface navigation logic for your user interface screens. In WOZ Pro generate two additional user interface screens representing the information web pages for a standard mouse and a cordless mouse in the Design Screens mode. Now switch to the Edit Screen Transitions mode by tapping on the Edit Screens Transitions application task bar item.

When you are done with this step of the tutorial, please turn the page.


Step 6: Run Screens to Ensure that Transitions are Correct


The Run Screens Mode allows you to navigate through the screen architecture that you defined in the previous step. Before you simulate the website for a test user, you need to ensure that you have defined the website correctly. That is, make sure that your screen transitions accurately reflect the architecture of the target website.

To test your website, follow these steps:

1. Switch to “Run Screens” mode by clicking on the “Run Screens” tab in the lower-left corner of the screen. Notice that the start screen now occupies the entire screen, and that there is a set of navigation tools in the lower left-hand side of the

screen: 

2. Click on the forward button . If you have defined the transitions correctly, you should see a pop-up menu appear that contains the one next screen that is valid: the “mice” screen. Choose that screen to navigate to it.

3. From the “mice” screen, click on the forward button  again. If you have defined the transitions correctly, you should see a pop-up menu appear that contains the two next screens that are valid: the “standard mouse” screen and the “cordless mouse” screen. mice” screen.

4. Continue navigating the site until you are confident that you can correctly simulate the website.

When you feel you are ready to simulate the website for a test user, please verbally inform the experimenter.

When you are done with this step of the tutorial, please turn the page.

Step 7: Test the Website with a Test User

In this final step of the tutorial, the experimenter will come in the room and serve as a test user for your site. While WOZ Pro is in “Run Screens” mode, the test user will attempt to perform the two tasks, which he will clearly state as he attempts to perform them. Your job is to act as the “wizard of oz” by navigating the web site in response to the test user’s actions.

Once this test is complete, are finished with this tutorial.

PLEASE TURN TO THE NEXT PAGE ONLY WHEN YOU ARE ASKED TO DO SO.

STUDY TASK

(Please follow along as the experimenter reads these instructions aloud.)

You will now create and test a different website prototype. This task is nearly identical to the task you completed in the tutorial, except that you will be creating and testing a more complicated website prototype. Therefore, the steps you completed in the tutorial, which are summarized below, provide excellent guidance for this task.

You have up to **90 minutes** to complete this task in its entirety. You will be given up to **75 minutes** create the website prototype, and up to **15 minutes** to test the website prototype with a test user. **Please complete the task as quickly as possible, without sacrificing accuracy.**

We recommend that you follow these general steps to complete this task:

1. ***Explore and map out the target website.*** On the left-hand laptop computer, the “Study Website” has already been launched. This is the website that you are to replicate in WOZ Pro. Take some time to navigate the web site in order to obtain a feel for the website’s page layouts and architecture. To help you replicate this website, use the scratch paper provided to sketch out a *state-transition diagram* that includes a node for each web page in the site, and links that connect each web page to those web pages that are reachable from it.
2. ***Create the screens of the target website.*** On the right-hand laptop computer, WOZ Pro has already been launched for you, and an empty project has already been saved under the appropriate name. In “Design Screens” mode, sketch out the screens for the website, using the functionality that you learned in the tutorial (sketching, selecting and deleting sketches, and cloning screens) as needed to streamline the screen creation process.

Note: Sketch the screens as quickly as you can, making sure that your screens (a) are legible (in your own handwriting) and (b) reflect the general layout of the corresponding screens of the target website. Please not waste time making the screen text styles and layouts exactly match those of the target website screens! We are not measuring your artistic abilities or your ability to exactly replicate the target website screens.

3. ***Define screen transitions.*** Once you have created the screens of the target website, switch to “Define Screen Transitions” mode, and define the valid links between screens. **Again, do this as quickly as you can, without sacrificing accuracy.**
4. ***Run screens to ensure that transitions are correct.*** Once you have defined all screen transitions, run your screens (in “Run Screens” mode) to ensure that you have defined screen transitions that accurately reflect the architecture of the target website.

5. When you are confident that you have defined the target website correctly in WOZ Pro, please verbally inform the experimenter, who will then enter the room and serve as a test user as you simulate the website.

ONCE YOU ARE READY TO RUN YOUR WEBSITE WITH A TEST USER, PLEASE INFORM THE EXPERIMENTER.

Finishing Up the Study

Congratulations on finishing the low fidelity prototyping study! We would now like you to reflect on your experiences in this lab by taking a few minutes to fill out the exit questionnaire with which you have been provided. Once you have completed this exit questionnaire, you are free to leave.

One last reminder: **In order to ensure the scientific validity of our research study, please remember *not* to discuss what you did today with anyone in class until Spring Break. Thanks!**

PLEASE FILL OUT THE EXIT QUESTIONNAIRE NOW. THANKS!

TUTORIAL AND EXPERIMENTAL STUDY WEBSITE PAGES

Tutorial Website Pages

Pedro's PC

CPUs
RAM
MB's
Video cards
Sound cards
Hard Drives
Key boards
Mice
Caffiene

Checkout

We have scanned your
brain for the appropriate
credit card number.

Pedro's PC

CPUs
RAM
MB's
Video cards
Sound cards
Hard Drives
Key boards
Mice
Caffiene

Shopping Cart

Item	Price
Cordless Mouse	\$27.95
Total:	\$27.95

Pedro's PC

CPUs
RAM
MB's
Video cards
Sound cards
Hard Drives
Key boards
Mice
Caffiene

Shopping Cart

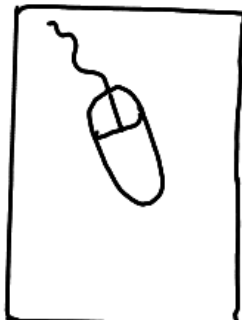
Item	Price
Standard Mouse	\$8.00
Total:	\$8.00

Checkout

Pedro's PC

CPUs
RAM
MB's
Video cards
Sound cards
Hard Drives
Key boards
Mice
Caffiene

Mice



standard
mouse
\$8.00

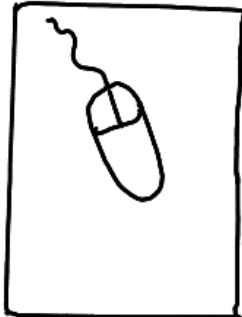


cordless
mouse
\$27.95

Pedro's PC

CPUs
RAM
MB's
Video cards
Sound cards
Hard Drives
Key boards
Mice
Caffiene

Mice:: Standard
Mouse



standard
mouse
\$8.00



Add to Cart

Pedro's PC

CPUs
RAM
MB's
Video cards
Sound cards
Hard Drives
Key boards
Mice
Caffiene

Mice:: Cordless
Mouse



cordless
mouse
\$27.95



Add to Cart

Pedro's PC

CPUs
RAM
MB's
Video cards
Soundcards
Hard Drives
Keyboards
Mice
Caffiene

Success!

Your creditcard has
been charged

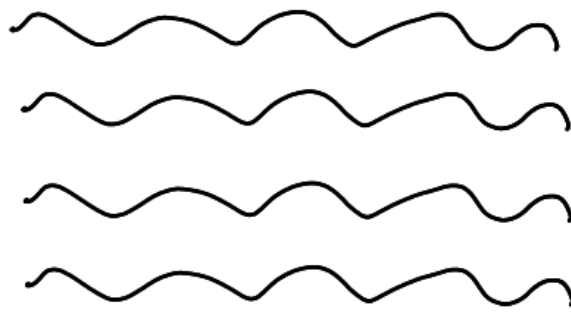
Thanks for
Shopping at
Pedro's PC!

[Back to main](#)

Pedro's PC

CPUs
RAM
MB's
Video cards
Soundcards
Hard Drives
Keyboards
Mice
Caffiene

Welcome to
Our Store!



Experimental Study Website Pages

About our Company

News

Account Summary

A C C O U N T S

Product Name	Account Type	Account #	Balance
<u>statement savings</u>	savings	1924501-6	3050.00
<u>free checking</u>	checking	0235126-8	7899.37

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About our Company

News

ACCOUNT # 0235126-8

TOTAL BALANCE \$ 7899.37

DATE ▾	PLACE ▾	AMOUNT ▾	TOTAL ▾
10/15/00	amazon.com	-\$168.20	\$ 8000.00
10/18/00	Good Guy's	-\$67.61	7932.39
11/02/00	Safeway	-\$39.02	7899.37

more functions

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

ACCOUNTS

About
our
Company

News

▷ Account Summary

▷ Account Information

▷ Transaction History for
Account Number
 Go

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

BILL PAYER

About
our
Company

News

Payee List

Scheduled Payments

Recurring Payments

Payment History

YourBank.com
LOGO

Accounts

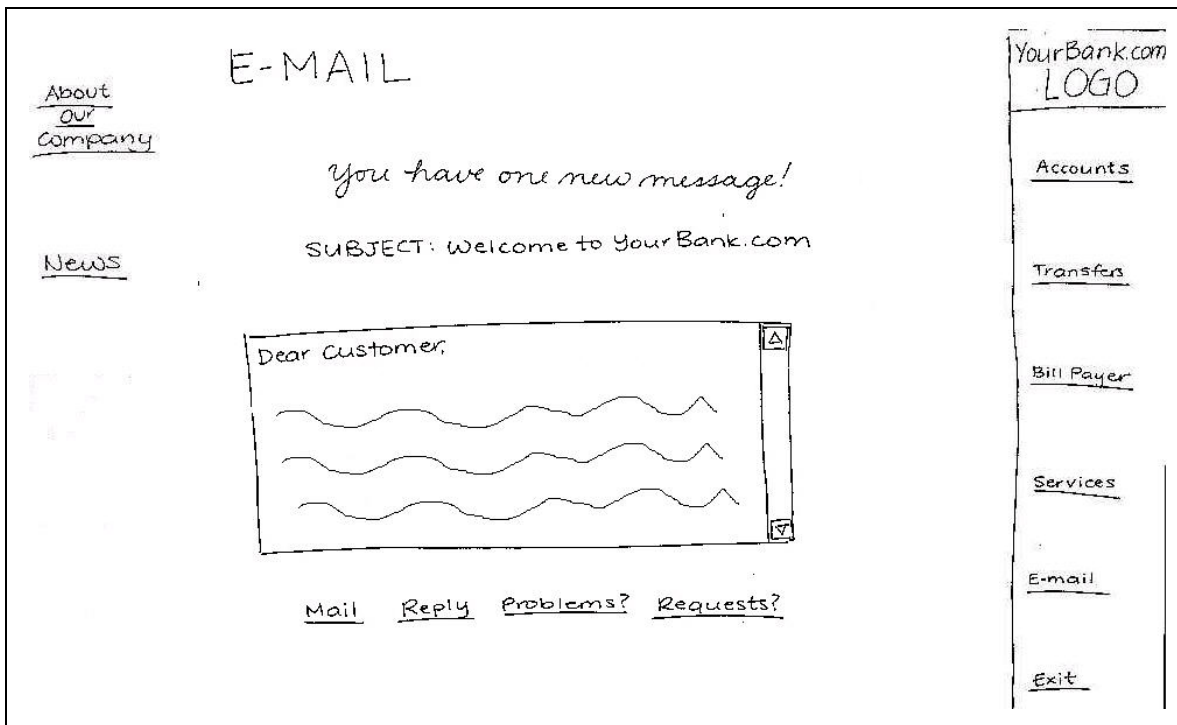
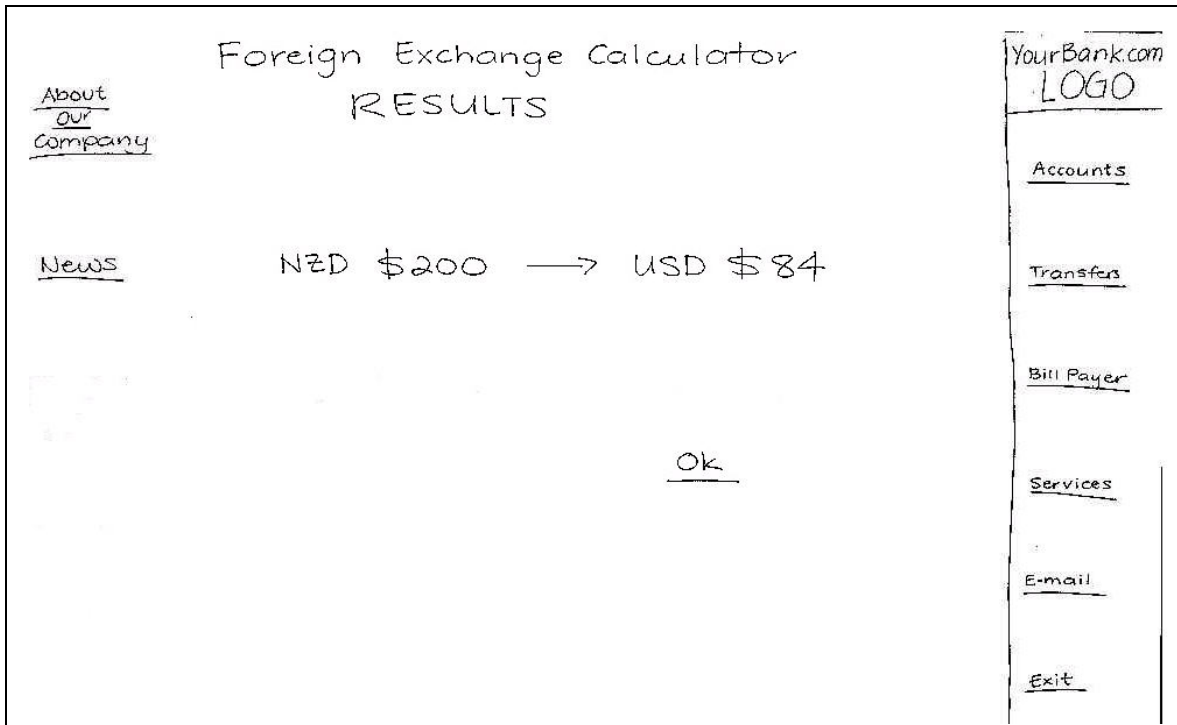
Transfers

Bill Payer

Services

E-mail

Exit



About Our Company

News

Foreign Exchange Calculator

calculate:
 \$?
 US dollars → ▼

Calculate:
 ?
 (NZD) (✓) → US dollars

Calculate It

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About Our Company

News

Welcome 575-36-7104!

Main Menu

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

ACCOUNT # 0235126-8

TOTAL BALANCE \$ 7099.37

About Our Company

News

more functions

<p><u>Email statement</u></p> <p>to <input style="width: 80%;" type="text"/></p> <p>as a <input style="width: 80%;" type="text" value="pdf"/> file.</p>	<p><u>Print statement</u></p>	<p><u>Subscribe me to yourbank.com mailing list</u></p> <p>Email address <input style="width: 80%;" type="text"/></p>
---	-------------------------------	---

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

Payee List

About Our Company

News

* There are currently no payees on your account.

To add a new payee fill in the fields below.

name of payee

account # with payee

your name as registered with payee

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About
our
Company

Payee List

YourBank.com
LOGO

<u>PAYEE</u>	<u>ACCOUNT #</u>	<u>DATE ADDED</u>
Cingular	555-1234	today

News

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

To add a new payee fill in the fields below.

name of payee
account # with payee
your name as registered with payee

Return to Bill Pay Menu

Add

About
our
Company

NOTICE:

You will be charged a fee
of \$3.00 for each
automatic bill payment.

YourBank.com
LOGO

News

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

OKAY

About
our
Company

Scheduled Payments

YourBank.com
LOGO

*There are currently no scheduled payments
for your accounts.

News

To set up a new scheduled payment...

Please choose a payee:

Please choose account from which to pay

Please choose amount to pay \$

Date of payment in the future

mm/dd/yyyy

Okay

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About
our
Company

SERVICES

YourBank.com
LOGO

News

Change Password

Change Address

Change E-mail

Order Foreign Currency

Calculators

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About our Company

News

Setting up a transfer within your accounts.

Please enter amount you wish to transfer:

\$

Complete

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About our Company

News

Your transfer has been processed.

Your transaction will be confirmed within the next 24 hours.

Ok

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About
our
Company

News

Setting up a transfer within Your accounts

Please enter the following information
(all fields are required)

FROM ACCOUNT #

TO ACCOUNT #

Enter

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About
our
Company

News

TRANSFERS

- ▷ Set up an automatic transfer
from one account to another
- ▷ Transfer within my accounts
- ▷ Transfer History

YourBank.com
LOGO

Accounts

Transfers

Bill Payer

Services

E-mail

Exit

About our Company

New Online Account

Please enter your account numbers.

YourBank.com
Logo

News

Social Security Number:

Password:

About our Company

USER INFORMATION

Yourbank

News

First Name

Last Name

E-mail Address

Phone Number

Street Address

city state

Zipcode

About
our
Company

News

WELCOME!

OUR MISSION STATEMENT

OUR GOALS

Yourbank.com

Sign-in!

Social Security number

password

Open a New
Online Account