USING PAPER PROTOTYPING AS A USABILITY TESTING METHODOLOGY FOR WEB APPLICATION DEVELOPMENT

by

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BCom., University of British Columbia, 2001

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ABSTRACT

This research focuses on prototyping methodology by studying the usability of two different prototyping media: paper and web. My intent is to conduct a quantitative analysis while attempting to follow the structure of a formal experiment in the design of user sessions. The experiment involved six participants testing the usability of a web application prototype. Three conducted the usability test on a paper prototype while the rest used a web prototype. Although this was not a formal experiment, my planning and careful design of the user sessions enabled me to collect better data. Although the sample size is small, the data quality is high. By using a quantitative approach, this study indicates that both prototyping media generate similar usability results. With thematic analysis, a qualitative approach, the research indicates that paper prototype is not as effective as indicated by the quantitative approach and other researchers’ studies.

Keywords: paper prototype; qualitative; thematic analysis; usability; web prototype
To my friends and family

who provide me with their greatest love and support.
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CHAPTER 1: INTRODUCTION

1.1 Introduction: Usability Testing

Have you ever used a product that you found difficult to use? Creating an item may not be a complicated task but developing a user-friendly product that satisfies users’ requirements involves much more work and diligence. ISO 9241-11 from the International Organization for Standardization defines usability as “the extent to which a product can be used by specified users to achieve specified goals in a specified context of use with effectiveness, efficiency, and satisfaction”. To build usability into a product, companies conduct usability testing. In Usability Testing and Research (2002) by Carol M. Barnum, usability testing is “the process of learning from users about a product’s usability by observing them using the product” (2002, p. 9).

1.2 Research Question

Since the emergence of the Internet, web applications have become widely available to the general public. Leading best practices on web application design, such as usability testing, are essential to improving the user experience. During the usability testing phase, the web application may not be sufficiently complete to allow for hands-on use. Thus, the development team creates prototypes as substitutes for the product. There are two types of prototyping
media: paper and web, each with its own distinctive advantages and disadvantages.

Paper prototypes and web prototypes are different ways of solving the same problem in usability. I am interested in finding out if there are similarities and differences in paper prototypes and web prototypes. My focus is on participants’ reactions, processes and types and impact of issues uncovered. Are paper prototypes an effective prototyping medium in usability testing? Will usability testing conducted using paper prototypes yield similar results as those conducted using web prototypes? If paper prototypes provide similar results as web prototypes, do paper prototypes have any additional flaws or issues that may create unforeseen consequences?

1.3 Literature Review

There are many books and articles in the software engineering research field that discuss paper prototyping methodology. Below are highlights of research results relevant to my studies.

Carolyn Snyder's *Paper Prototyping: The Fast and Easy Way to Design and Refine User Interfaces* (2003) introduces paper prototyping methodology. The author outlines the advantages of using paper prototypes in usability testing. She steps readers through creating a paper prototype and provides guidelines on what to do and what pitfalls to avoid. She also discusses the drawbacks of paper prototypes and their suitability in different usability test scenarios. Snyder mentions that paper prototype participants may resist the process, as they are
not used to testing on this medium. The prototype medium refers to the material a prototype is made of, such as paper or web coding. This is a phenomenon that my study further investigates.

Grady (2000) from Mercer University documents her journey of using paper prototypes in usability testing for a teaching and learning resources website. She focuses on content more than visual design. Paper prototype is an inexpensive and time saving methodology for Grady’s study with which she uncovers content related usability issues. Because her use of paper prototypes focuses on answering content structure questions and not on visual quality, her study leads me to question whether visual formatting on paper prototype (e.g. clarity of handwriting, spacing of lines) has any impact on usability testing.

Virzi, Sokolov, and Karis (1996) from GTE Laboratories Incorporated focus their two experiments on fidelity. Fidelity is measured by how closely the prototype resembles the final product: high being closely resembled while low is a rough sketch. The experiment has a sample size of 20 college students to compare the usability problems discovered using low- and high-fidelity prototypes. This is to answer their research question of whether low-fidelity prototypes could identify similar usability issues as high-fidelity prototypes in the later stages of user-interface design. As low-fidelity prototypes are commonly used in earlier stages of the development life cycle, such as in the design phase, the researchers aim to investigate whether low-fidelity prototypes are appropriate for other phases in the development life cycle. They use a CD-ROM based electronic book as the product for the first experiment and an interactive voice
response system for the second. One group of participants uses a low-fidelity paper-based prototype while the other operates either a high-fidelity prototype or the actual product. They detect similar usability issues in both low-fidelity and high-fidelity prototypes. Thus, the experiments conclude that low-fidelity prototype is a valid prototyping protocol throughout the product development life cycle. At the end of the conference paper, the researchers poise questions for future studies about varying the fidelity of the prototype to match the actual product in terms of fonts, images, and colours in the graphical user interface. The conclusions from this study lead me to wonder whether the prototyping medium as opposed to the fidelity have any impact on the effectiveness of the prototyping methodology.

Walker, Takayama, and Landay (2002) from the University of California at Berkeley assess the level of fidelities and media that will provide the best feedback with 28 participants. They compare the results from user testing with low- and high-fidelity prototypes in both computer and paper media. They base their experiment on an online banking system for small banks. They adopt the factorial design (two-by-two) methodology for their experiment and create four different prototypes (low-fidelity in paper, high-fidelity in paper, low-fidelity in computer and high-fidelity in computer). The researchers use a quantitative approach to analyze the experimental data, such as the number, type and severity of usability issues. The results of their study indicate that both low- and high-fidelity prototypes uncover usability issues equally. Usability testing results are independent of the testing medium. Therefore, designers should select the
prototyping medium and fidelity based on their practical needs and design goals. The researchers mention that computer prototypes generate significantly more comments than paper prototypes (approximately five more comments per participant). This study encourages me to further investigate the similarities and differences between paper and web prototypes.

Liu and Khooshabeh (2003) from the University of California at Berkeley, performed a usability experiment comparing the effects of fidelity and levels of automation on paper prototypes and interactive prototypes of Kitchen-Net, an application for locating items in industrial kitchens. The results from their study show that the interactive prototype based on the medium of handheld PCs captures more usability issues than the paper prototype. The interactive prototype elicits more comments because the fidelity of the paper prototype is not sufficient enough to convince participants of the features of a high capacity system such as Kitchen-Net. The automation of the interactive prototype allows the study to be conducted in a larger scale. In contrast, the paper prototype requires more people to run, which limits the scope of the usability study. The researchers also discover that the shuffling of paper in the paper prototype will unintentionally provide hints to users for where they should be focusing for the next task because there is a high potential the task will be on the newly updated sheet of paper. Liu and Khooshabeh conclude in their study that “paper prototypes give designers more flexibility in the early phases. However, they are insufficient for formal user studies because of their validity issues and need for
more staff to support interaction over long periods of time and large locations” (2003).

Sefelin, Tscheligi and Giller (2003) from the CURE Center for Usability Research and Engineering in Austria investigate the differences in computer-based and paper-based low-fidelity prototypes. They carry out a comparative study to answer their research question of whether participants’ willingness in providing suggestions would differ when using paper or computer prototypes of same fidelity. The researchers use two products, a calendar system and a touch screen ticket machine, and develop a paper prototype and a computer prototype for both products. During their 24 test sessions and 48 usability tests, each participant is presented with a paper-based calendar system and a computer-based ticket machine (and vice versa). At the end of the session, participants are interviewed about their preference on the two prototyping methodologies. The researchers conclude that low fidelity paper- and computer-based prototypes lead to almost the same quantity and quality of user comments. However, most participants indicate that they prefer computer prototypes.

In summary, past researchers use quantitative methods to analyze experimental results. Even though the results indicate that paper prototypes uncover similar issues as web prototypes, there are a number of unanswered questions. Firstly, there may be user resistance for paper prototypes and hence less feedback may be generated. Secondly, the visual formatting of paper prototypes may affect or confuse participants during testing. Thirdly, human manipulation of paper prototypes may cause visual coherence or guide
participants to focus on particular parts of the interface while ignoring the rest. These questions suggest that further comparative study of paper prototypes and web prototypes may yield new insight. In particular, they suggest that the issues at stake may not be well-understood. There may be substantive differences between the two media that are invisible in prior studies.
CHAPTER 2: PROTOTYPING METHODOLOGY

2.1 Paper Prototyping

Paper prototyping has been widely used in usability testing since the early 1990's. Due to the substantial costs of the hours spent on modifying software to suit users' ever-changing needs, developers collect continuous feedback throughout the software development life cycle to ensure that they are developing the application according to market and user requirements. Thus, developers create prototypes for usability testing to generate feedback when the application itself is not ready for testing. As paper is quick and easy to use to mock up the actual product, it has become a popular medium for software prototyping.

According to Carolyn Snyder's *Paper Prototyping: The Fast and Easy Way to Design and Refine User Interfaces* (2003), the definition of paper prototyping is:

Paper prototyping is a variation of usability testing where representative users perform realistic tasks by interacting with a paper version of the interface that is manipulated by a person "playing computer," who doesn't explain how the interface is intended to work (Snyder, 2003, p. 4).
2.1 Benefits of Paper Prototyping

Paper prototyping provides many advantages. They include:

- Cost and time benefits: Paper prototypes use inexpensive raw materials and are created with minimal time and effort. Technical skills are not required to create a paper prototype.

- Instantaneous change: Due to the simplicity of a paper prototype, the Usability Testing Facilitator (Facilitator) can make instant changes to the prototype (e.g. by crossing words out) per users' input. The Facilitator can create different or alternate versions in minimal time with little effort.

- Improved interaction between the end users and the product developers: Developers can observe the users in action and appreciate their viewpoints and incorporate their suggestions to their product.

- Customer focus and customer satisfaction: Involving end users early in the product lifecycle, such as at the conceptual review stage, will reduce user resistance in the future. Furthermore, developers can modify the prototype based on customer feedback without having to invest significant time and material.

2.1.2 Limitations of Paper Prototyping

Despite the many benefits that paper prototyping offers, there are limitations to this methodology. They include:
Performance testing: Paper prototyping cannot simulate the loading time of an application for validating system performance. In addition, it cannot assist in stress testing for system load.

User resistance: Users may not be accustomed to testing a software simulation that appears on paper and thus, are more hesitant to play with the prototype or spend time exploring it.

2.2 Web Prototyping

Web prototyping is another usability testing methodology. Web prototypes are commonly developed using visual or text based HTML tools, such as Microsoft FrontPage, Macromedia Dreamweaver or Macromedia HomeSite. A web prototype can have HTML pages that simulate the web application or the application's pre-release version. In the usability testing field, many researchers use the terminology “web prototype” to refer to prototyping tools developed via the above methods. For example, Julie Stanford (2003) uses the term as does the GUUUI survey on web prototyping tools (GUUUI, 2002). In contrast to paper prototyping, web prototyping requires usability test participants to operate a computer to test the web prototype.

2.2.1 Benefits of Web Prototyping

Benefits of web prototyping include:

- Clear presentation: Web prototypes are designed using computer software that avoids the problem of illegitimate handwriting or inconsistent font sizes, a potential challenge in paper prototypes.
• Ease of use: Testing participants may feel more comfortable working with a computer interface than a paper interface, as computers are now part of everyday life.

2.2.2 Limitations of Web Prototyping

Limitations of web prototyping include:

• Time of development: It may require more time to develop a web prototype than a paper prototype.

• Cost of development: Technical resources are required to develop the web prototype using web development tools.

• Delayed change: Immediate changes to the web prototype requires a developer on site. Programming a web prototype may not be feasible during a usability testing session and will require more time than manually manipulating a paper prototype.

2.3 Developing Prototypes

Before developing the prototypes for this study, it is essential to review the general methodologies in creating web and paper prototypes.

2.3.1 Web Prototype

A web prototype can be the actual web application or a pre-release version. Alternative methods for creating web prototypes include using wireframes, Microsoft PowerPoint or other software engineering applications.
2.3.2 Paper Prototype

Creating a paper prototype requires the following materials and supplies:

- Paper
- Glue
- Tape
- Scissors
- Colored felt pens

After the requirements have been developed and the design of the target web application has been completed, the creation of a paper prototype can start. There are many different techniques to create a paper prototype but as long as the author’s handwriting is legible, the easiest way to create a paper prototype is by hand. If not, the researcher may use screen shots or graphics software to draw frames and buttons.

The first step is to create the platform for the system to be based on. This is called the background in paper prototyping. A background can be as simple as a piece of cardboard. The background for web applications is usually a browser, such as Internet Explorer or Netscape.

Common features for a website include navigation bars (both horizontal and vertical), buttons, hyperlinks, text boxes and pop-up windows. For common features that appear on many different screens, such as the help button, they can be cut out and reused by placing them on the new screen with double-sided tape to keep them stable but remain easily removable.
2.4 Planning and Task Creation

The planning and task creation is a key phase in usability testing. This phase determines the goals that are key success factors for a product. User profiles should be determined to select appropriate test candidates. The Facilitator and project owner should also decide on the right number of test candidates. Usually, the number is between four to eight users.

After setting product goals, the usability team designs tasks that are important to the user profile as well as the business requirements. Tasks should be within the scope of the product so that they can generate possible solutions. The assigned tasks should be specific to encourage users to focus on the step at hand instead of developing opinions that are outside the scope of the product.
CHAPTER 3: PRE-STUDY

3.1 General Introduction

To validate the research question of whether usability tests conducted using paper prototypes yield similar results as conducted using web prototypes, I developed two prototypes for a proposed web application. Both the paper and web prototypes resemble the proposed web application.

The web application selected for this study is an online book review community based on a platform by Plone (http://www.plone.org), a content management server built with Zope (http://www.zope.org) technology. Plone is an open source technology that enables developers to customize their deployment of applications. Using Plone for this research allows me to fully control the web application for the purpose of usability testing.

The proposed web application of an online book review community resembles many popular online communities, such as Yahoo!, MSN and MyNetscape. The Plone online book review community shares similar features with those online communities, such as a search capability, news headlines, and members' areas.
For the usability test, I pre-defined the following six tasks.

1) Find a book review
2) Sign in as a defined user
3) Add a book review as the defined user
4) Register as a new user
5) Sign in as the newly registered user
6) Add a new book review as the newly registered user

The figures in subsequent sections show both web and paper prototypes for each task component.

3.1.1 Task 1 – Finding a Book Review

Description of Task 1

The user begins at the Welcome screen. The participant finds a book review through his or her assigned prototype.

The purpose of this task is to let users explore the interface to find information. During this task, Facilitator can observe how users approach this online application. This task also allows users to become familiar with the online interface for performing upcoming tasks.

Since the Welcome message does not contain any clickable element, I did not align the text on the paper prototype to the same level of details as the web prototype. However, for the second screen with clickable links to the book reviews, I carefully wrote each line on the paper prototype to resemble the web application to minimize any differences between the two prototypes.
Welcome to ePortal

Online Book Review Community

This is an Online Book Review Community for the public to view the book reviews while members can share their thoughts.

Please click on the "book review" tab to view available book reviews written by members.

Please click on the "news" tab to look out for latest events and news.

Welcome Screen of Web Prototype

Figure 1:

Welcome Screen of Paper Prototype

Figure 2:
Figure 3: Book Review Screen of Web Prototype

Figure 4: Book Review Screen of Paper Prototype
3.1.2 Task 2 – Sign in as User “cloud”

Description of Task 2

In task 2, participants sign in as a user named “cloud” using the pre-assigned password “cloud”. In the web prototype, the participants type in “cloud” in the username field on the web interface and input password “cloud” and then click the “sign in” button. For the paper prototype, participants write the username and password on sticky notes that are manually attached to the paper prototype. They write the user name and password using the pen provided.

The purpose of the second task is to inform users that they are required to sign in to access the Member Zone. At this stage, users are given a default username instead of creating a new user. This task tests the usability and clarity of the sign in window.

The paper prototype was created with careful alignment of the hand written text box to closely reflect the web application. The colour tone of the screen is the same as the web prototype.
Figure 5: Sign In Screen from Web Prototype

Figure 6: Sign In Screen from Paper Prototype
Figure 7: Signed In Welcome Screen from Web Prototype

You are now signed in

Welcome!

You will notice that the top right bar has changed, it now contains several personalized items. These will stay there as long as you are signed in, and allow you to access your settings and your personal area.

We wish you a pleasant stay here.

Figure 8: Signed In Welcome Screen from Paper Prototype
3.1.3 Task 3 – Adding a Book Review

Description of Task 3

Task 3 is adding a new book review to the website application. Participants click on the link “My Stuff” and the application leads them to a window for adding book reviews. Once participants arrive at “My Stuff”, they click on the button “add new item”.

After the “add new item” button is clicked, a screen displays different options for users to add items, such as documents, files and images. For this task, participants should choose the “add” button next to the Document Item.

After clicking on the “add” button next to “Document”, participants go to a screen to add a book review by filling out the fields, such as “title”, “summary”, and “body text”.

They click on the “save” button once they fill in the fields.
Figure 9: My Stuff Screen from Web Prototype

Figure 10: My Stuff Screen from Paper Prototype
Add new item

Select the type of item you want to add to your folder:

- **Document**: Documents can contain text that can be formatted using 'Structured Text'.
- **Image**: Images can be embedded in Portal objects.
- **Link**: Links to pages that contain additional information.
- **Home Item**: Home items often contain text articles and carry a title as well as an optional description.
- **Video**: Videos are stored within the organizing portal, and are often linked into the catalog.

Note: Home folders can define custom new actions, or will behave like directories within a tree.
Figure 13: Add Book Review Screen from Web Prototype

Figure 14: Add Book Review Screen from Paper Prototype
Figure 15: Add Book Review Confirmation Screen from Web Prototype

The Art of Project Management
This is a book by Scott Berkun telling his story in Microsoft as Program Management. This book appeals to people who want to learn about the project management field outside of the world software leader, Microsoft. I enjoyed reading the book as the tips that the author Scott Berkun gave will be extremely useful and applied to many domains of project management.

Figure 16: Add Book Review Confirmation Screen from Paper Prototype
Task 3 is the most complex task among all six tasks because it requires users to explore the interface to find the correct location to add a new book review. The workflow of this task is also the core function of this website, which is adding book reviews to the online application. The purpose of including this task in the study is to understand whether users find this interface intuitive or difficult to use.

The paper prototype follows the online interface closely to avoid any distractions that may be caused by hand written texts. The colour scheme on the text boxes and links is exactly the same as the online interface.

3.1.4 Task 4 – Register as a New User

Description of Task 4

Participants are required to register as a new user in task 4. Since the participants have already signed in as “cloud" during the last task, they need to sign out before they can register as a new user. After signing out, they click on the “New user?” link in the “sign in” box on the right hand side of the interface.

A registration form is displayed for participants to fill in their information (sample data is provided to participants to protect their privacy). After entering the required information, participants click on the “register” button at the bottom of the page to complete the registration process.
Figure 17: Signed Out Screen from Web Prototype

You are now signed out

We hope you enjoyed using our services. We look forward to seeing you again.

Best Regards from the ePortal - Online Book Review Community team.

Figure 18: Signed Out Screen from Paper Prototype
Please register

By registering with us, you will have your own account with the possibility to have personalized content, and you will be able to add your own documents, images and files to the site.

- **Full Name**: Enter your full name.
- **User Name**: Enter the user name you wish to use. This is the name you use to sign in.
- **Email**: Enter your email address. This is necessary in case you lose your password and need to reset it. We will not give your address away to any third parties.
- **Password**: Enter the password you want. Minimum 5 characters.
- **Confirm Password**: Re-enter the password. Make sure the passwords are identical.
- **Mail Password**: Check this box to have your password delivered to your mailbox, so you won't lose it.

![Figure 19: Register New User Screen from Web Prototype](image1)

![Figure 20: Register New User Screen from Paper Prototype](image2)
Participants are signed in with an existing user profile. In order to register as a new user, they have to log out from the current profile first. This task is to understand whether most users are aware that they are already in the member area. The purpose of this task is also to test the usability of the interface for registering a new user.

The sign in box on the paper prototype closely resembles the online application. However, handwriting of the messages on the paper interface, such as the signed out message, does not align very closely to the web interface because there is no clickable component embedded within. It is simply a message to tell users that they have signed out.

3.1.5 Task 5 – Sign in as a New User

Description of Task 5

After registering as a new user in task 4, a welcome message is displayed. In the message, there is a link to log on immediately by clicking “here”. Participants click on that link and the system automatically signs the participant in as the newly registered user.
Figure 21: New User Welcome Screen from Web Prototype

Figure 22: New User Welcome Screen from Paper Prototype
Task 5 is a natural step following task 4 as it asks users to sign in as a newly registered user. This task is to observe whether the sign in link in the Welcome message is obvious enough for users to click.

Since the Welcome message contains a link, the look of this screen on the paper prototype closely resembles the web interface.

### 3.1.6 Task 6 – Add a New Book Review as the New User

**Description of Task 6**

Task 6 is the last designated task. Participants add a new book review under the log in of the registered user from task 4. This is similar to task 3 but with a different user account. The purpose of this task is to observe whether the participants have learnt from their previous experience of going to “My Stuff” and adding a document as a book review to the application. Due to the participants’ previous experience, they should perform this task easier and faster than task 3.

Task 6 is the same as task 3. Its purpose is to understand whether users develop and take advantage of prior learning experiences.

The interface of task 6 reuses most of the components from task 3.

### 3.2 Task Flow Diagram

The following diagrams outline the workflow for each task in sequence as described in previous sections.
Figure 23: Task Flow Diagram 1

- Start
  - Click on the Book Review Tab
  - Find a Book Review by choosing one of the many book titles available

- Task 1
  - Sign in as User "Cloud" using pre-assigned password
  - Successful sign-in registered by the prototype

- Task 2
  - Click on "My Stuff"
  - Click on "add new item"

- Task 3
  - Click on "add" that is next to "Document" Item
  - Fill in the fields for the "Add Book Review" form and submit form
  - A new book review is added to the system

- Task 4
  - Sign out as user "Cloud"
  - Click on "New User?" link
  - Fill in the fields for "Registration Form" and submit form
  - Display Welcome new user page
Figure 24: Task Flow Diagram 2

1. Welcome New User screen
2. Click "here" to log on immediately
3. Successful sign-in registered by the prototype
4. Click on "My Stuff"
5. Click on "add new item"
6. Click on "add" that is next to "Document" item
7. Fill in the fields for the "Add Book Review" form and submit form
8. A new book review is added to the system

End
CHAPTER 4: EXPERIMENTAL METHOD

4.1 Research Methodology

In the user experience field, the terms “fidelity” and “medium” have specific meanings. Fidelity is measured by how closely the prototype resembles the final product: high being closely resembled while low is a rough sketch. The prototype medium describes the material from which a prototype is made of, such as paper or web coding.

Generally, usability researchers focus on testing fidelity or a combination of fidelity and medium to investigate whether low fidelity prototyping is an effective methodology. However, the medium plays a key role in prototyping software programs, such as web applications. Today, many people have access to computers and the Internet and this trend may affect the effectiveness of the prototyping medium. For example, users may prefer performing a usability test on a computer instead of paper. This study extends prior research and aims to validate whether the prototyping medium has any influence on usability testing.

My initial experiment sought to confirm if paper prototyping and web prototyping will yield the same or similar usability issues. This research uses an empirical methodology where the working hypothesis (research question) is testable using observation or experiment. I conducted the experiment by observing how participants interact with the paper and web prototypes. The factor or the independent variable of the experiment is the medium of prototypes.
The treatments, the variables that are expected to influence the experiment, are paper and web. The structure of the experiment is a completely randomised design as participants are allocated to the two experiment units receiving the treatment of paper and web prototype randomly.

I randomly selected six participants from a population of computer literate people who participate actively in online communities, such as Yahoo and MSN. Recruitment of participants was conducted via email call out and online announcements. Participants were each rewarded with a five dollar gift certificate to Future Shop.

This usability study was conducted in six test sessions. Three were conducted using the paper prototype while the remaining used the web prototype. All six sessions were conducted in the living room of the facilitator's home either after lunch or dinner. The environment of the testing location was quiet with no disturbance. The same paper prototype was used for the three paper prototype participants while the same web prototype was hosted on the same labtop for the three web prototype participants. Before the commencement of the sessions, an internal walkthrough was conducted with the paper prototype medium to ensure a smooth process flow.

The usability testing team included two members: the Facilitator - the person in charge of conducting the testing session, and the Computer - the person who acted as the computer to operate the paper prototype. Each usability testing session involved one test participant.
4.2 Creating Prototypes for Experiment

As this study aimed to confirm the validity of the paper prototyping methodology, both the web prototype and the paper prototype should be identical to avoid external factors that may affect results. To ensure the consistency of the prototypes, the web prototype was developed first and the paper prototype was created based on the web prototype. All features required for the pre-defined tasks explained in Chapter 3 were fully developed in both the paper and web prototypes.

4.2.1 Developing Web Prototype

The web application selected for this study is an online book review community based on a platform by Plone, a content management server built with the Zope technology. In order to create a web page in Plone, the developer used HTML, Python and DTML coding. The web prototype required 16 hours of development time. The web prototype can be accessed through the following link: http://tonka.iat.sfu.ca/margaret/eportal.

4.2.2 Developing Paper Prototype

I developed the paper prototype of the online book review community following the methodology outlined in Chapter 2.3.2. The paper prototype was finished in 4 hours.

4.3 Internal Walkthrough

An internal walkthrough served as a rehearsal of the usability testing sessions to enhance the readiness for the usability testing team. Before the first
usability test, an internal walkthrough was performed by the usability team on the paper prototype. This session served to train the person who would act as the Computer during the actual usability test sessions. I acted as both the Facilitator and the Computer for this internal walkthrough. This session was video taped for future reference.

4.3.1 Observations

At the start of the session, the internal walkthrough participant was curious about the structure of the usability test. The participant noticed that there were many pieces of information to be memorized before he could become the Computer for the actual experiment. The participant remarked that the “loading” time, the period of finding correct paper pieces for the interface, was too long. He inquired about whether the blue text in the interface indicates a hyperlink and also whether password should be “typed” in as text or as “*” or actually as the word “password”. Significantly, the participant was confused about finding the book review tab when asked to perform the task of “finding a book review”. The participant also showed hesitation and confusion over task 3, which is adding a new book review. Finally, he was not certain whether adding a document or adding a file was the correct choice.

After the session, I interviewed the participant and he reported that the information he needed to know to perform as the Computer was significant. He needed to spend time to review the tasks and to become familiarized with the interface. He also mentioned that hint cards and a script would be helpful to
make his duty as the Computer successful as various interface changes that relate to the participants' responses were difficult to remember.

4.3.2 Analysis and Results of the Internal Walkthroughs

I performed a second internal walkthrough and had the Computer conducted the test on me. This was a pre-run practice. This session was useful for the Computer to become familiarized with the paper prototype and the process to manipulate the interface. There were no changes to the paper prototype after the internal walkthroughs.

4.4 Usability Test Sessions

After the two internal walkthrough sessions, the Facilitator and the Computer were ready to start the usability test sessions. I was the Facilitator while the other person acted as the Computer to perform the tasks on the three paper prototype sessions. All six usability test sessions were video taped for result analysis. For the Facilitator's script, please see Appendix A.

The test started with an introduction by the Facilitator to explain the format and procedures. All participants were required to sign a consent form to ensure that they understood the terms of agreement. After the briefing, the participants started the six pre-defined tasks.

After completing the six defined tasks, all participants could freely perform tasks without any prompting or instructions from the Facilitator.
5.1 Qualitative vs. Quantitative Approach

I reviewed the results from both the paper and web prototype sessions by comparing the participants' success in completing the assigned task and the number and type of issues identified. I did not focus on the severity of errors because the application tested in this experiment is not a complicated design that is prone to critical errors. The sample size of six participants is sufficient only to suggest trends as it has little statistical power. The results suggest that both the paper and web prototypes can provide similar results as all six participants completed their pre-defined tasks successfully. For example, paper and web prototype participants both found similar interface issues and made similar user errors. For descriptive statistics, please review Appendix B.

This first review of the data suggests that, in terms of a medium, a paper prototype is as effective as a web prototype. However, there are factors not captured in my first analysis. I recalled responses and reactions from the participants during the paper prototype sessions that did not occur during the sessions for the web prototype. Since I recorded the usability test sessions, I reviewed my tapes and re-evaluated the findings from another perspective using a qualitative approach. As qualitative methodologies are widely used (particularly in the social science domain) to discover potential relationships
among data, I apply this approach to uncover potential similarities and differences in paper and web prototypes.

5.2 Thematic Analysis

My second evaluation of the data is based on the thematic analysis approach. According to Richard E. Boyatzis’ *Transforming Qualitative Information: Thematic Analysis and Code Development* (1998), “thematic analysis is a process for encoding qualitative information” (Boyatzis, 1998, p. 4). To systematically analyze qualitative data, researchers need to generate a code or a list of themes representing patterns found in the data. Using this code, researchers can organize data into different themes to interpret the results. By using this method, researchers can “…make sense out of seemingly unrelated material” (Boyatzis, 1998, p. 4).

In the Literature Review Section in Chapter 1.3, I noted previous studies that compare web and paper prototypes. However, none are based on a thematic analysis approach. Boyatzis (1998, p. 30) argues that codes can have one of three origins: from analytic argument (theory-driven), from existing codes (prior research-driven) or from the data at hand (data-driven). The first two sources are not available as all previous researchers used a quantitative method of analysis and provided only anecdotes on aspects of the data not captured by the measured variables. In this study, I used the data-driven approach in thematic analysis. “Data-driven codes are constructed inductively from the raw information” (Boyatzis, 1998, p. 30).
There are three stages in developing and using an inductively derived code. The first stage is to decide on sampling and design issues, including selection of the subsamples. The second stage is to develop themes and a code that differentiates the subsamples. The third stage is to apply the code to the full samples to determine valid differences. The procedures for each stage on how I derived the thematic code for this study are explained in subsequent sections.

The main source of data in my study is the video tape containing the six usability test sessions, which was used for the thematic encoding process. A transcript was created for future reference during my first review using the quantitative method. It acted as a cross reference to generate examples and quotes in the results reported in the Stage III section. A summary of the observations can be found in Appendix C.

**Stage I – Sampling and Subsamples**

The first stage is to decide on sampling and design issues. The data to be coded must have two or more subsamples. One set of the subsamples is used as the basis to derive the code while the other set is used for validation purpose. As indicated in the experimental setup section in Chapter 4, the sample size of my experiment is six participants. They were randomly selected into two categories: paper prototype and web prototype. With a small sample size of only three subjects in each category, I decided to develop themes and code that efficiently differentiate the data. This means that my code is not validated. New data in the form of video recordings of paper and web prototyping on common tasks is required before the code can be used predictively.
One of the key requirements in developing data-driven codes is identifying the criterion reference, in which researchers need to set criterion variables to predict outcomes. Criterion-referencing is a compare-and-contrast process that extracts observable differences among samples using pre-specified criterion variables. The prototype medium of paper and web are my criterion variables, which are independent variables in the experiment. Boyatzis mentions that criterion variables “will determine the likelihood of developing a code that can be validated in further studies, as well as the quality of the code” (1998, p. 42).

**Stage II – Developing Themes**

The process of transcribing usability sessions into a written transcript gave me strong hints on what the themes might be. I noticed patterns that led me to develop themes 1 and 2. For example, there were moments when participants expressed their confusion verbally (e.g. “I don’t understand”) or by body language (e.g. frown). Theme 1 refers to occurrences of confusion and aims to capture all moments of doubt related to the application being used.

Theme 2 refers to the time when participants experience problems with the experimental method (e.g. the process towards a particular prototyping methodology) instead of the application itself. For example, I coded an occurrence of theme 2 when the participant asked clarifying questions on how to use the equipment (such as the pen for paper prototype or the mouse for web prototype). This aim is to compare whether participants in one medium encounter more problems than the other.
Themes 3, 4 and 5 were derived when I reviewed the video tape the second time for the thematic analysis approach. I noticed that web prototype participants were more likely to try different methods than paper prototype participants when performing the six pre-defined tasks. Theme 3 is focused on encoding moments when participants deviate from the default workflow. This is to validate whether the web prototype will facilitate participants to explore the interface outside normal workflow.

The focus of theme 4 is to find out whether the paper prototype will cause any page coherence issues. Page coherence in this context means that changing of components on the screen of itself does not attract or distract the attention of the participant. When the paper prototype is being manually manipulated, there will be a disturbance during the change of pages that may cause participants difficulty in understanding the entire screen or performing the task. Theme 4 is to confirm or disconfirm this assumption, which only happens in paper prototype.

Theme 5 is to encode screen update impact, which is a phenomenon in paper prototype sessions. When the Computer updates the paper prototype for the next screen, only a section of the prototype is updated, leading the participants to focus only on those areas. For example, when the participant clicks on the “Book Review” tab, the Computer will only add a new piece of paper with the book review topics instead of updating the entire screen. On the other hand, the entire screen of the web prototype will be updated when the participant clicks on “Book Review” tab. Theme 5 will confirm whether the paper prototype
provides more visual cues than the web prototype in guiding participants to follow a particular workflow.

Here is a table outlining all five themes and their corresponding labels, definitions, indicators, exclusions and differentiations. Each theme is labelled and defined. The indicators provide the criteria for coding the occurrence. For some themes, there are exclusions to disqualify incidents that should not be coded. Differentiations apply to themes that only relate to a particular category of the sample.
<table>
<thead>
<tr>
<th>Theme</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
<td>Moments when the participant is confused</td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td>The participant shows a sign of confusion towards the prototype or tasks.</td>
</tr>
<tr>
<td><strong>Indicators</strong></td>
<td>Coded when the participant frowns, shows frustration, or says “I don’t understand”, “what do I need to do”, etc.</td>
</tr>
<tr>
<td><strong>Exclusion</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Differentiation</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theme</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
<td>Problems with the experimental process or method</td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td>The participant asks clarifying questions regarding the process of the experiments.</td>
</tr>
<tr>
<td><strong>Indicators</strong></td>
<td>Coded when the participant asks questions regarding the use of equipments, methods, or how to indicate answers, towards a particular prototype</td>
</tr>
<tr>
<td><strong>Exclusion</strong></td>
<td>If the question is directly related to the experiment itself independent of the prototype format</td>
</tr>
<tr>
<td><strong>Differentiation</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Theme</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
<td>Deviation from the “default” method</td>
</tr>
<tr>
<td><strong>Definition</strong></td>
<td>The participant performs a task in an approach different than the expected process</td>
</tr>
<tr>
<td><strong>Indicators</strong></td>
<td>Coded when the participant is completing a task in a way that is different than the default method, compare to Figure 23 and Figure 24 Task Flow Diagrams.</td>
</tr>
<tr>
<td><strong>Exclusion</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Differentiation</strong></td>
<td></td>
</tr>
</tbody>
</table>
Stage II - Applying Code to Full Sample

After the themes are identified and formed as a code, they can be applied to encode the full sample. Two coders (Coder A and Coder B) reviewed the video and encoded the data into the five themes defined in stage II. Both Coder A and Coder B watched the video and marked down each occurrence that corresponded to the five themes. Coders' scores were combined as average per prototyping medium. Inter-rater reliability ratios were calculated based on the percentage of agreement on presence between the two coders per each theme for each prototyping medium (Boyatzis, p155).

\[
\text{Percentage agreement on presence} = \frac{2 \times (\text{no. of times both Coder A and Coder B saw it present})}{(\text{no. of times Coder A saw it present} + \text{no. of times Coder B saw it present})}
\]
Here are the results.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Coder A</th>
<th>Coder B</th>
<th>Inter-rater Reliability</th>
<th>Average</th>
<th>Coder A</th>
<th>Coder B</th>
<th>Inter-rater Reliability</th>
<th>Average</th>
<th>Paper Average minus Web Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theme 1</td>
<td>25</td>
<td>32</td>
<td>0.88</td>
<td>28.5</td>
<td>17</td>
<td>17</td>
<td>1.00</td>
<td>17</td>
<td>11.5</td>
</tr>
<tr>
<td>Theme 2</td>
<td>20</td>
<td>18</td>
<td>0.95</td>
<td>19</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Theme 3</td>
<td>2</td>
<td>3</td>
<td>0.80</td>
<td>2.5</td>
<td>6</td>
<td>5</td>
<td>0.90</td>
<td>5.5</td>
<td>-3</td>
</tr>
<tr>
<td>Theme 4</td>
<td>14</td>
<td>14</td>
<td>1.00</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>1.00</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Theme 5</td>
<td>10</td>
<td>12</td>
<td>0.91</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>1.00</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>

During the process of reviewing the data, the six participants were assigned a name for identification. Names were altered to protect the privacy of the participants. Here is a table of the participant names:

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Participant Name</th>
<th>Prototype Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>Alan</td>
<td>Paper Prototype</td>
</tr>
<tr>
<td>Participant 2</td>
<td>Beatrice</td>
<td>Paper Prototype</td>
</tr>
<tr>
<td>Participant 3</td>
<td>Charles</td>
<td>Paper Prototype</td>
</tr>
<tr>
<td>Participant 4</td>
<td>Dennis</td>
<td>Web Prototype</td>
</tr>
<tr>
<td>Participant 5</td>
<td>Emily</td>
<td>Web Prototype</td>
</tr>
<tr>
<td>Participant 6</td>
<td>Fiona</td>
<td>Web Prototype</td>
</tr>
</tbody>
</table>
Theme 1: Moments when the participant is confused

For theme 1, the number of occurrences of confusion on the paper prototype is higher than on the web prototype.

Example 1

When Alan is working on task 1 to find a book review after the Computer has completed loading the page on the paper prototype, he looks perplexed and asks, "What is this?", while pointing to the list of topics on paper and requiring the Facilitator to explain. This same incident happens with Beatrice as she asks the same question, “What is this?”, when the interface presents her with a list of book topics on paper. On the other hand, Dennis, one of the web participants, is also confused and asks about whether he can pick anything from the list or not. Unlike Alan and Beatrice, Dennis knows that the list is clickable but is simply not sure whether he should pick a particular topic on the list.

Example 2

Adding a book review is another task that participants find confusing. Participants from both paper and web prototype sessions encounter problems that are encoded to theme 1. All three paper prototype participants have issues with finding out where to add a book review. Alan looks lost. Beatrice is nervous and murmurs, “New book review”, while scanning the entire paper prototype without an idea of how to start. Charles also does not know where to start. Throughout the process of adding a book review, Charles is uncertain and keeps asking questions, such as “Where do I write?” and “What book should I add?” On the other hand, web participants know where to add the book review but need
to confirm their ideas with the Facilitator. Dennis asks the Facilitator whether he is required to choose a book first before he can add the book review. Another web participant, Emily, asks whether she should actually add a book review.

Example 3

Another moment of confusion identified for both paper and web prototype participants is due to an interface error. The title of the screen “Add Document” is displayed as “Edit Document” during the task of adding a new book review. When Beatrice from the paper prototype session performs task 3 of adding a new book review to the system, she is surprised that the title is displayed as “Edit Document” and exclaims, “Why is the title: Edit? It should be called Add.” One of the web prototype participants, Fiona, notices the same issue when she tests task 6 of adding a new book review under the newly registered user. She asks the same question, “Why is this called Edit instead of Add?”

Example 4

Registering as a new user is a task in which some participants show signs of confusion. I noticed this phenomenon in both paper and web prototype sessions. At the paper prototype session, Charles cannot register as a new user and keeps scanning the entire prototype interface. He continues to check with the Facilitator and asks, “Should I click home?” The Facilitator responds that he should sign out first. Emily also encounters issues on the web prototype when she tries to register as a new user. Her first attempt to use the sign in feature results in failure. The Facilitator then guides her to use the registration feature instead. Fiona has the same problem as Emily when she attempts to sign in via
the web prototype. In addition, she complains that the "New User" button should be called "Register Now".

Conclusion

There are moments of confusion in both paper and web prototype sessions. However, paper prototype participants show a substantially higher rate of confusion and some of their problems are critical issues that prevent participants from continuing their testing.

Theme 2: Problems with the experimental process or method

The results of the data encoding indicate that the majority of problems with the experimental process or method is from the paper prototype sessions.

Example 1

The most prominent example is the usage of sticky notes on the paper prototype. All three participants ask clarifying questions regarding the sticky notes. During task 2 of signing in to the application, Alan asks, “Do I use these sticky notes?” Beatrice attempts to take off the sticky notes and asks, “Am I supposed to tear off the sticky notes?” Charles is confused as well and inquires, “Do I need to write or just click on them?” All three participants are unsure about the purpose of the sticky notes until the Facilitator explains that they are to be used throughout the paper prototype as text boxes for participants to input data.

During the first session, the sticky notes are missing on the paper prototype interface. When Alan selects “Add Document” during the task of adding a new book review, the Computer and the Facilitator notice that the next
screen do not have sticky notes to allow Alan to input information. The experiment is paused while the Computer and the Facilitator prepare sticky notes. Even after resuming the testing process, Alan is confused and keeps shaking his head when seeing misplaced sticky notes due to the hastiness of the Computer adding the sticky notes after the first mistake.

In summary, participants are not accustomed to this paper prototyping experimental method and are not comfortable with the process.

Example 2
Another incident that confirms the problem with the paper prototyping methodology is with the coordination and manual process of Computer loading the paper screens. There are two instances where the Computer takes away the paper screens before Beatrice completes her task. Beatrice says, "Wait, I have not clicked the button yet" when she signs in to the interface. The Computer is mistaken and thinks that Beatrice has finished with her action. During the last task of adding a new book review, she exclaims, "I missed this one. Wait." while the Computer starts to update the next screen.

Example 3
Participants are perplexed a number of times when the Facilitator announces that the task has been completed. Alan is still fidgeting with the sticky notes when task 3 is completed and he looks stunned when he is asked to start the next task. The same event occurs with Beatrice. When she completes task 3 to add a new book review, she still looks like she is wondering about something.
Conclusion

The above observations are not found in web prototype sessions because participants are familiar with an actual computer. Compared to the paper prototype, web prototype participants are only required to focus on the application itself instead of worrying about the experimental method. Paper prototype participants are distracted by the problems they encounter with the methodology. They need to cope with the human manipulation of the interface that occasionally presents with flaws, such as the issue of missing sticky notes during the first session.

Theme 3: Deviation from the “default” method

Deviation from the “default” method is the only theme of the five where web prototype sessions have a higher count than paper prototype sessions.

Example 1

Web prototype participants have a tendency to deviate from default testing workflows. When the Facilitator asks Emily to sign in as the newly registered user in task 5, she uses the sign in box on the left side of the screen instead of clicking on the “Sign in Now” link embedded in the middle of the welcome message.

Example 2

Fiona, in her web prototype session, deviates from the expected workflow a number of times. She looks at the interface and clicks on the “Add Favourite” link when she is supposed to add a book review in task 3. She tests email and password functions to ensure error checking in task 4 when she is registering as
a new user. Instead of typing her book review summary, she uploads a word document to test the uploading process in task 6.

**Example 3**

In contrast, paper prototype participants do not deviate from the default workflow or planned testing as much as the web prototype participants. The only noticeable incident is when the participants click on “My Stuff” on the top menu bar to start the process of adding a new book review instead of the intended workflow of choosing the “My Stuff” link on the welcome screen. Both Alan and Charles choose the different workflow by clicking on the top bar rather than using the default link.

**Conclusion**

The above examples lead to the hypothesis that the web prototype may promote different workflows. Participants may feel more comfortable with testing the web interface via a computer, as it may encourage them to be more open to explore the interface.

**Theme 4: Page Coherence**

During paper prototype sessions, participants wait for the Computer to manually load the paper interface after each click or action. During the page transition process, participants may lose their coherent view of the interface. This phenomenon does not happen during web prototype sessions as the computer loading time is very short.
Example 1
Alan is disoriented when he performs various tasks on the paper prototype. There are multiple instances when Alan pauses and plays with the pen, which represents the mouse, while waiting for the Computer to load the next screen. After the screen completes loading, Alan takes time to focus on the interface again before performing the next task. The incident of missing sticky notes when Alan is adding a book review interrupts his work process as the Computer and Facilitator obtain sticky notes to allow Alan to write. Alan is confused and needs time to get his attention back to the paper prototype.

Example 2
Another paper prototype participant, Beatrice, also loses attention occasionally while the Computer loads the screen. After each click or action, Beatrice knows that there will be a prolonged loading time and she starts scanning around the room aimlessly waiting for her next screen to be ready. As noted previously, there are instances where the Computer takes away the paper before she can finish her action. When the paper is returned to the interface for her to officially complete her action, Beatrice takes time to reorganize her thoughts.

Example 3
Charles is more nervous than other participants and his head keeps following the Computer’s movement when the Computer is updating the paper screens. Charles is startled at the beginning when the paper interface is manually updated after he clicks on the “Book Review” tab. It takes him time to get used to the manual loading by the Computer.
Conclusion

Page coherence is only a problem found in paper prototype sessions. For the web prototype, the entire page is loaded by the web application instantaneously. The prolonged loading time caused by the manual manipulation of the paper prototype prevents participants from developing a holistic view of the interface. Commonly, participants need to refocus their attention after the interface is loaded to continue their testing workflow.

Theme 5: Screen Update Impact

The paper prototype is manually updated by the Computer when participants interact with the paper interface. The paper prototype is composed of many small paper pieces enabling the Computer to change only the required parts to save loading time. Therefore, participants will see the interface being updated by sections instead of the entire page at once. The participant may only focus on the updated screen and not on the rest of the interface. This phenomenon does not happen during the web prototype sessions as the web application is updated as a whole with a brief loading time.

Example 1

Alan only focuses on the updated screen every time a new piece is placed on the paper prototype. This phenomenon is consistently repeated throughout the entire session for all six pre-defined tasks. For example, when he is finding a book review in task 1, he only reads the updated piece of paper interface with the book review topics instead of looking at the interface as a whole.
Example 2

Beatrice displays similar behaviours. She focuses only on the new pieces of paper that the Computer places on the prototype for every task. For instance, she clicks on the “My Stuff” link on the welcome message right away when the Computer places this new part on the interface.

Example 3

Charles has the same issue as the previous two paper prototype participants. He only focuses on the updated pieces for every action he takes. For example, at the end of task 4 of registering as a new user, Charles clicks on the “Sign in Now” link in the welcome message immediately after the Computer updates the screen with this section.

Conclusion

All subjects show that screen updates on paper prototype lead participants to focus only on the updated sections of the interface. This is because the entire screen of the paper prototype is not loaded as a whole but rather piece by piece. Therefore, the paper prototype has a high potential of exaggerating a particular workflow and provides stronger guidance or cues for action than does the web prototype.
CHAPTER 6: CONCLUSION

6.1 Conclusion

Having an effective prototyping methodology leads to valuable usability testing. Choosing the appropriate prototyping medium is a key factor for developing a user-friendly product. Paper and web are the two prototyping media studied in this research. They are the two most widely used and discussed prototypes in the software engineering research field.

My intent was to conduct a quantitative analysis while attempting to follow the structure of a formal experiment in the design of user sessions. Although this was not a formal experiment, my planning and careful design of user sessions enabled me to collect better data. Although the sample size may be small, the data quality is high.

In my first quantitative review, the experimental data indicates that the paper prototype provides similar results as web prototype in terms of the participants’ success in completing the assigned tasks and identifying the number and type of issues. Although I have a small sample size, my results correspond to findings in previous studies.

With thematic analysis, a qualitative approach, my research indicates that paper prototyping is not as effective as suggested by my quantitative review and other researchers’ studies. Since I video taped all usability sessions and
transcribed the conversations, I re-evaluated the raw data by applying the thematic analysis methodology to encode the data into five themes. The results from thematic analysis paint a different picture from my initial quantitative review. Paper prototype participants experience a higher rate of confused moments (theme 1) and encounter more problems with the experimental method (theme 2) than their counterparts using web prototypes. Participants are not comfortable with testing on a paper interface as indicated from the results from themes 1 and 2. They are constantly confused with either the functionalities on the interface or the paper prototyping experimental process. On the other hand, web prototype participants have a higher tendency to deviate from the expected workflow (theme 3) than paper prototype participants. Since participants are accustomed to using computer as the testing medium, they are comfortable to explore the web application and experiment the different workflows.

From my thematic analysis, I discovered a page coherence problem (theme 4) using the paper prototype. With the human manipulation of the paper prototype, participants need to pause and wait for the next screen to load. After each pause, participants are constantly disoriented and have to refocus their attention to continue testing. The shuffling of paper when the Computer updates the interface also disrupts the natural transition of the workflow. Another issue that occurs only in paper prototype sessions is the impact of screen update (theme 5). Since the Computer updates the paper prototype section by section, participants only focus on the newly update screens instead of the entire prototype. Paper prototype may promote particular workflows to guide
participants to follow. However, web prototype does not have problems with
document coherence and partial screen update because the web application always
loads the entire page instantaneously.

When developing a web application, time and resource management are
due factors. If a paper prototype is as effective in uncovering usability
issues as a web prototype, it will certainly be preferable because paper
prototyping is a low cost method that requires less time to develop. From this
usability study, my initial quantitative review shows that paper prototype and web
prototype yield similar results, confirming previous studies that paper prototyping
methodology is effective in usability testing for web applications. However, my
second qualitative review using thematic analysis brings up observations that
paper prototype is not as effective as my first review and other researchers’
studies. Paper prototypes may confuse users and provide stronger cues to guide
users to follow expected workflows.

The findings in my research using the qualitative approach shows patterns
and trends on differences between paper prototype and web prototype. I cannot
confirm that paper prototype is not as effective as web prototype because I need
another subsample of data to validate this research. My results from the
thematic analysis strongly suggest that there are significant differences between
paper prototype and web prototype. Paper prototype may have unforeseen
consequences, such as page coherence issues and screen update impacts.
Every application design is different and there is no easy answer to whether a
paper prototype or a web prototype should be used. My research serves as a
guideline to warn people of potential pitfalls of using a paper prototype. This also opens the door to future research opportunities that use a qualitative approach to observe similarities and differences between paper and web prototypes.
Appendix A: Script for the Facilitator

Step 1: Greet the participant

Step 2: Brief the participant on the format of the experiment

Step 3: Explain to the participant that he or she can stop or leave the experiment any time

Step 4: Explain to the participant regarding the confidentiality on his or her information will be appropriately kept according to the Ethics standards

Step 5: Ask the participant to review and sign the consent form

Step 6: Hand the participant with the gift certificate as a gratitude

Step 7: Start the experiment

1. Find a book review
2. Sign in as a defined user
3. Add a book review as the defined user
4. Register as a new user
5. Sign in as the newly registered user
6. Add a new book review as the newly registered user

Step 8: Ask the participants to explore the interface

Step 9: The experiment is completed and thank the participant

Facilitator Intervention Conditions:

- Participant asks questions
- Participant explicitly requests help
- Participant becomes emotional or uneasy during the experiment
Appendix B: Comparative Analysis by Tasks

Here are the results on the comparative analysis from the first review using a quantitative approach. I classified the issues that paper or web prototype participants encountered into different categories: questions, interface issues, user errors and action slips.

<table>
<thead>
<tr>
<th>Type of Issues</th>
<th>Paper Prototype</th>
<th>Web Prototype</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions (counted when participants asked questions)</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Interface Issues (counted when participants reported interface problems)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>User Errors (counted when participants made user errors)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Action Slips (counted when participants performed actions with right intention but executed wrongly)</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

The following sections outline the detail analysis on comparing results from paper and web prototype sessions.

Task 1

For Task 1, all paper prototype participants showed uncertainly on what was clickable and what was not. One out of the three web prototype participants showed the same behaviour.

At the beginning of the test sessions, participants from the paper prototype took time to become familiar with doing the task on paper instead of a computer screen. After a few attempts, participants were used to the paper method and
started to perform naturally. On the other hand, participants from the web prototype were inherently comfortable for testing the application on the computer screen.

Task 2

Task 2 yielded similar results between the paper prototype sessions and the web prototype sessions. For the paper prototype, participants successfully signed in as the user "cloud" except for inquiries about the purpose of the sticky notes. On the other hand, web prototype participants signed in as user cloud without problems.

Participants working with the paper prototype began to get used to this testing method and started to treat the paper interface as a “real” application.

Task 3

Paper prototype and web prototype showed the same results for Task 3. 2/3 of all web and paper participants completed the task without major challenges while 1/3 of them were not able to go further without significant assistance from the Facilitator. One participant from each of the two groups spotted the problem with the title of “Edit Document”. It should be renamed as “Add Document”. In addition, a web prototype participant got distracted by the interface when the participant went on testing and questioning about other features.
Task 4

For both paper prototype and web prototype, 2/3 of the participants did not realize that signing out from the previous user login was necessary. People were confused about which parts of the interface required log-in and which parts did not. One from each of the prototype groups suggested that the “New user?” link at the bottom of the “Sign in” window was not obvious for users to find and it should be moved to a more noticeable location on the interface or had the text changed as “Register Now”. In addition, two participants from the paper prototype group and one from the web prototype group automatically clicked on the link of “Sign in Now” after the registration process and without prompting from the Facilitator.

Task 5

Half (2 paper prototype, 1 web prototype) of the participants signed in using the “Sign in Now” link in the welcome message from the previous task. 2 of the participants who had not yet signed in from the task 5 used the link in the welcome message while one of the participant (from the web prototype) used an alternative way to sign in, which was typing in the username and password in the “Sign In” window on the side. For half of all participants, the “Sign in Now” link was an obvious step after registering as a new user and was quite practical, as they did not need to retype the username and password. They did not wait for the Facilitator’s prompting for Task 5 and naturally signed in at the end of Task 4. For the other half who waited for the Facilitator, they explained that they would like to wait for the next task before making any further moves. In addition, some
participants saw the “Sign in Now” link as unnecessary because the system should automatically sign the registered user in.

**Task 6**

All the participants showed that they had learnt from the previous experience from Task 3 of adding a book review. When they were requested to add a new book review as the new user, they performed the task without the hesitation that was shown earlier. This observation suggested that users were able to learn and get used to the system in a very short time. This fact was observed for both the paper and the web prototypes.

After the six designated tasks, the Facilitator asked the participants to freely test the interface on their own.

**Free Tasks**

Many common features that were tested included “News”, “Calendar”, “Members” and “Search”. 1/3 of all participants (one from paper prototype and one from web prototype) wondered where their book reviews have gone because they could not find it from the book topic list. It was a common inquiry that participants would have and they spotted that this important feature was missing (by design limitation at the prototype stage). Since the query list for book topics was hard coded at this stage and new items could not automatically associate with the query unless the developer modified the underlying code.

Another key observation was that participants in the web prototype were more eager to test the interface. This might be due to people being familiar with
computers. However, it is important to note that Participant 5 from the web prototype group did not spend a lot of time to explore even though the testing medium is a real electronic computer instead of a paper prototype. Reasons that might contribute to this situation include the fact that this participant was worried about clicking on new areas. Another exception was Participant 3, who took more time to explore the paper interface. The participant became comfortable with the paper after doing all six tasks.

Performance issues and bugs were discovered during the web interface testing that did not get noticed during the paper sessions. Participant 4 tested the loading time for the member roster as well as whether text fields were case sensitive. These kinds of issues would not be found in the paper prototype sessions.
In conclusion, most interface features could be tested using both paper and web prototypes. For example, users from both prototypes discovered feature design issues, such as the “Calendar” and the embedded hyperlink in News items, being not clickable. While the paper prototype collected feedback regarding the usability of the application as well as the logic of the task workflow, it does not help detect performance issues.
Appendix C: Experiment Observations

Here are the observations from the experiment during the first analysis.

Task 1: Find a book review

Participant 1 <Paper Prototype>
Participant 1 was not sure what the next step was upon seeing a list of book topics. The Facilitator needed to inform this participant that words in blue were hyperlinks.

Participant 2 <Paper Prototype>
Participant 2 started by asking whether blue stood for hyperlinks.
Participant 2 commented that there was no next page feature for the subtopics, the title for the listing, in the book listing and questioned on why there was a parameter, a default line from the topic display feature, in the subtopic (it is a by design issue on the interface).

Participant 3 <Paper Prototype>
Participant 3 inquired whether signing in to the interface was necessary for doing this task 1. After clicking on the book review tab, Participant 3 was uncertain what the next step was when seeing the book listing and needed a clarification from the Facilitator.

Participant 4 <Web prototype>
During the web prototype sessions, participant 4 completed Task 1 right away without any question.
Participant 5 <Web prototype>
Participant 5 required the Facilitator to hint on blue representing hyperlinks that could be clicked on when working on Task 1.

Participant 6 <Web prototype>
Participant 6 tried on clicking different things to experiment whether they were clickable or not and successfully completed Task 1.

Task 2: Sign in as a defined user

Participant 1 <Paper Prototype>
Participant 1 did not understand the purpose of the sticky notes. The Facilitator needed to explain that the sticky notes represented text fields that users could write on. After that, Participant 1 successfully signed in as user "cloud".

Participant 2 <Paper Prototype>
Participant 2 also inquired about the sticky notes and was unsure whether they should be taken out or should be written on. After the Facilitator explained the purpose of the sticky notes, Participant 2 wrote the username on them and also "XXXX" to represent the password assuming the interface will hide the password through encryption. Participant 2 then successfully signed in as user "cloud".

Participant 3 <Paper Prototype>
Participant 3 did not encounter any problem and successfully signed in as user "cloud" after reading the instructions from the screen as well as those in the task list carefully.
Participant 4 <Web Prototype>
Participant 4 completed task 2 with no issue or question.

Participant 5 <Web Prototype>
Participant 5 completed task 2 of signing in as user “cloud” successfully.

Participant 6 <Web Prototype>
Participant 6 asked the Facilitator whether he/she was required to sign out before signing in as user “cloud”. After the Facilitator clarified that task 1 was performed without signing in, Participant 6 signed in as user “cloud”.

Task 3: Add a book review

Participant 1 <Paper Prototype>
The Facilitator started off by telling Participant 1 to click on “My Stuff”. Participant 1 showed no difficulty in finding the “add new item” button. After that, the participant went on to add “Document”. Participant 1 successfully added a new book review to the system.

Participant 2 <Paper Prototype>
Participant 2 got a hint from the Facilitator to click on “My Stuff”. Same as the first participant, Participant 2 successfully found “add new item” and chose the option to add a new “Document”. On the screen for adding a new document, Participant 2 spotted a problem regarding the title for that screen as “Edit Document” instead of “Add Document”. The Facilitator modified the title on the interface instantly to “Add Document” by crossing out the word “Edit” with a pen and wrote “Add’ above it. Participant 2 filled out all necessary fields and completed the addition of a book review.
Participant 3 <Paper Prototype>
Participant 3 showed doubt on the meaning of adding a new book review. The Facilitator explained the context of the web application as a place for participants to add their comments on books. Same as the format for Participant 1 and 2, the Facilitator told Participant 3 to start with “My Stuff”. Participant 3 did not easily spot the “add new item” button until a hint was given by the Facilitator. After that, Participant 3 had difficulties choosing the correct items to add when the screen for adding different items was depicted. After some time, the participant figured out the correct option was adding “Document”. When the screen for adding “Document” is shown, Participant 3 paused for awhile and asked what to put as the “title” field. The Facilitator explained the function and purpose of each field. After that, Participant 3 found the save button and added the book review to the system.

Participant 4 <Web Prototype>
Participant 4 asked whether it was required to add a book review related to an existing book listed in the system. The Facilitator explained that the participant could add reviews on any book. After that, Participant 4 successfully added the book review to the web application.

Participant 5 <Web Prototype>
Participant 5 did not find the task clear even after the Facilitator hinted on clicking “My Stuff”. Participant 5 could not find the “add new item” button before the Facilitator pointed it out. In addition, the participant was not certain what to add once the screen depicted different options of items to add. Participant 5 asked the Facilitator to confirm whether “Add Document” was the correct choice.
The Facilitator also hinted on scrolling down to the bottom of the page to click on the “save” button to complete the process of adding a book review to the system. Overall, Participant 5 required hints and help from the Facilitator through the task in order to complete successfully.

**Participant 6 <Web Prototype>**

Participant 6 got the hint from the Facilitator to click on “My Stuff” to start with task 3. The participant inquired why this option was called “My Stuff” instead of “Add My Book Review”. The participant was also interested in knowing whether the “add to favorite” option was related to the one on the Internet Explorer. With the many options on the web interface, Participant 6 was distracted to go to the right option, “add new item”. The Facilitator led the participant back to the right track by pointing out the correct button. Participant 6 also pointed out that the title of the screen should be “Add Document” instead of “Edit Document”. Rather than choosing default options like other participants, Participant 6 tried on the “html” format and uploading option. Participant 6 pointed out the message displayed after clicking on the save button should be “document uploaded” instead of “document changed”. Since the interface that the participant was testing on was a web application, instant changes would be more complex as it involved code changes and the Facilitator could not instantaneously change the interface as it could be done easily on the paper prototype. After successfully adding the book review, the participant was intended to view the added document.
Task 4: Register as a new user

Participant 1 <Paper Prototype>

Participant 1 was not aware that signing out from the current login (user “cloud”) was a necessary step. The Facilitator provided hints after noticing the participant hesitating. After that, Participant 1 had no problem with the new user registration process.

Participant 2 <Paper Prototype>

Participant 2 signed out from the previous login and registered as a new user successfully. The participant also automatically signed in as the new user from the “Sign in Now” link within welcome message displayed at the end of the registration process.

Participant 3 <Paper Prototype>

Participant 3 hesitated on how to start task 4. The Facilitator hinted that signing out from the previous login was necessary. The participant did not perform the sign out but tried clicking on the “Home” tab. The Facilitator suggested to the participant to try clicking on the “New User” button. After that, Participant 3 registered as a new user. The participant commented that this task was not clear because the button was not “register now” or something similar. After successfully registered, a welcome message was shown with the link “Sign in now” and Participant 3 clicked on that link right away to sign in as that newly registered user.

Participant 4 <Web Prototype>

Participant 4 signed out from the previous login and registered as a new user successfully.
Participant 5 <Web Prototype>

Participant 5 was confused on how to proceed with this task. The Facilitator suggested signing out from the previous user login would be the first step. Participant 5 signed out from user "cloud" but attempted to use the sign in username and password textboxes in “Sign In” window to register as a new user. This attempt failed. The Facilitator hinted on clicking on the “New User” link at the bottom of the “Sign In” window. After that, the participant could finally register as a new user. The participant recommended to the Facilitator that the link “New User” was not prominent and should be moved to a more noticeable place on the interface or the text should be “Register Now”.

Participant 6 <Web Prototype>

Participant 6 signed out from the previous user login first. However, same as Participant 5, Participant 6 tried to sign in as a new user instead of using the “New User” link to register. After failing the first attempt, the Facilitator suggested using the “New User” link. Participant 6 proceeded to the registration screen and tested the email field to see whether it could detect email format errors. The participant was also cautious enough to test the password field. The system responded to those tests with correct mechanism. Participant 6 successfully registered as a new user. In addition, the participant signed in as the newly registered user from the link “Sign in Now” in the welcome message.
Task 5: Sign in as the newly registered user

Participant 1 <Paper Prototype>
Participant 1 found the “Sign in Now” link in the welcome message and clicked on it to sign in as the new user.

Participant 2 <Paper Prototype>
Participant 2 automatically signed in from the “Sign in Now” link in the welcome message.

Participant 3 <Paper Prototype>
Participant 3 automatically signed in from the “Sign in Now” link in the welcome message from the previous task after the registration process had completed.

Participant 4 <Web Prototype>
Participant 4 found the “Sign in Now” link in the welcome message and clicked on it to sign in as the new user.

Participant 5 <Web Prototype>
Participant 5 signed in as the new user using the “Sign In” window on the right side of the interface instead of using the link of “Sign in Now” within the welcome message. The participant filled out the “username” and “password” fields and signed in successfully.

Participant 6 <Web Prototype>
Participant 6 automatically signed in from the “Sign in Now” link in the welcome message from the previous task after the registration process had completed.
Task 6: Add a new book review as the newly registered user

Participant 1 <Paper Prototype>
Participant 1 had learnt from the previous experience and performed task 6 of adding a new book review to the system efficiently.

Participant 2 <Paper Prototype>
After the first experience of adding a book review, Participant 2 performed this task successfully.

Participant 3 <Paper Prototype>
Participant 3 had learnt from previous experience in task 3 where the participant encountered problems. The participant knew the first step was to click on "My Stuff" and performed the add book review task without hesitation. However, Participant 3 raised a question on whether the ID for the document meant user id or the something else. The Facilitator clarified the point right away and stated that it was an ID to uniquely identify each document.

Participant 4 <Web Prototype>, Participant 5 <Web Prototype>, Participant 6 <Web Prototype>
Participant 4, 5 and 6 had learnt from the previous experience and completed task 6 of adding a new book review to the system.

Free Tasks

Participant 1 <Paper Prototype>
- Tried to view the book reviews entered during designed tasks and could not find them as a topic in the book list
- Asked about the difference between topic and document
- Clicked on "Member"
• Clicked on "Search"

• Clicked on "Calendar"

• Tried "My Preference"

• Clicked on "News"

• Wondered what the function of "undo history" did

Participant 2 <Paper Prototype>
• Clicked on "News"

• Clicked on the "Back" button on the browser twice

• Clicked on "Calendar" and then clicked on the date

• Tried the "Member" and view profile "Melody’ and it’s preferences

Participant 3 <Paper Prototype>
• Clicked on "Search"

• Inquired about "Navigation" and "About"

• Clicked on "News"

• Clicked on "Book Review"

• Chose the review on Da Vinci Code

• Inquired about the logo of Plone

• Commented that the mouse pointer did not change to indicate whether the texts were clickable or not

• Clicked on the "Back" button of the browser

• Clicked on "Book Review" again

• Clicked on "News" and chose the news on “Harry Potter Series”
• Inquired whether the hyperlinks in the News message were clickable or not
• Clicked on “Members”
• Clicked on “Calendar” and was disappointed that it was not a clickable area
• Tried to look for profiles
• Inquired about the syndication

Participant 4 <Web Prototype>
• Could not locate the book reviews that were entered during the designed tasks
• Clicked on “Calendar” and wondered what the use of it
• Clicked on “News” and found out the hyperlink embedded in the news message was not clickable
• Clicked on “Navigation” and commented on those document names were not recognizable
• Tested and confirmed that could not change the document that owned by another user
• Tested Search feature and searching for image worked
• Clicked on “Member” roster and found out the loading time was slow
• Found a “bug” that username text field is case sensitive which should not be the case for best practice coding

Participant 5 <Web Prototype>
• Signed out from the user login that was created in task 4
- Clicked on "News"

**Participant 6 <Web Prototype>**
- Clicked on "Publishing" process
- Clicked on "Calendar"
- Viewed "Metadata"
- Posted a comment
- Tested "Search" feature and found out that it searched based on "or" query structure
- Inquired about how to add a comment to other users' reviews
- Clicked on "My Preference" and added a portrait and listed as a member
- Clicked on "Member" and listed all people
- Renamed items
- Wondered what the difference was between different file types such as a document and a file
- Published a document and then tested on deleting it and the participant was surprised the system deleted items without a confirmation message
- Commented on if "syndication" was not allowed, it should be hidden from users
- Tested "undo" feature and found out the user did not have right to perform such a function

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BIBLIOGRAPHY


