

Optimising information-rich web page browsing on mobile devices

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Declaration

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Abstract

This study examined the usability problems with browsing information-rich web pages on small screens and how these problems can be addressed. A prototype was developed to address two specific issues: how users can understand the content and structure better; and how physical and mental efforts involved in browsing can be reduced. The prototype introduced the overview mode, which outlines the content and the scrollbar that visualises the content structure. Empirical evaluation was conducted and the overview mode of prototype was proven to improve user experience. With the overview mode, users are given more control over navigation and are provided with a summary of the page content.

Keywords

Mobile web browsing, Usability, Overview + details

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1 Introduction and Objectives

1.1 Background and Problem

Mobile web usage is growing by leaps and bounds. As of August 2014, 28.57% of web traffic came from mobile devices. (Gs.statcounter.com, 2014) The smartphone market is also continuing to evolve and change, offering better and faster wireless technologies and services. However, despite how powerful smartphone processors have become, and how much displays have improved, mobile web browsing continues to suffer from small screen usability issues.

Nowadays, smartphone browsers can render full desktop web sites, just as you see them on desktop browsers, but studies show that the quality of user experience is worse on mobile browsers. (Nielsen, 2014) Accessing information on small screens is difficult for many reasons. Nielsen identified four areas of usability challenges: small screens, input methods, slow data transfer, and incompatible designs. (Nielsen, 2014)

The simple act of navigating a page involves greater physical and mental efforts, even with mobile-optimised sites. Figure 1 shows a screenshot of the Boston Globe site as rendered on iPhone's Safari browser. The only way to navigate is by scrolling up or down, not knowing where you are or where you are going to. The screen shows no indication of how long the page is and there is no way for users to know what the page offers unless the entire length of the page is scrolled through.

This project examines the usability issues with accessing information on small screens. The focus is on browsing information-heavy web sites, such as news and information portals like BBC and Wikipedia. Following a study of usability issues, a solution was designed and evaluated to address these issues.

1.2 Objectives

The overall aim of this project is to investigate the problems with browsing information-rich web pages on smartphones and design a solution to improve

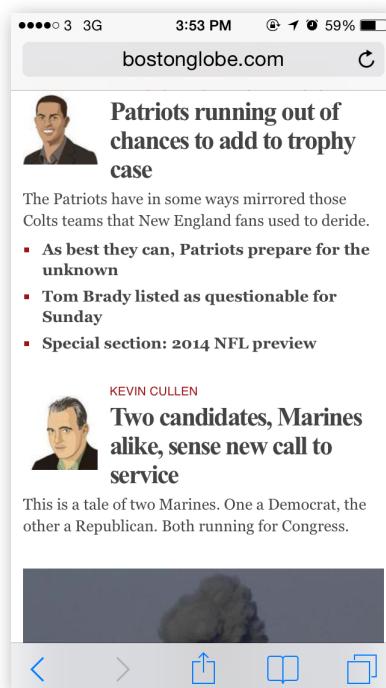


Figure 1: Boston Globe (<http://www.bostonglobe.com/>) as seen on iPhone Safari browser.

the user experience.

The main objective is broken down as follows:

1. Review the usability problems with mobile web browsing, focusing on information-rich web sites. In addition, review how past and current research has addressed these issues.
2. Design and develop a new solution to solve these usability problems.
3. Evaluate the developed prototype to:
 - i. review the usability of prototype.
 - ii. compare the prototype with current mobile browsers, in terms of efficiency and user experience.
4. Review the evaluation results for further improvements and suggestions.

1.3 Project Beneficiaries

With this project's outcome, it is hoped to have contributed to the ongoing research in small screen usability and benefit wider community of researchers who are continuing to investigate and design new solutions for mobile web browsing. Issues examined in the project are current and the developed prototype explores new solutions. In addition, future users of smartphones can benefit from the potential of improved mobile browsing experience. Web designers and developers can also benefit from improved mobile browsers as they develop the mobile web.

1.4 Methods

The following methods would be employed to meet the project objectives:

1. **Review the usability problems, and the technologies that address these problems.**

This objective would be met by using two methods. The first method would be a literature review of usability studies on mobile web browsing. The review would also include mobile site strategies and past and current solutions for mobile browsing.

Secondly, a user study would be conducted to collect data on mobile browsing issues. The participants would be smartphone users with varying degree of mobile web browsing experiences. The user study would include an interview and an observation. A semi-structured interview would cover the topics about the participants' browsing habits. An observation would set tasks for participants to complete and record how they browse and find information on

smartphones.

2. Design and develop a solution.

Based on the data collected from the user study, a new solution would be designed by:

1. Developing three to five concept sketches.
2. Building low-fidelity wireframes of selected concepts.
3. Designing high-fidelity wireframes with Adobe Photoshop to refine the visual design.
4. Conducting guerrilla usability testing for the selected wireframes.
5. Refining the final design, based on the testing results.
6. Building an interactive prototype with front-end development technologies - HTML, CSS and JavaScript.

3. Evaluate the prototype.

The developed prototype would be used in the final evalution to compare the prototyped browsing method with the current mobile browsing method. The prototype's usability would also be evaluated.

4. Review the evaluation results.

The evaluation results would be analysed both quantitatively and qualitatively. Any usability problems with the designed prototype would be analysed and performance metrics would be measured for comparison purposes. From the results, further recommendations for improvements would also be proposed.

2 Literature Review

2.1 History of Mobile Web

Users do not think of the mobile web as separate from the desktop web. It simply means that their point of web access is through mobile devices. However, for web designers and developers, the mobile web is an entity that comes with its own set of guidelines and technologies. (Firtman, 2013) It is useful to review how the mobile web and devices have developed over the years to allow web access.

The mobile web first started to appear around the end of last century. (Schmiedl, Seidl and Temper, 2009) At the time, WAP (Wireless Application Protocol) was the standard for accessing the internet through mobile devices. Web sites started to offer wap subdomains of their sites (e.g. <http://wap.yahoo.com/>) and web access was limited to these set of subdomains. (Firtman, 2013) With WAP2, wap subdomains were phased out for the m subdomains (e.g. <http://m.facebook.com>) The m subdomains still exist today. As a result, WAP split the web into two domains - one for the desktop and one for the mobile. (Firtman, 2013)

As early as 2003, some mobile browsers were able to access the full web, rather than just the mobile subdomains (Kaikkonen, 2008). These browsers adopted different rendering methods. The content was adapted to fit the screen display width, resulting in a long and narrow layout. Research by Roto and Kaikkonen showed that users' familiarity with scrolling on the desktop helped them to scroll intuitively on mobile. The study noted that users could not see where they were scrolling to. There had to be a more efficient way to scroll through extremely tall and narrow pages. (Roto and Kaikkonen, 2003)

With the introduction of the iPhone in 2007, mobile browsers offered true access to the full web. (Firtman, 2013) New interaction and input methods, such as zooming, gestural inputs and touch interfaces were introduced. As smartphones began to dominate the mobile market, users' expectations evolved. They wanted to be able to access the same content as on the desktop and complete more complex tasks. (Bridges and Rempel, 2013)

Currently, every major browser works with HTML5 and CSS, and all other sub-standards such as HTML4. (Firtman, 2013) There is now a strong push for "One Web", where a single web URL can be accessed through many different devices. (W3.org, 2014) Responsive web design has become a popular method

of adapting a web page for various screen sizes. Users will receive the same content as the desktop, with familiar design and experiences across all platforms and devices.

Responsive web design is a content adaptation method and is still dependent on traditional desktop browsing methods. A study on current mobile browsers by Dharmasiri et al points out that the mobile browsers are based upon desktop browser navigation and layout techniques. (Dharmasiri et al., 2013) Desktop web browsers were not designed for small screens and this has led to poor user experiences on mobile.

2.2 Usability of Mobile Web

According to Nielsen's mobile usability study in 2011, the average success rate on mobile was 62%, in comparison to 84% on desktop. (Nielsen, 2014) Nielsen's study also compared the success rate between mobile optimised sites and the full desktop sites on mobile. Success rate with mobile optimised site was 64%, while full desktop site's success rate was 58%. A study by Schmiedl et al also did a similar research and concluded that users can complete tasks 30-40% faster by using mobile optimised designs. (Schmiedl, Seidl and Temper, 2009) The users from Schmiedl et al's study also commented that they felt limited by mobile tailored versions, in terms of site features and content.

A negative relationship between the screen size and the task completion rate has been studied as far back as 1999. A study by Jones et al concluded that the users were twice as likely to complete a task successfully on larger screens. (Jones et al., 1999) This study also indicated that navigation on small screens required significantly more actions from users to browse.

The usability of small screens has been a subject of much research. Researchers were particularly interested in how information can be displayed on small screens and how users can effectively navigate through the information hierarchy. The following sections examine various usability challenges of small screens.

2.2.1 Keyhole Viewing

Mobile-optimised sites linearise the content into a single long column. Trying to find information in such environment is much like trying to see what the entire room is like through a keyhole. There is a limit to how much you can see and be able to understand the context of what you see. When users are trying to find information on small viewports, they will either have to remember what is outside the viewport or move around the page more to remind themselves. More movements around the screen will lead to taking longer time to find

information. What's more, users' short-term memory will degrade as their attentions are diverted to navigating the long page. (Nielsen, 2014)

There is a catch-22 to the keyhole viewing experience. Viewing a lengthy page through a small viewport requires extensive scrolling. Users must scroll quickly to be able to gain an overview and see what topics are available. However, quick scrolling can lead to missing information and lead to even more scrolling.

2.2.2 Accessibility

The keyhole viewing experience on small screens is comparable to how blind users find information on web pages. The users in both situations have to process information in a linear sequence from top to bottom of the page. If the page has been semantically structured with accessibility in mind, blind users can make use of the headings and a list of links to quickly scan the entire page and understand the structure. (Roberts, 2014)

The accessibility guidelines can be applied to the research on small screen usability for the benefit of both users and researchers. In numerous papers that propose solutions for small screens, designing an algorithm to extract semantic content outline has been a stumbling block. There are too many web sites that have been coded without a proper structure. If web sites have been coded accessibly, their content can then be adapted and presented on many different platforms. (Montes and others, 2006) Outlining content semantically is a research challenge that still remains today.

2.2.3 Scrolling

Users are familiar with scrolling for more content but they would still prefer to interact with visible content on screen. (Su, Chan and Chan, 2005) It is not knowing where you are or where to go that cause negative user experience. (Hoi, Lee and Xu, 2003) Since there is much less context on small screens, users would need to scroll up and down more to gain context. Additionally, there is very little navigational tools available to the users. Navigational tools such as scrollbars are hidden away on smartphones to optimise the space for more content. This is a balancing act that has yet to be mastered. Users can view more content with UI hidden away, but having no visual cues cause laborious scrolling and consequently users can feel lost (Chae and Kim, 2004).

2.2.4 Cognitive Load

Having limited amount of information on small screens means that the users' cognitive load is larger. Small screens also require users to remember where they have been so that they can retrace their steps. An instance of this occurs

when users browse information on Wikipedia. Users expand and collapse topics to view content under each topic. In order to collapse a topic, users have to remember where the topic heading may be and scroll back up to relocate it.

Paper from Mobile HCI in 2011 concluded that the mobile users spend on average 72 seconds on a page while average desktop session is 2.5 minutes (Budiu, 2014). In other words, small screens must be able to communicate what the page is about, in much less time on much smaller display.

2.2.5 Design implications

What design requirements for mobile sites can be found from these usability issues?

First of all, it is important to code web sites so that a semantic content outline can be formed from the code itself. It also helps to help a good information architecture for the page, note just the site. Good content structure can communicate the essence of content to the users. Additionally, there should be an easy access to the search functionality. The layout of information should prioritise the content outline to the top of a page (Hoi, Lee and Xu, 2003).

It is not possible to provide the same user experience as the desktop browsing, but mobile sites can be coded and designed to minimise number of actions such as scrolling and clicking, thus improving the mobile user experience.

2.3 Mobile Web Strategies

Diagram in figure 2 shows different mobile web strategies available today.

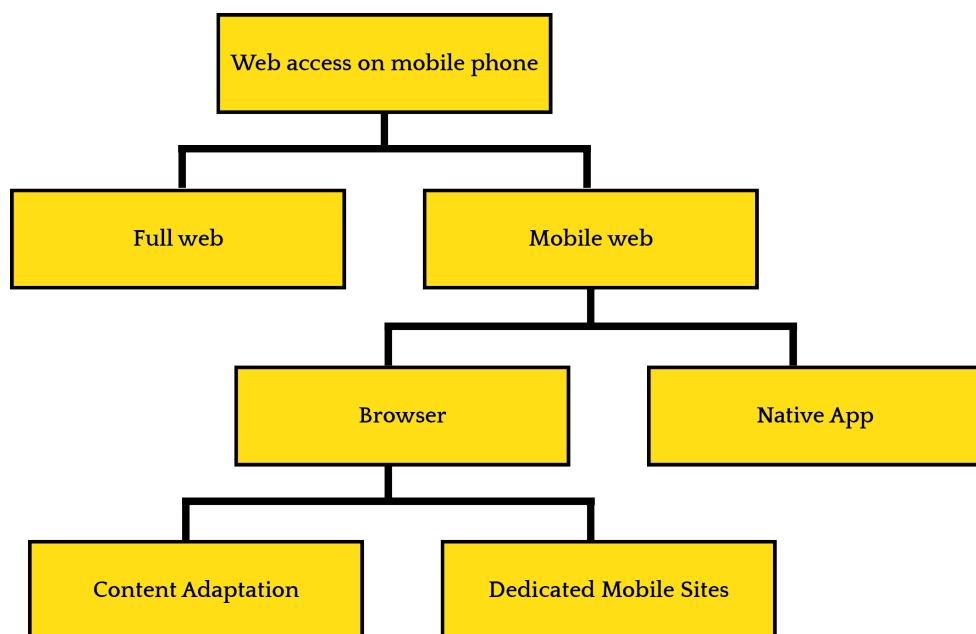


Figure 2: Mobile web strategies.

When accessing the web on mobile phones, users are either viewing mobile tailored web sites or scaled down full web sites. Some web sites offer options to switch between the mobile and full versions.

The mobile web can be accessed through browsers or by installing native applications, built specifically for mobile devices. For browser access, mobile sites can adapt their content by restructuring the information to fit into small screens or the content can be offered through dedicated mobile sites. Both dedicated mobile sites and native applications involve manual re-authoring and are the most expensive methods.

All of these strategies are discussed in further detail in the following sections.

2.3.1 Full Web

Browsing the full web on mobile devices is facilitated by client-side navigation methods, such as scaling and zooming. Smartphone users have become used to gestural inputs such as pinch-and-zoom to see the content. With full web sites, the content has not been optimised for mobile and there are usability issues, such as readability and excessive scrolling both horizontally and vertically (Roto, 2005).

2.3.2 Mobile Tailored Web

Mobile optimised content can be provided by browsers or installed native applications. Delivering mobile content through a browser can be achieved through content adaptation methods such as responsive web design or dedicated mobile sites with their own mobile domains (e.g. <http://m.facebook.com/>).

Whether or not native apps should be developed depends on a lot of factors (Summerfield, 2014). Does the content need to be personalised and regularly accessed? Does the site's functionalities need access to the device features and processing powers? For example, Instagram would need access to the camera on smartphones. Another important factor is the budget. Native apps can be expensive to develop and maintain, and need to be customised for an operating system. Content adaptation methods can be more time and cost-effective. It is also well-suited for the "One Web" vision. Various solutions for adaptive layout will be discussed under "Content Adaptation Methods".

2.4 Mobile Browsing Solutions and Techniques

Many different solutions and techniques for small screen browsing have been researched and developed in the past. Some research dates back to the

late 1990s, when devices were text only, with black-and-white display. The solutions discussed in the following sections are categorised as either a content adaptation method or a client-side navigation. Content adaptation methods restructure and adapt the content and layout while client-side navigation methods are browsing techniques that do not change the content. There can be an overlap between these two strategies. For example, page segmentation method can be used for content adaptation method or client-side navigation.

2.4.1 Client-side Navigation

Client-side navigation methods are designed for browsing desktop web sites on mobile devices. Since vast majority of web sites are still not optimised for mobile, client-side navigation is an important strategy that allows users to view sites on their devices. For example, pinch and zoom method is widely practiced on touchscreen devices. The following sections discuss various client-side navigation techniques.

2.4.1.1 Thumbnail Based Zooming

The thumbnail based zooming technique provides a visual overview by generating a thumbnail view of the page. Double-tapping or pinching allows users to zoom into an area for detailed view.

A different take on the thumbnail based zooming is to provide visual context. This was implemented with Nokia's Minimap (Roto et al., 2006). As a user moves around the screen, a small thumbnail of the entire page with the user's location clearly marked is displayed. The purpose is to show the page's overall structure as well as the user's location to give more context to what the user sees on the screen.

2.4.1.2 Slicing and Scaling

The thumbnail based zooming method requires a lot of actions on user's part to navigate. In order to minimise this, slicing and scaling method combined scaling of the page with slicing of the content. The content is sliced into smaller blocks of content based on the source code (Ahmad and Hong, 2012). This method is designed to reduce horizontal scrolling in thumbnail based zooming.

TutMobi, designed by Lehtonen et al, sends a miniature version of the page as a thumbnail image and detailed views as sliced information blocks via proxy servers. (Lehtonen et al., 2006) The proxy servers are often suggested methods to reduce the download size of the page. A proxy servers acts as an intermediary between the browser and the web server and only sends the needed content and code to the browser.

2.4.1.3 Fisheye

The fisheye technique provides an interesting alternative for providing context (Lamping, Rao and Pirolli, 1995). It presents the entire information hierarchy on a hyperbolic browser screen and allows the user to bring any node of information into view. While the user is viewing a node of information, the rest of information hierarchy will shrink away from the centre.

2.4.2 Content Adaptation Methods

Content adaptation methods restructure and optimise the web content and layout for mobile devices. The adaptation can be carried out on the client-side (user's browser) or the server-side (the web). Server-side methods send optimised and mobile-ready content to the users' browsers. Client-side methods transform the content once the content data has been received. There are also intermediate adaptation methods such as RESS (Responsive design + Server Side components) and usage of proxy servers. (Firtman, 2013)

Various solutions over the years include the textual summaries of pages, optimisation of multimedia components such as images, extraction of content blocks based on visual layout or source code. One of the most popular and enduring methods is single-column method - the layout is restructured into one column whose width fits into the viewport.

The following sub-sections will examine past and current research on adapting content for the mobile platform.

2.4.2.1 Reading View

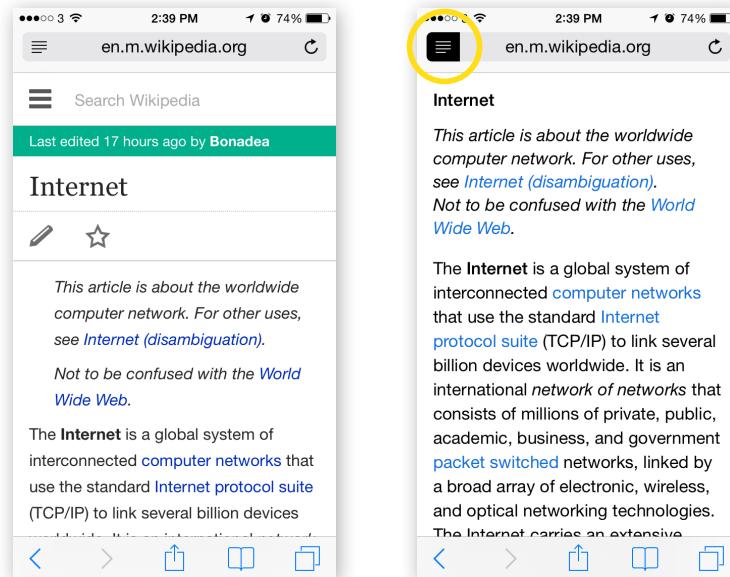


Figure 3: Reader mode on iPhone 5 Safari browser.

The reading view solution is best suited for reading a single article. The reading view optimises content space by stripping away distracting elements such as the header and the footer and improves the readability of content (Dharmasiri et al., 2013). An example of the reading view method can be seen on the Safari browser's reader mode (figure 3). The screen on the right in figure 3 shows how reader mode has transformed the content in the left screen into more readable format.

2.4.2.2 Transducing

Transducing refers to the automated conversion of web content into native mobile formats (Schilit et al., 2002). When WML (Wireless Markup Language) was more prevalent, transducing involved transforming content into a deck of pages. Proxies and third party services such as AvantGo were used to transform the data. Transducing transformed the text into readable formats for mobile, and then into a deck of pages (Schilit et al., 2002). Media formats such as images, audio and video were also compressed and optimised into suitable mobile formats.

2.4.2.3 Overview + Detail

Overview + Detail methods provide content outlines to users. Various Overview + Detail methods have been implemented both visually and textually. Scaling and zooming on mobile browsers can be considered a thumbnail-based visual Overview + Detail method. Wikipedia's mobile site is an example of textual content outline. The content on Wikipedia's articles are collapsed into a list of headings, and can be opened and closed by users. Most research in Overview + Detail methods involves generating an index or a page map, based on algorithms that can recognise blocks of content (Lai, 2013).

2.4.2.4 Page Segmentation

The page segmentation method breaks up a single page of content into multiple sub-pages. Page splitting can be based on the size of the screen or on the page content and structure. Flipboard application is an example of page splitting (figure 4). For Flipboard, the segmentation is based on the number of words in the article and the screen size (Dharmasiri et al., 2013). A page segmentation method with an



Figure 4: Page segmentation on Flipboard app.

overview has also been proposed to facilitate finding information among the split up sub-pages (Hoi, Lee and Xu, 2003).

2.4.2.5 Content Prioritisation

Content prioritisation involves content personalisation for every user and is a technique that has been suggested from several usability studies. Based on the users' interests and browsing history, either only the relevant content is delivered or the content is reordered according to relevance for each user (Roto and Kaikkonen, 2003). This solution is often used for native applications.

2.5 Future of Mobile Browsers

The 2013 survey of mobile browsers and technology by Dharmasiri et al. highlighted where the gaps are between current mobile technology and research (Dharmasiri et al., 2013). Accurate content outlining across all the sites is pointed out as a challenge that is still left unresolved. The study concluded that current lack of innovation in mobile browsers is due to the influence of desktop browsers. This is also a major cause of poor user experience on mobile. The study recommended stepping away from the desktop browsing methods and conducting further research on how generic desktop sites can be viewed on mobile platforms.

3 User Study

3.1 Purpose

A user study was planned and conducted to collect data on how users browse and find information on smartphones. The focus of the user study was to gain insights into following questions:

- What strategies do users employ to find information?
- How do users understand the structure and content of the page?
- What usability issues can be observed while users browse on smartphones?
- What navigational issues do users have? Do they know where to go to find information? Do they know where they are in the page?
- How much physical and cognitive efforts are involved in finding information?

3.2 Study Plan

The study consisted of a semi-structured interview and an observation. A pilot study was conducted and the evaluation plan was adjusted to include a more familiar web site to the participants to induce more natural browsing behaviour.

3.2.1 Session Outline

All of the sessions took place at the City University London library. Each session began with an introduction and the signing of a consent form, followed by a five-minute interview and a twenty-minute observation of assigned tasks. The observation consisted of three parts and was performed in this order:

1. BBC (browsing task) - BBC's mobile site is a separate mobile site with its content curated for mobile. The desktop site offers the full content.
2. The New York Times (browsing task) - The New York Times is also a dedicated mobile site. The content on their homepage is significantly longer than the BBC.
3. Wikitravel (information-seeking tasks) - The content and layout is adapted into a single column.

Overall, each session lasted about twenty to thirty minutes. The entire session was audio and video recorded for transcribing and analysis.

3.2.2 Participant Profiles

Four participants were recruited for the study. The study was open to any age (above 18), gender and occupation. The only requirement was for the participants to have had some experiences with web browsing on smartphones.

Participant	Age	Gender	Occupation
1	33	Male	Animator
2	27	Male	Retail Store Manager
3	29	Female	UX Intern
4	27	Female	UX Consultant

Table 1: User study participant profiles

3.2.3 Interview

The purpose of the interview was to gather basic demographic information about the participants and inquire about their past experiences with smartphones. The interview was semi-structured around topics of mobile browsing habits - how, when and where the participants browsed the web and what problems they have experienced.

Following is the list of questions prepared for the interview:

- What mobile devices do you own?
- What type of web sites do you access through your mobile phone?
- What type of information do you try to find on the web through your mobile phone?
- Some web sites (e.g. Timeout) are not optimised for mobile and requires zooming in. Some websites (e.g. BBC) are optimised for mobile.
 - » Which do you find easier to browse and read?
 - » What are some of the problems you had with browsing mobile optimised sites?
 - » What are some of the problems you had with browsing desktop sites?
- How much time do you spend browsing the web with your mobile phone?
- What are your favourite websites to browse on mobile?
- What sites have you visited today?
- Did you have any problems with them?

3.2.4 Observation

In order to examine the usability issues with browsing on smartphones,

two types of tasks were assigned - browsing and information-seeking. The observation was in three parts: first two parts involved browsing news web sites and the final part involved looking for information on a very long and content-heavy article.

3.2.4.1 Browsing Tasks

BBC (<http://m.bbc.co.uk>) and the New York Times (<http://mobile.nytimes.com>) were chosen for casual browsing tasks. BBC's mobile site is a separate, dedicated site that significantly condenses the full site's content so that users do not have to scroll very far to see the entire page.

Initially the Boston Globe (<http://www.bostonglobe.com/>) was chosen as the second site. The Boston Globe is well known within the web design community as a great example of responsive web design. Being a responsive site, the Boston Globe's homepage is extremely long and provides the full desktop content. This site was chosen to compare how the length of the page would impact the browsing experience.

After the pilot study, the second news web site was changed to the New York Times for its instant brand recognition. People are more familiar with the New York Times and its content, and would not need to spend time trying to figure out what the Boston Globe is about. The New York Times and the Boston Globe are very similar in terms of their layouts and styles.

In order to observe natural browsing behaviours, the participants were asked to find an article of their choosing from the news web sites. Topical suggestions were also made so that the participants do not have to spend time trying to come up with topics. How they browsed and found articles was observed. The observation recordings were used to analyse usability issues and how the participants coped with the issues.

The secondary purpose to the browsing tasks was to observe how people get familiar with the content structure of the page. News portal sites have a usability challenge of presenting many different topics, headings and sections. After they have browsed the homepage and chosen an article to read, they were asked about what they remember from the homepage. Do they remember any of the topics from the homepage? Did they know how the page was structured?

3.2.4.2 Information-seeking Tasks

For the information-seeking tasks, Wikitravel (<http://www.wikitravel.org>) was chosen. Wikitravel's homepage is not mobile optimised but its articles utilise the same content adaptation method as Wikipedia. Content is collapsed into

topic headings and could be opened and closed on click.

Given a scenario of planning a vacation, the participants were asked to perform two tasks for the same page. The second task was added to observe if it helps to have previous knowledge of the content structure.

Scenario: You are planning to visit Bali for two weeks on vacation.

Task 1: Find out the visa requirements for Indonesia as a UK passport holder. For example, do you need a visa as a tourist? If so, how much does it cost and how do you get a visa?

Task 2: Find out if there are any compulsory shots before you go to Indonesia.

As with the browsing tasks, the purpose was to observe any usability issues and how the participants cope with these issues. The difference is that the participants are looking for a specific piece of information. Do they know where to go? What is the user experience like? Do they feel frustrated and lost?

3.2.4.3 Observation Set-up

Mobile usability testing app Magitest (<http://magitest.com/>) was used on iPhone 5 to record the observation sessions. Magitest screen captures everything that is happening on the device and creates a video file. All gestural inputs and the participant's face during the session are also recorded and overlaid on top of the screen recording. An example of Magitest recording is shown in figure 5.

3.3 Analysis

After the completion of each session, transcriptions were made from the audio and video recordings. These session transcripts of the participants' actions and words from both the interview and the observation were coded into themes by noting what parts were significant to the purpose of the user study. For example, when navigational issues such as excessive scrolling were observed, they were noted with a theme "Navigation". Several iterations were needed to unify some of the themes and to categorise them into five broad themes. The coding of the transcripts can be found in appendix C. The transcripts were



Figure 5: A Magitest screenshot from one of the user study sessions.

colour coded according to the themes.

The main themes and each main theme's subthemes are defined in table 2. The first column contains the broad main themes and the second column breaks down a main theme into subthemes. The interviews provided the data for the theme "Smartphone usage" and the observations provided the data for the other four main themes.

Theme	Subthemes
Smartphone usage - How do the participants use their smartphones to browse the web?	<p>What - What kind of web browsing do users conduct on their smartphones? This subtheme includes information about what users look for on the web and what type of sites they visit on mobile.</p> <p>Where - Where do users browse the web on mobile devices? This subtheme includes information about the setting and environment.</p> <p>Why - Why were they browsing the web on mobile devices? What might have prompted their search for information?</p>
How - How users browse the mobile web and how they use the browser.	<p>Visual browsing - Users browse by the visual elements on the page such as pictorial content, visual hierarchy, and visually distinct elements. Example includes browsing by headings and page sections.</p> <p>Desktop knowledge - Users transfer their desktop web browsing knowledge, habits and skills to mobile browsing.</p> <p>Above-the-fold content - Users' browsing behaviour is affected by the content in the first screen.</p>
User strategy - How users cope with the mobile browsing problems.	<p>App - Users use apps to browse the site (e.g. Facebook, Twitter)</p> <p>Skimming - Users quickly skim and scroll through the page for highlights and keywords.</p> <p>Find by topic - Users find information by categories and topics in the headings or the site menu.</p> <p>Site search - Users utilise the site's search functionality to find information.</p> <p>Find by word - Users find information by using the "Find by word" functionality of the browser.</p> <p>Zooming - Users zoom into a part of the page for better readability and legibility.</p> <p>Customise content - Users curate their own content by methods such as RSS feeds.</p> <p>Viewport mode - Users switch from portrait to landscape mode, or vice versa.</p>

Theme	Subthemes
User strategy - How users cope with the mobile browsing problems.	<p>Detailed reading - Users read through the content carefully to find what they're looking for.</p> <p>Use alternative methods - Users abandon the site and use alternative methods. For example, they will go to Google or use their desktop computer instead.</p>
Mobile site and browser strategy - Strategies employed by the mobile sites and browsers to optimise the content and improve the user experience.	<p>Content outline - The content is outlined by methods such as a table of content or a list of headings (e.g. Wikipedia).</p> <p>Content prioritisation - The content is curated and prioritised for mobile versions of the site.</p> <p>Content customisation - Users have an option of personalising and customising the content on mobile sites.</p> <p>Hidden UI - In order to optimise the space for content, browser UI are hidden or reduced from the users (e.g. scrollbar).</p>
Usability problems - Issues that users encounter while browsing the mobile web.	<p>Readability - Users are unable to read or understand the content due to issues such as small font size, and extremely dense content.</p> <p>Content overview - Users do not understand what content is available nor how the page is structured.</p> <p>Content needs - Content chosen for the mobile site does not meet users' needs. This leads to users seeking alternative methods or switching to the full desktop site to find what they are looking for.</p> <p>Desktop sites on mobile - This subtheme encompasses all issues users experience while using a full desktop site on their smartphones.</p> <p>Unexpected results - User's interactions with the site cause unexpected results. Examples include browser opening links in a new window or in an app.</p> <p>Hidden cues - There is no visual cues or hints for users to complete an action.</p> <p>Keyhole viewing - This refers to the usability problems caused by having limited amount of content available on the screen.</p> <p>Navigation - Users have difficulties navigating the page. Example includes excessive scrolling.</p> <p>Success rate - Users are unable to complete a task on the mobile site.</p> <p>Content visualisation - Poor visual design and information hierarchy cause usability issues. Users are unable to distinguish different elements or recognise elements.</p> <p>Ads - Users find full-sized ads on mobile to be disruptive to the reading flow.</p>

Table 2: User study coding theme and subthemes

3.4 Results

The following sub-sections summarise the findings for each of the main themes in the table 2. Each main theme section is further broken down into subthemes. User data has been obtained from the interviews and observations. The relevant quotes from the participants were included where available.

3.4.1 Smartphone usage

3.4.1.1 What

User Data & Quotes	Ptc.
Social media: P1 - Twitter, Tumblr, Facebook P2 - Instagram, LinkedIn, Twitter, Facebook P3 - Facebook P4 - LinkedIn, Facebook	All
Reading news	P1
Information seeking tasks through web sites such as Google, Wikipedia, IMDB.	All
Visiting links from elsewhere, such as Facebook links and links sent by friends.	All
Same browsing habits as desktop. <i>"Same thing I do on desktop... Like if I want news, go to a news website."</i> - P1	P1

Table 3.1.1: Summary of subtheme "What"

3.4.1.2 Where

User Data & Quotes	Ptc.
Mobile setting. P1 reads his Twitter messages while on the public transport. P3 browses the web while waiting for an appointment. <i>"... like if I'm waiting, doctor's appointment or something, and I'm browsing on Facebook and there are links."</i> - P3	P1, P3
Social setting. P3 browses in social settings - in a bar with friends. The social setting naturally leads to looking up information during the conversations. <i>"let's say you're in a bar with friends and you're talking about a movie and you look for an actor."</i> - P3	P3

Table 3.1.2: Summary of subtheme "Where"

3.4.1.3 Why

User Data & Quotes	Ptc.
<p>Looking up information related to environmental and contextual factors. Example: finding out address or contact information.</p> <p><i>"Usually, news, direction, reviews, stuff like that. Which restaurant to go to." - P4</i></p>	P3, P4

Table 3.1.3: Summary of subtheme "Why"

3.4.2 How

3.4.2.1 Visual Browsing

User Data & Quotes	Ptc.
<p>When the participants were asked what they can remember from the homepage of BBC, they could name elements that visually stand apart from the rest of the content. From the BBC homepage, they could remember the weather widget and the fact that left side contains news sections.</p>	P1, P2, P3
<p>Text-heavy sections were more likely to be missed while quickly scrolling and skimming through. When P2 was asked to look for an article about Ukraine, he missed the article title because the list of article headings were too similar to each other.</p>	P2
<p>Pictures were helpful to understand the content and pique the participant's interests.</p> <p><i>"I found the pictures to be helpful - it was quick to go through. Like it was a guidance for me to go through, just by pictures." - P2</i></p>	P2
<p>Pictures can disengage the participant's interest. P1 mentioned that he has no interest in scrolling further down the BBC homepage because pictures were not interesting.</p>	P1
<p>Heading elements form a visual information hierarchy and outlines the content. When asked to remember the New York Times homepage, P3 said she remembered the groupings and was able to name a few of the headings.</p>	P3

Table 3.2.1: Summary of subtheme "Visual browsing"

3.4.2.2 Desktop Knowledge

User Data & Quotes	Ptc.
Everyone was familiar with scrolling to view more content.	All
P1 and P3 wanted to find information on Wikitravel by using "Find by word" but did not know how to do "Find by word" on the iPhone.	P1, P3
P4 was familiar with both BBC and the New York Times and was able to browse the mobile version faster than other participants.	P4

Table 3.2.2: Summary of subtheme "Desktop knowledge"

3.4.2.3 Above-the-fold Content

User Data & Quotes	Ptc.
The participants could recall the topmost content of the page best. When asked to recall the topics from BBC homepage, they remembered the content in the first screen (above-the-fold).	All
Above-the-fold content affected how a mental picture of the page content and structure is formed. From the first screen of Wikitravel article, no one could tell what content was available. P4 assumed that there was just general information available because the first screen just showed a picture and title.	P4

Table 3.2.3: Summary of subtheme “Above-the-fold content”

3.4.3 User Strategy

3.4.3.1 App

User Data & Quotes	Ptc.
Frequently used social media websites were almost all browsed using the installed apps. Facebook was the most mentioned app in use. If an app is available, it is the preferred method of browsing. Only one person, P4, mentioned using Safari to browse LinkedIn. She still used Facebook app. <i>“If there is an app available, I always use those.” - P2</i>	All
P3 stated that she is used to app-style browsing methods. She pointed out the app’s easy access to main menu, no matter where you are in the page. <i>“I guess I’m very used to apps. I feel like, since they don’t have a lot of space, having access to the menu...from any point.” - P3</i>	P3

Table 3.3.1: Summary of subtheme “App”

3.4.3.2 Skimming

User Data & Quotes	Ptc.
The participants quickly scrolled down the page to gain an overview of the content. For browsing tasks, participants stopped scrolling after 5–7 screens worth of content and went back up to reassess the content. For information-seeking tasks on Wikitravel, they had to scroll the entire length of the page, sometimes more than once. When reading an article, participants also skimmed to quickly gain an overview of the content and scrolled back up and down to read the details. P1 stated that he will read in detail if the article is a literary piece. <i>“Well, if it’s just a sports article, I’d just scroll through for highlights. If it’s a literary article, I’d read through.” - P1</i>	All

Table 3.3.2: Summary of subtheme “Skimming”

3.4.3.3 Find by Topic

User Data & Quotes	Ptc.
<p>The participants categorised information on their own, and searched by topic. The site menu and the page content headings were the primary means of finding information by topic. When they could not find information quickly by skimming, they would browse by topic with the headings or the menu.</p> <p>On the New York Times, participants scrolled back up and accessed the menu where news categories are available. For an article about Ukraine, P1 went to the menu, accessed "World" and then "Europe". P2 found World Cup articles by the heading "Sports".</p>	P1, P2
<p>P4 was familiar with the BBC and NYT sites and tried to browse by topic after scrolling down the page a few times. P4 went to the menu to find the "Video" section since she has used the site menu recently.</p>	P4

Table 3.3.3: Summary of subtheme "Find by topic"

3.4.3.4 Site Search

User Data & Quotes	Ptc.
<p>P2 and P4 used the site search function to look for information.</p> <p>On the New York Times, P2 could not find articles about Ukraine by browsing and used the site's search function.</p> <p>For Wikitravel, P4 started using the search functionality from the start. However, this was not a successful search due to limitations of Wikitravel's search engine.</p>	P2, P4

Table 3.3.4: Summary of subtheme "Site search"

3.4.3.5 Find by Word

User Data & Quotes	Ptc.
<p>P1 and P3 wanted to use the "find by word" functionality but they did not know how to do this on the iPhone. They were accustomed to using this functionality on desktop browsers.</p> <p><i>"I'd do search by word." - P1</i></p> <p><i>"On mobile?" - Researcher</i></p> <p><i>"Actually, I don't know if I can do search by word." - P1</i></p>	P1, P3

Table 3.3.5: Summary of subtheme "Find by word"

3.4.3.6 Zooming

User Data & Quotes	Ptc.
<p>P3 tried to zoom into small image captions on the New York Times article but pinch-and-zoom was disabled on the site.</p>	P3

User Data & Quotes	Ptc.
The only page that needed navigation by zooming was Wikitravel's homepage, which is not mobile optimised. P4 struggled with the homepage because she did not know how to get to the content articles. She could not find the search functionality. She zoomed in and scrolled horizontally and vertically many times to view the content and the left column main site menu. She had to be eventually helped on using Wikitravel's search after several minutes.	P4

Table 3.3.6: Summary of subtheme "Zooming"

3.4.3.7 Customise Content

User Data & Quotes	Ptc.
P1 and P3 curated and customised their own content. P1 used news apps and picked topics that is of interest to him. P3 used RSS feeds, where she can subscribe to the content that she wants.	P1, P3

Table 3.3.7: Summary of subtheme "Customise content"

3.4.3.8 Viewport Mode

User Data & Quotes	Ptc.
P3 and P4 would switch to landscape mode to fit more content into the viewport horizontally, and for better readability. P3 found accidental viewport mode change to be disorienting. <i>"I go into landscape mode because it's easier to read." - P4</i>	P3, P4

Table 3.3.8: Summary of subtheme "Viewport mode"

3.4.3.9 Detailed Reading

User Data & Quotes	Ptc.
All participants read the content in detail to find what the answer to information-seeking tasks on Wikitravel. This would occur after they could not find information by skimming. The participants would read through the content carefully once they found the right section of the page. P2 read through it more than once to see if he missed anything.	All

Table 3.3.9: Summary of subtheme "Detailed reading"

3.4.3.10 Use Alternative Methods

User Data & Quotes	Ptc.
P4 stated that she would switch to a desktop computer, if she needed to use "Find by word" on a mobile device.	P4

User Data & Quotes	Ptc.
P2 and P4 stated that they would go to Google if information cannot be found quickly. <i>"I would only want to spend like next some seconds to find what I'm looking for. Otherwise, I'm going to Google." - P2</i>	P2, P4

Table 3.3.10: Summary of subtheme "Use alternative methods"

3.4.4 Mobile Site and Browser Strategy

3.4.4.1 Content Outline

User Data & Quotes	Ptc.
Wikitravel uses the same mobile structure as Wikipedia - the page content is outlined by the main headings of the page. All participants were familiar with the Wikipedia structure and knew how to open and close the topic headings. Before opening a topic, they always closed a topic that has been opened previously. This involved scrolling to find the opened topic heading. <i>"The layout of information was fine, very good flow. Quickly find out how it was sectioned." - P2 on Wiki</i>	All

Table 3.4.1: Summary of subtheme "Content outline"

3.4.4.2 Content Prioritisation

User Data & Quotes	Ptc.
In order to keep the length of the page on small screens manageable, BBC curates the content for its mobile site. Three participants scrolled the entire length of the BBC homepage. Only P1 expressed dislike for not having access to the full desktop content on mobile. <i>"I'm assuming everything on the homepage is hot news of the day. So it's like very time-effective and very interactive." - P2</i>	P2, P3, P4

Table 3.4.2: Summary of subtheme "Content prioritisation"

3.4.4.3 Content Customisation

User Data & Quotes	Ptc.
BBC allows users to pick sections they are interested on its homepage. Only one participant (P3) noticed this option.	P3

Table 3.4.1: Summary of subtheme "Content customisation"

3.4.4.4 Hidden UI

User Data & Quotes	Ptc.
<p>Safari optimises the space for content by:</p> <ul style="list-style-type: none"> • hiding scrollbar • reducing the top address bar's height • hiding the bottom toolbar <p>P3 stated that she appreciates this feature as this leads to more space for content.</p> <p><i>"Another annoying thing is they kept, you know, the header and the footer bar when I tilt. Like the space is already limited, and the address bar won't disappear." - P3</i></p>	P3

Table 3.4.1: Summary of subtheme "Hidden UI"

3.4.5 Usability Problems

3.4.5.1 Readability

User Data & Quotes	Ptc.
<p>Dense content in a small viewport was difficult to read and caused P2 to miss the article with Ukraine in the title. He chose to use the site search.</p> <p><i>"It was too much content. And it was too much black and white, just black and white. It makes it boring. There were barely any pictures. Just link after another." - P2</i></p>	P2
<p>P3 thought the font to be too small on the New York Times' photo captions and found it unreadable.</p>	P3

Table 3.5.1: Summary of subtheme "Readability"

3.4.5.2 Content Overview

User Data & Quotes	Ptc.
<p>P4 did not know what content is available on the Bali Wikitravel page after viewing the first few screens of the page. Topmost portion of the page contained a large picture, title and general stats about Bali and she stated that only general information was available on the page.</p>	P4
<p>Even though content outline is provided on Wikitravel pages by a list of headings, all participants had difficulty knowing what content was available and had to read through the topic list more than once.</p> <p>For visa information, P2 thought it would be under "Consulate". P3 thought it would be under "Understand".</p> <p>For travel vaccination shots, P3 thought it would be under "Stay safe". P4 went through several topics to find "Stay Healthy" - her first topic choice was "Learn". P1 chose "Get in" and then "Understand".</p>	All

Table 3.5.2: Summary of subtheme "Content overview"

3.4.5.3 Content Needs

User Data & Quotes	Ptc.
<p>Both BBC and the New York Times limit available content on their mobile sites. P1 felt like he was missing out on information. P3 also felt that the BBC mobile site was limited when compared to its desktop site. She tried to guess why certain articles are at the top of the page.</p> <p><i>"Well... it feels more limited, in terms of ... well, like the items here (top two articles at the top of the page) are probably most visited." - P3</i></p> <p><i>"Sections cut off, missing information. Because they decide what's important and cut stuff out." - P1</i></p>	P1, P3

Table 3.5.3: Summary of subtheme "Content needs"

3.4.5.4 Desktop Sites on Mobile

User Data & Quotes	Ptc.
<p>When a site is not mobile optimised, users view scaled down version of the site on their smartphones. P1 found that viewing scaled down versions of desktop sites is good for gaining a general overview.</p> <p><i>"if it's something like a portal - with lots of different information, I'd rather see the original. So that I can zoom in and stuff." - P1</i></p>	P1
<p>There are many usability problems with viewing desktop sites on mobile. P4, in particular, had a lot of difficulties with Wikitravel homepage. She scrolled horizontally and vertically to look around the entire page and had to be assisted to find Bali page eventually. P3 did not see the search function on the homepage due to its small size in scaled down state. Only P1 found the search functionality on Wikitravel homepage easily.</p> <p><i>"When I'm zooming in, I can't. I'm not getting a very good track of my own, where I'm reading. And you know, the interfaces, you can't track it properly because they're scattered everywhere." - P2</i></p> <p><i>"You're like zooming and moving around and it disrupts your flow. And apart from that, I might miss out on a point, because my page is so zoomed in. And while zooming in and out, I might miss out on a point, a tab or an icon, something I was looking for. They're chance of, probability of losing content while having badly managed interface." - P2</i></p>	P2, P3, P4

Table 3.5.4: Summary of subtheme "Desktop sites on mobile"

3.4.5.5 Unexpected Results

User Data & Quotes	Ptc.
<p>P3 thought that the mobile browser would open an app when photos are clicked.</p> <p><i>"I'm a little scared of clicking on some of these pictures, I wonder if it'll open in a new app because I thought it's a video." - P3</i></p>	P3

User Data & Quotes	Ptc.
<p>Mobile browsers zoom into an element when a user clicks on the said element. This was designed to help users see the clicked element better. P3 found this feature to be “annoying”. On the other hand, P4 was familiar with this interaction and stated that she would double-tap on page elements to zoom in.</p> <p><i>“... in the tablet, when you click on something. It kind of zooms. It’s kind of annoying... but it helps, I guess.” - P3</i></p>	P3
<p>When the viewport mode changes from portrait to landscape or vice versa, the page layout would change. P3 did this accidentally, and was surprised at what happened to the page. She could not find where she was within the page.</p>	P3

Table 3.5.5: Summary of subtheme “Unexpected results”

3.4.5.6 Hidden Cues

User Data & Quotes	Ptc.
<p>Not all participants knew the shortcut to go back to the top of the page. There was no visual cues or hints about this shortcut. P2 scrolled quickly with both hands to go back to the top.</p>	P2, P3
<p>The site menus on BBC and the New York Times are closed by default. P1 felt that there is no incentive to view the site menu when it’s closed. Hidden content could lead to less engagement with the site and its content.</p> <p><i>“I’m not sure I’d be inclined to look into the menu, unless I knew there’s more.” - P1</i></p>	P1

Table 3.5.6: Summary of subtheme “Hidden cues”

3.4.5.7 Keyhole Viewing

User Data & Quotes	Ptc.
<p>Since only a small portion of the page can be seen, P4 made wrong assumptions about the Wikitravel page. The first screen of the page only contained a photo and a title.</p>	P4
<p>A lot of scrolling was involved to review the page content. This was observed for longer pages like the New York Times homepage or the Wikitravel article where the participants were looking for specific information.</p>	P2, P3, P4
<p>Participant could not see the content outside of the viewport and missed information by not scrolling. P1 chose not to scroll the entire BBC homepage because pictures did not interest him.</p> <p><i>“There’s all the pictures I don’t care about and I’m already ready to go back up.” - P1</i></p>	P1

Table 3.5.7: Summary of subtheme “Keyhole viewing”

3.4.5.8 Navigation

User Data & Quotes	Ptc.
<p>Navigation was frustrating and difficult when “blind scrolling” is involved. On the Wikitravel page, participants had to scroll to close opened topics and they could not remember where the topic headings were. They scrolled until the target was eventually found.</p> <p><i>“But if it’s long like this, I really doubt that this solution is the best. You really lose the structure of the page, right? You just have to keep going...” - P3</i></p>	All
<p>Excessive scrolling was experienced by all participants. This occurred when scrolling through the long content of Wikitravel page or when they were trying to reach the top of the page. They found it particularly frustrating to not know when they will hit the target.</p> <p><i>“It’s really horrible that I have to scroll everything to get to the menu again.” - P3</i></p>	All

Table 3.5.8: Summary of subtheme “Navigation”

3.4.5.9 Success Rate

User Data & Quotes	Ptc.
<p>Three participants gave up on the Wikitravel task. Only P1 completed the Wikitravel task.</p>	P2, P3, P4

Table 3.5.9: Summary of subtheme “Success rate”

3.4.5.10 Content Visualisation

User Data & Quotes	Ptc.
<p>P2 missed the article about Ukraine on the New York Times even though “Ukraine” was contained within the title. There was not enough visual difference between all the links and he could not tell them apart as he scanned the page.</p> <p><i>“I’ll have a constant feeling in my mind that I might miss something. It creates this... this discomfort.” - P2</i></p>	P2

Table 3.5.10: Summary of subtheme “Content visualisation”

3.4.5.11 Ads

User Data & Quotes	Ptc.
<p>There was a full-size ad near the top of Wikitravel article and on the New York Times articles, and took up most of the screen while it’s in view. P3 pointed out that you can click on ads accidentally.</p> <p><i>“And look how huge that ad is. You can click on that by mistake.” - P3</i></p>	P3, P4

Table 3.5.11: Summary of subtheme “Ads”

3.5 Discussion

The focus of this study was on finding usability issues with understanding the page content and structure and investigating navigational issues with long pages. These usability issues were particularly evident on the information-seeking tasks. Only one out of four participants was able to complete the visa information task successfully. Even though the Wikitravel article provided an outline of the content through a list of topic headings, the participants were not able to use it to their advantage since they could not understand what some of the headings meant. They were not able to quickly determine what content was available and had to reassess the topic list several times, which involved a lot of scrolling to collapse sections that were opened. The most frustrating part of navigation seems to occur when they had to scroll without knowing where the information they are looking for is located.

The browsings tasks were useful in showing how the participants browse and what strategies they use. The participants did not mind scrolling to casually browse. They were dependent on the visual design of the page to let them know what content is clickable and what are different sections of the page. They mostly skimmed and scrolled very quickly to see what content is available. When asked to recall the content, they could not remember the text-based content very well but were able to recall visually distinct parts of the page.

4 Design

The design phase of the project is documented in a chronological order, with the results from the previous phase carrying over to the next phase. The design phase was in four parts:

1. **Concept sketches** (section 4.1) - Three concepts were created and they are discussed in their own sub-section in section 4.1. Other concepts that were not carried forward to the next phase were also briefly described.
2. **Low-fidelity wireframes** (section 4.2) - Each concept was developed into a set of two or more wireframes that detail how the concept could work. For one of the concepts, more than one set of wireframes had to be created to explore how content outlining could be accomplished. At the end, there were six sets of low-fidelity wireframes.
3. **High-fidelity wireframes** (section 4.3) - Three sets of low-fidelity wireframes were carried forward to be created as high-fidelity wireframes. High-fidelity wireframes refined the visual design.
4. **User testing** (section 4.4) - Three sets of high-fidelity wireframes were tested to evaluate the usability of each concept.

To begin the design phase, the results from the user study were used to form design goals:

- Help users understand the overall content and structure of the page.
- Make the navigation of a long page easier by reducing the physical efforts involved in browsing. An example from the user study is the number of scrolling actions involved to reach a far point in the page.
- Lighten the cognitive load involved in browsing. Users have to remember more of what is outside the viewport to effectively navigate the page. For example, in order to close a topic heading on the Wikitravel page, they have to remember where they have been and how far down the page they scrolled to retrace the steps to the topic heading.

4.1 Concept Sketches

The original goal of this phase was to develop three to five concept sketches to explore various solutions to the design goals. Concept sketches were created by pencil sketching method. Three main concepts were sketched and are documented in sections 4.1.1 to 4.1.3. These concepts were then carried over to the wireframing phase to be refined further. Section 4.1.4 details other solutions

that were explored during the sketching phase. These solutions were created to see how the physical form and features of the smartphones could be used to solve the design goals. These concepts were abandoned due to technical limits in developing an interactive prototype.

All the pencil sketches can be found in appendix D.

4.1.1 Scrollbar

The scrollbar was a ubiquitous element of web browsers that has now become obsolete. This is especially true on mobile devices where space is at a premium. On iPhone's Safari browser, the scrollbar only appears when user is scrolling up or down. It shows where the user is in the page but cannot actually be used to navigate the page.

The concept shown in figure 6 brings back the scrollbar with additional functionality. Users can expect to use the scrollbar to know where they are in the page and to quickly get to other points in the page. The scrollbar in the concept also visualises the page's content structure by segmenting the scrollbar track according to the sections in the page. These are shown as horizontal lines in the scrollbar track in figure 6. Segmentation in the scrollbar track communicates visually where different sections of the page start and end. Users can also see how long each section is in context of the entire page and how far they have to scroll to get to a different section.

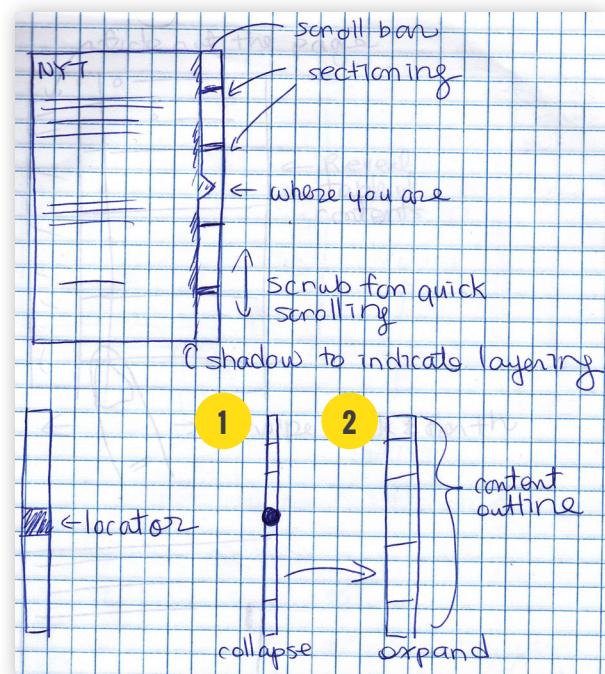


Figure 6: Scrollbar concept

The scrollbar is hidden from view on most mobile browsers. In this concept, the scrollbar is always present in contracted form (1 in figure 6) to allow users to find their location on the page. When users wants to use the scrollbar, it will expand (2 in figure 6) so that they can comfortably touch the scrollbar and navigate the page. In its expanded state, the scrollbar would let the users scroll the page quickly and jump to a different section of the page.

How can the scrollbar let users know where they are scrolling to? Since there is no hover state on mobile devices, one solution was sketched and shown in figure 7. In this solution, users can swipe the scrollbar left to open the table of contents, and swipe right to close it. The table of content is built with the page's main headings and the content can be further broken up by using subheadings in each section.

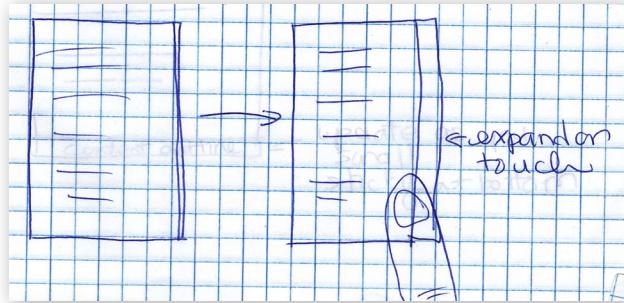


Figure 7: Scrollbar's table of contents revealed on swipe.

One advantage to this concept is that nearly everyone knows how to use the scrollbar and users should find it intuitive to use. The challenge was finding a way to show the content outline. Jumping to a different section could be a useless functionality if users do not know where they are jumping to.

This concept addressed the design goals by:

- Visualising the structure of the page with the scrollbar track segmentation. Users will be able to see the context of their current location in the page.
- Providing the textual content outline of the page - how this is accomplished were explored further with low-fidelity wireframes.
- Providing a quicker means of navigation with the scrollbar.

4.1.2 Status Bar

This was another concept that adapts a familiar UI element from desktop browsers. The sticky status bar (figure 8) at the bottom of viewport updates the current location in the page as the user scroll the page. Current location is shown by the heading of current page section, as well as by a numeric percentage indicator. For example, if the indicator says 34%, it means users have scrolled down 34% of the entire page. It also means that 66% of the page content is below the current location.

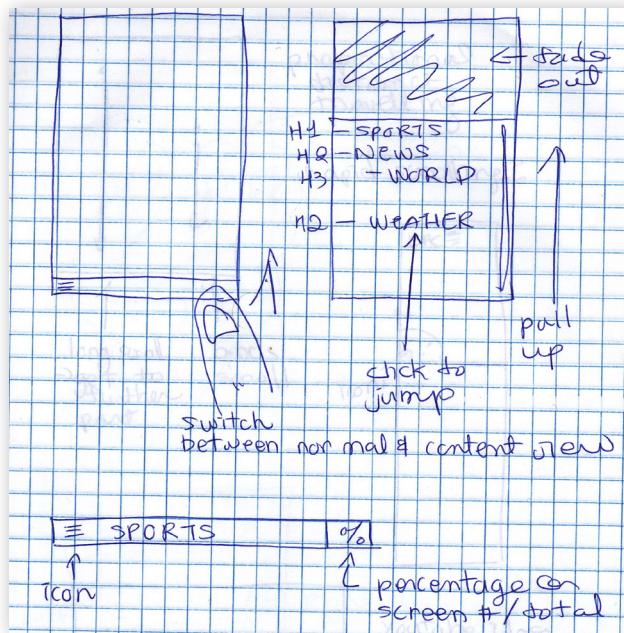


Figure 8: Status bar with hidden table of contents.

A content outline for the page is also included in this concept. Either with a click or a swipe-up gesture, the content outline layer can be brought into view. This layer is scrollable since it could potentially become very long, depending on the number of topic headings in the page. The levels of subheadings to include in the content outline could be an option available for users to control.

This concept addresses the design goals by:

- Updating the users on where they are by displaying the heading of the section they are currently browsing.
- Showing the current location within the page with the percentage indicator. The percentage shows the location in the context of overall length of the page and how much of the page still below the current screen.
- Providing a textual content outline with a single gesture.
- Providing an easier and quicker access to different sections of the page.

4.1.3 Overview Mode

The concept in figure 9 explored a possible content outline solution for the desktop sites on mobile. With a click of a button, users switch between normal and overview mode, where the entire page's content is outlined with main headings in a list format. Clicking on a heading in this overview mode will take users to the corresponding section within the page and zoom into the section for detailed view.

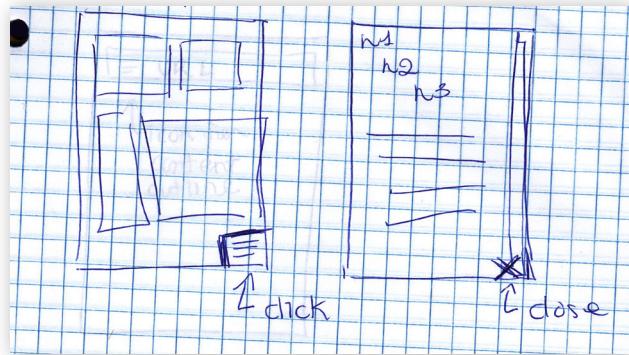


Figure 9: Document outline on desktop sites on mobile devices.

Based on this idea, another overview mode concept was developed for mobile-optimised sites (figure 10). Similar to the concept in figure 9, a single click will outline the content in overview mode. The difference is that the content will be outlined on the page itself. The page will collapse into a list of section headings, similar to how Wikipedia's mobile pages are constructed. One advantage of this method is that outlining will happen directly on the page and user's attention will not have to be divided between two different layers. The page simply enters another mode and can go back to normal with a single click on a button.

This concept addresses the design goals by:

- Providing a textual content outline in a different mode. Users will be able to see the entire structure at a glance in overview mode.
- Providing access to different sections of the page with a single click.

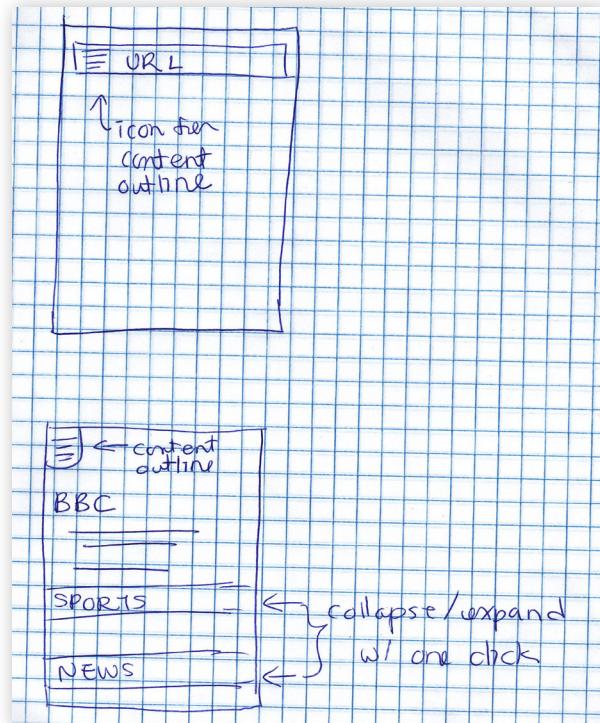


Figure 10: Content outlining on page

4.1.4 Other Concepts

The following sections discuss other concepts that were designed during the sketching period. They were not developed further due to the technical limitations in developing a prototype. These concepts explored how the physical form and features of mobile devices could be used to improve the

browsing methods and try out new ideas. Most of the concepts tried to include the content outline functionality.

4.1.4.1 Gestural Interactions

These concepts were designed to see how scrolling could become easier by utilising novel gestural inputs.

Long and short gestures

Scrolling a page currently involves a swipe gesture in the direction of choice. This concept (figure 11) adds a length variable to the swipe gesture. The length of the gesture is proportional to how far you want to travel within the page. A short gesture means you'll travel a short distance within the page. Longer gesture would indicate that user wants to travel even further down the page in the same amount of time. This would result in the page being scrolled much quicker.

One-handed operation

This concept was designed for mobile settings such as walking, where users might only use one hand to operate the device. Instead of swiping in a straight line, the scrolling gesture is a circular motion from the thumb. Upward circular motion will scroll the page up and downward motion will scroll the page down. Since the thumb may be positioned in the middle of the device, the UI element for this functionality was designed to be in the middle of the viewport, to the left or right. The left or right positioning would depend on the user's preference. The UI element was meant to launch content outline with a click.

This concept was too specific to a situation and had potentially serious usability

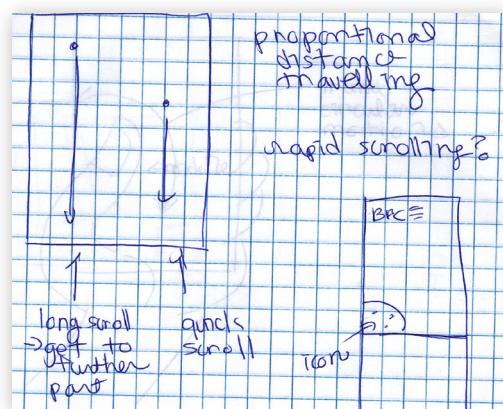


Figure 11: Long and short gestures

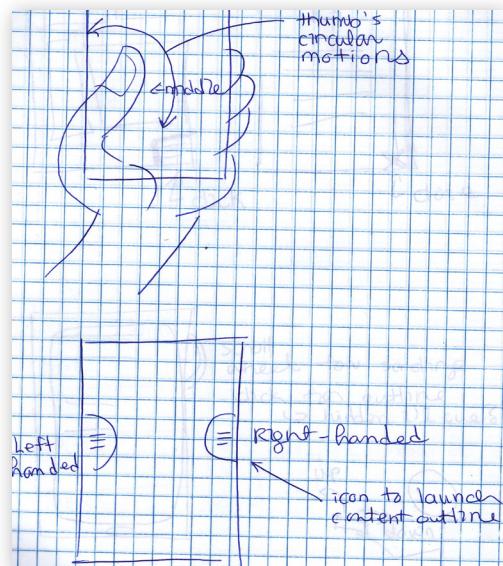


Figure 12: One-handed browsing

issue – the web content could be covered by either the user's thumb or the new UI element.

4.1.4.2 Physical Form of the Smartphones

These rough concepts in figure 13 explored possibility of adding new physical elements to the mobile device. The drawing in the figure 13 numbered as 1 shows an idea of adding a scroll wheel for quick scrolling through the page and clicking the wheel for content outline. The drawing numbered as 2 shows an idea of using the smartphone's built-in gyroscopic sensor to scroll the page. If you tilt the device towards you in downward motion, the page will scroll down. If you tilt the device in opposite direction, the page will scroll up.

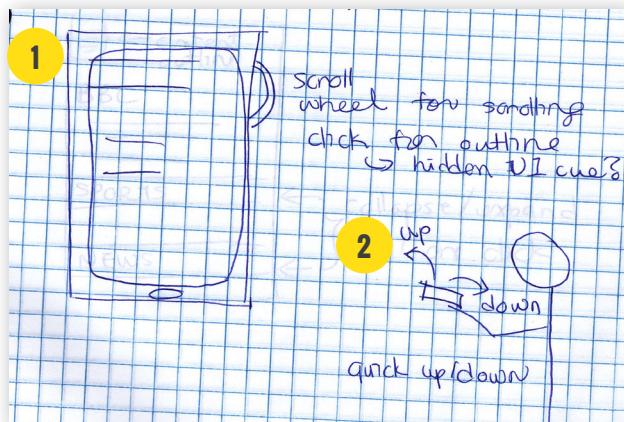


Figure 13: Rough concepts with gyroscopic sensor and physical wheel.

4.2 Low-fidelity Wireframes

This section discusses the low-fidelity wireframes that were developed from the concept sketches in sections 4.1.1 - 4.1.3. The wireframes were created with Balsamiq software (<https://balsamiq.com/>), which allows quick, digital wireframing with ready-made elements such as an iPhone layout in pencil sketch style. The wireframes were then developed to detail how the concepts could work.

For each concept, low-fidelity wireframes included at least two screens showing the initial state and a screen with content outline. Every concept had its own method of content outlining, i.e. showing the overall structure of the page content with headings.

Section 4.2.1 discussed the wireframes based on the scrollbar concept in section 4.1.1. Several different solutions for the content outlining were designed to explore how content outlining could be accomplished with the scrollbar.

Section 4.2.2 discussed the wireframes based on the status bar concept in

section 4.1.2.

Section 4.2.3 discussed the wireframes based on the overview mode concept in section 4.1.3. Another set of wireframes was created to combine the scrollbar and overview mode concept and was also discussed in section 4.2.3.

4.2.1 Scrollbar Concept Wireframes

Figure 14 shows the scrollbar's default state and its expanded state. The location of the user in the page is represented with an arrow and the current section in view is highlighted. Page sections are represented with simple horizontal lines in the scrollbar track. In this initial wireframe, the sections in the scrollbar track included the header and the footer sections of the page. The header and the footer are shown with darker colours in the scrollbar.

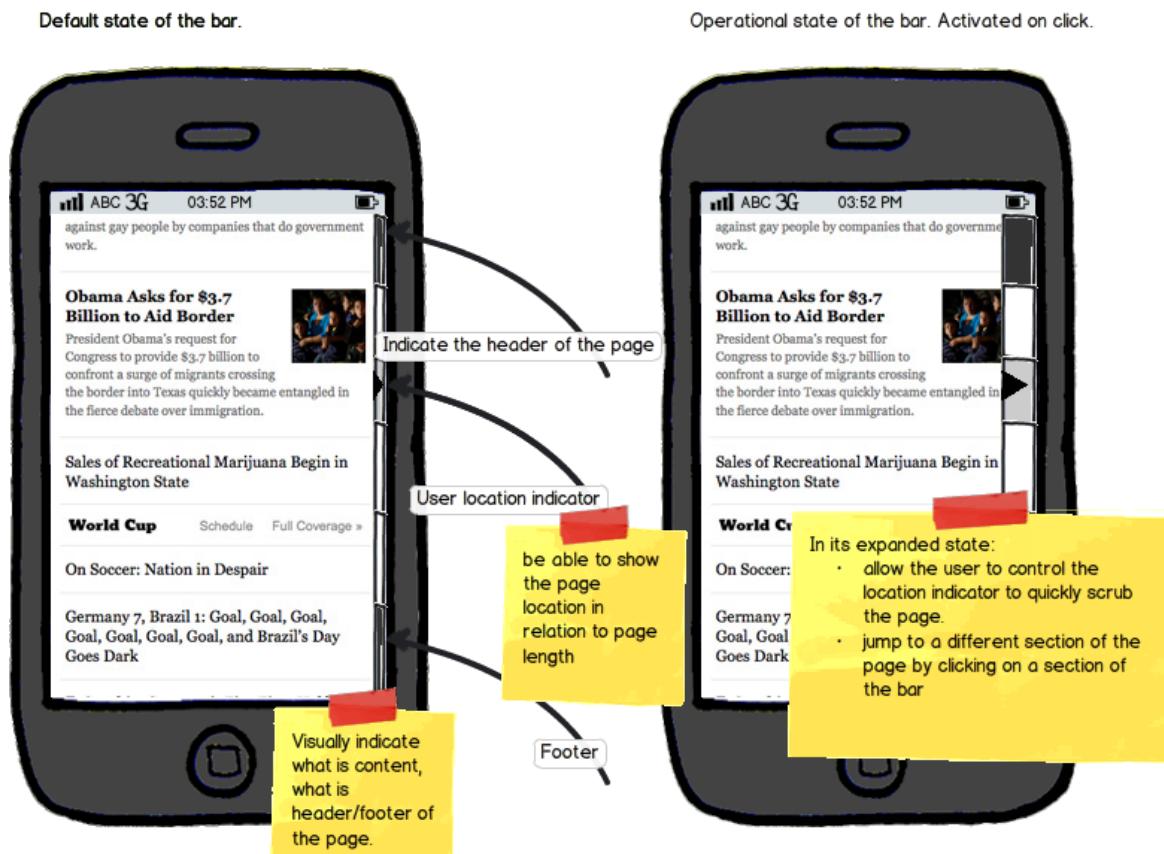


Figure 14: Scrollbar default and expanded state wireframes

Showing the textual content outline of the page was the most challenging aspect of this concept. A scrollbar is not normally associated with content outlining and there is a concern that users will become confused. The following three sub-sections discuss the three separate solutions for content outlining.

4.2.1.1 View a Single Section Outline on Click

This was the first attempt at showing a content outline. While the scrollbar track is in its expanded state, the user can click on a section to reveal its content outline. The content outline layer will be displayed on top of the page and can be closed with the close icon (figure 15). User can view another section outline by clicking on a different section of the scrollbar track.

This solution did not offer a content outline for the entire page. Depending on how many sections there are in the page, many clicks may be needed to view the entire outline for the page. Users' short-term memory may become overloaded as they try to remember what some of the previously clicked sections were.

4.2.1.2 View a Page Outline on Click

This solution built on top of previous idea in figure 15 and addressed the issue of providing an outline for the entire page. Once again, a new layer is displayed on top of the page (the left screen in figure 16) and shows the entire page's outline. Sections in the page outline align with how the scrollbar track is sectioned.

There may be cases where a section of the page contains many headings and becomes very large. In such cases, clicking on a section will show the full section outline (the right screen in figure 16). Users can also switch between section outlines by clicking on other sections. The right screen in figure 16 shows two ways of getting out of this mode. Clicking on "X" icon on the right exits the overview mode and goes back to the normal page view. Clicking on the back arrow on the left top corner will go back to the page outline view.

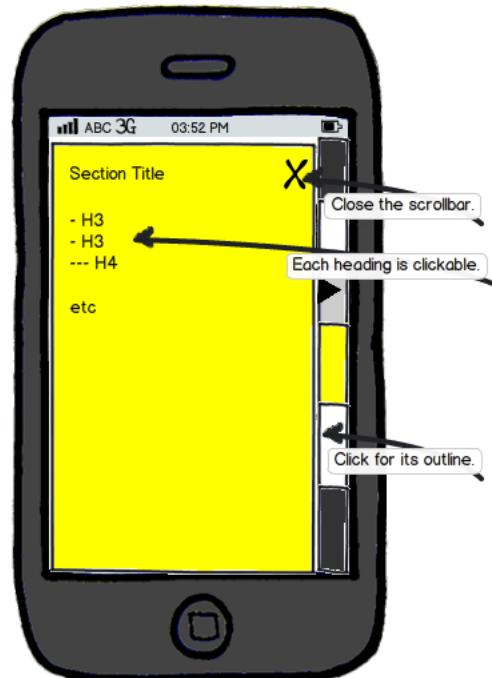


Figure 15: A section outline on click

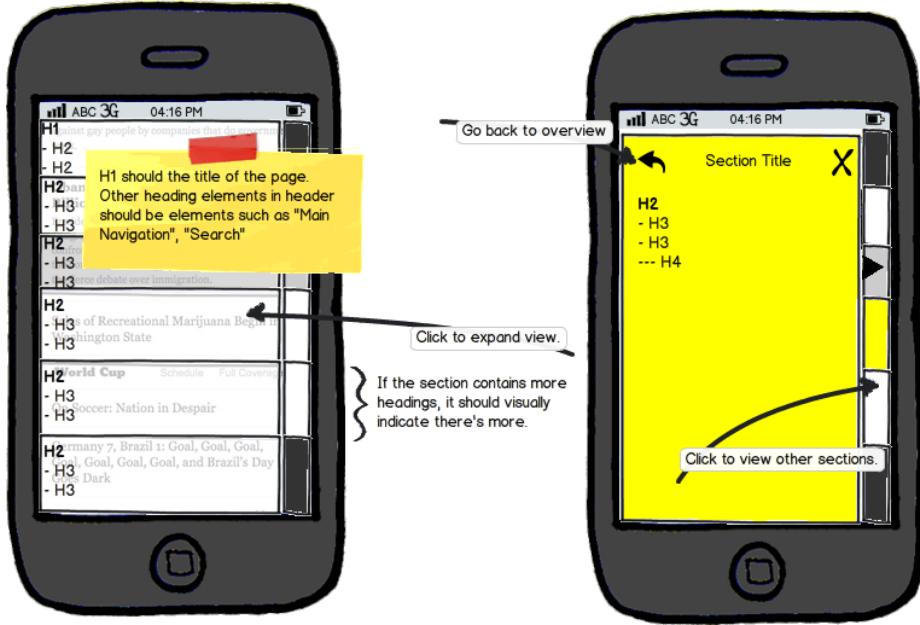


Figure 16: View a page outline on click.

4.2.1.3 View a Content Outline with Swipe

This solution was part of the concept sketches (figure 7) in section 4.1.1. The content outline is revealed with a left swipe gesture on the scrollbar. The left screen in figure 17 shows arrows in the direction of the swipe to indicate that it can be opened for more information. Since most users' first instinct with touch devices is to tap, the outline should also open with a tap. The right screen in figure 17 shows the opened content outline.

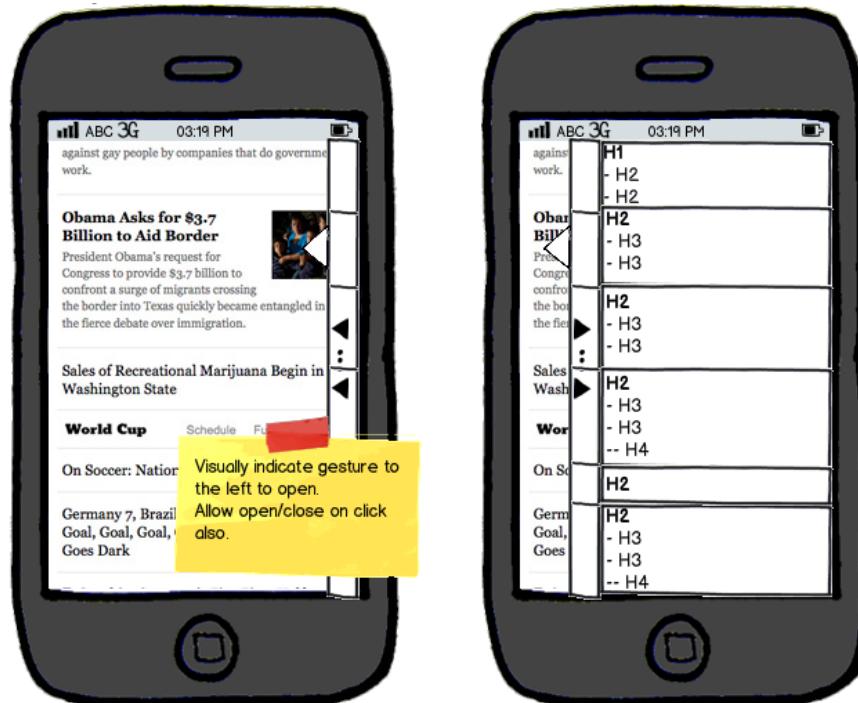


Figure 17: View a page outline with swipe.

4.2.2 Status Bar Concept Wireframes

This section discusses the wireframes based on the status bar concepts in section 4.1.2. Figure 18 shows the two wireframed screens. The left screen shows the default state and the right screen shows the opened content outline.

There are two parts to the status bar - a percentage indicator of the current location and the current section heading. A “list” icon is displayed (the left screen in figure 18) besides the section heading to communicate that a content outline in list format can be viewed. This icon will change to “X” (the right screen in figure 18) for closing when the content outline has been opened. The content outline can be opened on click or with swipe-up gesture. Clicking on a heading in the content outline takes the user to the corresponding point in the page.

As shown in the right screen of figure 18, the content outline layer can be scrolled up or down, depending on the length of the outline. As with all the other concepts, the outline will be based on the page’s main headings and subheadings.

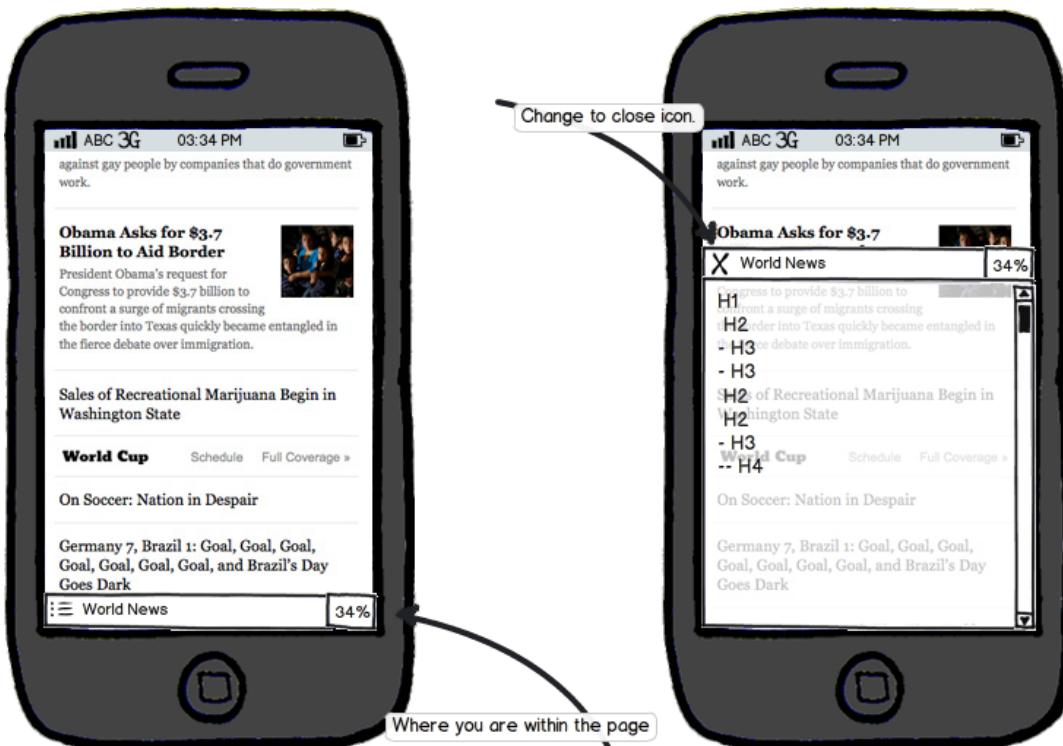


Figure 18: Status bar wireframes

4.2.3 Overview Mode Concept Wireframes

This section discusses the wireframes developed from the overview mode concept sketches in section 4.1.3.

Figure 19 shows the two screens wireframed for the overview mode concept. The left screen is the normal view of the page and the right screen shows the page with its content outlined in overview mode.

The content used in the wireframe is based on the BBC's mobile news site. The overview mode on the right screen is activated by clicking on the icon in the right bottom corner. The icon's position is temporary for the purpose of this wireframe. Ideally the overview mode functionality should be a part of the browser's interface. The icon in overview mode changes to an icon for "going back" to normal mode. On click, the page will go back to the normal viewing mode in the left screen of figure 19.

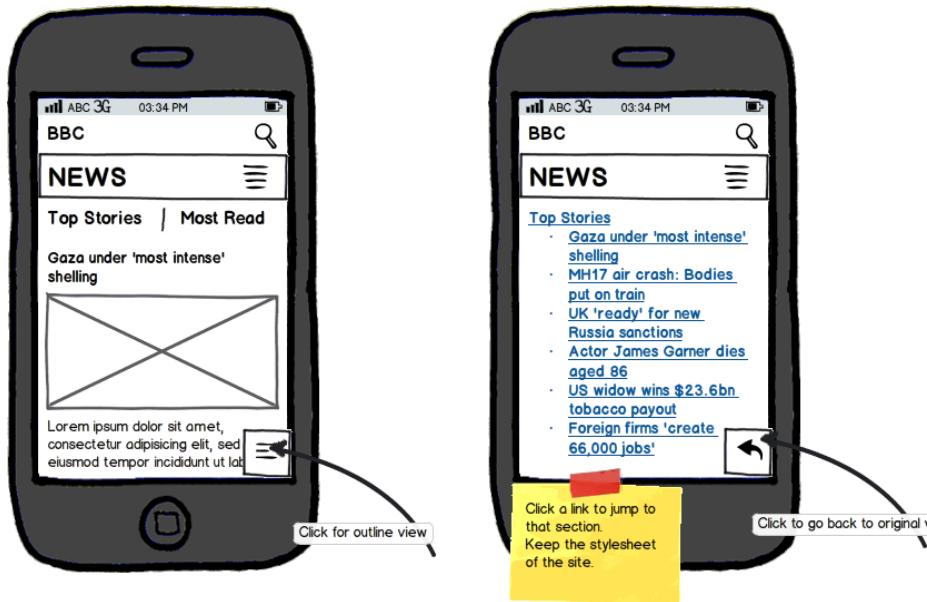


Figure 19: Overview mode on click.

4.2.3.1 Combining the Overview Mode and the Scrollbar Concept

Another set of wireframes was developed to combine the scrollbar and the overview mode, while trying to improve the content outlining solutions in sections 4.2.1.1 and 4.2.1.2. Figure 20 shows the two wireframed screens. The left screen shows the default state and the right screen shows the overview mode.

The scrollbar's functionality still remains the same, but it is no longer used to launch the content outline layer. Instead the content outlining has become a separate function and will be done directly on the page. The scrollbar's design was slightly changed to explore different visualisations for the section segmentation in the scrollbar track and the location of the user in the page. Segmentation was done with alternating colours in this design and the user's location in the page is now a simple rectangle. The design of the scrollbar was further improved in the next design stage - high-fidelity wireframes.

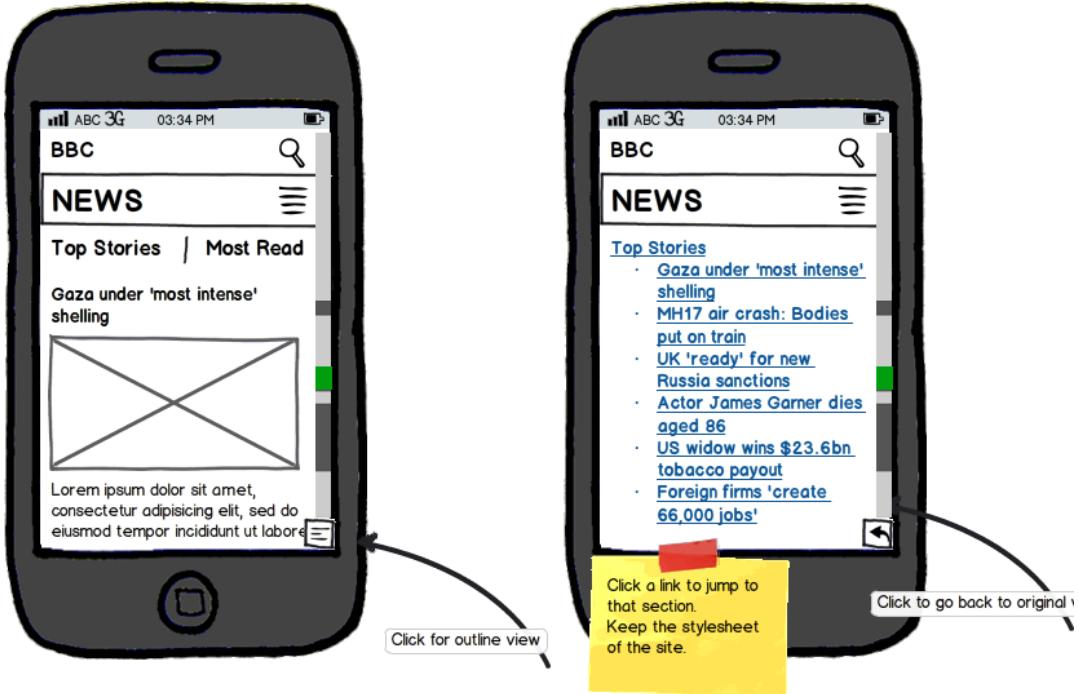


Figure 20: Combining the scrollbar with overview mode.

4.3 High-fidelity Wireframes

The low-fidelity wireframes were great for detailing how the concepts could work. However, they were too crude visually and needed further refinements in visual design in order to be user tested. The following three sets of high-fidelity wireframes were created with Adobe Photoshop:

- Scrollbar and overview mode - based on the wireframes in section 4.2.3.1.
- Scrollbar with swiped-in content outline - based on the wireframes in section 4.2.1.3
- Status bar - based on the wireframes in section 4.2.2

For each set, a different web site was chosen to be the content. A chrome extension for taking screenshots was used get an image of the entire page. All of the designed wireframes show accurate representations of the chosen page's content.

In each set, three screens were designed:

- Home screen - an initial view of the page with everything in default state.
- Overview mode screen - shows how the page is transformed in the overview mode. The term overview mode has been used to generally state that the page's content outline is in view.
- Completion screen - what happens when the user selects a heading in the

overview mode.

In the following sub-sections, home screen is shown on the left, the overview mode screen is shown in the middle and the completion screen is shown on the right.

4.3.1 Scrollbar and Overview Mode

The wireframes from figure 20 in section 4.2.3.1 were the basis for the screens in figure 21. BBC News (<http://m.bbc.co.uk/news>) screenshot was used as the content.

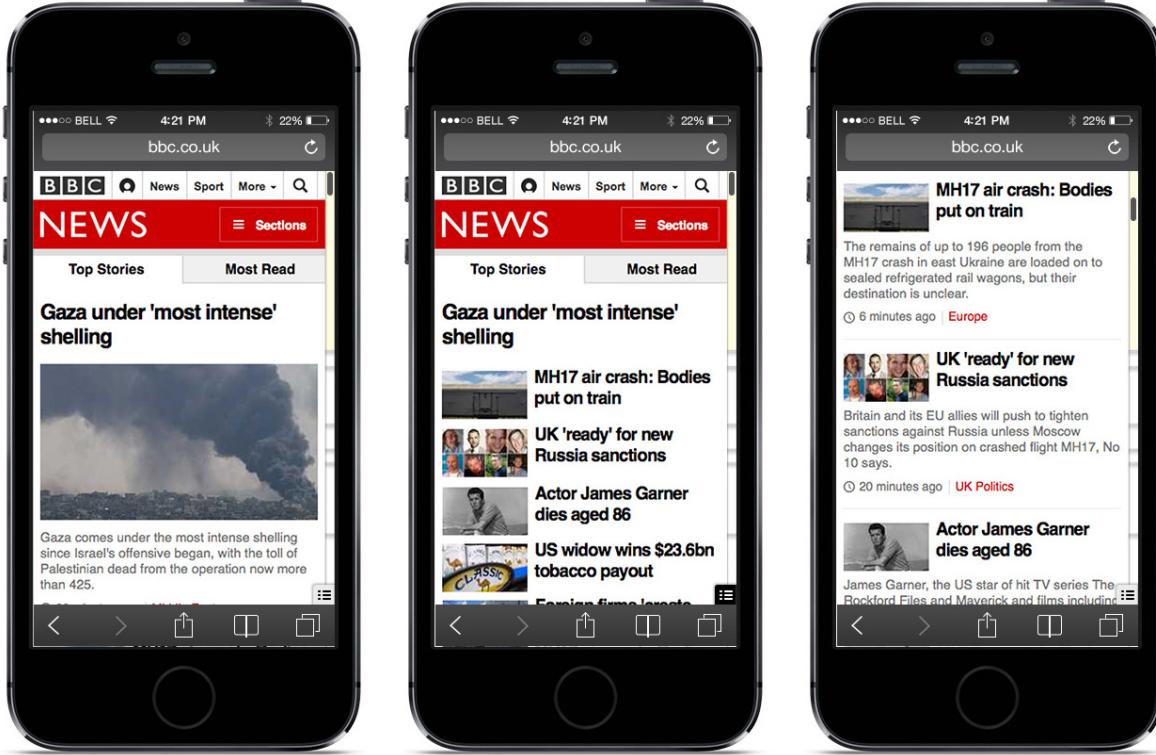


Figure 21: Scrollbar and overview mode high-fidelity wireframes.

Home screen

A drop shadow effect in Photoshop was used to separate the scrollbar track from the content and to segment the sections. The current section in view is highlighted in light yellow. The scroller is visualised as the familiar gray bar from the Safari desktop browser. The segmentation in the scrollbar and the scroller were sized according to the actual content in the screenshot. The overview mode button is located in the bottom right corner. It uses list-item icon since the overview mode converts the page into a list of headings.

Overview mode screen

The colour scheme of the button is reversed in overview mode screen to give

visual feedback to users to indicate that they are currently in the overview mode. The overview mode shows a photo for each heading since the BBC site uses photos with their article titles. Including the photos with the headings will most likely be not the case for most sites.

Completion screen

The third screen shows what happens when users clicks on a heading. The browser will get out of the overview mode and goes to the corresponding section for the clicked heading. The location of the user is updated with the scrollbar.

4.3.2 Scrollbar and Swiped-in Content Outline

The high-fidelity wireframes in figure 22 are based on the wireframes from figure 17 in section 4.2.1.3. “Visit London”’s travel page (<http://www.visitlondon.com/traveller-information>) was used as a content sample.

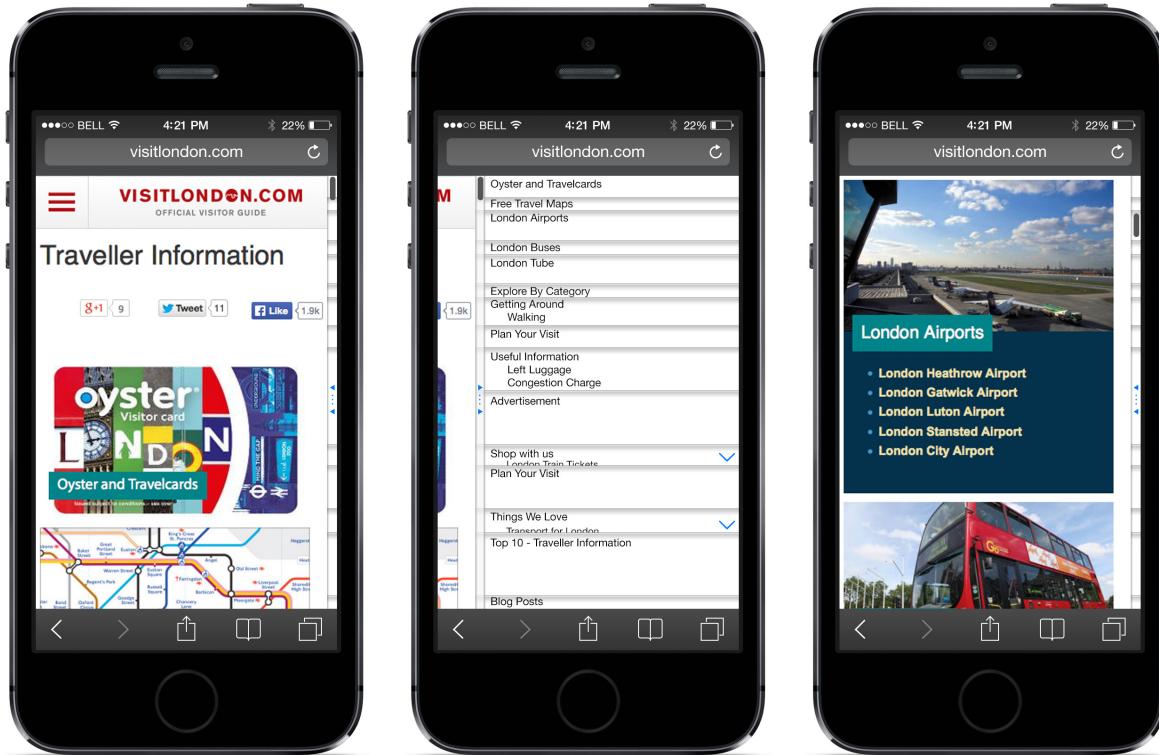


Figure 22: Scrollbar and swiped-in content outline high-fidelity wireframes.

Home screen

The scrollbar was styled the same as the wireframes in figure 21. The scroller and the section segmentation are also accurate in terms of the size and how many headings there are. This particular page is a good example of what happens when the page contains many headings.

The scrollbar needed to communicate to users that there is more information

available to be seen. Arrows were laid on top of the scrollbar to show that it can be swiped to the left. Vertical ellipsis was also used between the arrows to communicate that there is more information to be seen.

Overview mode screen

The arrows' direction is reversed when the content outline layer is open. There are blue arrows in downward direction in two of the sections in the content outline layer. This was done to show that there is more content for those two sections. Once the blue arrow is clicked, the section slides open to reveal more subheadings for that section.

The font size used in the content outline layer is slightly smaller than the system font size. This could be problematic for touch target sizes.

Completion screen

The third screen shows what happens when the user has clicked on one of the headings in the content outline layer. The page has scrolled to the clicked heading section and the scrollbar has been updated accordingly.

4.3.3 Status Bar

The high-fidelity wireframes in figure 23 are based on the wireframes from figure 18 in section 4.2.2. The New York Times' homepage (<http://mobile.nytimes.com>) was used for the content.

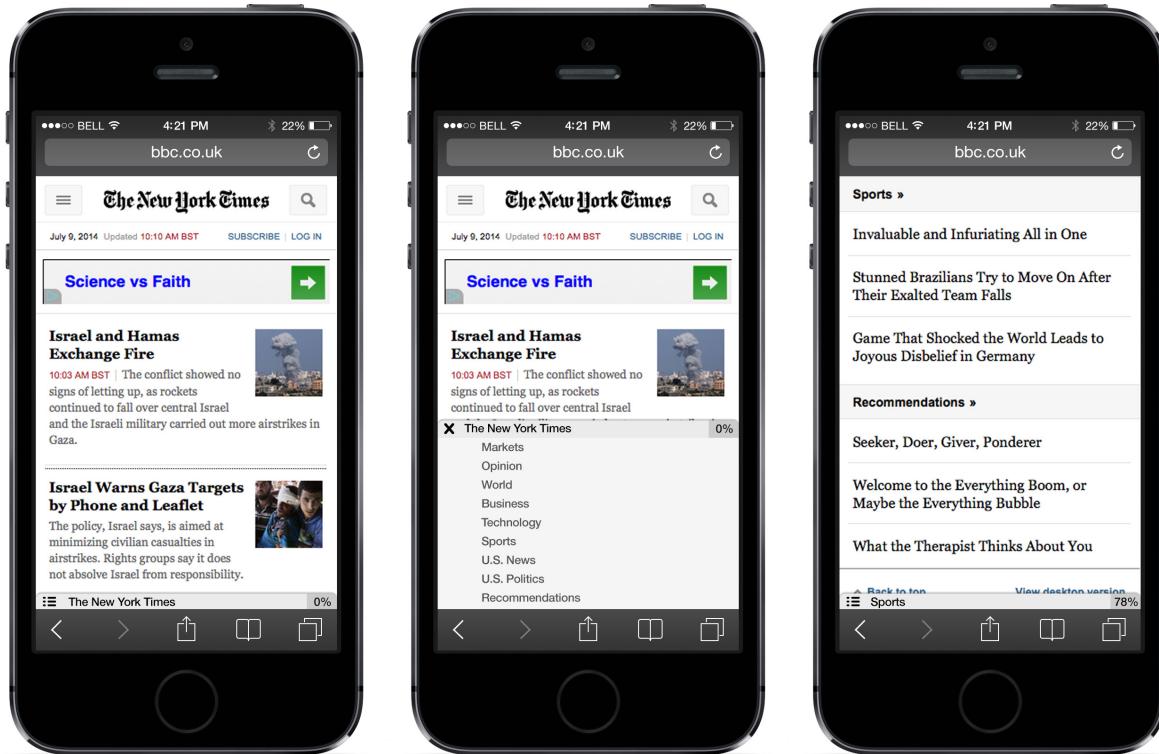


Figure 23: Status bar high-fidelity wireframes.

Home screen

A drop shadow effect was used to visually separate the status bar from the rest of the page. Two tones of gray have been used to separate the percentage location indicator from the section heading.

Overview mode screen

The content outline layer has been opened and is laid on top of the page. The content outline icon in the status bar has been changed to “X” to indicate that this layer can be closed. The New York Times only has main headings and no subheadings and the content outline has been formatted accordingly. Information hierarchy is formed visually by indenting the text.

Completion screen

The third screen is the result of clicking on one of the headings. The status bar is closed and the percentage indicator for location has been updated. 79% shown in the percentage locator is accurate to where the sports section is in the page.

4.4 User Testing

4.4.1 Purpose

Guerrilla user testing was conducted to evaluate the usability of high-fidelity wireframes. User testing was designed to answer the following questions:

- Does the new browsing functionality help with understanding the content and structure of the page?
- Do users intuitively understand how the new browsing method works?
- Do users intuitively understand how to use the new UI elements on the browser?
- What usability problems do users have with the new browser functions?

There was another important purpose for this testing. The results would be used to choose a concept for the final design, and any found usability issues would be addressed by making further design changes.

4.4.2 User testing plan

To start the session, there was a brief introduction and signing of a consent form to audio and video record the session. The participant would then complete a short pre-session questionnaire where basic demographic information such as age, gender and occupation is collected. The following questions were asked to determine their level of experiences with smartphones and any problems they had in the past with mobile web browsing:

- Do you own any mobile devices? (E.g. smartphone, tablet)
- What mobile devices do you own and use?
- What sites have you visited today on your smartphone?
- Did you have any problems while browsing that site?

Each session involved three separate parts to test all three sets of high-fidelity wireframes:

1. Scrollbar and overview mode
 - i. Home screen
 - ii. Overview mode screen
 - iii. Completion screen
2. Scrollbar and swiped-in content outline
 - i. Home screen
 - ii. Overview mode screen
 - iii. Completion screen
3. Status bar
 - i. Home screen
 - ii. Overview mode screen
 - iii. Completion screen

Participant 1 and participant 2 went through the same sequence. Participant 3 was assigned a reverse order to assess if the order of concepts had any effect on how well participants understood each new concept. The learning and order effect was further minimised by using a different web site for each concept.

To be able to compare different concepts to each other, the same set of questions were asked for each screen to determine how well the participants understood what they saw on the screen.

Home screen - This is the initial screen that the participant sees with all functionalities in their default state.

- Questions about how well the users understand the content and structure from only viewing the first screen:
 - » How long do you think the page is?
 - » From this first screen, what can you say about the content and structure of the page? (In terms of how many different topics and sections are available on the page?)
- Questions about how the users will navigate the page with what they see on the screen:

- » How would you get to a different section of this page?
- Question about how the users will try to see an overview of the page with given functionalities in the screen:
 - » How would you see an overview of this entire page? Overview, in this case meaning what content is available on this particular page. (The participant is instructed to click on any part of the mockup.)
- Question specific to the first time the participant sees the scrollbar:
 - » What do you think the lines in the scrollbar indicates?

Overview mode screen - This is the screen shown after the participant has activated the content overview mode from the home screen.

- Question about how well users understand what the overview mode does:
 - » What do you think has happened to the page?
- Questions about how users will use the new functionalities:
 - » How would you get back to the original page?
 - » How would you get to the bottom of the page?

From the overview mode screen, the participant is asked to find information on the page. Since a different web site is used for each concept, different task was assigned:

- Scrollbar and overview mode: Select an article about the Malaysian plane crash.
- Scrollbar with swiped-in content outline: How do you get to London from Gatwick airport?
- Status bar: Select a sports article to read.

Completion screen - This is the screen shown after the participant has completed the task from the overview mode screen. User is taken to the point of chosen information with everything updated accordingly.

- Question about how well users can orient themselves on the page:
 - » Do you know where you are on this page?
- Question about whether users will navigate after having experienced the new functionalities:
 - » How would you get to a different section of the page from here?

4.4.2.1 Participants

Three participants were recruited for the testing. Participant 2 had no previous

experiences with mobile touch devices and the other two participants were very familiar with smartphones. Participant 1 was also a participant in the user study.

Participant	Age	Gender	Occupation
1	33	Male	Animator
2	36	Male	Assistant Store Manager
3	40	Male	Environmental Technician

Table 4: User testing participant profiles

4.4.2.2 Test environment setup

Participants were presented with a high-resolution image of each screen on Macbook Pro laptop. Using laptop to view the high-fidelity wireframe allowed screen recordings of participants' mouse movements and clicks. Audio and video of the screen were recorded with Quicktime player.

After completing a set of questions for each screen, next image was shown until the set was complete.

4.4.3 Results

After the completion of each session, the recordings were used to transcribe the participants answers and actions for each screen. To determine how well the participants understood the concepts and used the new functionalities, their actions and answers were assembled into a table format. For example, to compare how well the participants understood the segmentation in the scrollbar, the scrollbar segmentation was taken as a theme and every participant's answers can be compared against each other in the table.

The complete session transcripts from which the results are taken are in appendix E and the resulting tables are in the following sub-sections.

4.4.3.1 Scrollbar and Overview Mode

Screen 1 - Home screen

	Participant 1	Participant 2	Participant 3
Current section highlight	Highlighted section in the scrollbar track confused P1. He thought that the highlighted section is the entire page.	P2 did not notice the highlight.	P3 did not notice the highlight.

	Participant 1	Participant 2	Participant 3
Page length	Based on the highlighted section, P1 made a wrong assumption that the page is only a couple of screens long.	P2 correctly understood that the page was long from the scrollbar size.	P3 thought the number of sections in the scrollbar indicated how many "pages" there are in the page.
Scrollbar section segmentation	Scrollbar section segmentation was assumed to "signify different headings" or "bookmarks". P1 was able to form a connection between the scrollbar and the page content. P1 thought that the scrollbar doesn't stand out enough.	P2 was able to relate the sections with the page content. He assumed you can either expand on a section or skip to a section with the scrollbar.	The length of each section in the scrollbar track was correctly associated with how long each section is on the page.
Overview	Correct action was taken to view the content outline.	P2 thought that the site menu at the very top was for the page and clicked on it for content overview. This seemed to be a common theme throughout user testing, where there is a confusion about whether or not a menu is for the entire site or for the page.	P3 clicked on the right icon to launch a page overview. It is not clear whether he thought the menu at the very top is for the site or the page.
Navigation	P1 would either scroll manually or click on the scrollbar to navigate. However, his first instinct is to scroll manually.	P2 misunderstood the question as being asked what actions could be performed on the first screen.	P3 would scroll or click on photos or headings to view content.

Table 5.1.1: User testing results for scrollbar and overview mode - home screen.

Screen 2 - overview mode

	Participant 1	Participant 2	Participant 3
Overview mode	P1 correctly assumed that he is viewing the headline version of the page.	P2 correctly deduced that he was seeing a summary version of the page.	It took a while to understand what has happened to the page but P3 eventually understood that the page has become a summary version.
Going back to normal view	To get out of the overview mode, P1 would either try the browser's back button or click on the outline icon again. P1 didn't think it was clear that the overview mode icon has been clicked on. It also wasn't clear to him that he was in a different mode.	Since P2 did not notice the content outline icon button in the previous step, he would use the browser back button to exit the mode.	P3 correctly chose to click the same icon to go back.
Navigation	P1 would use the scrollbar to get to the very bottom of the page.	P2's instinct is to use the scrollbar to navigate the page.	P3 would either scroll as usual or use the scrollbar.

Table 5.1.2: User testing results for scrollbar and overview mode - overview mode screen.

Screen 3 - completion screen

	Participant 1	Participant 2	Participant 3
Location within the page	P1 was confused by the outcome due to unfamiliarity with the page content. P1 expected to be taken directly to the article. Visual hint or cue may be needed to indicate that clicking on a heading will expand its content.	P2 deduced that the page has expanded to the original view.	P3 understood that the page has scrolled to the headline he clicked on. P3 was able to see where he was located within the page from the scrollbar.
Navigation	P1 would use the scrollbar by moving it up or down.	P2 would use the scrollbar for navigation.	P3 thought he can click the scrollbar to get to another point in the page.

Table 5.1.3: User testing results for scrollbar and overview mode - completion screen.

4.4.3.2 Scrollbar and Swiped-in Content Outline

Screen 1 - home screen

	Participant 1	Participant 2	Participant 3
Page length	P1 did not see the scrollbar to get a sense of how long the page may be.	The scrollbar helped with guessing the page length only when directly asked about it.	P3 used the number of sections in the scrollbar track to guess how long the page is.
Scrollbar section segmentation	P1 thought segmentation was like bookmarks for the page. He thought bookmarking was similar to "Find by word" functionality on desktop browser where found words are highlighted in the scrollbar track.	P2 did not connect segmentation with page content. Whether or not users will be able to form a connection with interactive prototype is unclear.	P3's understanding of the page content is limited to what he sees. He did not use the scrollbar segmentation to guess how many different topics there may be. Like other participants, he did not make a connection between the scrollbar and the page content.
Overview	P1 noticed the arrows on the scrollbar and was able to guess the direction of opening. His preference was to tap the scrollbar as he thinks it would be faster.	P2 did not notice the arrows and clicked the site hamburger menu for the page overview.	P3 was not sure of action to take and clicked on the site hamburger menu.
Navigation	P1 would use the scrollbar to go to a different section.	P2 would use the scrollbar to scroll down.	P3 would use the scrollbar first. Second method is to use the site hamburger menu.

Table 5.2.1: User testing results for scrollbar and swiped-in content outline - home screen.

Screen 2 - overview mode screen

	Participant 1	Participant 2	Participant 3
Overview mode	P1 said he understood the outline view. He thought the outline is visually plain and needed colour coding. He correctly understood how to open and close expandable sections in the outline.	P2 found partially hidden web page view with outline was "interesting".	P3 thought the outline was for the entire site, not the page. Blue arrows' functions were easily understood to open expandable section in the outline.
Going back to normal view	P1 guessed correct gestures to close the outline.	Partial view of the web page helped P2 to understand that he can slide or swipe to close.	P3 would try to click or swipe to close.
Navigation	P1 would use the scrollbar.	P2 is familiar with using scrollbar to navigate.	P3 would navigate by swiping up the scrollbar and the outline menu.

Table 5.2.2: User testing results for scrollbar and swiped-in content outline - overview mode screen.

Screen 3 - completion screen

	Participant 1	Participant 2	Participant 3
Location within the page	P1 correctly used the scrollbar to orient himself.	P2 looked at the scrollbar to correctly guess that he was down 2-3 sections.	P3 used the scrollbar to guess where he is within the page.
Navigation	P1's first instinct is to manually scroll unless the page is really long.	P2 would use the outline or the scrollbar, now that he knows how it works.	P3 would manually scroll the page to browse, unless there was something specific to look for.

Table 5.2.3: User testing results for scrollbar and swiped-in content outline - completion screen.

4.4.3.3 Status Bar

Screen 1 - home screen

	Participant 1	Participant 2	Participant 3
Page length	0% in the percentage indicator was confusing and P1 had no idea how long the page may be.	P2 found 0% to be confusing and guessed that it was "super long".	P3 did not try to guess.
Overview	Site menu icon and status bar icon were too similar and confused P1. He thought the colour scheme between the New York Times and the bar was also too similar. P1 clicked on the status bar to get an overview.	P2 did not notice the site hamburger menu and used the status bar icon.	P3 did not notice the status bar. His first instinct was to use site hamburger menu to understand the site is about and get to somewhere else.
Navigation	P1 would try the search or use the site hamburger or the status bar's icon.	P2 would click on the status bar to go to a different section.	P3's first instinct was to use the site menu. Second guess was the status bar.

Table 5.3.1: User testing results for status bar - home screen.

Screen 2 - overview mode

	Participant 1	Participant 2	Participant 3
Overview mode	P1 correctly used the outline's headings to view a section.	P2 understood the purpose of the menu.	It is not clear P3 understood that the status bar menu is for the page, not the entire site. He guessed that the menu may be for filtering the content since he was seeing news categories as headings.
Going back to normal view	The close icon was easily located and correctly used to close the section.	P2 correctly used the close icon to close.	Correct action was taken to close.

	Participant 1	Participant 2	Participant 3
Navigation	P1 would prefer to scroll manually. He assumed he can input a percentage number to jump to different point. However, he stated it's easier to scroll. He will use the outline menu if given a specific topic.	P2 used the page menu to skip to a different section of the page.	P3 would scroll to navigate.

Table 5.3.2: User testing results for status bar - overview mode screen.

Screen 3 - completion screen

	Participant 1	Participant 2	Participant 3
Location	P1 understood how far down the page he was by the percentage indicator.	P2 noticed the percentage indicator and understood how far down the page he is.	This is the first time P3 noticed the percentage and guessed correctly how far down the page he is. However, it took a while to see the indicator.
Navigation	P1 assumed links with arrows would go to different sections or function like accordion menu. He did not mention using the status bar.	He would use status bar for navigation. Overall, P2 did not make any mistakes with this design and he thought this was the easiest to use.	P3 noticed "Back to the top" link hidden partially behind the menu and would use it get back to the top. His second choice was to use the status bar.

Table 5.3.3: User testing results for status bar - completion screen.

4.4.4 Conclusions

Overall, the results showed that the participants found all three concepts to be easy to use. They were able to intuitively understand how the new elements in each of the concepts would function, based on the static image of the screen alone. This was particularly encouraging to see with participant 2, who had no previous experience with touchscreen devices.

One issue that should be addressed in the next stage of finalising the design is to make sure users know that the content outline applies to the page, not the entire site. More than once, participants assumed that the new layer of information was for the entire site, not the page. There was a dissociation

between the page and the content outline when it is brought in as a new layer of information.

The results from all three concepts showed that the participants did not mind scrolling and would rather scroll manually. If it takes a significant amount of scrolling to get to a point, then they would consider another method. This seems to indicate that participants would rather not switch the focus of their attention from the page content to another UI element. While the participants are looking and browsing around the content, their attention is on the content and they may not notice any changes in the browser's user interface. However, this would need further testing with interactive prototype since the participants were only dealing with static images.

General visual design issues to be noted for all three concepts were:

- Any new UI elements have to be visually distinct from the web site and be connected to the browser's interface. Otherwise, users can become confused by associating the new UI elements with the web site.
- The icon used for the overview mode does communicate the idea of outlining or making a list. However, it is too similar to the site hamburger menu (an example can be seen in both figure 22 and 23, in upper left corner of each the home screen). There is a need for different icon, or at the very least something that is visually distinct from the site menu's icon.

One final point to take away from the overall results is that it would be important to implement an animated transitions within the page. This will help users understand that they are still viewing the same page.

The following two sub-sections discuss the usability issues found specific to the scrollbar and status bar. Since the scrollbar's design was the same for both "Scrollbar and overview mode" and "Scrollbar and swiped-in content outline", the issues apply to both concepts.

4.4.4.1 Scrollbar

- Participants were able to recognise what a scrollbar is from the mockup and how it should function. As expected, the design challenge was in connecting the sections of the page with segmentations in the scrollbar.
- Highlighting the current section was either not very well understood or not noticed at all. Therefore, highlighting should be abandoned and current location should be indicated by the scroller only.

4.4.4.2 Status Bar

- Participants found the status bar to be easy to understand and operate. Having all UI elements - location indicator, current section title and outline icon, in one place seemed to have been helpful.
- On-click operation was deemed to be the more intuitive than the swipe up gesture.
- Percentage location indicator was easy to understand once participants noticed that it changes as page scrolls.

5 Building the Prototype

5.1 Choosing a Concept

In the previous chapter, three concepts were created and user tested:

1. Scrollbar and overview mode
2. Scrollbar and swiped-in content outline
3. Status bar

In order to start developing an interactive prototype, one of these concepts had to be chosen to finalise its design. The results from user testing the three concepts were used to select one concept.

No one concept stood out as the easiest to use and understand than others. The participants in the user testing sessions were able to figure out how the new functionalities would work from looking at the static images. One functionality that was not quite intuitive was content outlining, since this is not an option that is currently available on the mobile browsers. When the content outlining was done directly on page as in the “Scrollbar and overview mod” concept (figure 21 in the section 4.3.1), it was easier for the participants to figure out that the page has been transformed into a summary version of itself. When the content outlining was brought in as a new layer on top of the web page, the participants thought of it as a separate system. For example, one participant thought it was a site menu and another thought it was filtering system for the topics on page. For this reason, the “Scrollbar and overview mode” concept was chosen for further development into an interactive prototype.

Another advantage is that users’ first instinct for navigation is to scroll the page. Participant 1 stated that he would rather scroll than to use another element. When the content outlining is provided on the page, the users can simply scroll through the list of topics as they always do and keep their attention in one place.

5.2 Final Design

The following design changes were made to the design in figure 21 (section 4.3.1), based on the user testing results:

- To clarify that the new UI elements (the scrollbar and the overview mode button) are connected to the browser rather than the web page, the overall colour scheme has been changed to match browser’s interface.
- The segmentation on the scrollbar is now done with dotted lines, since

dotted lines are associated with dividing a single page into one or more parts.

- The icon for the overview mode button is still be a list view icon, but it'll be sufficiently distinct from the three line hamburger menu icon. The button will also have text associated with the icon for clarity.

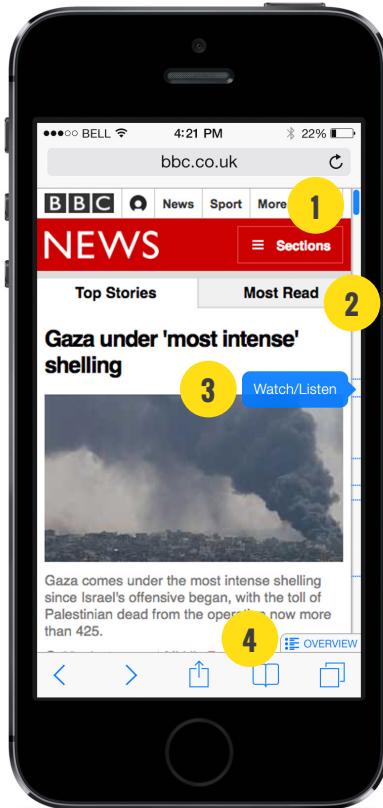


Figure 24: Final design for the scrollbar and overview mode concept.

The final design of the “Scrollbar and overview mode” concept can be seen in figure 24. The following list summarises the functionalities of the concept. The number in the list refers to the corresponding number in the design in figure 24.

- 1 **Scroller** - The scroller is the blue location indicator and serves several functions:
 - i. The location of the user within the page is shown by the scroller. As users scroll the page, the scroller's location is updated accordingly.
 - ii. The size of the scroller should give visual approximation of how long the page is. The size is calculated according to the height of the viewport (the window that contains the web page) and the length of the entire web page. Minimum height should be set so that users can still touch and grab the scroller on the screen.

iii. The page can be scrolled quickly by grabbing and moving the scroller up or down.

2 Scrollbar track segmentation - The scrollbar track is the entire length of the scrollbar area you see on the right. This track is segmented according to the sections of the page. The size of each segment accurately represents how long each section is in the page. A secondary function to the scrollbar track is to provide a shortcut to any point in the page. For example, clicking on the bottom portion of the scrollbar track will take the user to the bottom part of the page immediately.

3 Scrollbar's content hints - This is a new functionality has been added to the scrollbar to facilitate navigation. When users are navigating the page with the scrollbar, content hints will be given by showing the section headings. This is shown as white text in blue tooltip box, pointing to the corresponding section. Clicking on this text takes users to the corresponding section. This functionality should help users to know where they are scrolling to and quickly get to that section.

4 Overview mode - This is the button that turns the overview mode on or off. When the button has been clicked, the main content will be collapsed into a list of main headings. Only the main content area will change and the header and footer will remain the same. While the page is in the overview mode, there should be a visual feedback to the users that they are in a different mode of viewing the page. Another click on the button or a click on one of the headings will change the page back into normal mode.

5.3 Development

The technology chosen to develop the interactive prototype were:

- JavaScript - This scripting language drives the functionality of the prototype.
- CSS - A style sheet language CSS is used to visually format and style the elements of the prototype.
- HTML - Both JavaScript and CSS must work with a web page, which is written in HTML.

Before the development could begin, a web page had to be chosen. The prototype files must be included on a web page to create the scrollbar and the overview mode on that page. The prototype files can be included on a web page by changing the page's HTML source code to link to the files. Since live web sites cannot be changed, a web page had to be chosen and downloaded as a copy on the developer's computer. Then, editing the page's HTML code and writing the prototype files just needs simple text editing software, such as Notepad.

5.3.1 Target Web Page for Development

Since the prototype was to be used for the final evaluation, the target web site had to be chosen carefully. Various types of web sites were examined in terms of both content and source code.

For development purposes, the web page had to have accessible, semantic and clean source code. How semantic the source code is can be seen by turning off CSS stylesheets and reviewing the text. Chrome's developer tool can turn off CSS on a page so that plain text can be viewed. Figure 25 shows what happens when the stylesheet has been turned off on the New York Times site. You can still clearly see what the topic headings are and how it forms a content outline of the page.

Opinion

1. [Op-Ed Contributor: The Ancestors of ISIS](#)
2. [Editorial: Wrong Turn on Syria: No Convincing Plan](#)
3. [Thomas L. Friedman: ISIS Crisis](#)
4. [Nikos Konstandaras: Crete Finds Self in Union](#)

World

1. [Airstrikes Target ISIS in Syria Near Turkish Border](#)
2. [Submit Your Questions on U.N. Efforts to Fight ISIS](#)
3. [Obama, at U.N., Lays Out Forceful Blueprint to Fight Islamic Extremism](#)

Figure 25: The New York Times mobile site with no stylesheet.

For the final evaluation, the chosen web site had to be information-heavy to show the usability issues with a long page and the tasks should be commonplace enough for most people to understand and carry out. Examined websites included travel web sites, Moodle, Timeout, and government web sites, where people go to find information.

Eventually, the Rough guide's mobile website (<http://m.roughguides.com/>) was chosen to develop the prototype with. Their travel essential articles covered many different topics in detail. The Thailand article (<http://m.roughguides.com/destinations/asia/thailand/travel-essentials/>) was one of the longest articles on the site and was chosen for the prototype development.

5.3.2 Prototype Files and Testing Environment

Two prototype files were created to be included with the downloaded Rough Guide page:

- **prototype.js** - JavaScript file implements all functionalities of the scrollbar and the overview mode.
- **styles.css** - CSS file implements the visual styles for the scrollbar, overview

button, overview mode and any other style changes for the page.

In order for the prototype to interact with the user, it needs to be able to detect users' gestural inputs. For example, how would the prototype know when the user has clicked on the scrollbar track? The gestural inputs such as tap or swipe creates touch events. A touch event is triggered on the device every time there is a touch gesture input from the user. A tap creates a touch event. The event contains information such as where and what type of touch it was - tap. These touch events need to be captured so that the prototype would know what to do with these events.

The touch events can be detected by a JavaScript plugin called "**jquery.touchSwipe.min.js**". The file was downloaded from <http://labs.rampinteractive.co.uk/touchSwipe/demos/> and was included along with the two prototype files on the Rough Guide's Thailand HTML file.

As the two prototype file codes were being written, testing was continuously being conducted to see that the prototype works as it should. Testing was done by:

1. Uploading the prototype files and the HTML file to a web host.
2. Accessing the HTML file through the iPhone's Safari browser.
3. Turning on the Web Inspector option on the iPhone's Safari browser.
4. Connecting the iPhone to the developer's desktop computer through USB.
5. Launching the desktop computer's Safari browser with its Web Developer tool on (figure 26). With this tool, the touch events and all scripted functionalities being tested can be seen.

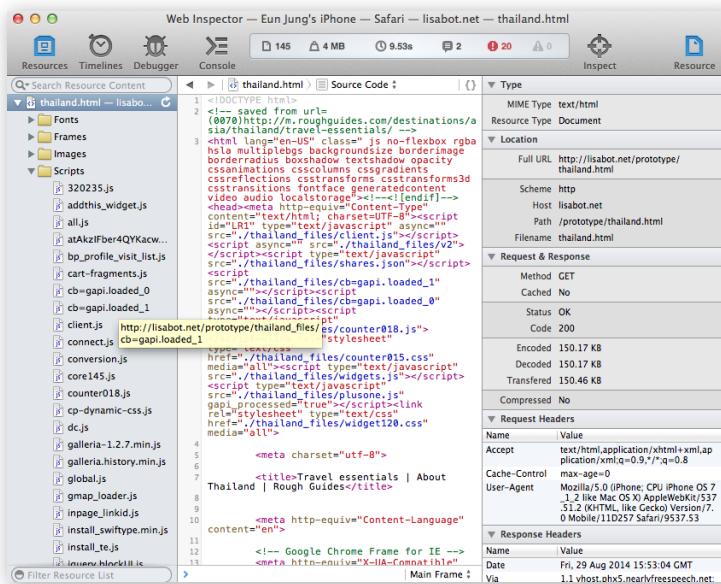


Figure 26: Safari's Web Developer tool.

5.3.3 Changes to the HTML File

The downloaded HTML file of the Rough Guide page was changed from its original version for both development and evaluation purposes. Figure 27 shows the original page on the left and its modified version on the right.

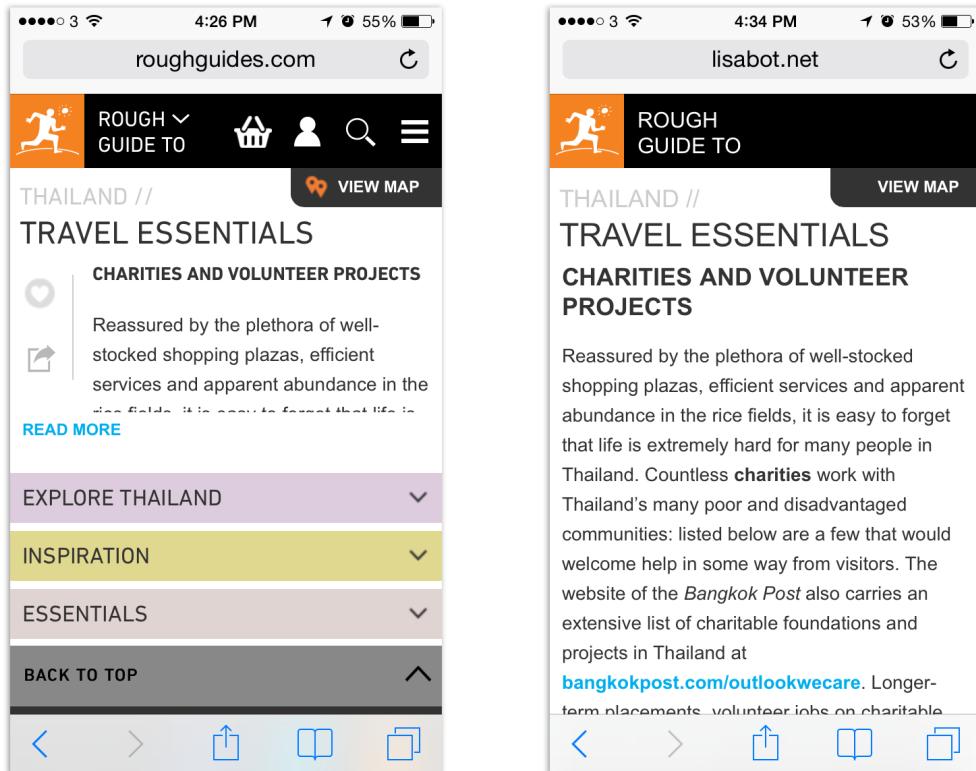


Figure 27: Original Rough Guide page (left) and modified page for the prototype (right).

The following list summarises the changes:

- “Read more” functionality has been removed. The modified page has its entire content available by default and bypasses the “read more” click to view and read the page.
- The site menu is not necessary as the prototype is built for a single page.
- “Share and like” functionalities were removed as they are not needed for finding information on the page.
- The visual information hierarchy in the main content area was slightly changed and improved. There is now more font size differences between the body copy and the headings.
- There are only second level headings in the main content area. What looks like third-level subheadings are actually bolded text. This does not form a semantic content outline as bolding is just a font style change. These subheadings were marked up as third-level headings `<h3>` and their font size was increased slightly to distinguish it from the body copy.

5.3.4 Scrollbar

This section discusses how the scrollbar was constructed and how its functionalities were developed. First, the basic construction of the scrollbar is discussed, followed by the segmentation of the scrollbar track. Since the segmentation is based on the main content area sections, how the prototype can recognise the main content area is discussed. Finally, three types of touch events that drive the functionalities are discussed. There is a brief sub-section what development challenges there were with the scrollbar.

5.3.4.1 Constructing the Scrollbar

The scrollbar was added directly to the HTML file and visually styled with CSS. The width of the scrollbar track began as 14px but it changed as coding and testing progressed to account for touch sensitivity issues. The scrollbar's width was 18px by the time the prototype was finished.

The height of the scroller depends on the length of the entire page and has to be dynamically calculated. The height was set by the JavaScript file "prototype.js". Once the page has been fully loaded by the browser, the prototype obtains the height of the viewport and the height of the entire document. The scroller's height is then calculated as:

```
(viewport height / document height) * viewport height
```

The minimum height of the scroller was set to 44px by CSS since it cannot be too small to touch.

5.3.4.2 Segmenting the Scrollbar Track

`<h2>` refers to second-level heading in HTML and heads a section. `<h3>` would be next level down and could be thought as a subheading to `<h2>`. The scrollbar track was segmented by parsing through a list of `<h2>` headings in the main content area. Therefore, it is important for the prototype to correctly recognise where the main content area is from the source code. The main areas of the page are defined in the figure 28's diagram.

These sections can be detected by the sectioning elements and their role attributes (table 6). Sectioning elements

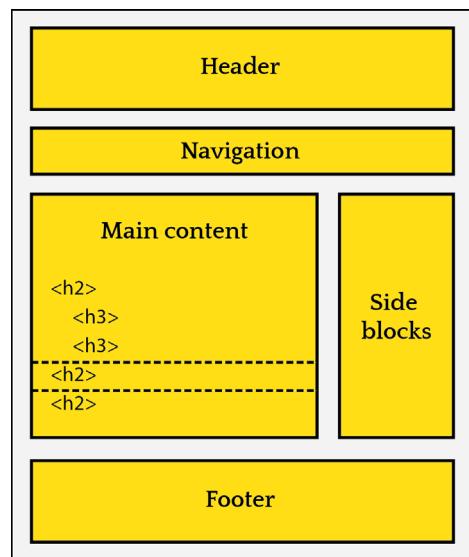


Figure 28: Diagram of main content areas in a web page.

refer to HTML tags such as <div> that contains content and form a section. For example, the main content area in figure 28 can be sectioned with <div> or <section>. The sectioning element can be assigned a role such as “main” to be semantic. The prototype can recognise the main content area by the role attribute “main” and parses through the headings in that area only.

Document content block	Sectioning element	Role attribute
Header	<header>	banner
Navigation	<nav>	navigation
Footer	<footer>	contentinfo
Side blocks	<aside>	complementary
Main content	<div>, <section>, <article>	main

Table 6: Document content blocks.

Based on the list of <h2> headings in the main content area, the prototype can segment the scrollbar track by:

1. Creating a new scrollbar track segment for a <h2> heading.
2. Creating a content hint for the new segment.
3. Calculating and setting the position of the new segment.
4. Calculating and setting the height of the new segment.

5.3.4.3 Scrollbar Functionalities

With “jquery.touchSwipe.min.js”, the touch events on the page can be detected to drive the interactivity between the page and the user. For the prototype, the touch events “swipeStatus”, “tap” and “hold” were detected to trigger appropriate actions.

SwipeStatus events

When a user touches the scrollbar and swipes across the scrollbar track, “swipeStatus” event is detected by the prototype. During the swipe, the content hints will be shown for five seconds. If the scroller is being moved up or down, the page scrolls according to the position of the scroller. Essentially, this emulates the scrolling function of a desktop browser’s scrollbar while also showing content hints.

Tap events

When users tap the scrollbar, “tap” event is detected. The location of tap event is recorded and corresponding location in the page is calculated:

```
Tap event position * Document height / Window height
```

Then the page scrolls to the calculated position and the content hint is briefly shown.

Hold events

“Hold” event is detected when users tap and hold for longer than 500ms. It is also considered a longer tap. When a “hold” event is detected, a content hint for the tapped section is shown.

5.3.4.4 Development Challenges

Since the scrollbar was manually created for the page, visually there is a conflict with the browser’s own scrollbar. The browser’s scrollbar can be seen when the page is being scrolled and there is a visual overlap with the manually created scrollbar and the browser’s scrollbar. During the early phase of development, another version of the prototype was developed to counter this problem. With this version, the entire scrolling functionality of the browser had to be re-created from scratch, which was not possible and had to be abandoned. Fortunately, the browser’s default scrollbar is only visible during scrolling and testing showed that it was too small to be noticeable.

5.3.5 Overview Mode

This section discusses how the overview mode was created. The overview mode is based on the page structure, as defined by its headings and sectioning elements such as `<div>` and `<section>`. Therefore, the HTML5 specifications on correct document outlining was first discussed. It is then followed by a sub-section on how the prototype attempted to find content blocks from the headings. Since it was not possible to develop an outlining algorithm that could work for every web site, a simpler solution was developed for the prototype.

5.3.5.1 Document Outline

The Rough Guide’s main content area did not use sectioning elements to form different topic areas. Instead only the heading levels at `<h2>` were used to section its extremely long content. Prior to HTML5, this was not an incorrect method of document outlining. (W3.org, 2014) Now with HTML5 specifications, the sectioning elements such as `<div>` and `<section>` define sections that create semantic document outlines. For example, following codes in table 7 contain same heading levels but creates two different document outlines:

	Source code	Document outline
1. No sectioning elements	<pre><h1>Title of the page</h1> <h2>This is an article heading</h2> <h2>This is another article heading</h2></pre>	<ol style="list-style-type: none"> 1. Title of the page 2. This is an article heading 3. This is another article heading
2. Sectioning elements	<pre><section> <h1>Title of the page</h1> <article> <h2>This is an article heading</h2> </article> <article> <h2>This is another article heading</h2> </article> </section></pre>	<ol style="list-style-type: none"> 1. Title of the page <ol style="list-style-type: none"> i. This is an article heading ii. This is another article heading

Table 7: Document content blocks.

The second outline is more meaningful to the users – clearly articles are shown to be article titles under a single page title.

The prototype is dependent on the sectioning elements and headings to create the overview mode.

5.3.5.2 Creating the Overview Mode

In order to collapse all the content blocks into headings, the prototype needed to be able to detect where each content block begins and ends. This algorithm was the first attempt at detecting the content blocks:

1. Find `<h2>` headings in the main content area.
2. Find the sectioning element of `<h2>`. This sectioning element should be stored or given a unique ID. If there is no sectioning element, a new sectioning element is created. In the figure 29 diagram, the new sectioning element is marked with dashed line.

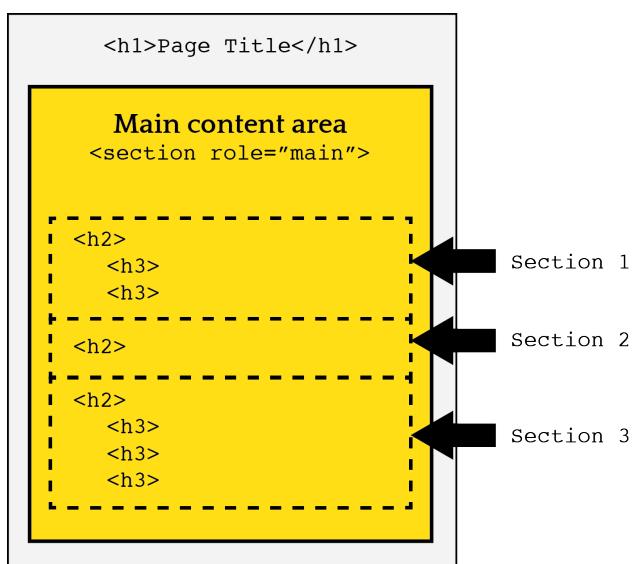


Figure 29: Sectioning the main content.

- All other elements in each section are detected to form a single content block. For example, `<h3>` is an element that is part of a content block formed with dashed line in the figure 29 diagram.

5.3.5.3 Development Challenges

There were many challenges with implementing document outlines across different web sites. For example, on the New York Times site, each content block with `<h2>` was not coded the same way, even if they look visually the same. Headings can also be hidden off-screen for accessibility reasons, or can be dynamically generated by JavaScript. Given the project timeline, it was not feasible to implement document outlining that works for all possible web sites.

5.3.5.4 Solution

Within the main content area, each content block headed by `<h2>` was wrapped into its own sectioning element `<div>`. The content of each section can then be collapsed by hiding all elements that are not `<h2>` or `<h3>`. To go back to normal mode, all hidden elements become visible again.

Additional visual styles were added to the overview mode with CSS to make clear where each section ends (figure 30). A horizontal line and an arrow were added to each content block. The scrollbar was hidden in overview mode since the distance to scroll is negligible.

The overview mode button in figure 30 is styled to be reversed in colour scheme to give visual feedback to the users that the overview mode is on.

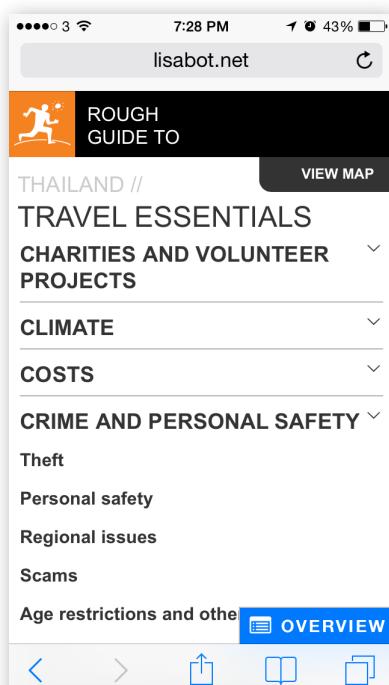


Figure 30: Overview mode.

5.5.6.7 Final Prototype

The Thailand prototype can be viewed at: <http://lisabot.net/prototype/thailand.html>

An additional prototype was developed with a different page from the Rough Guide: <http://lisabot.net/prototype/egypt.html> This prototype uses the same prototype files but uses different content.

The final source code for the JavaScript prototype file is available in appendix F.

6 Prototype Evaluation

6.1 Purpose

The goals of the final prototype evaluation were to:

- Evaluate the usability of prototype:
 - » Do users easily understand how the prototype's new browser functionalities work?
 - » What problems do users have with the prototype?
- Compare the prototype with current browsing methods:
 - » Does the prototype improve the task completion time?
 - » Does the prototype help users understand the page content and structure better?
 - » Does the prototype make the page navigation easier?
 - » Does the prototype improve the user experience of mobile browsing?

6.2 Evaluation plan

The initial evaluation plan was a between group experiment to compare the browsing experience with the prototype and without the prototype. In the original plan, one group would perform several information-seeking tasks with the aid of prototype while another group would perform the same tasks without the prototype. Due to the limited number of participants available, the experiment was redesigned to be within-subjects experiment. In the new plan, each participant would complete two sessions. One of the sessions would be completed with prototype. Each session would use different page with different set of tasks. Hence, the independent variable for this experiment was the availability of prototype tools.

A pilot study was conducted for the redesigned evaluation plan. During the pilot study, the participant was not introduced to the new tools in the prototype. This resulted in the participant trying to understand what is happening and impacted the performance metrics. To avoid situations where a participant spends too much time playing with the new functionalities or not using the prototype altogether, an introduction to the prototype was included in the session outline.

The complete list of questions and tasks are in appendix G. Further details of the evaluation sessions are discussed in the sub-section 6.2.3.

6.2.1 Order and learning-effect

The prototype was built with the Rough Guide's Thailand travel essentials page (<http://m.roughguides.com/destinations/asia/thailand/travel-essentials/>). For the experiment, a second prototype was made with Egypt travel essentials page (<http://m.roughguides.com/destinations/africa/egypt/travel-essentials/>). Both pages are the same in terms of information structure and cover mostly the same topics. Different tasks were designed for each prototype to minimise learning effect between the first and the second session. For example, visa information is covered under "Entry requirements" topic heading. The same task cannot be repeated for the second session since the participant would know which topic heading contains the visa information.

The order in which two sessions were performed was also varied. Half the participants did the session with prototype first while the other half did the session without prototype first. Overall, there were four conditions available and are summarised in the table 9.

	Condition A	Condition B	Condition C	Condition D
Session 1	Egypt without prototype	Thailand with prototype	Thailand without prototype	Egypt with prototype
Session 2	Thailand with prototype	Egypt without prototype	Egypt with prototype	Thailand without prototype

Table 9: Evaluation conditions summary

The participants were assigned to an experiment condition as shown in the table 10.

Condition A	Condition B	Condition C	Condition D
Participant 1	Participant 2	Participant 3	Participant 4
Participant 5	Participant 6	Participant 7	Participant 8
Participant 9			

Table 10: Participant assignments to experiment conditions

6.2.2 Participant profiles

Most of the recruited participants were expert users of smartphones with five or more years of experiences. Participant 8 had only three months of experience with smartphones. Participant 7 took part in the user testing sessions for the high-fidelity wireframes.

Participant	Age	Gender	Occupation
1	25	Male	Student
2	28	Female	Student
3	31	Female	Programmes Officer
4	27	Female	Student
5	24	Male	Student
6	24	Female	Student
7	40	Male	Environmental technician
8	54	Female	Administrator
9	27	Male	Developer

Table 8: Final evaluation participant profiles

6.2.3 Session Outline

The entire evaluation session ran for approximately 30 minutes.

At the beginning of each session, participants were asked about their first impressions of the page content and structure. The purpose of these questions were to determine:

- How limited is their understanding of the page content and structure.
- How does the prototype help with understanding the page content and structure.

An additional set of questions was administered for the session with the prototype. These questions were designed to introduce the prototype functionalities and evaluate the usability of prototype. The prototype introduction began with general questions about the new UI elements and how the participants would use them. The participants were then asked to use the new elements and see how they function.

The main part of the session was the completion of three different tasks. After each task, participants were asked to rate how easy it was to find information on a scale of one to five. Five meant that it was very easy to find information on the page and one meant that it was very hard.

Once the tasks have been completed, the participants were again asked about what they remembered about the page content and how well they knew the page structure. The purpose was to evaluate whether the prototype helped users to understand the overall content and structure of the page.

The diagram in figure 31 illustrates the entire session outline and how a session was varied per condition.

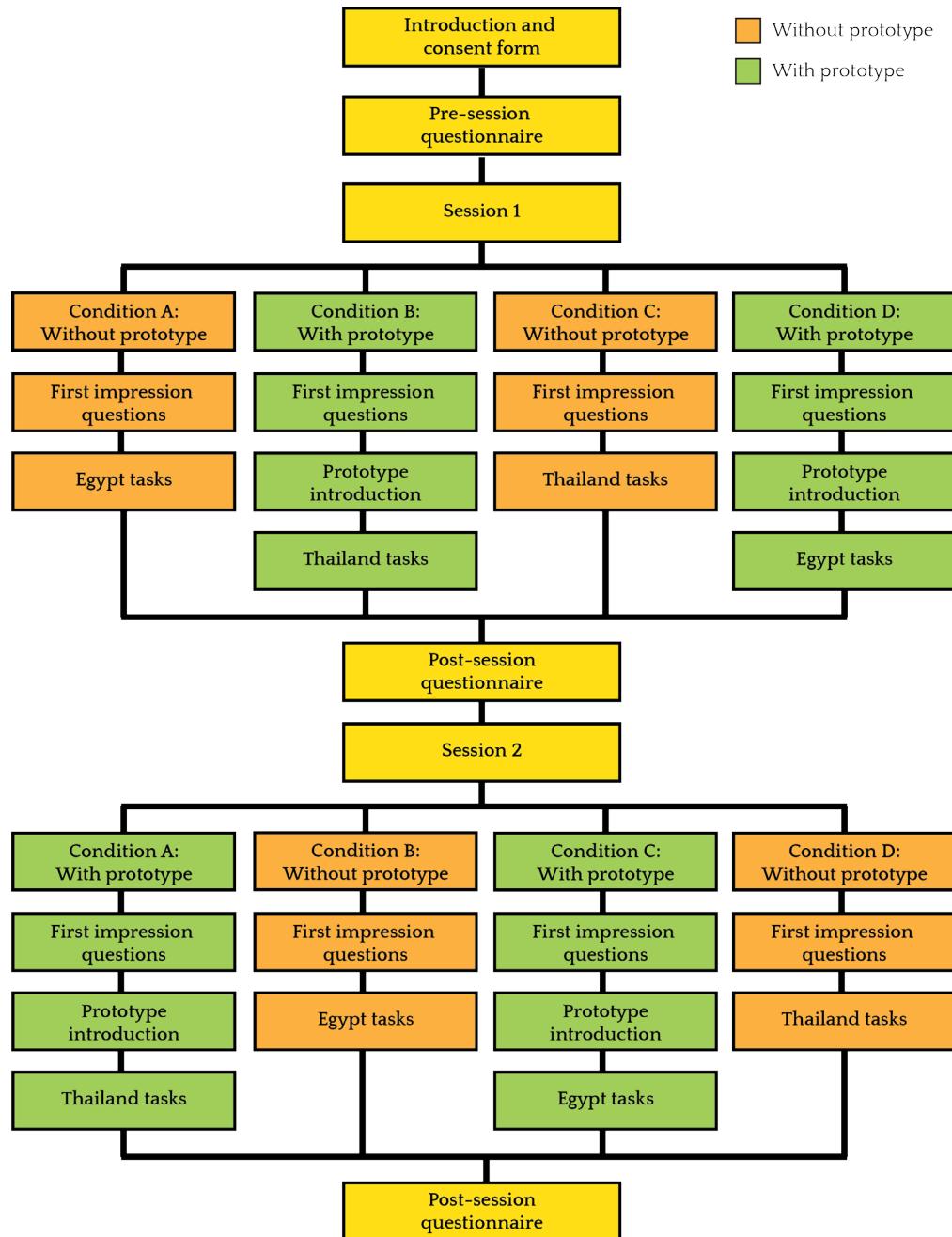


Figure 31: Session outline for all conditions.

6.2.4 Evaluation Setup

All the sessions were conducted at a City University Library room except for the two remote sessions (#7 and #9). For the local sessions, Magitest was used to record the audio and video of the smartphone screen. For the remote sessions, Reflector (<http://www.airsquirrels.com/reflector/>) was installed on the participant's desktop to mirror the smartphone screen to the desktop. The

desktop screen was then shared between the participant and the facilitator. The desktop is then screen recorded and all of the participant's actions and words can be captured.

The pre-session questionnaire and post-session questionnaire were administered and collected by using online forms.

6.2.5 Dependent Variables

The following dependent variables were measured for each task:

- **Time to complete a task** – the amount of time taken for a participant to complete the task successfully or to give up on the task.
- **User experience** – the participant rates how easy it was to complete a task on semantic differential scale, from very hard to very easy.

The user satisfaction level with browsing experience for each session was measured by a post-session questionnaire.

6.2.6 Pre-session Questionnaire

A pre-session questionnaire collected basic demographic information such as age and gender, and asked about the participants' past experiences with mobile touch devices. They were also asked about any problems they may have experienced with mobile web browsing.

6.2.7 Post-session Questionnaire

After each session, the participants were asked to complete Likert scale-based questionnaire about their session experiences. The following sub-sections discuss each of the nine questions in the questionnaire and what they aim to measure.

6.2.7.1 User Experience

The web page browsing experience was frustrating.

This statement measured the participants' emotional reaction to the overall browsing experience.

I felt lost while browsing the page.

This statement measured the participants' confidence levels in knowing where to go and knowing where they are within the page.

I knew where I was on the page at all times.

This statement measured whether or not prototype helped the participants to

orient themselves on the page.

6.2.7.2 Finding Information

It was easy to find information (e.g. section, content, link) on the page.

This statement measured how well the prototype helped the participants to find information on the page.

I knew where to go within the page to find what I'm looking for.

This statement determined whether the prototype helped the participants to figure out where to go to find information.

6.2.7.3 Ease of Use

It was easy to operate the browser.

This statement rated the overall operability and usability of the browser, since the prototype is intended to be a part of browser functionalities.

It was easy to navigate around the page.

This statement rated how well the prototype helped the participants to move around the page.

6.2.7.4 Understanding the Content and Structure

By the end of the session, I understood what information was available on the page.

This statement rated how confident the participants felt about knowing the content of the page by the end.

By the end of the session, I understood how the page content was structured

This statement rated how confident the participants felt about knowing the content structure by the end.

6.3 Evaluation Results

The sub-sections 6.3.1 to 6.3.3 discuss the quantitative analysis of the dependent variables and the post-session questionnaires. The sub-sections 6.3.4 to 6.3.5 discuss the qualitative analysis of the prototype usability. It is followed a discussion on the overall results and how the prototype can be improved.

The complete evaluation data can be found in appendix H.

6.3.1 Task Completion Times

The task completion time metrics were measured in seconds, from the time the participants began a task to the time participants thought they have found the

answer or gave up on the task.

The overall results (figure 32) for each participant showed that the average task completion time was improved with the prototype for six out of nine participants. There were several outliers in the data, since some of the tasks turned out to be more difficult than others.

For example, a couple of participants (#5, #6) had difficulties with words such as “inoculations” for Thailand’s first task and took a very long time to find the answer. However, they knew that the answer would be under the “Health” topic heading. Thailand’s second task also proved to be difficult because the participants expected to see a section devoted to the visa information and tried many different topics to find the information. Egypt’s second task about currency also provided outlier data because subheadings under “Money” did not provide any answers. The answer was under the main heading instead, and participants 4 and 8 never clicked on the main heading.

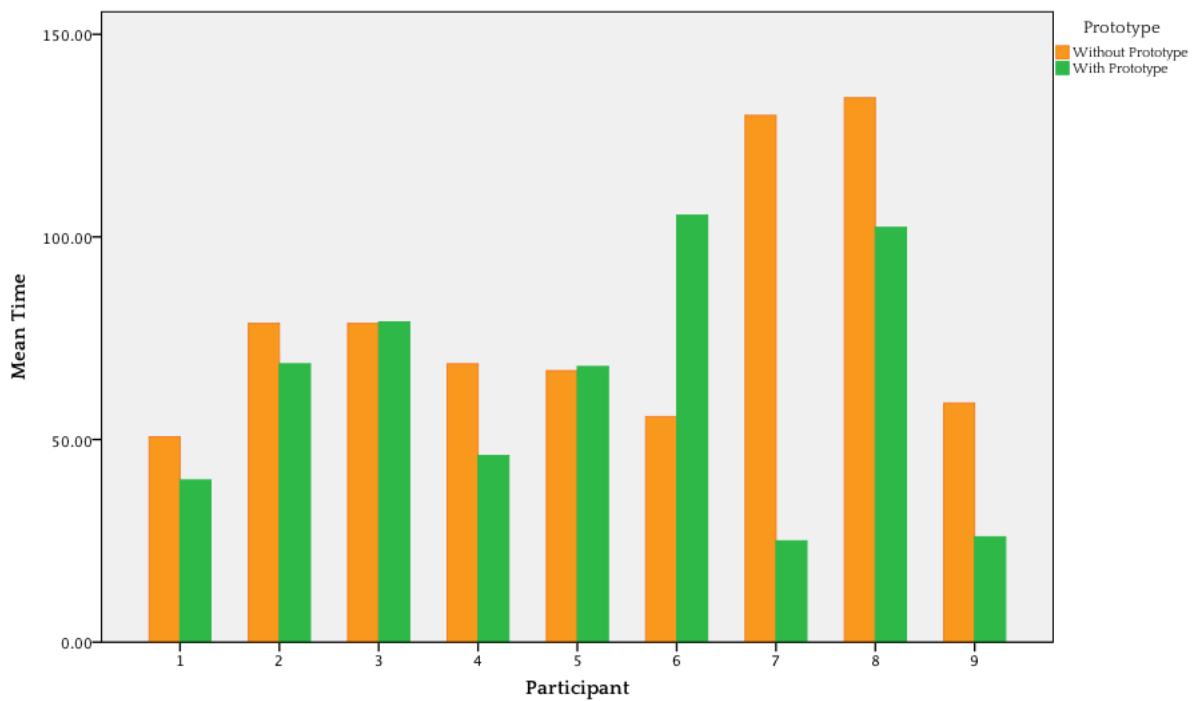


Figure 32: Average task completion time for each participant with or without prototype.

Table 11 shows the paired-sample t-test results for the following null hypothesis:

There is no difference in completion time between the session with the prototype and the session without the prototype.

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	d	Sig. (2-tailed)
-18.03704	86.33097	16.61440	Lower: -52.18843 Upper: 16.11436	-1.086	26	.288

Table 11: Paired-sample t-test for the task completion times.

The significance value of 0.288 is not less than 0.05. Therefore, the null hypothesis is not rejected and there is no statistical significant difference in mean completion time.

The mean task completion times are in table 12. On average, the task completion time was 18 seconds less by using the prototype, an improvement of 129%.

	Mean	N	Std. Deviation	Std. Error Mean
With Prototype	62.2593	27	59.08963	11.37180
Without Prototype	80.2963	27	46.31233	8.91281

Table 12: Mean task completion times

Overall, the prototype did improve the completion time for four out of six tasks (figure 33). If the topic headings in the page do not make sense for the participants, the tasks were difficult to complete with the prototype. Without the prototype, the participants would be forced to scroll through the content from top to bottom and would eventually find the answer.

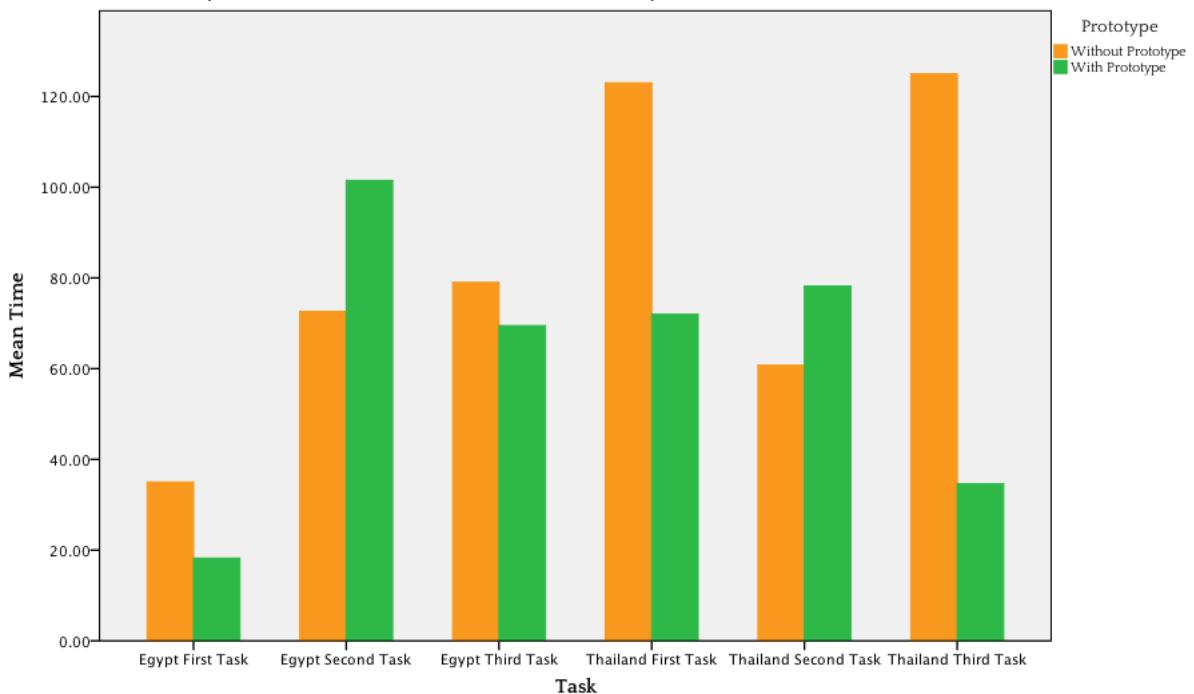


Figure 33: Average task completion time per task with or without prototype

The timing results are still encouraging as there is a definite improvement when the topic headings match participants' expectations.

6.3.2 Ease of Finding Information

After completing each task, the participants were asked to rate how easy it was to find information on a scale of one to five. Five would mean that it was very easy to find information and one would mean that it was very hard. The graph in figure 34 shows the mean task rating per participant.

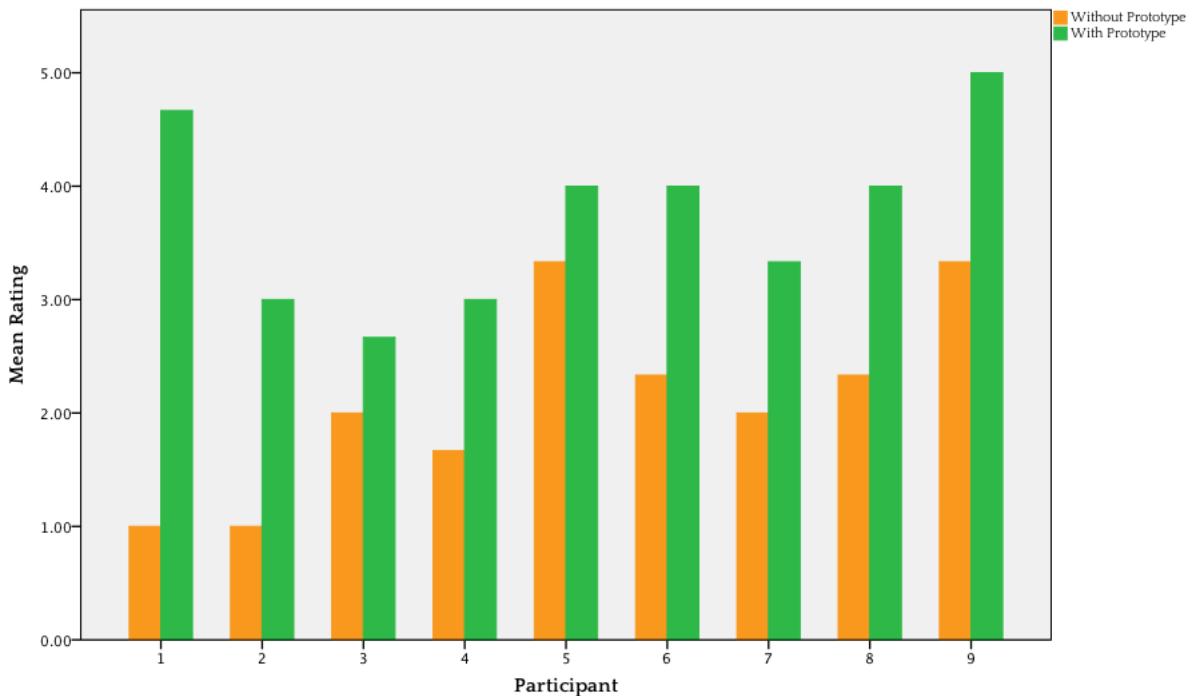


Figure 34: Average task rating for each participant with or without prototype.

The rating for ease of finding information was consistently improved with the prototype for every participant. All participants responded positively to the experience of using the prototype and this will be discussed further in the post-session questionnaire section 6.3.3.

The mean ratings for ease of finding information are in table 13. The participants rated ease of finding information 177% higher on average for the session with the prototype.

	Mean	N	Std. Deviation	Std. Error Mean
With Prototype	3.7407	27	1.31098	.25230
Without Prototype	2.1111	27	1.01274	.19490

Table 13: Mean task rating for ease of finding information

The paired-sample t-test was conducted for the task ratings with and without

the prototype for the following null hypothesis:

There is no difference in task rating for ease of finding information between the session with the prototype and the session without the prototype.

Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	d	Sig. (2-tailed)
1.62963	1.54168	.29670	Lower: 1.01976 Upper: 2.23950	5.493	26	.000

Table 14: Paired-sample t-test for task rating for ease of finding information

The significance value of 0 is less than 0.05. Therefore, the null hypothesis is rejected and the prototype does affect a participant's perception of how easy it is to find information.

There was no pattern to be found from first task to third task for both the rating (figure 35) and the completion time (figure 33). It was originally thought that becoming more familiar with the page and the prototype could improve the rating or the completion time. However, both metrics were dependent on how difficult each participant found a task to be.

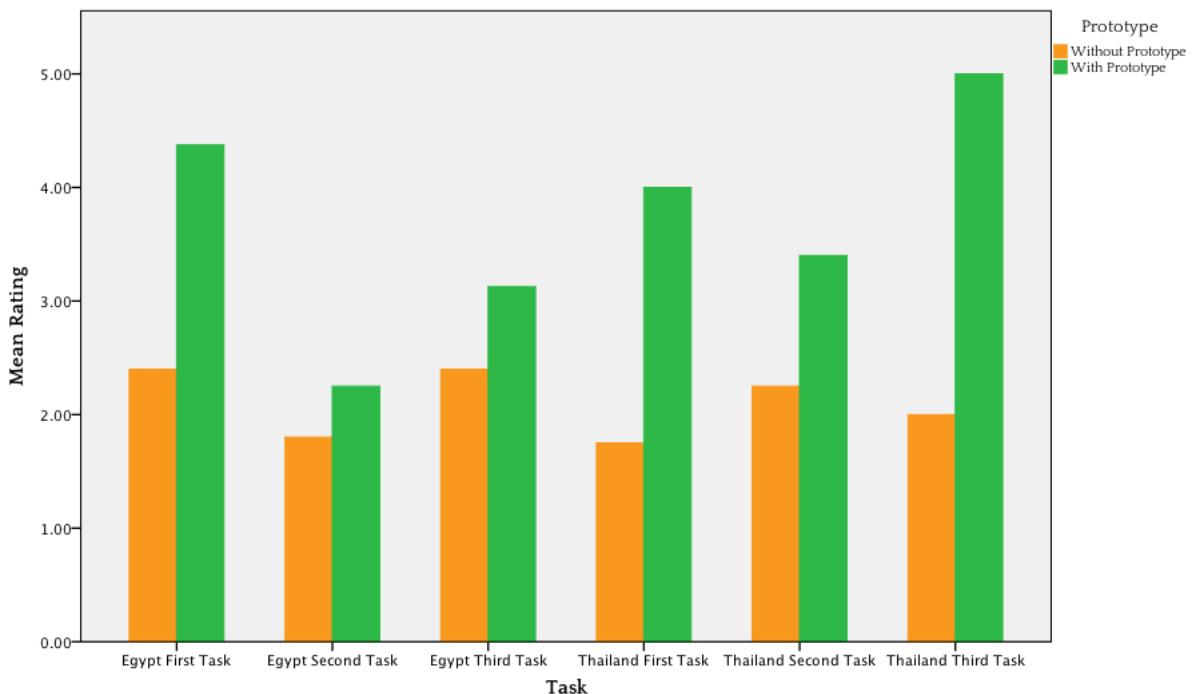


Figure 35: Average task rating for ease of finding information, with or without prototype

6.3.3 Post-session Questionnaires

6.3.3.1 User Experience

The web page browsing experience was frustrating.

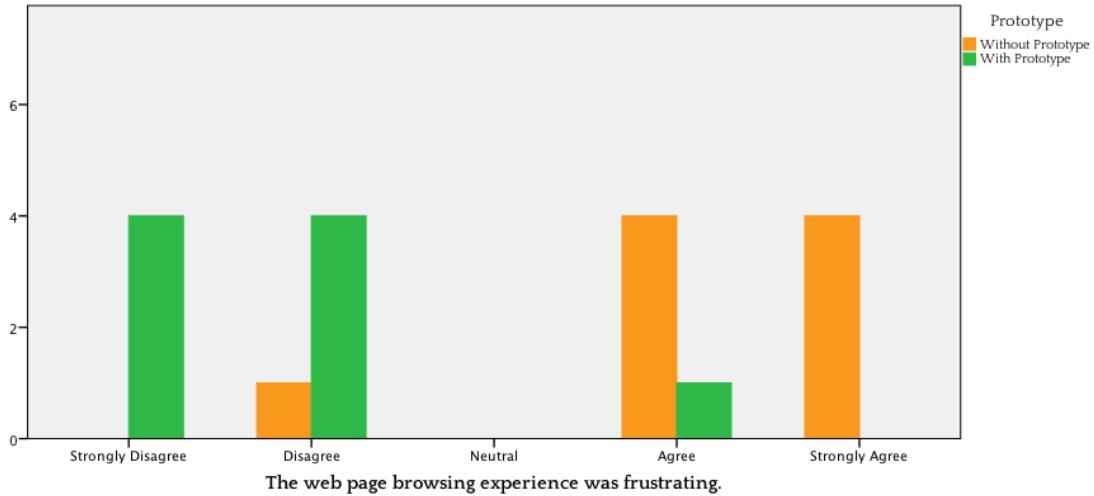


Figure 36: Questionnaire results for "The web page browsing experience was frustrating."

	With Prototype	Without Prototype
The web page browsing experience was frustrating.	1.78	4.22

Table 15: Average rating for "The web page browsing experience was frustrating."

Nearly all the participants except one (#5) agreed that the browsing experience without prototype was frustrating. In fact, it is the most agreed negative statement about browsing without the prototype.

I felt lost while browsing the page.

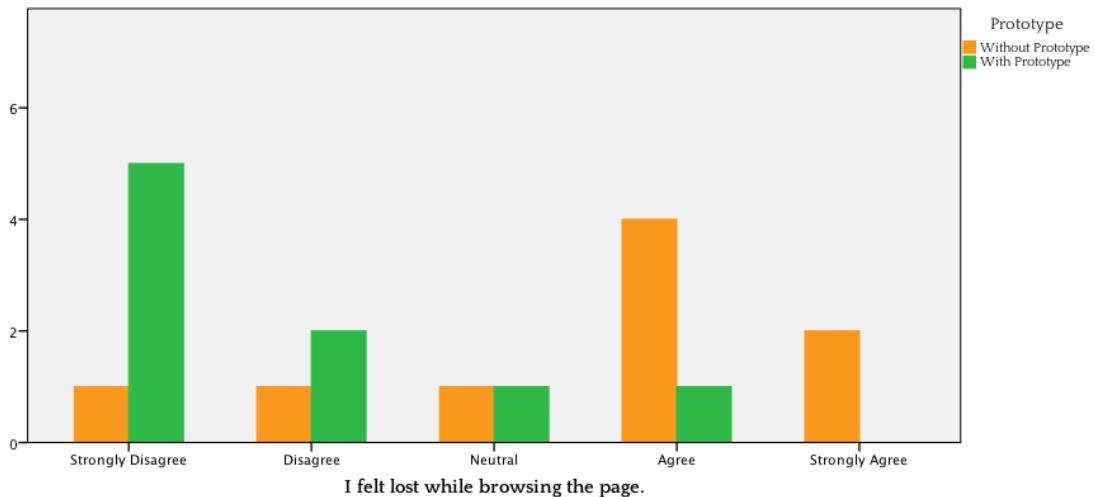


Figure 37: Questionnaire results for "I felt lost while browsing the page."

	With Prototype	Without Prototype
I felt lost while browsing the page.	1.78	3.56

Table 16: Average rating for “I felt lost while browsing the page.”

The responses for this statement was more spread out. Most participants agreed that they felt lost when browsing without the prototype. For the sessions with the prototype, some participants felt lost since they found the topic list in the overview mode to be too long.

I knew where I was on the page at all times.

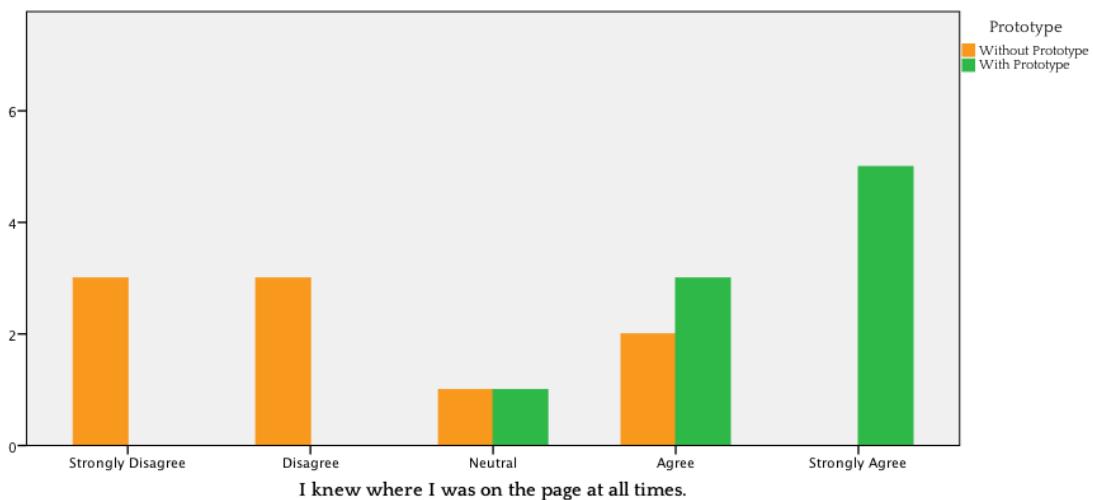


Figure 38: Questionnaire results for “I knew where I was on the page at all times.”

	With Prototype	Without Prototype
I knew where I was on the page at all times.	2.22	4.44

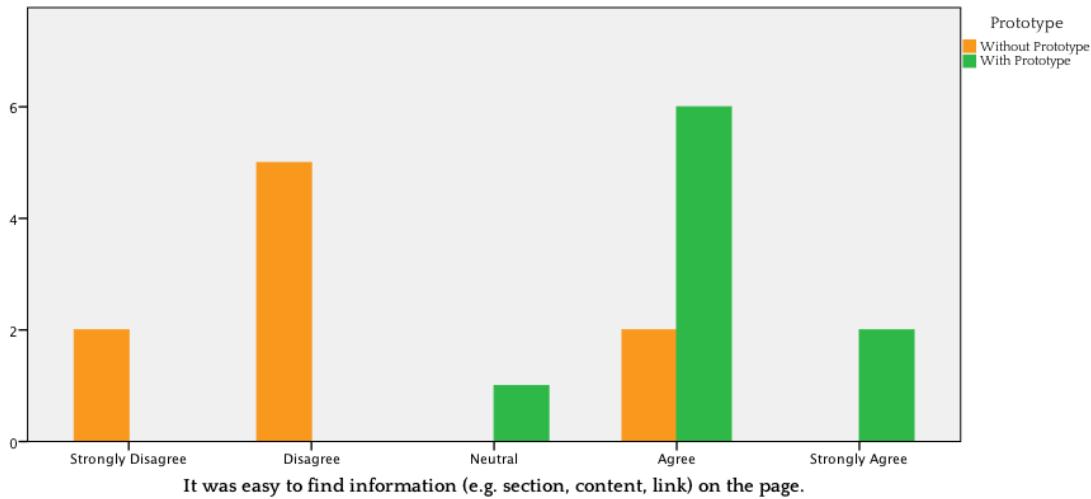
Table 17: Average rating for “I knew where I was on the page at all times.”

This was one of the highest rated positive statement for the prototype.

Without the prototype, overall responses were spread out, leaning more toward disagreement. Navigating in only one direction helped the participants to orient themselves, but they could not see where they are going or know how much more content there was to see.

6.3.3.2 Finding information

It was easy to find information (e.g. section, content, link) on the page.



It was easy to find information (e.g. section, content, link) on the page.

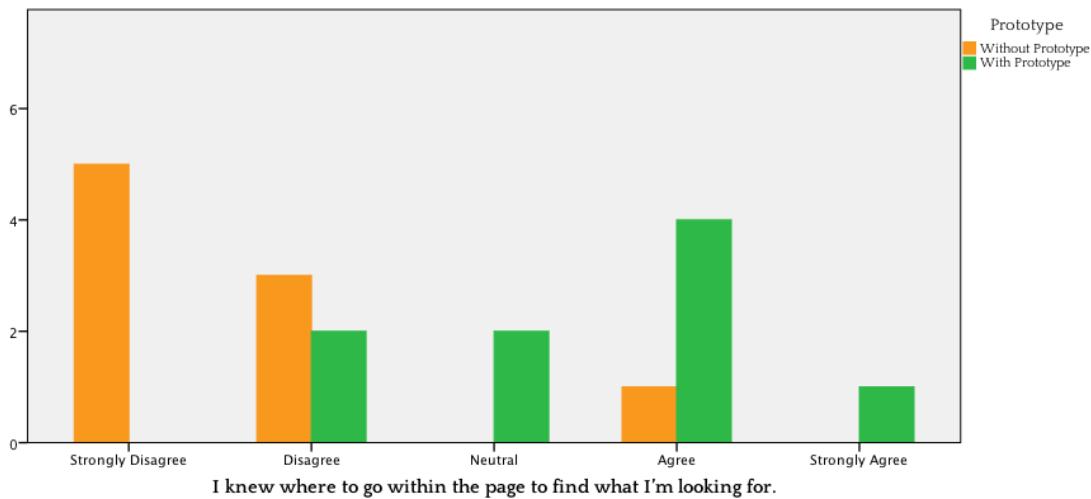
Figure 39: Questionnaire results for "It was easy to find information (e.g. section, content, link) on the page."

	With Prototype	Without Prototype
It was easy to find information (e.g. section, content, link) on the page.	4.11	2.22

Table 18: Average rating for "It was easy to find information (e.g. section, content, link) on the page."

Generally, the participants found it easier to find information by using the prototype but most had at least one or two tasks that they found difficult. Some participants commented that navigating was easy but the page's information architecture was poor.

I knew where to go within the page to find what I'm looking for.



I knew where to go within the page to find what I'm looking for.

Figure 40: Questionnaire results for "I knew where to go within the page to find what I'm looking for."

	With Prototype	Without Prototype
I knew where to go within the page to find what I'm looking for.	3.44	1.67

Table 19: Average rating for "I knew where to go within the page to find what I'm looking for."

Knowing where to find information was rated more toward neutral with the prototype and toward strong disagreement without the prototype. Information architecture of the page was poor to begin with, and the list of topics in the overview mode had no logical order.

6.3.3.3 Ease of Use

It was easy to operate the browser.

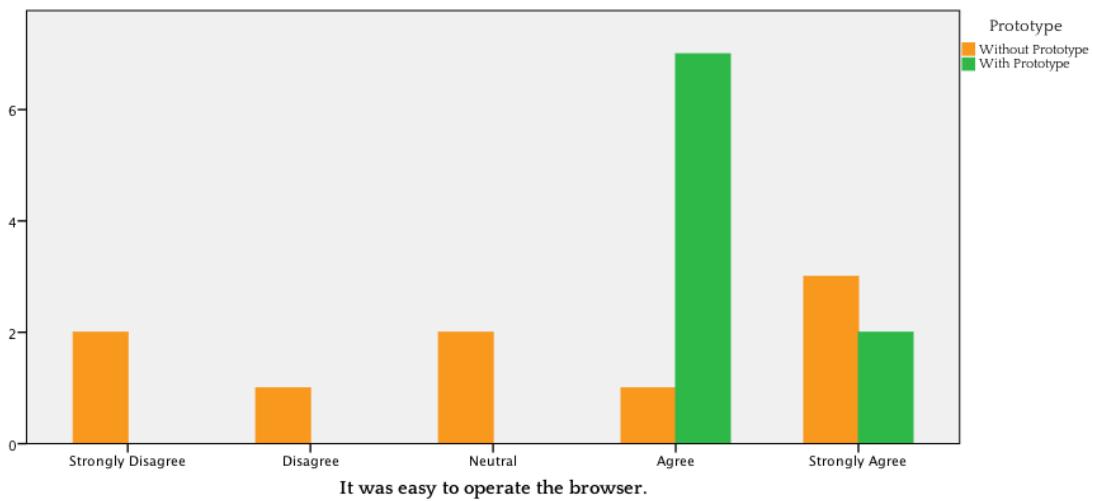


Figure 41: Questionnaire results for "It was easy to operate the browser."

	With Prototype	Without Prototype
It was easy to operate the browser.	4.22	3.22

Table 20: Average rating for "It was easy to operate the browser."

The sessions without the prototype was rated neutrally on average since all the participants found it easy to scroll.

All the participants found the additional navigation controls from the prototype to be helpful and rated the prototype experience very positively.

It was easy to navigate around the page.

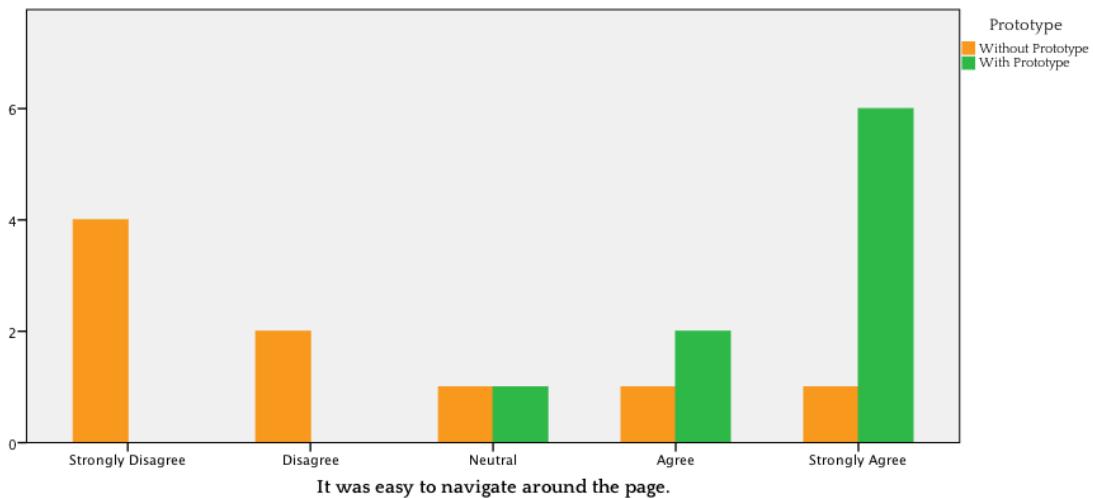


Figure 42: Questionnaire results for “It was easy to navigate around the page.”

	With Prototype	Without Prototype
It was easy to navigate around the page.	4.56	2.22

Table 21: Average rating for “It was easy to navigate around the page.”

Navigating the page by scrolling was easy for everyone, but was still deemed “ineffective”. The ease of navigation was markedly improved with the prototype. Six participants rated with strong agreement.

6.3.3.4 Understanding the Page Content and Structure

By the end of the session, I understood what information was available on the page.

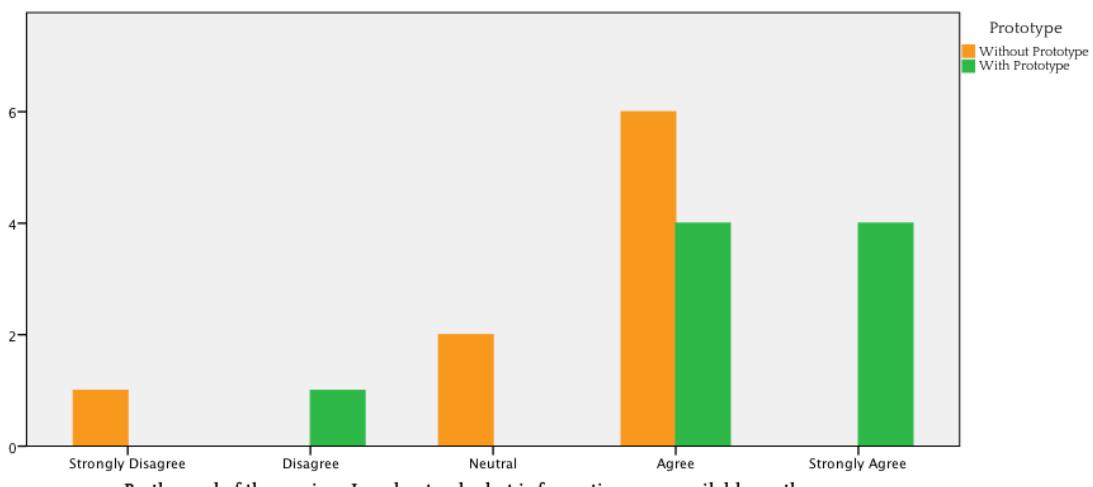


Figure 43: Questionnaire results for “By the end of the session, I understood what information was available on the page.”

	With Prototype	Without Prototype
By the end of the session, I understood what information was available on the page.	4.22	3.44

Table 22: Average rating for “By the end of the session, I understood what information was available on the page.”

By the end of the session, I understood how the page content was structured.

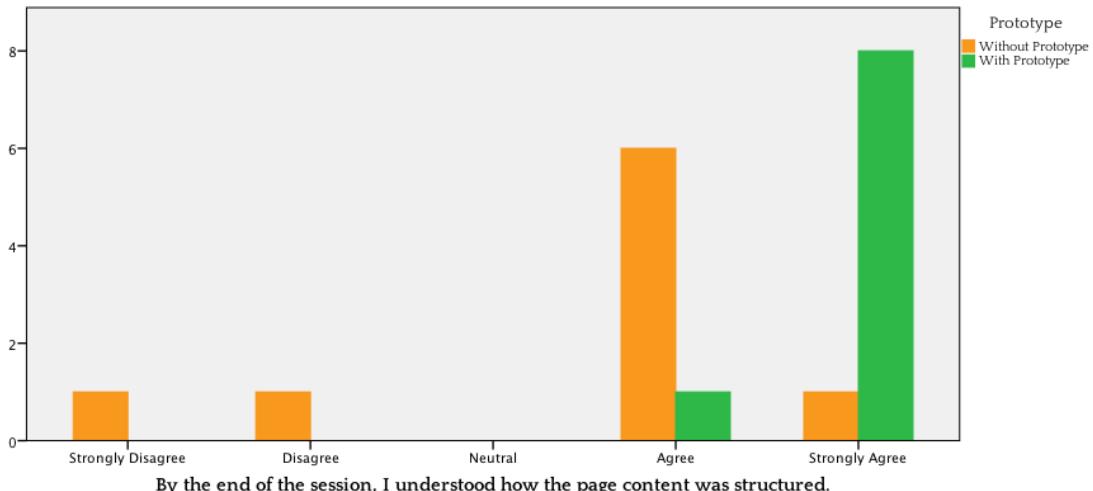


Figure 44: Questionnaire results for “By the end of the session, I understood how the page content was structured.”

	With Prototype	Without Prototype
By the end of the session, I understood how the page content was structured.	4.89	3.56

Table 23: Average rating for “By the end of the session, I understood how the page content was structured.”

Both statements were rated neutrally on average for the sessions without the prototype. Since the participants had to scroll through the page multiple times, they felt that they knew the basic structure and content.

For the sessions with the prototype, the participants responded very positively to the two statements. They could not recall all of the topics in the page but they still felt more confident since they had instant access to the overall topic list.

6.3.4 Prototype Usability

One of the main goals of this evaluation was to determine the usability of prototype and how well the participants could use the prototype to find information. The following two sections examine the usability of scrollbar and overview separately and then discuss the usability of the prototype in general.

6.3.4.1 Scrollbar

What does the scrollbar represent?

All the participants easily understood the function and purpose of the scrollbar by associating it with the desktop scrollbar. Most participants were able to estimate the length of page by the scrollbar and knew how to locate themselves on the page. However, a few participants did not notice the scrollbar right away. This may be due to the fact that scrollbars have all but disappeared on mobile devices.

What does the lines in the scrollbar track represent?

Only two participants noticed the lines and commented that they represent where new topics and sections begin in the page. When asked directly, other participants also concluded similarly and said the lines represent the headers and important bookmarks of the page.

Using the scrollbar

All the participants were familiar with using scrollbars on desktop and would use them the same way on mobile. Half the participants (#2, #3, #5, #6) also tried tapping on the scrollbar to jump to a different point in the page, especially when jumping to a far point like the footer.

Content hints in the scrollbar

All the participants were able to figure out that the content hints were headers of each sections. Two participants tried to click on these headers to make a jump to the sections.

6.3.4.2 Overview Mode

What is the function of the button?

“Overview” text is shown for ten seconds when the page has been loaded and then minimises itself into an icon in the bottom right corner. Two participant (#2, #7) noticed this while the page was loading and said that it will show the

overview of content. Other participants who did not see the “overview” text beside the icon still correctly guessed that the function is to show “table of contents”, “headers” or “index” of the page.

Two participants (#2, #5) thought that the button will launch a site menu or more options for the page. Once they saw what happens to the page after the button has been clicked, they were able to correctly deduce that the page has been turned into an overview with topics and categories.

Using the overview mode

All the participants found the overview mode to be easy to use and used it correctly on the first try. They would click on the heading to view content. A couple of participants (#3, #7) tried clicking on the arrow beside the heading. Addition of arrows to each heading may not have been necessary and could confuse the topic list with a type of accordion menu. Participant 9 wondered if the arrow indicated there is more to the heading.

To go back to the normal mode, everyone clicked on the same button. Two participants (#5, #8) tried using the “Back” button on the browser but made the correct action on the second try.

6.3.4.3 Using the Prototype

Everyone wound up using the overview mode to search for information. One participant (#4) tried using the scrollbar to view the content topics but used the overview mode in the end since she could not see all topics at once with the scrollbar.

The overview mode was frequently used to scan for topics and the participants found the navigation process to be much easier. The participants can still fail to complete a task if the topic headings and subheadings do not match their expectations. For example, several participants did not make connection between “Entry requirements” topic and visa information.

The original Rough Guide page already had usability issues by being overloaded with topics. Excessive content can cause fatigue, even on desktop. In the overview mode, several participants found the topic list to be too long to scan. It is not clear whether subheadings hindered or helped the information search process since subheadings made the topic list even longer. If the page does not have a good information architecture, the overview mode can be of little use since it is dependent on the page’s content.

To find out where they are within the page, the participants also relied on the

overview mode, rather than the scrollbar. Clicking on the headings reminded them where they were. If they scrolled too far, they used the overview mode again to get oriented on the page.

Overall, the overview mode was the most helpful functionality to look for specific piece of information.

6.3.4.4 Usability Problems without Prototype

There is one advantage to browsing without the prototype. Since the participants were actually viewing all the content as they scroll, they gained more context for the topics and were able to complete the tasks eventually.

However, overall user experience was negative even when the answers were found. Two main causes were fatigue caused by excessive scrolling and frustration from not knowing where to go. At the beginning of a session, they could not know what topics were available or where they are located. Even if they knew that the topic existed, they did not know where to go. For Thailand's second task, most participants noticed the visa information while scrolling for the first task. Despite this, they still could not remember which direction to go to find the topic again.

Since the participants cannot see all the topics at once, some never reached the right topic. For the third Egypt task, two participants (#5, #6) could not complete the task because they tried to find the answer from the top of the page. The answer was under a topic that was much farther down the page.

6.3.5 User Comments

The following comments are from the post-session questionnaire where participants were asked to provide feedback for the prototype.

At the beginning I thought the scrolling bar would be really useful to navigate around but in the end I didn't end up using it because the overview section was easier and quicker to find the desired topic. - #1

I was rating, not the navigation, but the information. Because I'll have to say all of them are five. Four or five. It's very easy. - #2

I liked the use of the overview but I wasn't sure which topics came under the info I needed. - #3

It was easier to navigate and find content with a menu or table of contents like in the previous one. - #4

Now that I saw the list and I understand that it's alphabetical, which again, to me, doesn't really make sense... But at least I can see it and I can understand it.

- #5

I think the structure is very nice. But... too many titles or topics. So I had to keep scrolling to see which topic. And sometimes, I'll misunderstand the size of the fonts. It's too similar to each other. So I wasn't sure which one is the title. - #6

It has more dynamic functions and features in it. So it gives more feedback, as well as more functionalities so you can jump around and search for things easier.

- #7

6.3.6 Evaluation Conclusions

The participants were able to learn to use the prototype very quickly and intuitively. Even when they were not able to complete the tasks, they still felt positive towards the overall experience since they had more control over the navigation.

The evaluation showed that the scrollbar's functionality does not lend itself very well to the given scenario, where the participants were looking for a specific piece of information. One major issue was that the participants were not able to view all the topics at once by using the scrollbar. On the other hand, the overview mode shows the entire content outline and helped the participants to navigate as well.

There are areas in which overview mode can still be improved:

- Several participants failed to complete tasks because they did not have context for the topics. How can the overview mode provide more context to users? Do subheadings help? How many levels of subheadings will help? What length of topic list will help users without exhausting them?
- One participant complained about not being able to distinguish headings and content. Should the overview mode use the web site's text styles or use its own with better visual text hierarchy? Would there be problems if the overview mode looked different from the original page?
- When subheadings were available under the main headings, a few participants only used the subheadings. Visualisation of the overview mode should be improved to communicate what headings contain more content.
- There is a need for an icon that is different from the icon used in mobile site menus. Designing a distinct icon that communicates content outlining will be challenging.

7 Reflections and Conclusions

The following sections discuss the overall project process, what has been achieved and how well the original objectives have been met. This chapter also discusses what could have been done differently, and what future research is possible regarding the prototype.

7.1 Objective Reviews

Objective one:

Review the usability problems with mobile web browsing, focusing on information-rich web sites. In addition, review how past and current research has addressed these issues.

This objective was completed by completing a literature review and a user study.

The literature review summarised the evolution of mobile technology, as well as past research and studies on small-screen usability issues. Various strategies and technologies for browsing the mobile web were also reviewed. Methods such as “Overview + Detail” were particularly helpful when concepts were being developed.

A user study was carried out to examine various usability problems that mobile users experience. The user study provided observable real-life data for the next phase of the project. Some of the issues experienced by the study participants were not observed by past research in literature review.

Objective two:

Design and develop a new solution to solve these usability problems.

The most challenging aspect of this objective was creating original solutions that have not been attempted before. Some concepts adapted elements from elsewhere, such as e-readers, desktop applications and video players. Other concepts were based on the capabilities and the physical form of mobile devices. Three different concepts were designed and refined further with low and high-fidelity wireframes.

User testing was conducted with high-fidelity wireframes to evaluate the usability of three concepts. Based on the results, one concept was successfully developed into an interactive prototype.

Objective three:

Evaluate the developed prototype to:

1. *review the usability of prototype.*
2. *compare the prototype with current mobile browsers, in terms of efficiency and user experience.*

The final evaluation was designed to compare the efficiency and the user satisfaction level between the current browsing method and the prototyped browsing method. The evaluation results also determined the usability problems of the prototype for further work.

All participants were able to quickly learn how to use the prototype. It was concluded that the overview mode was successful in helping users find information, while the scrollbar was hardly used. The measured metrics showed that the prototype improved both the completion-time and the user satisfaction level.

Objective four:

Review the evaluation results for further improvements and suggestions.

Observations and results from the final evaluation were used to suggest further improvements and work for the overview mode. The scrollbar prototype was not useful in the evaluation task scenarios and would need further testing with different types of browsing scenarios or alternate designs.

All objectives of the project have been met.

7.2 Reflections

Project plan

There were many different parts to complete for the project, especially during the design phase. Participant recruitment was needed at three different points of the timeline. The final evaluation plan had to be adjusted to account for the limited number of participants available. For the most part, the project was able to meet its original timeline.

Literature review

There has been much research on small-screen usability. Some of the research papers dated back further than the market introduction of smartphones and had to be sorted for relevance to today's technology. It was challenging to find

recent research on mobile usability issues. Online sources were more useful venue for information on today's technologies and trends. It was interesting to note that there was no research on usability issues with responsive web design. It is currently a very popular mobile web strategy but it utilises the single column technique with unresolved usability problems.

User study

The user study was able to confirm the usability issues found in past research. It also provided insights into how users deal with the issues. From the user study data, the project could have gone into a different direction at this point. The project could have researched mobile design guidelines to solve the usability issues. It was decided to pursue the original objective of designing a new browsing method. The observed problems in the user study were narrowed down to determine design goals.

Concept sketches

As part of the ideation process, the differences between mobile and desktop browsing were questioned. Most of these sketches were about achieving easier and faster navigation, and accommodating mobile scenarios such as walking. However, the concepts had to account for what was plausible to develop within the given timeline and resources.

Wireframing

Six different sets of low-fidelity wireframes were developed and three were chosen for high-fidelity designs. Generally, the design process should be more iterative with more user testing, but there was only one user testing period scheduled in the timeline. A few concepts had to be abandoned without testing.

User testing

The interactive nature of browsing was difficult to user test with static images. Some assumptions had to be made about whether users will have the same problems using an interactive prototype.

Development

Based on the user testing results, the final design was refined and additional functionality (the scrollbar's content hints) was added. Ideally, new functionality should have been user tested before being included in the prototype. However, no other user testing was scheduled during the development phase and subsequently it was left to be tested during the final evaluation.

At the beginning of the development phase, the Rough Guide web site was chosen for the development of the prototype. It would have been useful to develop with more than one web site, but compromises had to be made. The outlining algorithm was difficult to develop for every possible web site. Designing an accurate and semantic document outline algorithm could be a possible project on its own.

Development issues

There were several issues during the development phase:

- Touch sensitivity was a concern and the size of the UI elements were constantly being changed as codes were being written and tested.
- The prototype interfered with Safari's browser functionalities. There was already a scrollbar in the browser and the position of the overview button was problematic. Clicking the overview button can sometimes expand the toolbars in Safari browsers.
- There were too many sections in the Rough Guide page and the scrollbar content hints began to overlap, making it hard to see them.

Final evaluation

Limited responses to recruitment led to changing the evaluation from between-group to within-subjects experiment. One additional prototype was developed and different set of tasks were designed to conduct two sessions with each participant.

The sampling of the participants was not ideal as they were mostly recruited from Human-centred systems students. Only one participant could be considered a novice with three-months of experience with smartphones. The recruitment was expanded with remote sessions. The remote sessions had to be conducted with participants who owned an iPhone and this has reduced the pool of remote participants. Two remote sessions did work very well by reflecting the participant's iPhone screen onto the desktop.

Final evaluation browsing scenario

The chosen web site and the tasks were well-suited for measuring task completion times. Direct comparisons could be made between browsing with the prototype and browsing without the prototype. However, using only one web site meant the evaluation could only test one type of browsing scenario.

Final evaluation tasks

Several tasks were far more difficult than other tasks and produced some outlier data. This impacted the t-test results for task completion times. Difficulty of tasks was hard to predict before conducting the evaluation. Each task was worded to not give away the answer from the topic headings.

Data analysis

IBM's SPSS software was used to conduct a statistical analysis of the final evaluation data. It was initially challenging and had a steep learning curve to edit the data, generate graphs and conduct t-tests. Online resources for both SPSS and t-test tutorials were helpful.

7.3 What Could be Done Differently

Ideally, the design and the development process should be iterative with more user testing included. Unfortunately, additional user testing and design would have compromised the set project timeline. The project could have redesigned the methods and focus entirely on the design and development phase, with each new idea and functionality being user tested.

The project could have narrowed its focus during the design phase and develop only one concept to begin with. Instead six different wireframes were developed and this may have resulted in too many functionalities in the prototype. The participants only used the overview mode of the prototype to complete the evaluation tasks.

The user testing of high-fidelity wireframes resulted in too many issues being addressed. It would have been better for the prototype focus on what worked and refine the designs further.

7.4 Areas of Learning

The project provided an avenue to learn how to design and conduct evaluations. It was important to set definite goals and figure out how the evaluation can effectively achieve these goals.

Both quantitative and qualitative analysis of data was challenging to carry out initially. Extracting coding themes from the transcripts required many iterations and categorisations of the issues.

7.5 Further Work

The prototype should be considered first proof of concept. In addition to the

improvement suggestions made in the previous chapter's conclusion (6.3.6), following areas would benefit from further research:

- Develop guidelines for web authors to create semantic document outlines.
- Design a content outlining algorithm. Document outlining was the biggest challenge during the development phase.
- Investigate how the overview mode can be used with web sites that are not mobile optimised.
- Investigate alternate overview mode options. For example, the scrollbar and the overview mode can be combined into one function. Scrollbar headings cannot be seen all at once. This problem can be solved by allowing users to view all headings on click.
- Compare the overview mode with layered overview mode. Concepts with separate content outline layer were only tested with static images for this project.

7.6 Conclusion

Small screen usability has been researched over many years and many different solutions have been proposed. This project has contributed to the research by designing several new functionalities for the current mobile browsers. With the developed prototype, an empirical evaluation was conducted to compare the efficiency and the user experience of new browsing methods (the overview mode and the scrollbar) with the current browsing methods. The results have shown that the overview mode was successful in helping users to look for information in a long, narrow layout.

When parsing information on small screens, the most significant problem is that users are dependent on what they see on the screen. There is a limit to their short-term memory and a limit to how much information can be displayed on a small screen. The overview mode was successful in letting users see more of the content at once, as a summarised outline. It was also successful in helping users navigate a page easier and to know where they are on the page.

There are still more alternate designs to test and more opportunities for improvements. Developing an accurate and semantic document outline should be one of the first steps.

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