EVALUATING DIFFERENT MOBILE WEB NAVIGATION STYLES

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ABSTRACT

Web browsing is suffering from the problem of not showing information effectively and efficiently on a small screen. The main aim of this paper is to come up with a solution that will help to minimize this issue. We have compared three different styles and have conducted user study to come to a conclusion and analyze which style is better and solved the current issues. The first style that we have introduced is progressive browsing, it is designed with a perspective of what users want to see; the second style is list view, and is the most popular design; the third style is thumbnail, which incorporated the use of images and links. The results of the user study revealed that progressive browsing was least rated as compared to the other styles. There were many contributing factors that lead to this conclusion and the details are documented in this research paper.

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1. INTRODUCTION

We have all heard and used Internet over decades now. This started with browsing on the desktop and then with the advancement in technology the focus shifted to laptops. However to make things more easy the web is in consumers mobile devices. Web browsing is now available on cell phone and other small screen devices. Web Browsing on small screen is a relatively new concept but over a short period of time it has become a way of life. Consumers require information as they go. They do not wait to get to their desktops to get any immediate information but demand resource as they need. And with each passing day the process of attaining information is getting competitive. Web development companies and internet service providers are looking for ways to come up with the best ways of browsing the web pages on small screens so that the user does not have to do much work around and get information as prompt as they can. In order to surf web on small screen devices there are different navigation styles that have been widely used. These styles have also been evolved as the technology changes. In this competitive market it becomes very important and critical to analyze which style is more user-friendly than others and if a new style can be evolved to get information faster. A lot of study has gone into designing and researching various patterns or new styles.

Zheng [8] mentioned that the usage of web browsers on small screens has relatively increased and has become a major part of user interfaces for seeking information and browsing the Internet. We see the widespread usage of mobile devices for attaining any information at any time. Mobile devices have made it very easy and time saving for lot of users to get instant information. Seeing this constant growth we wanted to develop the easiest navigation style where user has control on the information they want to

seek. Jul and Furnas [17] summarized two major strategies to seek information on the web: searching and navigation. Searching is the process of "submitting a description of the object to a search engine which will return relevant content or information" [14]. Navigation is the action of "moving oneself sequentially around an environment seen so far" [14]. The use of these two strategies together helps the user to find relevant information from the web. Searching has attracted users, as it is an easy and quick way to find information. While navigation is still the essential way of getting useful information, as users need to navigate through the searched results to evaluate the relevance and usefulness of different search results. Also searching does not provide much help if the user is not sure of what he/she is looking for. For instance if the user is reading news they will usually navigate through the news to read the article they are interested in, rather than just searching the article. Another example of a similar scenario could be if a user wants to shop for laptops his/her search might be based on a particular brand preference but still he/she would want to navigate through all the available models before making a final decision. So navigation plays an important part in web searches, reading articles or browsing the web. In this study we have focused on how we can improve the navigation process on small screen devices and have compared three different navigational styles.

Navigating in information overloaded space is not an easy job, users often feel confused with massive amount of information available on the web and this problem is referred to as "getting lost" [16]. The "getting lost" problem gets even worst on small screen where usually all the information is not provided to make navigation easy. If information is provided it gets difficult to navigate and concentrate on what exactly the user is looking for. We have designed the progressive browsing navigation style keeping the

"getting lost" theory in mind, as there is less possibility for the users to get lost if the information is organized in a proper manner. Users can also get lost if they are not familiar with the website design or even if the information is buried deep in the site and cannot be located easily. To solve such problems on small screen devices good navigation style plays vital role in decreasing user's frustration. A good navigation design can decrease the problem of "getting lost" and can help in seeking information easily. According to Palmer [18] Navigation plays a key part in web usability, which studies the ease of use of the web applications and interfaces. Also according to Nicola, having control over the page with interface involves mutuality for the user where he feels control of the page he is surfing [17].

In this paper we will evaluate three different styles; two of them are commonly used styles: List View and Thumbnail. The third style is called the progressive browsing, which is designed to reduce the problems that users tend to face in most of the other styles. The major problems being: getting lost issue, lack of control on what information user wants to see, ease of use, sense of navigation and many more. The major benefit of progressive browsing is to provide control of what users want to see. To experiment this style we have conducted a medium sized user study and compared these three styles. The results are not very distinguishing as to which style is better than the other; however we did receive a positive perspective or feedback from users for progressive browsing. In the user study the participants had previous experience of browsing on small screens and had used the thumbnail and list view styles before. Progressive browsing was new to them hence they required some time to get used to the new style. We will discuss about all these three styles later in this paper.

2. LITERATURE REVIEW

2.1. Previous research

One of the main topics that previous research studies have expressed is that browsing web on mobile should be able to provide easier navigation. Since these days' users spend a lot of time browsing on small screens and the information they seek is usually urgent or critical, it becomes important that navigation is as easy as possible. If navigation is properly designed, even the large and complicated applications become easier to navigate. To make navigation simpler it is essential that the users should never be lost in the application and they should always feel in control by knowing what they are doing and accomplish the task they want to do at the earliest possible and by avoiding extra clicks [25]. We have developed progressive browsing keeping these issues in mind.

Early researches have suggested that reading, performing tasks or navigating on small screens is challenging. The user experience is not pleasing because the appearance and availability of information is not as real as experienced in the desktop environment. This is mainly because the size of the desktop screen is large and information is readily available on one page and is clear. There are many problems while browsing web on mobile devices which are developed for PC's or large screens [24]. The need to develop a mobile version of the websites has become very important and many companies are following this trend of having a website for small screens. In order to design a successful mobile version with the least minimum errors or issues there also arises a need to research more on how to improve the navigational style of these websites.

Carrying out tasks on mobile web browsers will place heavy intellectual demands on the user's short-term memory. With a small screen size, the user will initially struggle in acquiring the information and will have difficulty placing information within the existing mental model as they progress through the information [1]. Buchanan also found out small screen users made many more incorrect selections while navigating the web pages and were less enthusiastic to browse deeply into the information [2]. Similarly, usability tests on narrow layout browsing carried out by Roto found that reading text on mobile phone is easy and scrolling down to find the content is also simple, but he identified several other usability problems [21]. Hence these researches suggest the clear necessity of developments and discoveries to make web pages easily presentable on the small screens of mobile phones and that is what motivates us to compare and improve the navigation styles on small screen devices.

2.2. Related work

Some more studies have been made to analyze different navigation styles on mobile version web pages. For example, Costa and colleagues [5] compared four different navigation styles: Link, Scroll, Folio and Search on a mobile screen. According to their experiment, Links are more efficient and effective type of navigation. In our study we have included link which is similar to our list view style and Folio similar to our thumbnail, but we are comparing it with a new navigation design i.e. progressive browsing. Also Costa and Silva [5] focused on evaluating learn-ability and flexibility, whereas we are considering other criteria’s than those two like usability, ease of learn, satisfaction, memory and interest.

Robbins, Lee & Fernandez [20] wanted to provide an interface paradigm where users could easily perform the most common mobile scenarios through good navigation interactions, so they came up with an application called TapGlance. The main goal of this application was to provide an overview of the items the user would like to see at a glance. Their design was based on tile structure and they divided everything in tiles with images and had less text. This kind of design would work for shopping websites or playing music but for browsing websites like news, blogs or finding information this design would not be of much benefit. We also provided a similar kind of navigation style: progressive browsing where users could glance at the web page and can see the information he is interested in. If the user wants to read more, they can click on it and have access to more information rather than providing all the information at once where user gets lost or can get confused which is currently an issues for most of the web pages [12].

Burigat and Colleagues [4] focus on three navigation techniques for browsing web on large screens: First technique uses panning by dragging the portion of information vertically or horizontally; the second technique provides an overview of box implementation with the panning and zooming features, the overview is displayed as a small thumbnail of the page at the bottom right corner of the page; the last technique displays overview and the view finder which highlights the portion of space displayed in the detail view. Their results show that the second technique is more useful as it is important to quickly determine where the user is located. This study only focuses on zoom based web pages whereas we are concentrating on mobile based web pages which are easy to read and navigate without performing actions like zoom and slide as users get lost by doing so in small screen devices.

Gutwin and Fedak [9] compare three techniques for using large interface for small screens: panning, two-level zoom and fisheye view. Panning implements the sliding window used by desktop web browsers; Two-level zoom provides users with two different magnifications: an overview showing entire screen as reduced form and a zoomed view which behaved in a same way as panning; the Fisheye view presents an overview of the entire large screen, it is like two-level zoom but also includes a detailed region into the same view. According to their experiment users liked two-level zoom more. This study focuses on desktop web pages and concentrates on panning and zooming to make navigation easier whereas on mobile browsing using such techniques does not improve navigation for users and in fact may have a negative impact on usability.

Rabin and McCathieNevile recommend not to use too many links on a page, but to make sure that each page of the site is easily reachable [19]. Thus, the stability of depth and breadth of the web page is particularly important for the usability of an information structure [8], and we have designed the progressive browsing keeping this theory as our base that we need some stability in the depth of the links. Some of the recent studies carried out tests on Scrolling vs. Pagination to test for user preferred method of navigation on small screens indicate that users prefer scrolling to pagination [19] but some indicate the contrary and so it again highlights the need for more research in this area. Also we have chosen scrolling for our article than pagination.

Kaikkonen and Roto [15] found that the ideal length of a page depends on the page type that is, “an interactive page has to be much shorter than the information page”. In their test, twenty screens were fine for text page and six screens were considered long for an interactive page. In their

usability study, users did not prefer information split into too many pages and the users evidently favored a compressed list of items on one page. This analysis helped us in designing progressive browsing style better. All the major headings are presented on one page to the users rather than on many pages. Similarly, the results of Griller's study lead to the conclusion that in general a designer should have good reasons to use multiple pages method instead of a scrolling one [7]. Chaudry also mentioned in his design recommendations that sites should have scroll bars and hybrid navigation structure that combines linear navigation with the navigation bar [3].

These days, with many different varieties of mobiles, and the demand of better methods the scroll control mechanism is refined, so the size of the document being displayed within a scrollable page does not need to be inhibited [13]. Users quickly learn how to scroll and that scrolling is necessary, so avoiding scrolling is not recommended at the cost of adding pages [2]. Each page should contain as much relevant information as it can fit within its capacity. But the down side to this is dependent upon the bandwidth connection, the larger size pages may take longer to load and for some users' longer page jumbled with lots of information without some clear picturing of the content on small-screen mobile phones might be difficult to browse through. That is another reason we introduced the progressive browsing style, which does not present all the information at once to the users, so it takes less bandwidth or time to load the page. This will also provide users with control on what information they want to see on the screen. Also in the study of Giller, the sum of the data and the user statements gathered during the qualitative interviews show the trend that users prefer deep structures to broad ones although broad ones lead to faster search performances and the most striking reason is the more concise arrangement of items [7]. The experiment presented by Geven, shows that the

most effective hierarchy for use with mobile devices is one with only four to eight items on each level and "it is better to order in a hierarchy with more levels than in a hierarchy with more items per level" [6]. We have taken this suggestion from Gaven and have applied to our progressive browsing style.

As mentioned above, previous research studies show the most important characteristic of mobile web browsing that is providing easier navigation. If the navigation is properly designed, even complicated applications are easily steerable. The most significant thing to remember when developing an application's navigation is that the user should never become lost in the application [25]. Above all, on small screen devices, it is more important that users can freely move, focusing on their task in an effective and less time consuming manner, without having to worry about the site's structure. This is the main aim and motivation for our study and all the styles are designed considering the above recommendations from the research papers.

3. DESIGN OVERVIEW

This section provides you an overview of the three different navigation styles evaluated in this paper. We have mocked all the three styles in the form of a news website showing random news in all categories. All three web pages are created using HTML and Java Script and are given CNN styles to make it look like a real web page. They are also hosted to a server where anyone can browse them using any browser with internet connection.

3.1. List view

This is the most commonly used navigation style seen in most of the websites these days. All three levels are shown on one page together. The first level is the heading or category. In the example below (Figure 1) it is US, the second level is sub-heading which is the headline of the news in the example provided below (Figure 1) and the third layer is the main content or summary which is description of the news and if the user wants to read the full article they need to click on the link to open that article on a new page (Appendix A – Figure A6). All these three levels of information are shown at one place to the user and if the user wants to see more they need to scroll down to see more information. The main drawback of such web pages is that if there is too much data provided, it gets difficult for the users to scroll down and find the information they are looking for. The screen shot of mock up web page that we have developed for user study is displayed in Figure 1 & Figure 2 below.

Figure 1. List view

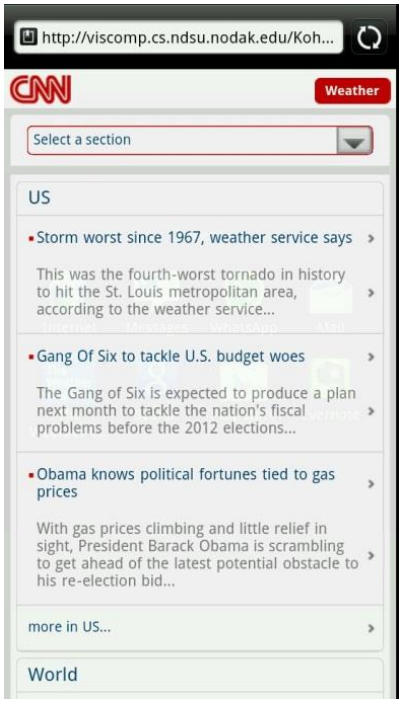
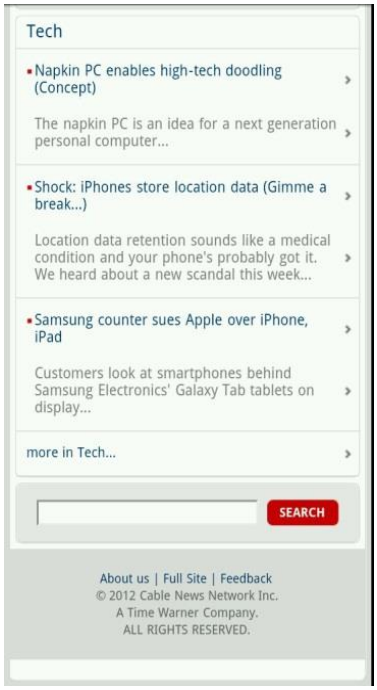


Figure 2. List view (continued)

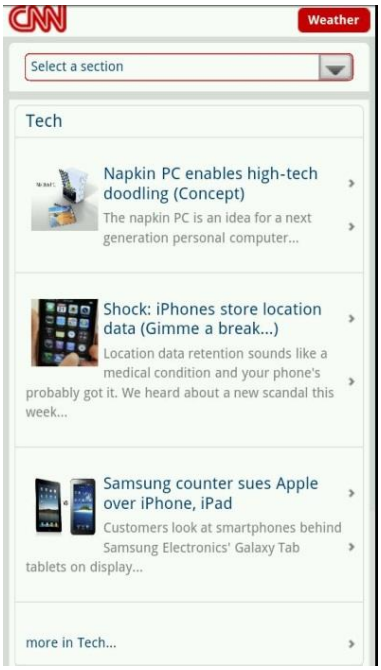


3.2. Thumbnail

This navigation style focuses on images more than text, like the first page (Figure 3) contains headings or categories with big thumbnails or images, then by clicking the image or category another page opens (Figure 4) with sub-categories and an abstract or summary of the article, this page contains the main image of the article as well. Then if the user wants to read more about the article he can click on the article to read it just like list view (Appendix A - Figure A6). The main setback of such design is that there are a lot of images so if there are more text, the page looks cramped. Also we need to click first and go to few different pages which take more time to load and user might get the feeling on "getting lost".

Figure 3. Thumbnail (main page)

Figure 4. Thumbnail (second page)



3.3. Progressive browsing

This is the design that we have proposed and the main purpose of this navigation style is to give users control of what they want to read or see in a website. We have named it progressive browsing because the definition of progressive is: happening or developing gradually or in stages; proceeding step by step. And that is how user's experience surfing on this style i.e. browsing each category step by step and gradually. It offers a highlight of the article, so that finding any information gets easier (effectively) and faster (efficiently) for the users. Another major objective of progressive browsing style is to provide control of what users want to see without the feeling of "getting lost". This style also has three levels like the previous two designs. First being the heading, if a user is interested in a particular heading they can click it to expand the sub

headings in that category, and if user is interested in particular news they can click on the sub-heading to expand further and display the summary of the news. In Figure 5, the categories of the news web site are displayed. Figure 6 displays the expanded version of headings. The sub-heading is shown by clicking "Tech" that further expands the category (in Figure 6). Furthermore if the news article for instance "Napkin PC enables hi-tech doodling" is clicked, the news article will be displayed in a different page (Appendix A - Figure A6). This style allows user to have complete control in what they want to read rather than providing all the information at once, avoiding any confusion for the user.

Some of the other advantages of this design are, that the time taken to load the page initially is less as we are not rendering everything on the first page, if the user is interested in a particular article they can read further by clicking on the article and then the page loads.

Figure 5. Progressive (collapsed)

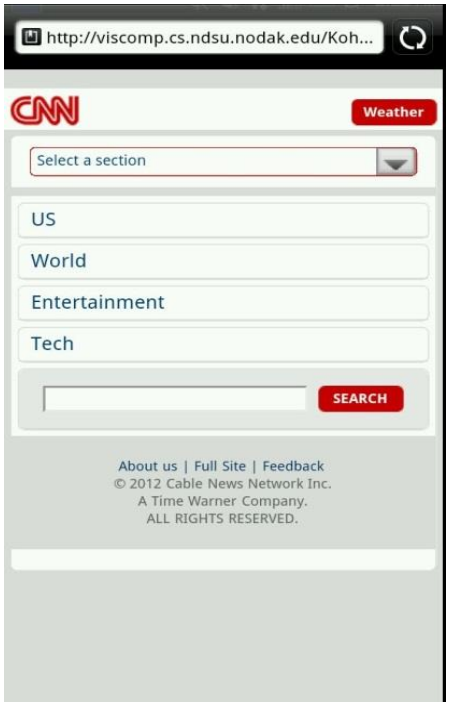
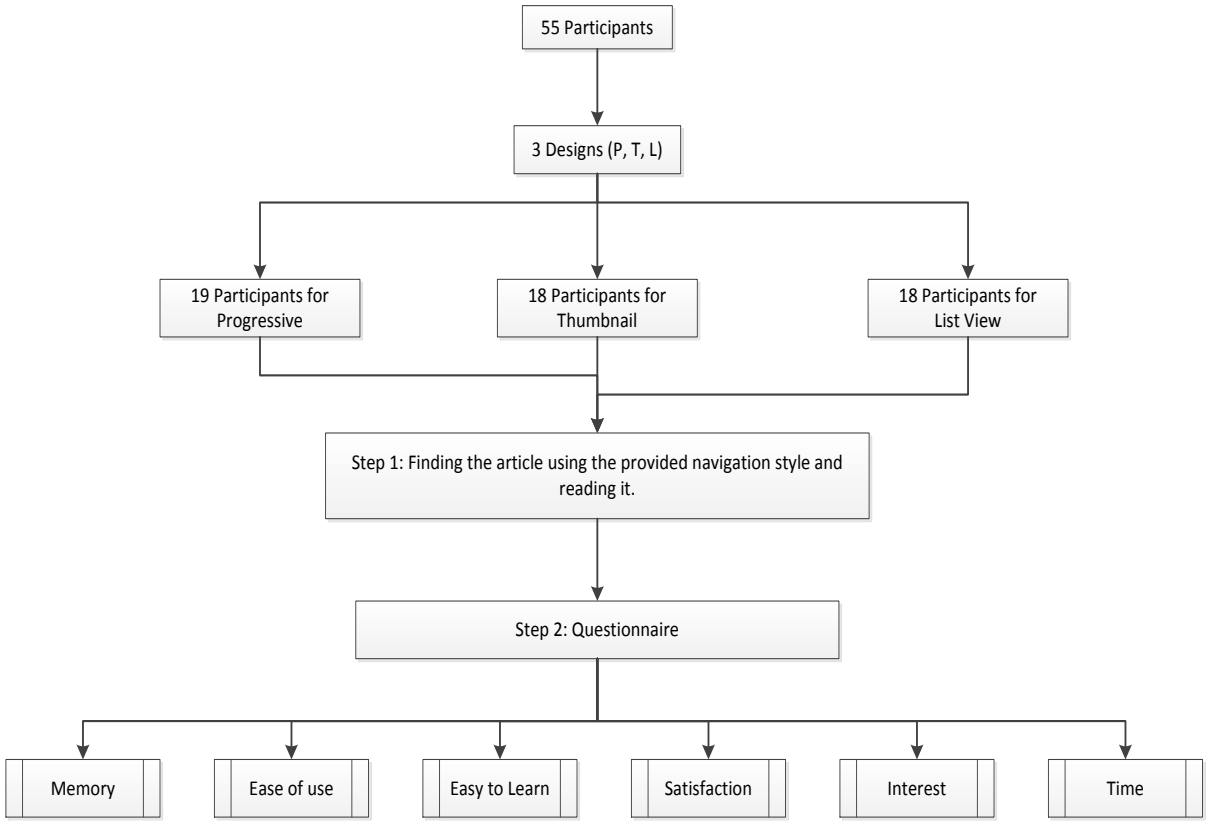


Figure 6. Progressive (expanded)

4. USER STUDY DESIGN

The user study was conducted in a controlled laboratory environment to allow participants perform the task on mobile device browser.

Figure 7. User study structure



The diagram above (Figure 7) shows the structure of the survey. There were 55 participants in total, who participated in the study, and each participant was given 1 design to evaluate and that participant was not shown the other two designs. The survey was divided in two tasks; first task was to find an article using the provided navigation style so that the user gets familiar with the design. Then the second task was to fill out a questionnaire based on task one.

4.1. Equipment

For the study Apple iPod touch was used, with the screen size of 3.5 inches (960 x 640 pixels), pixel resolution of 326 pixels per inch. The phone had colorful graphics and imaging capability. It also had a multi touch display, the browser used to display the mocked up websites was Safari [11].

4.2. Procedure

Participants were given instructions about how to use the phone so that there was no confusion or problem because of not being able to operate the phone. Then the participants were briefly introduced to the procedure of the study and were told that: "In this study you will be asked to read an article on a mobile device. Then you will be asked to complete a survey. Thank you for your time and participation".

After the introduction each participant was given a voluntary consent form to sign and a number in the order, which had P, L or T at the end. P was for progressive browsing or collapsing, L was for list view and T was for thumbnail.

Each participant was then stationed behind a view blocker (if there were more than 1 participant in a room) with the phone. The person who was conducting the study explained the user how to use the menu options and gave a brief introduction about the style and presented a demonstration of what they had to do. For the demonstration a sample test was used. After the demonstration was over, the users were asked if they had any questions about

the study or procedure. A stop watch was given to every user to note the time user took to read the article. They were explained how to use the stopwatch and were also told to start the timer when they begin to read the article, and stop the timer when they finished reading.

After setting up the users, explaining the procedure and providing the demonstration users started the study. All the participants were also provided with a slip, which mentioned what they had to search on the web page. The participants had to search the article and then read it to answer few memory questions. Participants also measured the time it took them to read the article and noted that on the questionnaire. Then they completed 36-item questionnaire after browsing in their respective navigation style.

4.3. Participants

Fifty-five undergraduate and post-graduate students from North Dakota State University took part in this study. The age of participants varied from 18 to 26 years and the average age was 20.24. Twenty users were females and thirty-five were males (see Figure A5).

All the participants were from different grade, around 44% of them were freshmen, 22% were seniors and others were from junior, sophomore or graduate grade (see Figure A1 for more details). The majority of participants reported their race as white (76%), 18% reported as Asians and 2% reported they were Hispanic, African American and others each (see Figure A2).

Out of fifty five, 41 participants used touch screen devices every day, five of them used several times a week, three used several times a month, one used several times a year and there were 5 who had never used touch screen devices before. So 91% of participants had used smart phones before (see Figure A3).

A question was asked whether participants browse the Internet using their smart phone devices. Twenty nine of them said they do it every day, eleven said they do it several times a week, four said several times a month, another four said several times a year and there were seven users who had never used their phones for browsing the internet. So around 87% of participants had browsed Internet and rest 13% had never browsed anything (see Figure A4).

5. USER PERFORMANCE

5.1. Step 1: Reading the article

The first step was to navigate the article mentioned to the user by exploring the browsing style so that user could use the style and then they had to read the article after finding it. Also before starting to read the article, users had to start the timer to note the time they took in reading the article. After reading the article users were provided with a questionnaire.

5.2. Step 2: Questionnaire

The questionnaire was divided in four sections: First section included memory questions to check if the user was paying attention in reading the article and it also included few simple multiple choice questions based on the article they read. The second section had 22 rating questions with ratings from 1 to 5, 1 being strongly disagree and 5 being strongly agree. Those questions were based on three measures: Ease of use (10 questions), Easy to learn (5 questions) and satisfaction based (7 questions). The third section was to see the overall attitude of users towards the navigation style. The fourth section had 6 questions on personal information like age, sex, ethnicity, and academic status and how comfortable user was in using touch screen device and browsing Internet. The results of the questionnaire are analyzed in next section and the questionnaire is in appendix B.

6. DATA ANALYSIS AND RESULTS

The reason the questionnaire was categorized in different perspectives, was because we wanted to analyze the results from all different angles to get the best results. The goal of the study was to reach to a conclusion that would tell us if progressive browsing was lacking or would require enhancement. We used IBM SPSS statistics software to analyze data and create charts. A one way analysis of variance (ANOVA) was carried out with the data collected from the user study to compare different navigational designs.

We divided the user study results into six different dimensions to analyze the data and they are briefly defined below:

I. Memory: We used recall and recognition memory to capture perceptual bandwidth, in this study to check if users were paying attention to the design of the navigational style or were just skimming through it and going to the next step.

II. Ease of Use: This measures the degree to which users believe that using a navigational style would be free of effort and would enhance the user performance. It also looks at the elegance and clarity with which the interaction of a style is designed.

III. Ease to learn: This perspective helps to know if the users understand the design easily or not and was the user's action predictable.

IV. Satisfaction: It measures the opinion and acceptance level of user about a specific design.

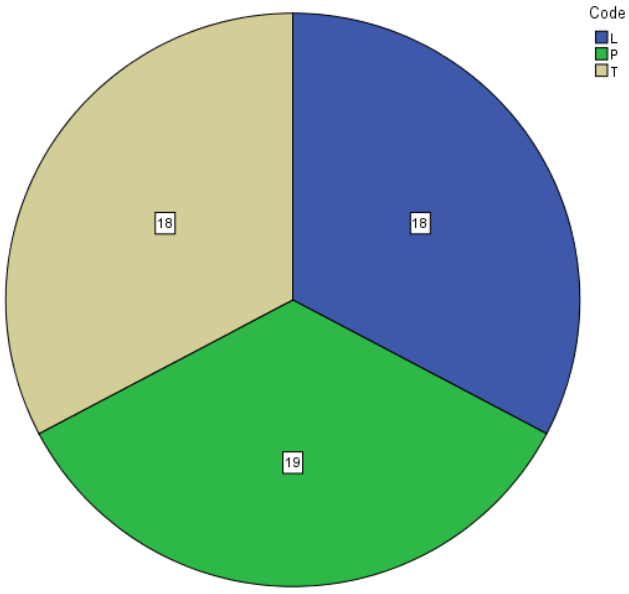
V. Interest: This measures the attitude, liking, interest and behavior of users towards the navigational design.

VI. Time: This compares if the navigational design was faster in finding the information the user is looking for.

6.1. Number of participants

In total 55 users participated in the user study. For list view and thumbnail, 18 participants evaluated and for progressive browsing total of 19 participants evaluated the design. The pie chart below (Figure 8) displays the number of participants for each design.

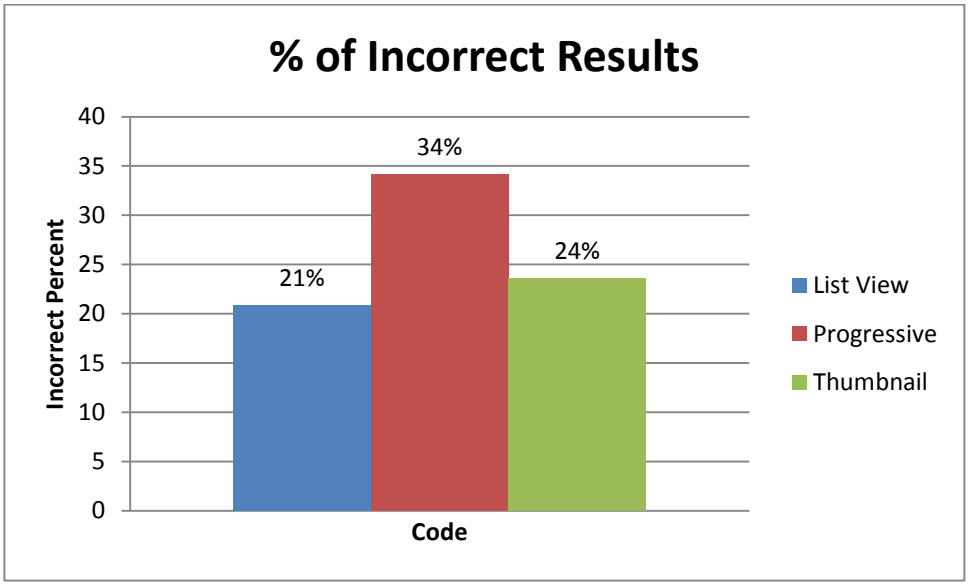
Figure 8. Number of participants



6.2. Memory

There were 4 questions asked to check the memory of users and to have an idea if users did pay attention to the design and explored the navigation style. The results displayed below (Figure 9) in a bar graph are in percent of incorrect answers. So on an average of all 4 questions for P, 34% of users answered it wrong as compared to L where users answered the questions wrong only 21% and for T they answered wrong 24% of the time. So for progressive browsing, 34% of the users have answered the memory questions incorrectly which is higher as compared with other two designs. There could be many reasons behind this, may be the users were paying more attention to the new design and did not read the article.

Figure 9. Memory



6.3. Ease of use

In this section we are comparing which design is easier to use as it is the most essential attribute that a web page should have. We asked 11 questions that reflected this attribute from the users and have calculated the mean and standard deviation using SPSS. From the results (in table 1) it looks like P has the lowest mean as compared with the other two designs and the standard deviation is 76.5 % (The standard deviation gives an idea of how close the entire set of data is to the average value). ANOVA showed that there was no significant difference between the 3 designs $F(2,52) = 0.5$, $p=0.61$.

The reason for this result could be that for users this design is a new design so there is some learning curve which users have to go through and the other two designs are one of the most commonly used designs so users do not need any learning or getting used to them.

Table 1. Ease of use

Descriptive Statistics

Code	Mean	Std. Deviation	N
List View	4.18	.965	198
Progressive	4.03	.765	209
Thumbnail	4.32	.916	198
Total	4.18	.891	605

6.4. Ease to learn

We asked users 5 questions that reflect how easy the design was to learn and the results show that P was more difficult to learn than other two. Based on the table below (Table 2) where we can see that P has a mean of 4.29 which is lower than the mean of L having 4.43 and T with a mean of 4.57. If we look at the standard deviation of P which is 68.9%, it looks like some users did find progressive browsing to be easy to learn, also no significant difference was found between the three when we look at the results of ANOVA: $F(2,52) = 0.65$, $p=0.53$.

We were expecting to have a low number in this category because of the fact that progressive browsing is a new design as compared with other two and given that there would be some learning time associated with this. But we think after the learning curve is over, this style has a potential to provide some great benefits on the table.

Table 2. Ease to learn

Descriptive Statistics

Code	Mean	Std. Deviation	N
List View	4.43	.784	72
Progressive	4.29	.689	76
Thumbnail	4.57	.766	72
Total	4.43	.752	220

6.5. Satisfaction

We asked 7 questions to measure the satisfaction level of users for each given designs. User satisfaction is one of the important measures of usability and is perceived to be the reason for success of any kind of interface. The results in the table below (Table 3) show that on average users rated P the least as compared with other two and the reason for this rating could be because they were exposed to this design for the first time and it took some time to figure out way the design works. P has the lowest mean on 3.88 but if we look at ANOVA results ($F(2,52) = 0.13$, $p=0.88$) there is no significant difference which shows that progressive browsing was not completely disliked by the users. For users to be satisfied with the design, they need to understand the design completely which was lacking in this study as users did not focus much on the characteristics of design.

Table 3: Satisfaction

Descriptive Statistics

Code	Mean	Std. Deviation	N
List View	3.92	.977	126
Progressive	3.88	.853	133
Thumbnail	4.03	.920	126
Total	3.94	.917	385

6.6. Interest

We asked users to rate four attributes that reflect the interest, attitude and behavior of the users in the questionnaire. The results show that users thought P was interesting than other two as displayed in the table below (Table 4). This is another positive sign that shows there is opportunity for this design to grow more with some improvements and learning time. But the results again don't show a significant difference when we look at ANOVA $F(2,52) = 0.95$, $p=0.39$. It is known that if users are finding a design interesting, they will tend to visit that more often than other designs which they perceive as less interesting, simple or boring. If we compare the numbers, P has a mean of 4.08 which is relatively higher than the other two and the standard deviation of other two is high as well which means most users did not find the List vies and thumbnail as interesting as compared to Progressive.

Table 4. Interest

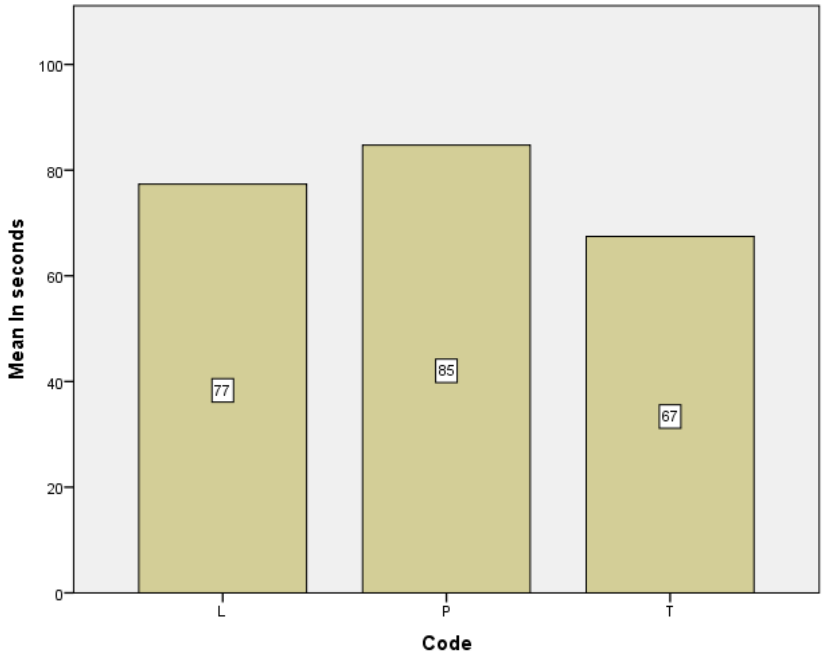
Descriptive Statistics

Code	Mean	Std. Deviation	N
List View	3.69	.959	72
Progressive	4.08	.813	76
Thumbnail	3.78	.938	72
Total	3.85	.915	220

6.7. Time

Users took more time in progressive browsing (on an average 85 sec) to find the article as compared to the other styles as shown in the graph below (Figure 10). The time is in seconds and average of the results is calculated. This was also expected as users need to click more to reach to the destination and also they might have taken some time to learn the design as compared with other designs where all the information is available on one page. But if we look at the time difference, on an average it only took 8 seconds more for users to find the information in progressive browsing as compared to list view. Taking this into consideration the clicking time required in progressive browsing is not as much as scrolling in list view.

Figure 10. Time



7. CONCLUSION

Technology today has given a new shape and idea to the way we saw the world earlier. Everything we see around is all technology. With the advent of mobile devices and wireless Internet services, web browsing has become very popular. Laptops and desktops have their own significance but in the fast pace technology era people move and work around the Internet on their smart cellular devices. They need not log on to their laptops anymore to get information. All the information is available to them at their convenience and at any given time and hassle free. The small screen web browsing has made life so simple for the consumer that users can access any information at any time. It becomes very essential that if the consumer is so habitual to these devices than the devices should be designed as user friendly as possible. They should allow the consumer/user to get prompt and accurate information. Any kind of lack of functionality or delayed information can make the user frustrated or even slow down the business of a user who works around his/her cellphone web page on an hourly basis. For instance an investor, who needs to invest in the stock market, needs to get the latest stock news as needed without any delay. The way the user attains information from these small web screens is very crucial. No one wants to get in it the harder way and wants to get the desired information as easily as possible.

This paper represents and discusses three different Navigation styles. The 2 existing styles – list view and thumbnail are the ones that exist and are commonly used by all but even these two designs have their own shortcomings. In order to deal or get away with this drawback a new design was created called the “progressive browsing”. This design has given a way to get rid of two major issues that were seen in the list view and thumbnail design. These two issues are majorly:

- "Getting lost" issue faced by the user
- "Lack of not having complete control over the navigation page"

A user study was conducted to reach to a conclusion about the effectiveness of the three styles.

From our user study, there were some questions asked to the participants based on whether they feel they have control over the web page or not. For example, one of the questions was: "The browsing style works the way I want" (refer to Appendix B – Questionnaire, Section II, question 19). On an average for this category, users rated progressive browsing 4 out of 5 (Section 6, Table 3). And according to Nicola, he has presented that it is very important for users to have control over the page for a navigation design to succeed [17]. By looking at the result, users did agree (rating 4 represents agree) that they were in control of the web page.

In the questionnaire, we asked participants around 11 questions (refer to Appendix B – Questionnaire, Section II, Questions 1 to 11) to find out if they actually feel that progressive browsing was easy to use or not. On an average, users rated 4 out of 5 (Section 6, Table 1). Considering the fact the progressive browsing was a new design for all the participants and no or very limited training was provided to the participants the average rating of 4 seems to be good. Some of the essential features of progressive browsing are collapsing of headers, categories and sub-categories which are very similar to what Smith showed in his paper that collapsing pages, different sections or categorization reduces the amount spent on scrolling on a website and makes the web page easy to use [22]. Users did not explore progressive browsing design much so we think after improving the

questionnaire where they get more opportunities and time to browse the design, there is good possibility of having a higher rating in this section.

We did see some positive perspective of users in one of the categories where progressive browsing aced in comparison to the other designs. It is the interest category of the user study. This category measured the attitude, liking, interest and behavior of the users towards navigation designs. Progressive browsing had an average of 4.10 as compared to the other two where the average was around 3.70 (Section 6, Table 4). This is an indication that with some improvisation in the design and survey, there is definitely a potential for progressive browsing style to help the users browse more efficiently on small screen devices.

We have created a comparison table (Table 5) to show which design is better than the other in the particular field. In the table below (Table 5), 1 represents highest and 3 represents the lowest mean in that particular field. If we see the overall comparison, according to the table and data collected Thumbnail is the most liked design, then is List view and then Progressive. We have discussed the reasons and analysis in detail below.

Table 5. Comparison of all 3 designs

	Memory	Ease of Use	Ease to Learn	Satisfaction	Interest	Time
Progressive	3	3	3	3	1	3
Thumbnail	2	1	1	1	2	1
List view	1	2	2	2	3	2

As stated that the results are not significantly different, one might feel that progressive browsing style is not the best proposal. But we need to consider a lot of reasons and contributing factors that have led to a lesser score as anticipated. One reason is that the mocked up web pages used for the study were kept simple as less news was shown as compared to real life news website where a lot of information or news is displayed with other advertisements. Therefore, in our future studies we will investigate with the actual web pages where there will be much more information on the page. So that the user can experience that progressive browsing can be helpful in filtering data the user is interested in. This can be really helpful where there is large amount of data to get confused or get lost easily. We also noticed that progressive browsing did not depict a higher result in usability and user-friendliness categories as compared to thumbnail and list. One of the reasons for this could be that progressive browsing is a new design so users are not used to such an interface whereas the other two are widely used designs and as already stated, 91% (Appendix A, Figure A1) of the participants had previously browsed websites on a mobile browser so they are used to the usual designs of the websites and they were not comfortable with this new design. We need to keep this in mind that adapting to new design and being comfortable to use it definitely takes some time.

The other reason for not having a significant result is because of the questionnaire, we should focus more on the design rather than the content and rational of the user. We feel that a comparison section (comparison of all three designs) in the questionnaire could be very helpful in getting better and accurate results. Every user has their own perspective and if the users were asked to compare different styles with progressive browsing, the results will be more focused and accurate as the user would have realized and felt the difference in browsing the web page. Instead of asking

questions on the article, we should ask questions on the navigational design itself. Also progressive browsing design requires further research and improvement as the more we worked on it we realized that there was a tendency for users to get lost. For example: If a user is going deep into a section they can get confused in which section they are. We do realize that more work needs to be done about certain aspects. But we also have confidence that after these improvements, progressive browsing has good potential in solving some of the browsing issues faced these days.

We have collected some feedback form the questionnaire in the comments section and identified some issues that will help us improve progressive browsing design. Some participants commented that adding images and icons to categories would help indicate the different sections more clearly. Then a user noticed that it is difficult to know on which section they currently are if they go deep into particular news. To solve this we can have sections or categories color coded and also has a back or up link so that users could go back in the section at any point with scrolling. This change should minimize the getting lost factor even more. Other users stated that they needed some more time to learn and understand the design better before analyzing it, which we think is really important for users so they can provide a better analysis of the design.

The progressive browsing definitely has an opportunity in future, as the user study results were not against the design, we need to make some further improvements in the user study questions and make participants focus more on the design. We do need to make some more changes in the progressive browsing design like adding tool tips to explain the functions for new users, making the links more color coded and provide some additional features that have been discussed in section 8.

There were three main findings which we observed from the study that can be used in designing a good navigation style for mobile web browsing:

- Use limited screen space efficiently by not displaying too much information. Overloading web page with text from beginning might confuse users. Also in pages with too much text makes users get lost in the pile of information available. All of this can be avoided by using collapsing method as users can choose what information they want to read and the presentation of data gets more organized. Users are also not overwhelmed from the time they open the page, as it looks well organized and not cluttered. The getting lost factor gets minimized in such a design because user will know on which section or part of the page they are in.

- Provide users with interfaces that offer control on what information they are interested in seeing or reading. This is important to have in small screen as users think they have lost control over the page because of the fact that very limited part of the page is visible to users at a time. Whereas in the desktop browsers, the screen size is big so users feel they have more control on information they are interested in as they can see a lot of information or page at a time. By collapsing related information together for small screens, users can see more headings or categories at a time and they can concentrate on the information they are interested in. This will also make searching and navigating for information much faster as they do not have to scroll thru a lot of information.

- Adapt the three level designs for websites where level one is table of content or categories; level two is summary of article or sub-category; and level three is the actual article or description. By following this hierarchy in small screen web pages, the information provided will look much more organized and easier to find for users. If any of those levels are missing, users will have a hard time to find the information they are looking for. For instance if there is no category in a news web page, users will not know if the news is a political news or a news related to technology. Similarly if the second level is missing for example in a shopping website where the category of books (first level) is available but it is then not divided by sub-categories (second level) and user is looking to purchase books related to computer science; it will get really chaotic for them to search for the particular book they are interested in. So essentially the mobile websites should follow at least a three levels or higher hierarch in there web pages.

8. FUTURE WORK

In future, we need to improve the questionnaire design and focus more on the navigational design instead of users rational by having more tasks to be performed on the navigation style rather than reading article. To check the actual time comparison we should note the time and number of clicks used by participants to find an article, number of clicks will help us determine if users were able to find what they were looking for in efficient manner or not. We also should show users all three designs so that users can compare which design was easier to find an article and to focus on information they were looking for, by this comparison it will be clear as to which design users prefer more when compared with other designs and could ask questions to users based on all three styles so that the result will be more accurate as to which one the users liked more when compared with other styles. A better understanding and the comfort level of participants towards the design should be focused by giving more time to the users to browse the design or may be a small introduction of each design might help users understand it better. As the browsing of websites on small screens is increasing really fast, there have emerged more widely used navigational designs so re-evaluating and considering the new designs with progressive browsing also needs to be done. In this study we have focused mainly on news website designs and 3 level hierarchies, in future we should also consider other fields like shopping, blog websites, and all to make sure progressive browsing works well with them. More participants can be used in the study as well to show higher significant results and differences between designs.

There is also room to improve progressive browsing style by combining some more techniques like adding images to the headings or using different color backgrounds and icons to represent the section so that user’s do not

get lost while reading an article. Instead of mock up news website, we can use real website pages with more data and ads as this would depict the real world scenario rather than just showing less data with no ads which can make the list view and thumbnail look less cluttered as full information is not shown.

Overall we think there is room for improvement in both questionnaire and the styles. Also the results were not significantly against progressive browsing so with improvement there is a good chance that the progressive browsing will show favorable results.

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APPENDIX A. CHARTS

Figure A1. Academic status

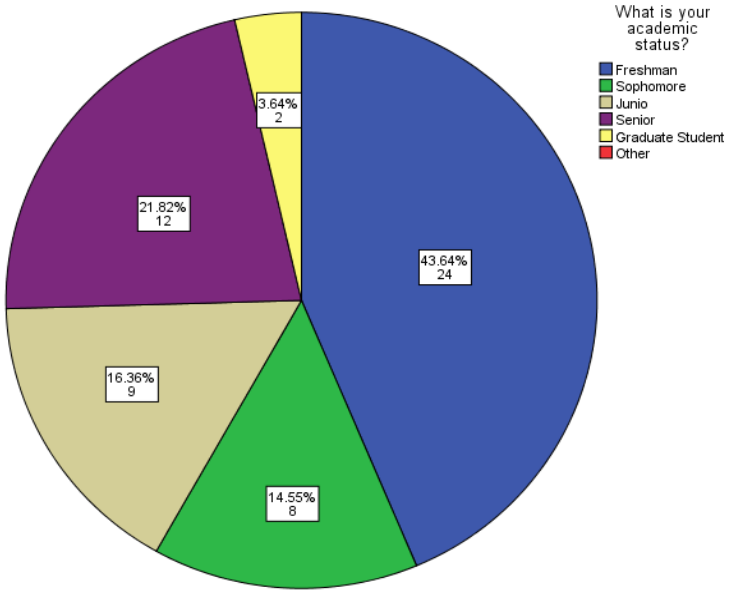


Figure A2. Ethnical group

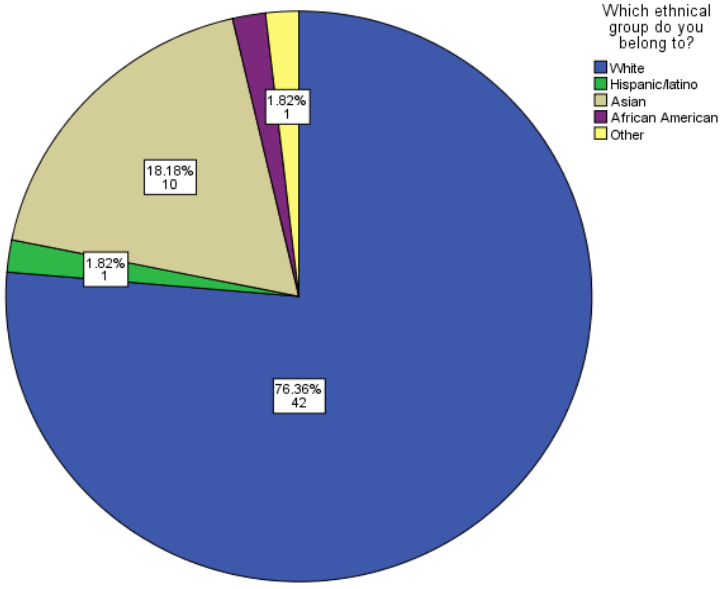


Figure A3. Use of touch screen devices

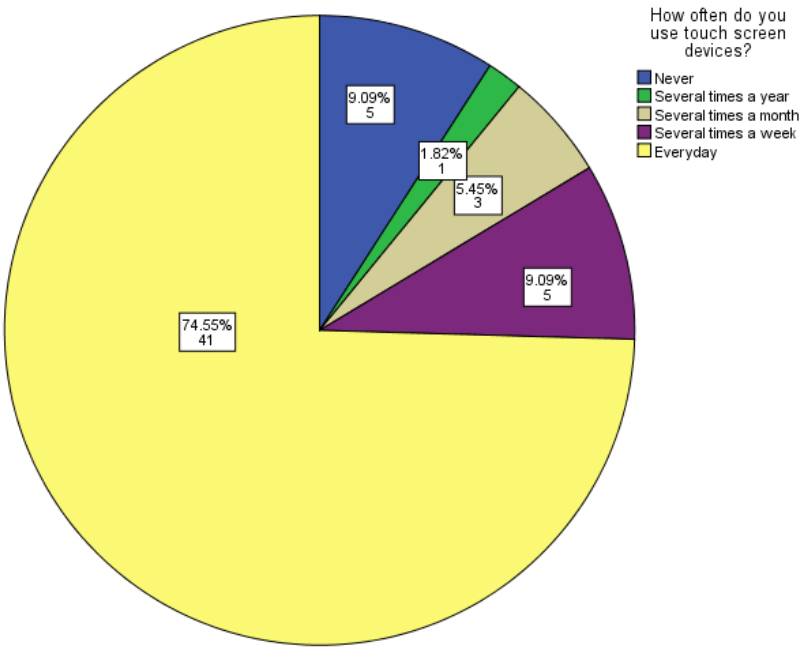


Figure A4. Browsing internet on mobile devices

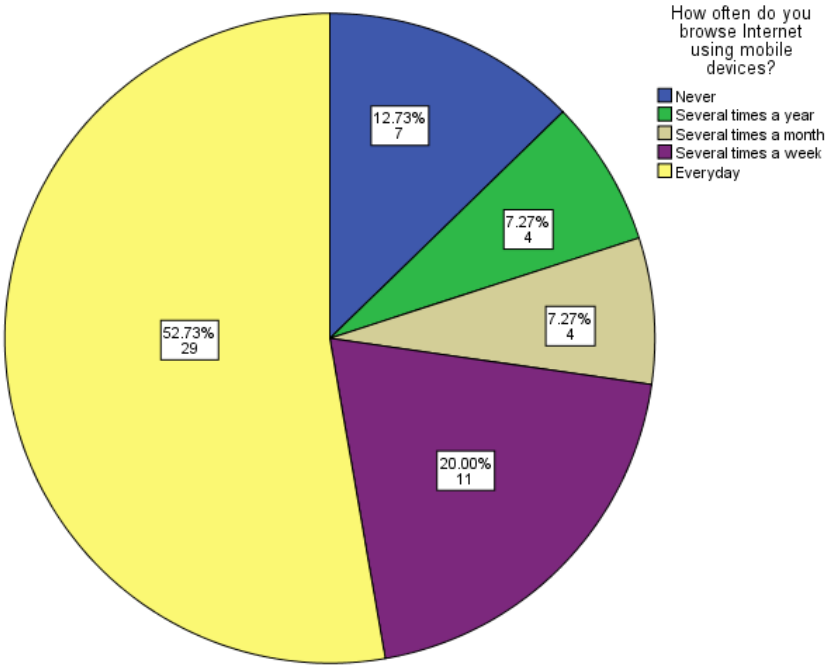


Figure A5. Gender

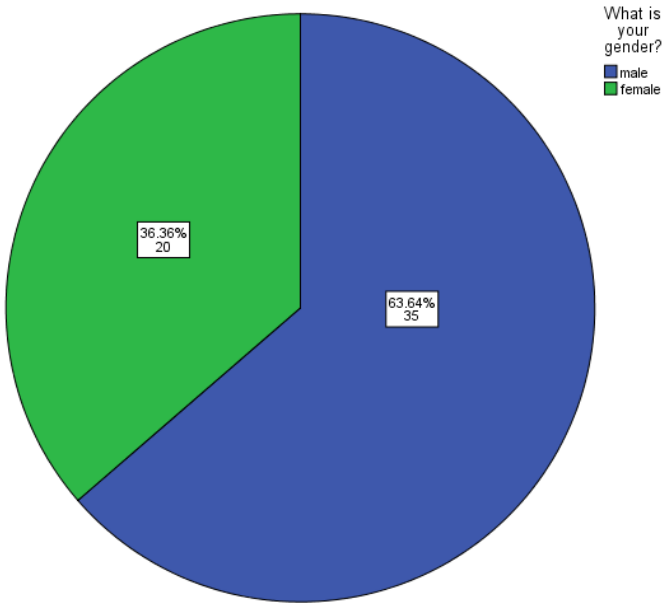
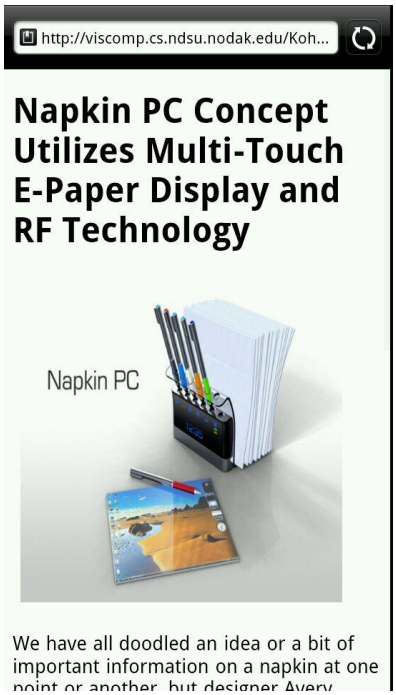


Figure A6. News article



APPENDIX B. QUESTIONNAIRE

Study Code _____ (Entered by Moderator)

Please enter your reading time here as shown on the timer: _____

Please answer the following questions based on your reading experience with the device.

I. Below are questions about the article you just read. Please answer to the best of your memory.

1. What type of power does the product rely on?
    1) Battery power
    2) Cables
    3) Inductive power
2. How long will the drawing stay on the epaper?
    1) Forever
    2) Until you change the e-paper
    3) For 24 hours
3. What is the holder of the product made out of?
    1) Paper towel
    2) Clothe
    3) Napkin
4. The product will reduce what type of waste?
    1) Paper waste
    2) Electrical waste
    3) Ink waste

II. Below are statements about your browsing experience. Please choose a number between 1 and 5 that best represents your agreement with the statement.

1= Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree

1. _____ The browsing style was easy to use.
2. _____ The browsing style was simple to use.
3. _____ The browsing style was user friendly.
4. _____ The browsing style required the fewest steps possible to accomplish what I wanted to do with it.
5. _____ The browsing style was flexible.
6. _____ Using the browsing style is effortless.
7. _____ I can use the browsing style without written instructions.
8. _____ I don't notice any inconsistencies as I use the style.
9. _____ Both occasional and regular users would like this style.
10. _____ I can recover from mistakes quickly and easily.
11. _____ I can use the browsing style successfully every time.
12. _____ I learned to use the browsing style quickly.
13. _____ I easily remember how to use the browsing style.
14. _____ It is easy to learn how to use the browsing style.
15. _____ I quickly became skillful with the browsing style.
16. _____ I am satisfied with the browsing style.
17. _____ I would recommend the browsing style to a friend.
18. _____ It is fun to use the browsing style.
19. _____ The browsing style works the way I want it to work.
20. _____ The browsing style is wonderful.
21. _____ I feel I need to have the browsing style.
22. _____ It is pleasant to use the browsing style.

III. I think the content I read was:

Not at all interesting	1	2	3	4	5	Interesting
Useless	1	2	3	4	5	Useful
Worthless	1	2	3	4	5	Valuable
Not beneficial	1	2	3	4	5	Beneficial

IV. Please CIRCLE the answer that matches your demographic information.

1. What is your gender?
    1. Male
    2. Female
2. What is your age? _____
3. What is your academic status?
    1. Freshman
    2. Sophomore
    3. Junior
    4. Senior
    5. Graduate Student
    6. Other/Please specify _____
4. Which ethical group do you identify yourself with?
    1. White
    2. Hispanic/Latino
    3. Asian
    4. African American
    5. Other/please specify

5. How often do you use touch screen devices?

    1. Never
    2. Several times a year
    3. Several times a month
    4. Several times a week
    5. Every day

6. How often do you browse Internet using mobile devices?

    1. Never
    2. Several times a year
    3. Several times a month
    4. Several times a week
    5. Every day

Feedback / Comments: