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**Evaluation of Scrolling Techniques on the
websites in the context of universal design**

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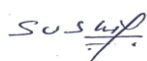
Preface

This study is about the usability and preferences of scrolling techniques used in the websites in the respect of usability principles. The four scrolling techniques have been studied, namely; Normal scrolling, Infinite scrolling, infinite scrolling with load more, and infinite scrolling with pagination. The research has been undertaken as the requirement for the partial fulfillment of master's degree of Computer Science taught in the Faculty of Technology, Arts, and Design at the OsloMet University. The inspiration behind this attempt was the article about 'infinite scrolling is not for every website' written by Loranger (2014) in Nielsen Norman group and also I was intrigued by her way of assessing and frequent use of scrolling in websites currently being designed. Undertaking this work, I have learnt about importance of scrolling on a website in the context of universal design and able to explore possible solutions to make infinite scrolling more user friendly and accessible to everyone, collaborated with a student's group from the university, and most importantly gained hands-on experience on conducting an academic thesis and producing the respective report.

I am heartily thankful to the Department of Computer Science, Oslo Met University, Norway for providing me with such an opportunity to undertake the Master level thesis. My sincere gratitude goes to my thesis supervisor, **Dr. Pietro Murano**, whose valuable guidance and suggestions supported me for the completion of my master's degree coursework. He deserves my high admiration and gratitude for the contributions and it has been an honor to be his pupil and beneficiary as a master's student.

I would like to extend my profound gratefulness to the friends, colleagues and students from universities agreed to participate in the lengthy and tiresome testing of the websites. Their enthusiasm has helped shape this thesis to bear its fruit in the form of this report.

My confederate, my support base; my wife, Mrs. Tanuja Bhattarai, has happily withstood several sleepless nights and gloomy days which have been spent on this thesis and preparation of this report. I am forever in her debt for having supported me in this endeavor.



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Abstract

This research study is about an investigation to find out why infinite scrolling is not a good option for every website. The study presents an evaluation of scrolling techniques used on the website in the context of universal design. Normal scrolling, infinite scrolling, and improved version of infinite scrolling techniques were compared based on people's activities; time-killing activities with serendipitous discovery and goal-driven finding activities. There are some studies done in the past to explore the issues scrolling techniques regarding usability and accessibility but not enough to investigate why infinite scrolling is not a good option for every website in the context of universal design. An empirical experiment was conducted with 16 participants. Four groups of tasks (based on people's activities) were used under within-subject design approach to evaluate the newly designed four prototype websites based on four different scrolling techniques; Normal scrolling, infinite scrolling, infinite load more scrolling, and infinite pagination scrolling. To measure the performance and user satisfaction, total task completion time, the total number of errors done and participant's opinion/preference (from post-experiment questionnaires) were used. Data collected from experiments were analyzed statistically using one-way repeated measure ANOVA tool. Statistically, there was no significant different result found for total task completion time and total numbers of errors done by participants. However, participant's opinions were statistically significant, and the mixed results were found. The participants preferred either infinite scrolling or normal scrolling or infinite load more scrolling techniques for time-killing with serendipitous discovery activities while in case of goal-driven finding they preferred to use either normal scrolling or infinite load more scrolling technique. However, no one preferred to use infinite scrolling techniques for goal-driven finding activities. The findings of the analysis presented important information regarding different scrolling techniques, however, did not show a clear pattern to suggest that Infinite scrolling technique would be an appropriate technique to use in every website to make them more accessible and user-friendly. The findings from this study may be useful to investigate the relevant subject matter for future researchers.

Keywords: Scrolling techniques, Infinite scrolling, Experimental research, time-killing activities with serendipitous discovery, goal-driven findings activities, prototype design, usability, accessibility, universal design, evaluation

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1. Introduction

1.1 Background

For some moment, just close your eyes and try to think how technology has been advanced these days and these make lives easier for everyone. With an incredible enhancement in the field of technology, touch base interface is one of the revolutionary inventions which makes people's life easier to perform daily tasks (Alvseike & Brønneck, 2012). While concerning the touch base interface, scrolling gesture is one of the most popular ways of interacting with the system and it gives the flexibility to access information. Basically, scrolling is a sliding movement which allows the user to find desired information displayed on the screen of electronic devices (Dou & Sundar, 2016).

Scrolling is typically performed with a mouse often with a built-in scroll wheel on a desktop computer and a touchpad on laptop computers whereas finger or a stylus are used to scroll in mobile devices. With the development of webpage design in the last few years, there has been done lots of enhancements in scrolling design. In the beginning, scrolling was taken lightly but after lots of improvements made in web development, scrolling technique has also been simultaneously advanced which helps people to interact on the web more easily.

With the development of website design, people's interactions with the webpage have also been increased. Designers and developers were more concerned to develop new techniques and interaction methods from which people get more benefits and can achieve more interesting and pleasure filled experience on the web (McCracken & Wolfe, 2004). Web contents are an ocean of information and people can find anything they wish. People need to move from top to down, left to right while looking for specific content on a website. Scrolling is a technique introduced in a website from which people can navigate pages from any direction in linear contents.

This research study is focused on the evaluation of scrolling techniques on websites by examining the common issues found in previous studies. Infinite scrolling along with normal scrolling techniques was investigated in this study and possible improvements were discussed in the context of universal design. Before inspecting the common issues found in infinite scrolling, it is important to know what actually infinite scrolling and normal scrolling are.

According to Ahuvia (2013), infinite scrolling is a web design technique where contents are automatically loaded in a single page and allows people to scroll continuously to feel like there is no end in a page. Whereas, normal scrolling is just a slide movement, which can be done either horizontally or vertically.

In this study, experimental research methodology and quantitative data analysis have been used to analyze the data collected from the real experiment. In total, there were four websites with the same content and design but differed in scrolling techniques, which were evaluated simultaneously using four different task groups. Four prototype websites; normal scrolling (with default pagination), infinite scrolling, infinite scrolling with “load more” button and Infinite Scrolling with “pagination” were developed with proper use of WCAG 2.0 guidelines (W3C®, 2008). All of the websites had two pages: Home and Shop Page, the Home page had news/blogs information in different categories and Shop page had different kinds of e-commerce products and electronic gadgets. A within-subject experiment (testing on each prototype websites by each participant) was conducted with target participants by using four different task groups. Participant’s subjective performance and subjective opinions were used for result analysis and conclusion to answer the proposed research questions.

1.2 Universal Design in Web Application

Universal design as defined by the Disability Act 2005 of Ireland is; " The design and composition of an environment so that it may be accessed, understood and used

- to the greatest possible extent
- in the most independent and natural manner possible
- in the widest possible range of situations
- Without the need for adaptation, modification, assistive devices or specialized solutions, by any persons of any age or size or having any particular physical, sensory, mental health or intellectual ability or disability."(Universal design, 2004)

A team of non-web designers led by Ronald Mace from North Carolina State University in 1997 have provided 7 principles of universal design. They are as follows:

1. Equitable Use
2. Flexibility in Use

3. Simple and Intuitive Use
4. Perceptible Information
5. Tolerance for Error
6. Low Physical Effort
7. Size and Space for Approach and Use(7principles, 2007)

In terms of universal design in web application, the webpage should be designed in such a manner so that it may be used by any person, such as: a user-friendly website with a customizable user interface and compatible with assistive technologies.

1.2.1 Website accessibility

This refers to the accessibility of the website contents to the user with the easy navigation options, high contrast contents, perceptible information to all users through the organization of related contents, use of graphics, and also ability to maintain user's interest.

1.2.2 Website usability

This refers to ease in use of the website by users to access available features. Such as scroll jacking limits user's ability to view website content at their own speed, ability to adjust the text size to increase readability, simple and intuitive website design enabling users with varying knowledge, language, the background to use them, preventing unwanted damages to the user and allowing undo feature in the website.

1.3 Problem statement

There are always pros and cons in every design techniques and tools used in web development, some people like the concept and while some do not. In most cases, neither side is fundamentally right or wrong, so it's better to weigh all considerations before starting of a particular study. This study is going to analyse the issues and barriers found in infinite scrolling techniques used on websites. Study of Loranger (2014) from Nielsen Norman Group explains that infinite scrolling webpages are good for time killing activities with the mind-set of serendipitous discovery but are not good option for websites that support goal driven

finding task. Karlsson and Larsson (2016) performed an experiment with adaption of infinite scroll to explain why infinite scrolling is not valuable for every website. They concluded, if there is a proper enhancement in infinite scrolling technique, it can be valuable for goal driven sites. After study of scientific papers, online journal's and blogs related to infinite scrolling, it is found that there are still some areas that need improvements to make every scrolling based websites more accessible and user friendly. This research study mainly focuses on why "infinite scrolling is not for every site"(Loranger, 2014) with detailed issues and also tries to explore other usability and accessible problems with infinite issues. Those issues or barriers will be used to develop research questions and hypothesis for further study.

The problems within an infinite scrolling technique are:

- Infinite scrolling is not favorable to perform a goal-driven finding activities (for example, finding a specific information by their attributes)Loranger (2014).
- Infinite scrolling website does not have footer due to which users can feel like drowning in an information abyss (Loranger, 2014).
- In infinite scrolling, there is no way to jump to next pages to quickly get a content much further down the list (Roselli, 2015).
- Infinite scrolling websites offer long pages with lots of content and choice, people may have low inaction and click through the pages and suffer from choice paralysis (Silver, 2015).
- User can lose their focus when navigating back and forced to re-navigate through all the content to locate actual position (Vomend, 2015).
- Infinite scrolling in a webpage degrades page performance, sometimes renders it unresponsive, which creates a bad user experience and low user satisfaction (Silver, 2015).
- Saving the webpage address(bookmarking) of the particular result is not easy in infinite scrolling.

1.4 Research Questions

Two research questions were proposed in this study related to issues found in infinite scrolling technique. All the relevant issues within these questions will be discussed later in the discussion section.

1. Which Scrolling technique among (Infinite scrolling with “Load more” button or Infinite scrolling with “pagination”, Normal Scrolling or Infinite scrolling) would be better to use in the website in the context of universal design?
2. Is infinite Scrolling on website justifiable in the context of usability?

1.5 Research Aim

The main aim of this research is to investigate and evaluate the scrolling techniques used in websites in the context of universal design. With the popularity of the website in information exploration, there are some questions that still need an answer to why infinite scrolling technique is not for every website (Loranger, 2014). With consideration of Loranger (2014) study from Nielsen Norman Group and barriers found in the previous study of infinite scrolling, an empirical experiment was performed with the following step by step procedure.

- Four prototype websites with four different scrolling techniques will be designed using universal design principles and WCAG guidelines.
- In total, four task groups will be designed based on two task activities; ‘time killing activities with mind-set of serendipitous discovery’ and ‘goal driven finding tasks’.
- A True experiment (prototype evaluation and questionnaire) will be conducted with targeted participants.
- Data will be collected from participant’s performance and from their opinions using post-experiment questionnaire.
- Statistics tools will be used for the analysis of data.
- With the statistical analysis of data, hypothesis and research questions will be discussed to find the conclusion.
- Finally, a result with future work will be suggested at the end of the study.

1.6 Study Overview

The picture shown in below is the step-by-step work done to complete this research study.

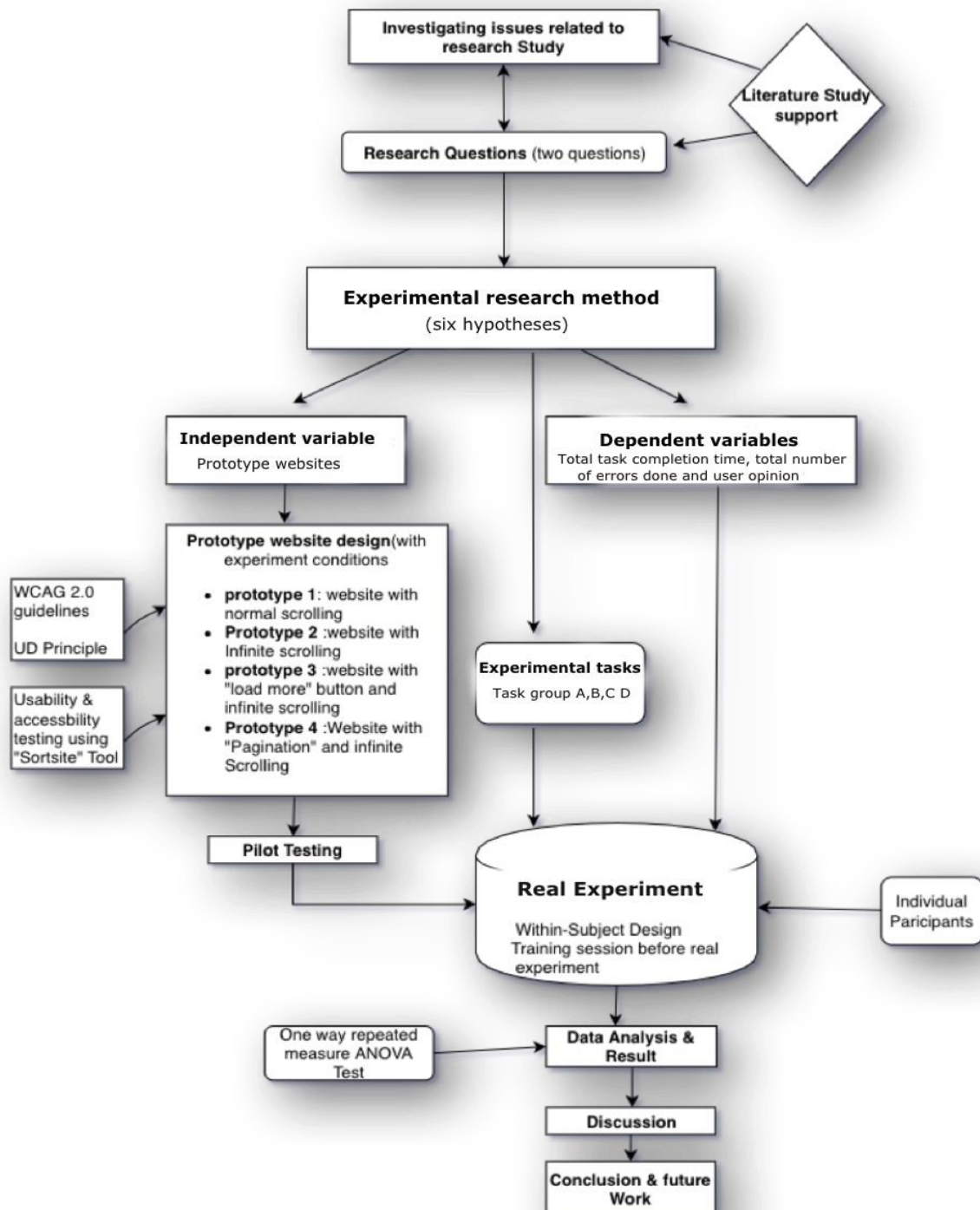


Figure 1.6-1 Study Overview

2. Literature Review

This chapter includes the related works done in past years to support the current research study, to help in identification of possible gap and analyse them to provide a most relevant solution regarding research area.

In this research, the main theme is to evaluate infinite scrolling used in a website in the context of universal design. Different quality research paperwork, articles and web content related to scrolling, infinite scrolling, successor of scrolling, how scrolling can beneficial in websites, what were the previous downfall in infinite scrolling, and relationship of infinite scrolling technique with universal design were discussed. All reference contents were taken from google scholar, books, OsloMet database and online websites.

2.1 Overview of Scrolling technique in websites

Scrolling are among the most frequently used commands in interactive application such as word processor, spreadsheets and web application (Neervoort, 2010). This is because the full content of interactive application is typically larger than can be presented in display screen, to get the overview of whole content, user likely to scroll to see all the part of content.

Until the mid-nineties scrolling was considered as an old fashion web design. If page content or length required scrolling, it was perceived that the page's table of contents needs to be accessible. It was a good idea to use frames to keep the table of contents visible in the left panel (YADRICH et al., 2012). A Jakob Nielsen's study found that the first-time users of a webpage did not like to use scroll, among the studied sample only 23% users used scroll while visiting a website (in Prioritizing Web Usability 8)(Jakob Nielsen, 2010).

Popular belief was that while designing webpage with scrolling, it should be ensured that the speed of scrolling to be good enough not to bother user's patience and horizontal scrolling should be completely avoided (Bernard, 2003; Preece et al., 2015).

Scrolling was generally used while users use the website for comprehensive reading. This was due to the delay during the retrieval of linked pages because of slow system response time might interrupt the user's thought process (Byrne et al., 1999; Spyridakis, 2000) .

But recently scrolling in websites has made resurgence as one of the most popular techniques. The credit owes to mobile devices and high-speed internet for this, as it has emerged as the necessity. And it is also contended that people don't like to scroll, study conducted by Chartbeat analysed data from 2 billion visits and found that 66% of attention on a normal media page is spent below the fold i.e. people do scroll (Haile, 2014). The usability expert Jakob Nielsen has changed its outlook on scrolling as one of its studies done using eye tracking technology has showed that people do scroll down, especially if the page is designed to encourage scrolling (Fessenden, 2018).

Hinckley et al. (2002) conducted an experiment with 27 people (12 male) from 22-50 years of age to evaluate scrolling interaction techniques essential for interaction designers to analyse scrolling performance, thereby providing a tool to evaluate and improve upon new techniques. They used Fitts' paradigm as a tool to study scrolling, IBM ScrollPoint Pro mouse with an isometric joystick (the "ScrollPoint") and the Microsoft IntelliMouse Explorer with scrolling wheel tool are used to vary the scrolling distance as well as the required tolerance of scrolling. They concluded that the performance of the wheel can be significantly improved using an acceleration algorithm and results show that their approach yielded a practical and rigorous method for the evaluation of scrolling techniques. Moreover, there are other criteria that affects performance and user acceptance, including device acquisition times, the visual diversion required to use a graphical scroll bar, or the integration of scrolling into complex tasks, for example, navigation and goal selection with the mouse. Researchers provide a solid foundation for future studies that will further examine cognitive factors, visual attention, and other aspects of scrolling.

Frederick et al. (2015) performed a study on Parallax scrolling technique that creates the illusion of depth on a webpage by making the background images move slower than the foreground images. In addition to parallax scrolling ability to engage users with a website, it has been claimed that it improves the user experience while using in websites. They hypothesised that parallax scrolling would positively influence each of five variables (usability, satisfaction, enjoyment, fun, and visual appeal) and subsequently the overall user experience. They performed test between a group experiment with 86 participants, 43 of them performed a test with a parallax website and other with a non-parallax website. The results of the study also showed parallax scrolling to be more effective when used in a hedonic and fun context,

with respect to perceived usability, enjoyment, satisfaction, and visual appeal, there were no differences between the Parallax website and the non-parallax website. It was found that two of participants suffered motion sickness and experienced significant usability issues while interacting with the parallax scrolling website, nevertheless, it has some significant benefits using in websites. Their study suggests UX geek and web designers should consider this issue when planning to implement parallax scrolling.

Lasch and Kujala (2012) investigated research on the comparative impact on driver distraction when searching music albums and user interface features of a touch-based mobile music player. They designed a driving simulator experiment where 9 males and 9 female volunteers between the age of 21 to 38 years were recruited and the experiment was conducted at the Agora User Psychology Laboratory in Jyväskylä, Finland. As the study focused on the comparison of three scrolling methods, buttons, swipe and kinetic, participants were asked to search for music tracks in a grid-style menu using three different scrolling methods. Swipe refers to a technique that enables page-by-page scrolling by using a swiping gesture. Kinetic scrolling utilizes the same swiping gesture, but it accelerates the menu, which then stops automatically after deceleration. Tapping on the menu can also stop the movement, whereas the number of music tracks presented in a list-style format varied between three, five and seven items per page. Nine of participants were told to use the music player in a portrait mode and remaining were told to use in a landscape mode. The study assumed that the swipe technique should support fewer distraction effects than kinetic or button due to the systematic page by page scrolling and low levels of pointing accuracy needed for browsing. They expected three items should enable more efficient visual sampling efficiency per page, though visual demands are increased compared to five or seven since more scrolling is required. Screen orientation should have had no distraction effects. Result of the study suggested that a list-style menu structure with a lower number of items per page made visual search safer than a grid-style menu with 12 items, and this applied even for a list with the kinetic scrolling. However, the swipe scrolling technique could again be recommended over kinetic or small buttons for in-car menu browsing tasks due to lower levels of visual accuracy required for changing the pages.

Wherry (2003) performed a research study to compare a touchpad scroll ring to a mouse scroll wheel and touchpad scroll zone using a Fitts' Law testing methodology. Twelve right-handed

subjects with prior scrolling experience (7 male) were volunteered to evaluate the time, error, and subjective result. With the lowest error rates and performance times and subjective data, it appeared that the scroll ring offered the most performance advantages over the scroll wheel and scroll zone. Future studies were recommended to investigate how the touchpad scroll zone performs when not integrated within the touchpad and how these scrolling devices perform in compound tasks when users are typing or navigating while also scrolling in an application. The study was expected to help develop future scrolling input devices that are quick, accurate, and easy to use.

2.2 Pagination in Websites

Pagination is the process of splitting content into discrete pages. Most of the websites use pagination to present a set number of results on web search tool results pages or demonstrating a set number of posts while seeing a discussion string. Pagination can be used as a part of some structure on each web application to isolate returned information and show it on different pages (Furche et al., 2012). Pagination additionally incorporates the rationale of planning and showing the connections to the different pages. Programmatically, pagination can be coded either as client-side or server-side (Oluwadoyin, 2017). Server side pagination is preferred when there is large dataset needed to be shown in websites and need faster initial page load whereas client-side pagination is applied when there is small dataset and need faster subsequent page loads.

The study from (Andrew, 2018; Esser, 2018; J Nielsen, 2013; Randall, 2018; Schenker, 2011; Tidwell, 2010), have listed following benefits of pagination:

- Consumes fewer computer resources.
- Provides User control whether to load next content or not.
- Always comes with reference point to go back and forth to pages
- It focuses on user's ability rather than the page's attractively
- Footer of the page can be achieved

From the study made by (Andrew, 2018; Esser, 2018; J Nielsen, 2013; Randall, 2018; Schenker, 2011; Tidwell, 2010), following drawbacks of pagination are listed:

- Can be problematic in mobile devices.
- May need instructions if user is novice.
- Requires more attention where there are many pages.
- Accessibility of navigation links.

Scrolling along with pagination, is a technique to view more content which cannot fit in the first page. Pagination enables users to view a part of the result on the current page, and then user has to click on a next button to see a new page with another part of the result. And scrolling is a method of traversing a web-page wherein users either roll the scroll wheel on their mouse, or manually move the scroll bar located on the right side of their browser's screen (USDHHS, 2003).

Kim et al. (2016) conducted a user experiment to investigate the effects of horizontal and vertical control types (pagination versus scrolling) performing web searches on mobile devices. They recruited 24 participants (14 male) aged 22–41 years in their experiment. Despite participants having greater familiarity with vertical scrolling during a search, their findings suggested that participants using pagination were more likely to find relevant documents, especially those over the scrolling; spent more time attending to relevant results; and were faster to click while spending less time on the search result pages overall. They also found that the main reason for the difference in search speed was the time taken for the scroll itself. Considering the limitations regarding users' individual differences and the lab conditions of their study, the researcher could not conclusively say that the horizontal control type is better than vertical scrolling. Rather they would suggest, at least, that it is worthwhile for search engines to provide both scrolling types to enhance the user search experience on touch-enabled mobile devices.

(Thung et al., 2010) performed a case study to analyse and compare a number of design patterns focusing on architectural and navigational design patterns for general features in web applications. The case study discussed the school's website and proposed several design patterns to enhance the usability of the website. They added pagination pattern was used for performance purpose to organize the search results in a simpler and more organized way. It enabled users to navigate results using controls such as page number or next, previous, first, and last. Pagination was suitable when users need to view a long list of items that cannot fit

on one page. In term of finding efficiency, pagination pattern could be more efficient as it only displays a few results in a page rather than showing all results in one page. It supports very well for unstructured information such as Google search results but it fails to support users' preferences for structured information. Researcher suggested some insights to software developers on the importance of design patterns that could affect the whole performance of web applications. The traditional way of design from scratch of web applications was not suitable in the current demands in time-to-market.

2.3 Why Infinite Scrolling is not Easy for Every Website?

Infinite(Continuous) scrolling is advantageous for content that streams constantly and has a relatively flat structure, where each unit of content belongs at the same level of hierarchy and has similar chances of being interesting to users(Loranger, 2014). However endless scrolling is not recommended for goal-oriented finding tasks, such as those requiring people to locate specific content or compare options. People who need specific types of information expect content to be grouped and layered according to relevance, by pages. They do not mind clicking links if each click is meaningful and leads them closer to the desired goal (Loranger, 2014). In addition, the way text is presented can interact with learner abilities to affect their learning outcomes (Sanchez & Wiley, 2009).

Infinite scrolling technique has been widely used in the websites with content of equal importance, such as in a social media (Leeds, 2014). But the site where users need to get the desired information quickly, such as in an e-commerce site, this technique won't be appropriate which might overwhelm the users with its vast contents. When loading endless amount of content, at some point some content needs be unloaded, otherwise the browser will eventually run out of RAM and crash (Karlsson & Larsson, 2016).

Infinite scrolling is a type of web interaction design where data is fetched asynchronously from a data store and inserted into the webpage as the user consumes the information (Leeds, 2014). This method results in the illusion that the information on the page is unending.

Since this technique asynchronously fetches data while the user is consuming the content, it depends solely on JavaScript (infinitemscroll, 2018). A point relative to the bottom of the page is usually set by the website, as soon as the user reaches this point new data gets loaded

automatically and inserted into the Document Object Model (DOM). This method is employed by social networks such as Facebook, Twitter, Pinterest and several others. As such this technique is much more suited to websites that produce large sets of data, especially websites that contain user generated content.

Since the technique is suited to websites with large sets of data, unfortunately it is not suitable for every website designs. Infinite scrolling as its advantages as well as its shortcomings. Some of the advantages associated with infinite scrolling (Akin, 2015; Andrew, 2018; Babich, 2016; Oluwadoyin, 2017; Schenker, 2011):

- Suited for touch devices.
- Better for visual content as it captures the interest of users and keeps them captivated.
- According to (Ahuvia, 2013), while viewing the google web-searches, only 6% advanced to the next page. Meaning the infinite scrolling served better content exposure.
- Requires less number of clicks from the user's side.
- Even novice users can use the website seamlessly as the contents get automatically updated.

And the associated problems have been presented below (Akin, 2015; Andrew, 2018; Karlsson & Larsson, 2016; Leeds, 2014; Loranger, 2014; Schenker, 2011) :

- Users need to stay focused on their desired information
- Returning back from a link in the page, the user's position gets lost
- Always feels like something more is there to be found
- Users can't control the amount of their internet data. There is no explicit consent from the users' side. Also, when returning to specific content, users can't skip the previous contents.
- Can lead to fewer clicks
- Users can't get to footer contents as the page keeps loading automatically.

- With infinite scrolling, Search Engine Optimization (SEO) is affected and the website developers have to take special measures to correct this.

Navigating through multiple collections of data can be very difficult. It needs the user to scroll or move through the data on a particular page. When there are thousands of such data it can get boring or the information one requires can become difficult to find. Dividing huge data sets and can solve this problem, and two scrolling methods pagination and infinite scrolling are the appropriate options to use. Oluwadoyin (2017) Conducted research to explore the scrolling techniques; infinite scrolling and pagination and contrast their strength and weakness and conclude with proper finding. The researcher performed a test with four participants, 2 were Male and 2 were female. Four websites (google, jumbo, eBay and open source social media) were used to explore the effectiveness of the infinite scrolling and pagination on the basis of Jakob Nielsen's 5 components; learnability, efficiency, memorability, errors, and satisfaction (Jakob Nielsen, 2003). The researcher concluded their result with the following points:

- If you have a goal-oriented website, where users perform specific tasks and expect to find specific results, infinite scrolling may hurt the usability of the website due to its disadvantages and significant result from the carried-out survey.
- Using scrolling as a prime method of exploring the data, it may make the user stay longer on a web page, and so increase engagement. However, the user won't be clicking much due to all the impressive content they occupied with.
- Infinite scrolling could be a best option for websites that have user-created content (Twitter, Facebook), visual content offers limited viewing like Google search by image or sites that intend to balance the traffic load on their content like Twitter. Pagination is generic options, and best for platforms that intend to satisfy the goal-oriented activities of the visitors like Google web search, and so on(Oluwadoyin, 2017).

Furthermore, in the same study the author suggested choosing to implement a hybrid approach to infinite scrolling, prompting the user to load more content when they reached the end of a page. It gives the flexibility to get back the control to the user to decide how much content to load. He added, this hybrid solution also helps with maintaining a consistent data

load on the server. After automatically loading a predefined number of pages, a button would appear prompting the user to load more manually.

Karlsson and Larsson (2016) conducted a quantitative study on how the user behaviour differed between a website with pagination and infinite-scroll. The study indicated that infinite-scroll could be useful on an intranet when adapted according to usability guidelines. The researchers evaluated user behaviour on an intranet of a health care company regarding which pagination technique to choose, pagination or infinite-scroll. Three versions of prototype website were evaluated simultaneously; an infinite scrolling website with a load more button, a version with pagination and, a specially designed version with infinite-scroll adapted to the specific intranet. They designed an evaluation task that made the site partly goal-driven, by finding specific information, and another part not so goal-driven when scrolling through the feed. Finally, the following conclusions and recommendations were drawn from their study.

- Implement the back-button functionality together with the automatic loading.
- Infinite-scroll can be valuable on a goal-driven site. The infinite-scroll and the paginated version performed similarly, the only area where differences were seen between the number of articles loaded per session.
- Use infinite-scroll, and implement support to retrieve the user's position when returning to the feed

Etsy (2019) spends a lot of time building the infinite scrolling features on their website and releases it with the aim of seeing more items faster as presumed to be a better experience. But it was found the feature had various negative effects, including fewer click on the result item and fewer items favorite from the infinite result page. An engineer McKinley (2013) from Etsy Inc. conducted a research study why basically infinite scroll failed in every major way. McKinley presented two assumptions behind the infinite scroll

- Users want more results per page.
- Users want faster results.

Both assumptions were tested with particular users but their engagement level was not statistically significantly different. McKinley said he didn't know why infinite scroll didn't

succeed for Etsy. There wasn't, as far as they could tell, a technical fault (i.e. infinite scroll breaking in a specific browser). It was just a bad thing and the reason wasn't clear. He added, the actual merits of infinite scroll itself is still a controversial feature – even if there aren't technical issues, which there almost always are. The most annoying issue of infinite scroll is that there is no footer, which probably the average Etsy user does not need when making purchasing/viewing decisions (McKinley, 2013).

Holst (2016) conducted a usability study at Baymard Institute which tested three design patterns for the usability factor to load products in e-commerce website; namely infinite scrolling, pagination, and load more options both on the desktop and mobile. The result concluded that load more buttons combined with lazy loading to be superior than others that provided seamless user experience. Infinite scrolling was not favorable in terms of usability for search results and on mobile in particular. Infinite scrolling is, therefore, ideal for quickly showing the breadth of an entire category; but because users aren't naturally halted when scrolling, they tend to scan more and focus less on individual products on the list. Their study concluded no single method to be perfect for all instances, different variations of the load-more approach have been suggested in different contexts.

2.4 Infinite Scrolling and Universal Design

While designing the accessible web content, scrolling technique could be a major area to be considered while rendering the information on the screen (Babich, 2016). The pace, delivery, and interactivity of the content could be adjusted with one of the creative scrolling patterns. While the span on the web has dropped about some seconds, a delightful scrolling experience might increase user interests (Sanchez & Wiley, 2009).

Infinite scrolling websites have not just an accessibility issue; a lot of usability proponent find failures in infinite scroll in user testing, depending on the application. In terms of 7 principles of Universal Design (7principles, 2007), infinite scrolling was analysed in the previous study with the following drawbacks:(Dennis, 2016; Langmo, 2017; Leeds, 2014; Loranger, 2014; Parker et al., 2012; Peri, 2018; roselli, 2014)

- With infinite scrolling, it is not possible to skip chunks of irrelevant content

- Focus is lost when navigating back. Keyboard-only users, including screen reader users, are forced to re-navigate through all of the content to locate the element activated when the focus is lost, the user has to reorient themselves on the page.
- With infinite scrolling, finding content that you viewed previously can be very difficult once a page is more than a few screen heights long.
- Not able to access footer content. With infinite scrolling, assistive technology users have an issue to navigate to the footer. The footer usually contains copyright and contact information that are always at the bottom of the page.
- Quick navigation is hard to achieve. The website has a lot of headings and links within each feed, navigation becomes very hard when it comes to the loading feeds infinitely even though the sites have proper heading elements and structure. Many contain news feeds with additional links, forcing users to navigate through the active elements for each feed.
- Hard to locate the content. Sighted keyboard-only users and screen reader users may have difficulty locating content using the search feature or navigation techniques.
- With infinite scrolling, it is hard to share a web address to a specific place on the page.
- Not able to go to the end of the page. Keyboard-only users are not able to use the Ctrl+End keyboard commands to navigate to the end of the page.

2.5 Conclusion drawn

Throughout the literature study, it can be seen researchers and usability experts have conducted research on different scrolling techniques used on websites to make it more accessible and usable. There is significant research that has been done on different scrolling techniques but very few on the infinite scrolling technique, since infinite scrolling is a new scrolling technique used on websites. Literature study outlined lots of usability and accessibility issues on the infinite scrolling technique used on websites by researchers, as Loranger (2014) said infinite scrolling is very good for time-killing activities with serendipitous discovery but not suitable for goal-driven finding tasks. Latest study was done by Karlsson and Larsson (2016) about adapting infinite scrolling with user experience and said that infinite scrolling could be

beneficial for goal-driven finding activities but should be used with improvements or with caution. Oluwadoyin (2017) conducted a comparison study to evaluate the pagination and infinite scrolling for finding tasks, author found that infinite scrolling with pagination version could be valuable for goal driven finding task and implement support to retrieve finding tasks.

With the gap or shortcomings, the current research done on infinite scrolling does not provide proper guidelines and evidence to developers and web designers to know exactly why infinite scrolling is not good for website and enhance infinite scrolling in the context of universal design. To identify the actual gaps and reasons studied from literature review motivates to conduct this research study, in regards, four scrolling techniques; normal scrolling, infinite scrolling, infinite load more scrolling and infinite pagination scrolling prototype websites were designed and evaluated in the context of universal design.

3. Research Methodology

HCI research based on computer science and on design focused more on the implications for interfaces and have less interest in theory and much more of an interest in the practical outcomes of the research on interfaces to look and feel of the interface (Carroll, 2003). When the topic of research study is new, it is important to start with a structured research method that can be utilized in exploratory ways, such as surveys, interviews, focus groups, ethnography (Lazar et al., 2017). Experimental research methodology (quantitative research method) offers manipulation of an independent variable, control of non-relevant variables through the random assignment and high internal validity as compare to non-experimental research methods. A non-experimental method like single-value research focuses on a single variable rather than the relationship between variables. Similarly, correlation and quasi-experimental research focuses on the statistical relationship but does not offer the manipulation and random assignment of variables. Qualitative research method focuses on broader research questions, a large number of data collection from a small group of participants and analysis perform non-statistically (Milgram, 1974). With the above research method analysis and study thoroughly focused on the manipulation of the independent variables, an experimental research design has been chosen.

3.1 Experimental research

Generally, choosing an appropriate research methodology for the research study is a very challenging job in terms of the purpose of study, time value, funding, participating target users and the research experience (Lazar et al., 2017).

The experimental research method is originated from behavioral research method and has a broad area in psychology (Lazar et al., 2017). The experimental research method has been a highly acceptable research method in behavioral science, and certainly, it becomes one of the most popular methods used in human-computer interaction (HCI). Lazar et al. (2017) added that experimental research method has a unique ability that allows the researcher to identify the true cause of the phenomenon, and also helps to manipulate the way of research and achieve the expected result.

According to the Creswell (2002), to make experimental research more appropriate, random

tasks, control over unnecessary variables, manipulation of the experiment conditions, proper measurement of outcome and group comparisons should be formulated in a correct form. In real experiment design, research can fully control the experiment conditions so that direct comparison can be made from multiple conditions while other factors kept the same. Having full control of factors, the researcher can randomly allocate participants in different experiment conditions (Lazar et al., 2017).

Successful experimental research depends on well-defined hypotheses that represent the dependent variables to be observed and the independent variable to be controlled. There is always a pair of null and alternative hypothesis created and the number of hypotheses totally depends on total number of dependent variables, more variables more hypothesis to validate. The Goal of the experiment is always to test which hypothesis can be rejected and accepted (Lazar et al., 2017).

With all due respect to experimental research used in this thesis, following steps were undertaken to complete the study more efficiently (Creswell & Creswell, 2017; Lazar et al., 2017; Shneiderman et al., 2016).

- Identified issues in the area of study.
- Developed research questions with the help of previous research conducted on the area of study
- Designed experimental prototype websites with taking care of conditions and variables.
- Usability and accessibility aspect over designed prototype was verified using the sorsite tool (automated tool).
- Performed Pilot testing to remove potential bias and make sure everything works fine as expected including experimental conditions and universal design Aspect.
- Recruited participants.
- Conducted an experiment, where actual data were collected.
- Analyzed data using one way repeated measure ANOVA in SPSS.
- Discussion and conclude the findings.

3.2 Research Hypothesis

Hypothesis is a purpose to find the answer to the research question. A hypothesis can be formulated in several ways but it always comes with the basic functionality of anticipating the final findings of the experiment (Gershman et al., 2009). Rosnow and Rosenthal (2008) added hypothesis is smaller, more focused statements that can be tested by a single experiment. The hypothesis generally setup after inductive reasoning, in which the researcher performs a series of observations in order to form a theory.

Nevertheless, sometime hypothesis may have negative value and some time it may be positive. According to the Haber (2010) hypothesis ensures the whole research process remains scientific and reliable. However, hypotheses are essential during the research process, it can produce contradiction with regards to probability, numbers of error and significance. A hypothesis is just an assumption/prediction based on observation of the topic chosen (Connelly, 2015). According to Lazar et al. (2017), a good hypothesis should have a reasonable scope that can be tested within an experiment; clearly explained independent variables can be controlled and clearly defined dependent variable can be accurately measured.

In this research, six research hypotheses were designed based on the total numbers of tasks to be tested and factors to measure.

Hypothesis 1:

H1: Participant will take less time to complete the ‘time-killing activities with serendipitous discovery’ task on the website with infinite scrolling technique while comparing to Normal Scrolling or infinite scrolling with load more or infinite scrolling with pagination technique.

H0: There will be no significant difference in terms of total task completion time for ‘time-killing activities with serendipitous discovery’ tasks on the website with all four scrolling techniques.

Hypothesis 2:

H1: Participant will incur less error while performing the ‘time-killing activities with serendipitous discovery’ task on the website with infinite scrolling technique while comparing to Normal Scrolling or infinite scrolling with load more or infinite scrolling with pagination technique.

H0: There will be no significant difference in total number of errors while performing 'time-killing activities with serendipitous discovery' tasks on the website with all four scrolling techniques.

Hypothesis 3:

H1: Participant completing the "time-killing activities with serendipitous discovery" task on the website with infinite Scrolling technique will have more user satisfaction as compared to normal Scrolling or infinite scrolling with load more or infinite scrolling with pagination technique.

H0: There will be no significant difference in terms of user satisfaction while performing 'time-killing activities with serendipitous discovery' tasks on the website with all four scrolling techniques.

Hypothesis 4:

H1: Participant will take less time to complete the 'goal-driven finding' task on the website with infinite scrolling technique while comparing to Normal Scrolling or infinite scrolling with load more or infinite scrolling with pagination technique.

H0: There will be no significant difference in terms of total task completion time for 'goal-driven finding' tasks on the website with all four scrolling techniques.

Hypothesis 5:

H1: Participant will incur less error while performing 'goal-driven finding' task on the website with infinite scrolling technique while comparing to Normal Scrolling or infinite scrolling with load more or infinite scrolling with pagination technique.

H0: There will be no significant difference in total number of errors while performing 'goal-driven finding' tasks on the website with all four scrolling techniques

Hypothesis 6:

H1: Participant completing the 'goal-driven finding' task on the website with infinite Scrolling technique will have more user satisfaction as compared to normal Scrolling or infinite scrolling with load more or infinite scrolling with pagination technique.

H0: There will be no significant difference in user satisfaction while performing 'goal-driven finding' tasks on the website with all four scrolling techniques.

Each hypothesis has one null(H0) and one alternative(H1) hypothesis. The null hypothesis states that there is no difference between experimental conditions whereas the alternative

hypothesis always says there is mutually exclusive with the null hypothesis (Rosnow & Rosenthal, 2008). The goal of experiment was to find statistical evidence to invalidate the null hypothesis in order to support alternative hypothesis.

3.3 Research Variables

3.3.1 Independent variable

Independent variable refers to that factor that the researcher is interested in studying or the possible cause of the change in the dependent variable. The term 'independent' itself has meant that those variables which has no association with participant's behaviour. In the computer-human interaction field, independent variables are mostly related to the technologies, users, and the context in which technologies are used (Lazar et al., 2017). Generally, the independent variable is controlled by the experimenter in order to see the changes in the dependent variables, therefore each independent variable should have at least two levels of treatment variables or conditions (Creswell, 2002).

Six hypotheses designed in this research consists of one independent variable, a prototype website and the independent variables have two factors; time-killing with serendipitous discovery activities and goal-driven finding activities, which are going to be tested in the real experiment. Four versions of websites were designed based on scrolling technique; website with normal scrolling, website with Infinite scrolling, website with 'Load more' button infinite scrolling and website with 'pagination' infinite scrolling. Each participant performed given tasks group on each website, and the dependent variables were measured in terms of websites they visit rather in type of the task or their complexity. All the participant's performance and opinions collected in the real experiment (evaluation of all four websites) were used to determine which scrolling techniques are better to use in the website to make it more usable and user-friendly.

3.3.2 Dependent variable

The word 'dependent' defines itself, i.e. has support from others that means a variable should depend on a particular object's behavior or changes in independent variables. Lazar et al.

(2017) said that in a human-computer interaction based research study, the dependent variable is used to measure efficiency, accuracy, subjective satisfaction, ease of learning and physical or cognitive demand. With the selection of the experimental research methods, there were three dependent variables were measured for the analysis of scrolling techniques.

- Total task completion time: - This variable was used to measure the efficiency of the task, how fast participant has finished the assigned task group on each of the prototype website (e.g., task per seconds)
- Total error (deviated from the optimal path): - This variable was used to measure accuracy of the task; how many error participants have done while completing the given task on the prototype website. Two types of errors were counted; Slips (unintended actions participant makes when trying to do something on prototype even though the goal is correct), and mistakes (when the goal is mistake) (e.g. number of errors)
- User satisfaction: This variable was used to measure participant opinion/preference to use scrolling technique and experience with experiment and design using a post-experiment questionnaire (e.g. rating from 1-5).

The dependent variables were measured with four different prototype websites in this study. While measuring dependent variables, there was a scenario like; different total task completion time and total error but they may be related to each other (Lazar et al., 2017). For e.g. participant can finish a task in less time with many errors whereas participant might finish the task in more time but with fewer errors. So, these conditions will take care during the data analysis.

3.4 Research Design

As per the study of (Lazar et al., 2017), the experimental design has been widely used in human-computer interaction (HCI) to develop, evaluate and modify different design solutions, task models, and answer the serious issues found in technology due to which technology are still not accessible and user friendly. For instance, this study focuses on usability and

accessibility barriers found in infinite scrolling and try to evaluate different scrolling techniques which would be an appropriate technique to use in websites.

Well-designed experiment can reveal important findings related to the study area. (Cooper et al., 2006; Rosenthal & Rosnow, 1991) specified the research design method into three groups: True experiment, quasi-experiment, and non-experiment. Among them, a true experiment design has been chosen in this study with the following characteristics:

- six testable research hypotheses have been presented in this study.
- Four experimental prototype websites (based on scrolling technique) have been developed for the experiment.
- Dependent variables were measured through quantitative analysis.
- Results were analyzed through the statistical significant test (One-way repeated Measure ANOVA test).
- There was no bias in between participants while conducting the experiment.
- Experimenter assigned four different task group (A, B, C, and D) to each of the recruited participant using randomization.

A flow chart of true experiment (Lazar et al., 2017) is presented below, to understand how it works in current study.

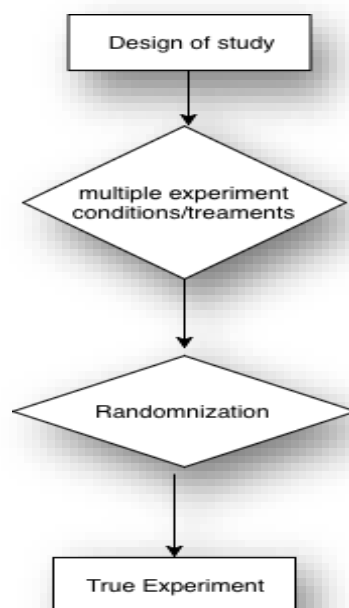


Figure 3.4-1 True Experiment design

3.4.1 Within Subject Design

One of the major challenges in human-computer interaction study is to collect appropriate participants regarding the research study. For example, in this thesis, the goal is to suggest an appropriate scrolling technique to use in a website in the context of universal design and including a large number of participants related to impairment is quite difficult task to accomplished. With the planning of the study, each of the participants is going to perform different tasks on each of four designed prototype websites, therefore, a within-subject design approach is selected. There are several advantages of choosing this design with reference to the area of study and experiment conditions (Lazar et al., 2017; Shuttleworth, 2009).

- It only requires fewer participants to make the process more efficient and less resource heavy.
- It allows to monitor the effectiveness of individual participant much more easily and lower the possibility of individuals differences skewing the result.
- It gives as many information as there are experiment conditions for each participant; the fact that subjects act as participant's own control provides a way of reducing error from individuals.

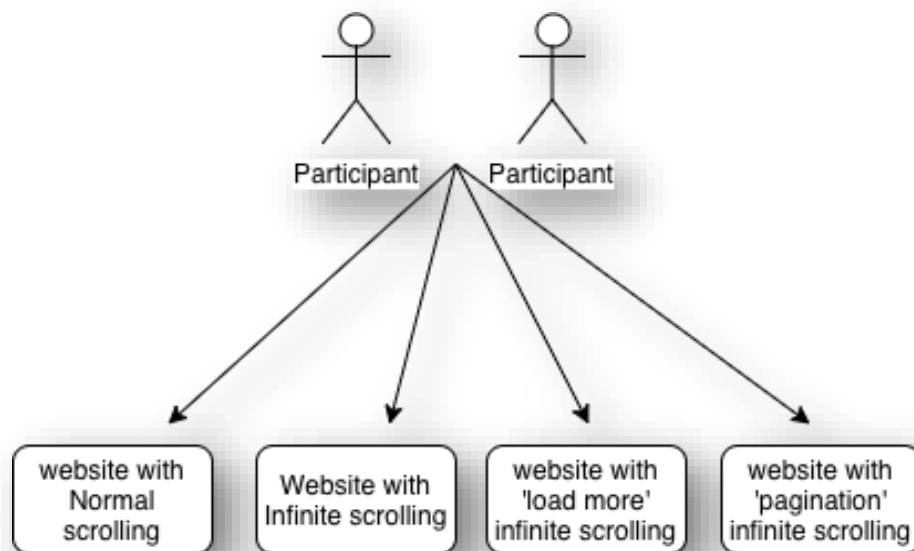


Figure 3.4-2 Within-subject design

With Noticeable advantages of within-subject design, there are some limitations within this design. According to the (Campbell & Stanley, 2015; Lazar et al., 2017), the biggest problem is the possible impact in learning effects. They added, since participants complete the same type of tasks under multiple experiment conditions, they are very likely to learn from experience and perform better in completing tasks. To minimize this limitation, randomization (Campbell & Stanley, 2015) is used in this study, due to which experiment conditions are randomly assigned to participants. Another possible problem fatigue, where participants have to complete each task in multiple sets of experimental conditions. The time to complete may be quite long and the participant may get tired or bored during the experiment. To overcome this issue, total average time is informed before the start of the experiment and participants are allowed to take a break (level of fatigue) after completion of each experiment condition during the experiment process.

The purpose of using randomization (Campbell & Stanley, 2015) in experimental design is equating experimental conditions and control group (within-subject group) and produce a design with great precision. Total of 16 participants was randomized into four different prototype websites and four task groups. There was total of four experiment session, where each participant had completed one task group in one prototype website with scrolling technique. For example, the participant had completed task group A in prototype website with normal scrolling, task group B with Infinite scrolling and task group C with infinite load more scrolling and task group D with infinite pagination scrolling. (please have a look on [appendix B-Randomization](#) for more details).

3.4.2 Factorial design concept

The experiment was designed in a way that independent variable (prototype website) were evaluated by using two different task groups based on user's activities; time-killing activities with serendipitous discovery tasks and goal-driven finding activities tasks. As research study aimed to investigate Loranger (2014) statement 'infinite scrolling is not for every website', it was really important to see the behavior of those two activities tasks on each of experimental prototype (including infinite scrolling technique website). A widely used factorial design was overviewed in the experiment to get a more accurate result. According

to (Lazar et al., 2017), the factorial design allows the researcher to investigate the impact of all independent variable as well as the interaction effect between multiple variables. Total eight experiment treatments(conditions) was designed based on the type of task and the number of prototype websites. In that way, each participant had performed each task group (contains serendipitous discovery and goal driven tasks) on each prototype. For example, Participant 1 had completed an experiment by performing task group A (a combination of serendipitous and goal driven tasks) in Normal scrolling website, infinite scrolling website, infinite load more website and infinite pagination scrolling website.

Table 3.4-1 factorial design of independent variable

Task Type	Prototype website 1	Prototype website 2	Prototype website 3	Prototype website 4
Serendipitous discovery tasks	Normal scrolling website	Infinite scrolling website	Infinite load more scrolling website	Infinite pagination scrolling website
Goal-driven finding tasks	Normal scrolling website	Infinite scrolling website	Infinite load more scrolling website	Infinite pagination scrolling website

4. Prototype Development

According to Preece et al. (2015), the prototype is a design that allows users to interact and explore its characters and suitability. They added prototype can be a paper-based outline of the display, ready-made components, an electronic pictures, mockups and complex piece of software or hardware. The best prototype always poses in the simplest and efficient way, makes the possibilities and limitations of design idea visible and measurable (Lim et al., 2008). With the help of proper research questions, hypothesis, and research method selection; the time has come to develop a prototype to identify the cause of the issue and potential evaluation of raised issues.

In this thesis, at the beginning a paper-based architect was designed and later that paper design was converted into the website using different web technologies; PHP programming, JavaScript, HTML, CSS, and WordPress Content management system, and MYSQL databases. In total, four prototype websites were developed, all the websites consist of the same content, design, and layout but different on scrolling techniques. Structure of the prototype website is divided into two different pages. First page of website is 'Home' that contains number of blogs or news feeds and second page 'shop' that contains e-commerce contents like, products, electronic gadgets and online goods.

4.1 Prototype Design Procedure

This study is thoroughly focused on the investigation of the infinite scrolling issues and possible enhancements. As described above, the aim of the study is to identify appropriate scrolling techniques to use in the website in the context of universal design by analyzing the barrier or issues of infinite scrolling in the previous study.

The main purpose of the study is to develop a prototype website that can be more user-friendly and accessible to everyone including elderly and impaired people. With the consideration of usability and accessibility, user-centered design has been chosen to develop an experimental prototype. Seven principles of universal design (NDA, 2014) and web content accessibility guidelines(W3C®, 2008) have been applied while designing the website so that more usable and accessible prototype website could be expected for the experiment.

Following steps of the user-center design procedure were used to develop a prototype(Abras et al., 2004; C. Lewis & Rieman, 1993; Petrie & Bevan, 2009).

- Understand user type, task type and context -As study thoroughly try to explore the effectiveness of scrolling in websites for time killing activities with serendipitous task and goal-driven finding tasks. So, both tasks are related to finding and exploration/discovery. User could be anyone, can use websites to find or explore web content in their own way.
- Sketch the design -After study of different popular websites, it is found that news/blog page and e-commerce page are highly visited by different internet users. So, with the popularity of webpages in internet and concern with current research, news and e-commerce webpage with different scrolling techniques were chosen to be designed in this study (please see figure 4.1 for the design of prototype)
- Develop prototype: After paper sketch design, four prototypes were designed in WordPress 5.0 framework using different software tool attributes.
- Evaluation/testing of the prototype: Developed prototype won't be perfect until it gets evaluated. Software tester (usability tester) and automatic evaluation tool(sorSite) were used to evaluate the developed four prototypes.
- Integration and final implementation: All the issues found after evaluation were resolved and integrated to develop a final prototype for the experiment.

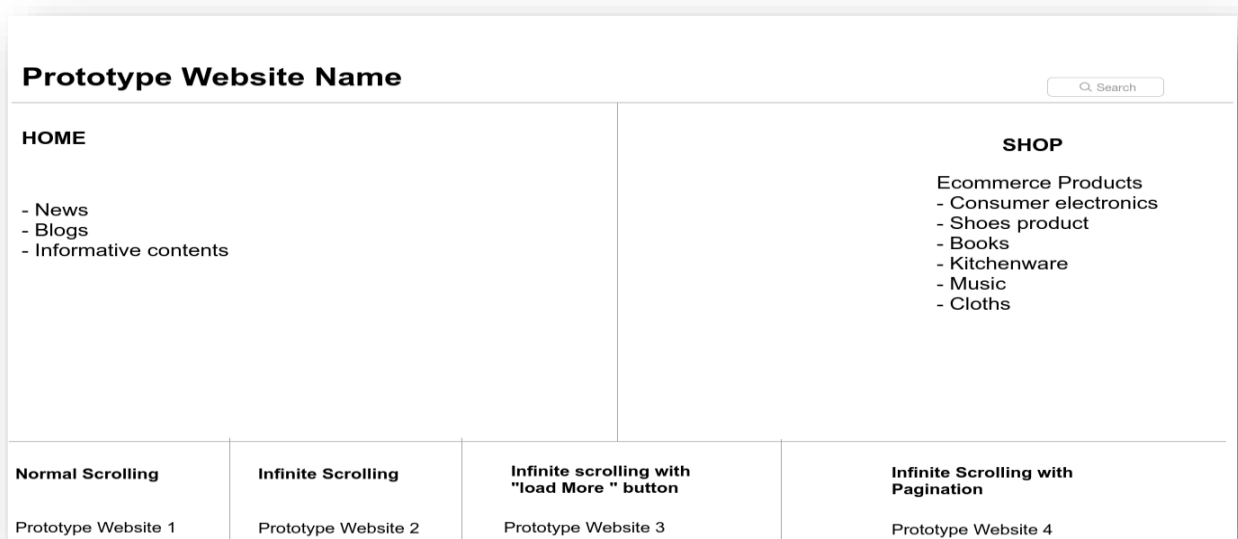


Figure 4.1-1Structure of prototype (paper Sketch)

4.1.1 Technology used

This section includes the hardware and software program used for prototype development. MacBookPro13 with Intel Core i5 Processor, Speed 2 GHz, and RAM 8 GB laptop was used to develop an experimental prototype. Developed prototype was copied to HP laptop equipped with Windows OS, having 8GB RAM, I3 processor which was also used in experiments. The reason for using two different operating systems for the experiment was to remove the potential bias in device compatibility.

To design the prototype website following software tools were used,

- HTML
- CSS
- WordPress 5.0 (content Management Tool)
- JavaScript
- Angular JS
- JQuery Plugin
- MYSQL database

4.2 Scrolling Techniques Used in Prototype

The central part of the research study is based on evaluation of the scrolling technique used on websites. Similarly, different four techniques of scrolling were designed on four different websites. The idea of designing four scrolling techniques prototype websites based on normal scrolling and infinite scrolling came after the thorough study from previous research conducted in this scrolling techniques and further enhancement has given to make it more accessible and user-friendly. Those prototypes later evaluated using different tasks designed based on user's activities. The most important reason is to investigate the issues described in the Nielsen Norman Group, 'why infinite scrolling is not for every website' by (Loranger, 2014). The scrolling technique used in the prototype website are explained below.

4.2.1 Normal Scrolling Technique

Normal scrolling is just an action of moving content like images, text (information), link, etc. displayed on the screen. Normal scrolling designed on the first prototype website was only in

vertical order because people hate horizontal scrolling and always comment negativity when they encounter it (Jakob Nielsen, 2005). According to the problem statement and possible enhancement in scrolling, normal scrolling is designed with default pagination and was evaluated in an experiment.

To design Normal scrolling technique, following JavaScript and PHP(WordPress) was used during development phase and can be compatible for every browser.

Normal Scrolling

```
// Using javascript method to add Normal page scroll
// number 800 denotes the number of milliseconds it takes to scroll to the specified area
$('html, body').animate({
scrollTop: $(hash).offset().top
}, 800, function(){
```

Pagination

```
?php if ( have_posts() ) : ?>
<?php while ( have_posts() ) : the_post(); ?>
<?php endwhile; ?>
<!-- Add the pagination functions here. -->
<div class="nav-previous alignleft"><?php previous_posts_link( 'previous' ); ?></div>
<div class="nav-next alignright"><?php next_posts_link( 'Next' ); ?></div>
<?php else : ?>
<?php endif; ?>
```

4.2.2 Infinite Scrolling Technique

Infinite scrolling is a web design technique where contents are automatically loaded in a single page and allows people to scroll continuously to feel like there is no end in a page(Ahuvia, 2013). User cannot find footer content when infinite scrolling is used in websites and did not get their previous position when they go and back from another page. Infinite scrolling technique was designed on second prototype website using following JavaScript code, which allows people to scroll constantly until the page content is finish.

Infinite Scrolling

```
// init Infinite Scrolling
$('.article-feed').infiniteScroll({
  path: '.pagination__next',
  append: '.article',
  status: '.scroller-status',
  hideNav: '.pagination',
});
```

4.2.3 Infinite Scrolling with ‘Load More’ Button Technique

In this technique, user can feel the same infinite scrolling effect, but it comes with the ‘Load more’ button at the end. The reason to use ‘load more’ button was, it allows user to get their position somehow better than infinite scrolling and they can control page when they want. This Load more button links with page id so that people can see their page number in the value in URL position, but it does not resolve the issue of getting own position when they go and back from other pages. Load more infinite scrolling designed with the following source code in JavaScript.

Load more button

```
// init Infinite Scrolling
$('.article-feed').infiniteScroll({
  path: '.pagination__next',
  append: '.post',
  button: '.view-more-button',
  // using button, disable loading on scroll
  scrollThreshold: false,
  status: '.page-load-status',
});
```

4.2.4 Infinite Scrolling with ‘pagination’ technique

In this technique, user can feel the same infinite scrolling effect, but it comes with the ‘Pagination’ button at the end. The reason to use ‘pagination’ button was, it allows user to

get their position better than infinite scrolling and user can use this pagination feature like as to go and back to the next pages. This scrolling technique was said one of the improved enhancements for infinite scrolling technique by the previous researchers and was measured through the true experiment to identify the efficiency of this technique. There were some tweaks while combining infinite scrolling and pagination functionality with the following code.

Infinite Scrolling with pagination

```
?php if ( have_posts() ) : ?>
<?php while ( have_posts() ) : the_post(); ?>
<?php endwhile; ?>
<!-- Add the pagination functions here. -->
<div class="nav-previous alignleft"><?php previous_posts_link( 'previous' ); ?></div>
<div class="nav-next alignright"><?php next_posts_link( 'Next' ); ?></div>
<?php else : ?>
<p><?php _e('Sorry, no posts matched your criteria. '); ?></p>
<?php endif; ?>
```

4.3 Prototype website 1

First prototype designed in this research experiment was Normal scrolling technique website. As mentioned above, every prototype has same content, design and layout but scrolling technique is different. Prototype website 1 was 'Normal scroll' designed with home and Shop page. Home page has blogs contents, news feed and tasks related to serendipitous discovery and goal-driven finding activities information which can be explored during experiment. Similarly, Shop page has E-commerce contents, like products, electronic gadgets and online goods. Categorized sort/ filter, and search button at the top of page, all features are disabled in this prototype website. Because tasks are designed neither to use filtering/sorting nor search functionality. Prototype website 1 has normal scrolling technique and pagination at the bottom. Glimpses of 'Normal scroll' with their webpages can be seen

below:

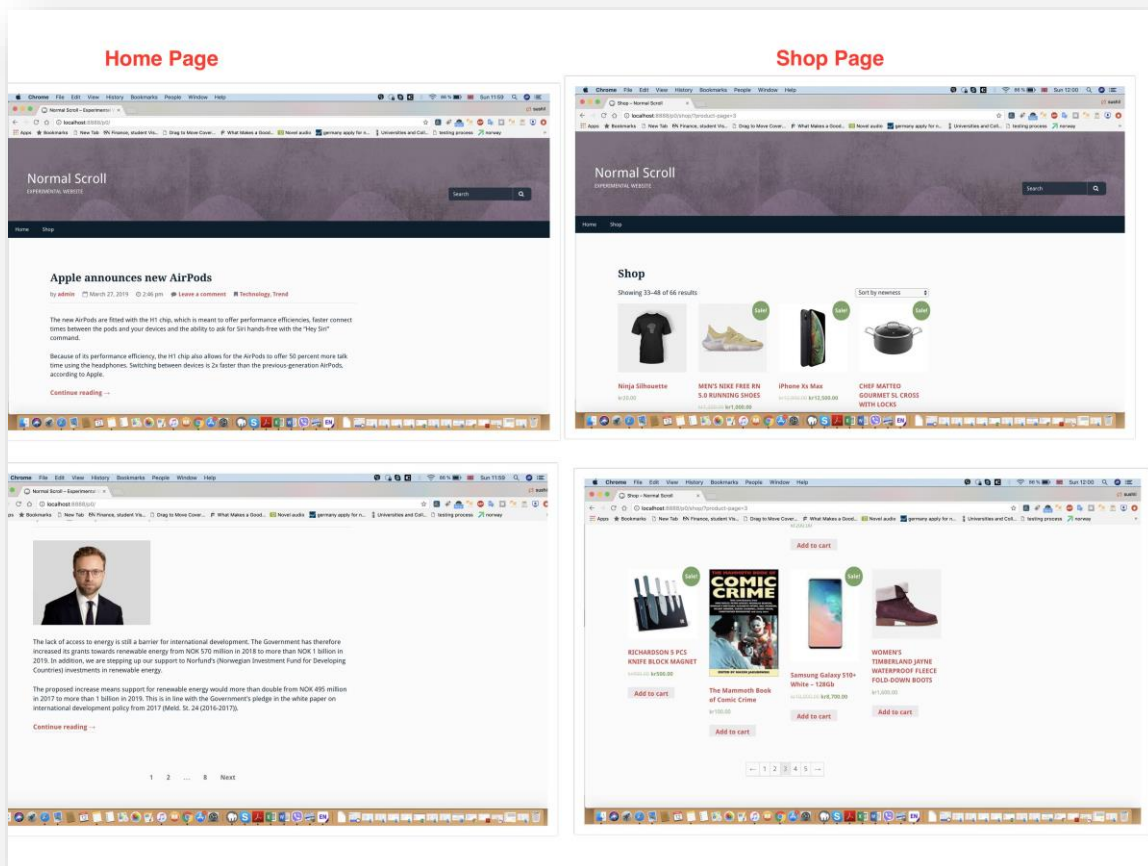


Figure 4.3-1: Prototype website 1 'Normal Scrolling website'

4.4 Prototype Website 2

Second prototype designed in this research experiment was Infinite scrolling technique website. With the experiment purpose, every prototype has same content, design and layout but scrolling technique is different. Prototype website 2 was 'Infinite scroll' designed with home and Shop page. Home page has blogs contents, news feed and tasks related to serendipitous discovery and goal-driven finding activities information which can be explored during experiment. Similarly, Shop page has E-commerce contents, like products, electronic gadgets and online goods. Categorized sort/ filter, and search button at the top of page, all features are disabled in this prototype website. Because tasks are designed neither to use filtering/sorting nor search functionality. Prototype website 2 is designed with Infinite scrolling technique. Glimpse of 'Infinite scroll' with their webpages can be seen below:

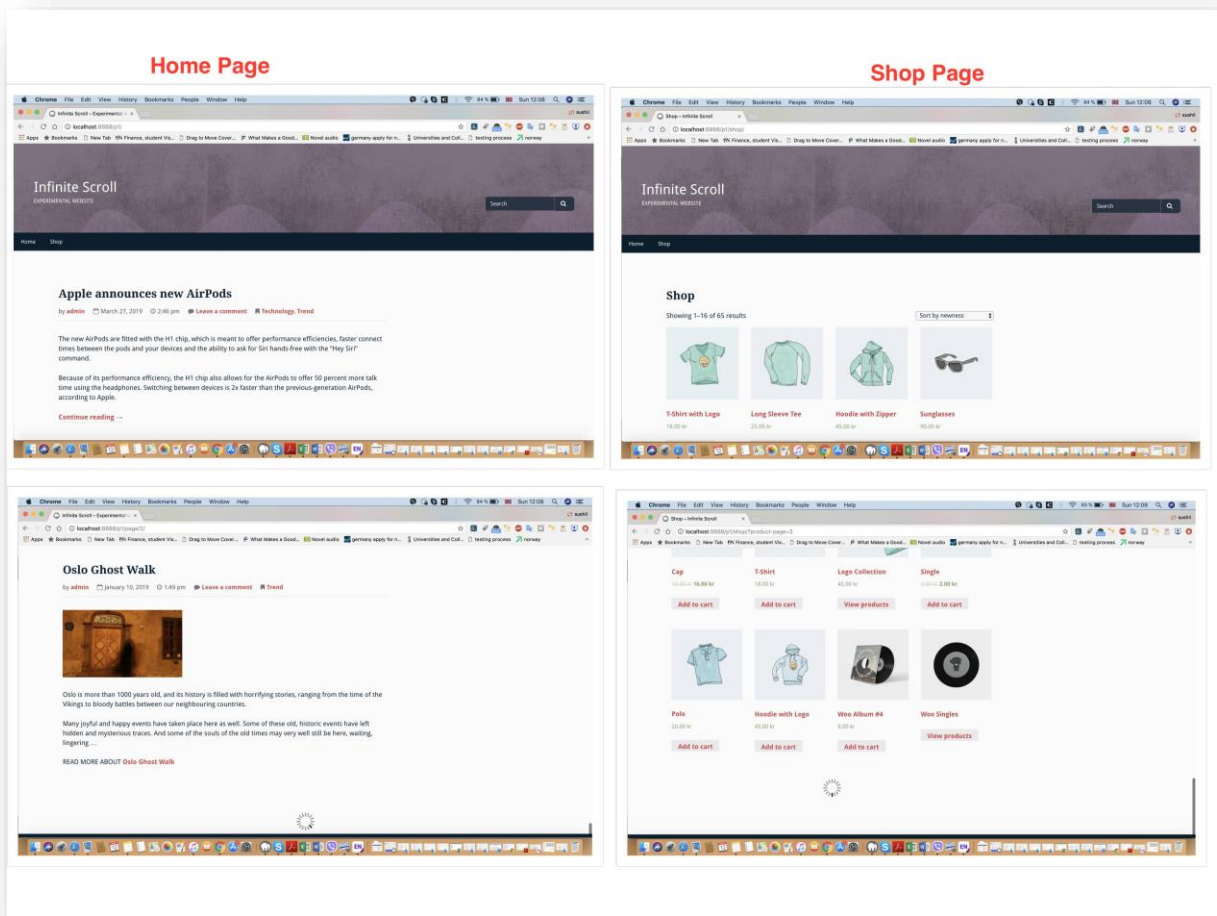


Figure 4.4-1 :Prototype website 2 'Infinite Scrolling website'

4.5 Prototype Website 3

Third prototype designed in this research experiment was infinite scrolling with load more button. With the experiment purpose, every prototype has same content, design and layout but scrolling technique is different. Prototype website 3 was 'Infinite scroll Load more' designed with home and Shop page. Home page has blogs contents, news feed and tasks related to serendipitous discovery and goal-driven finding activities information which can be explored during experiment. Similarly, Shop page has E-commerce contents, like products, electronic gadgets and online goods. Categorized sort/ filter, and search button at the top of page, all features are disabled in this prototype website. Because tasks are designed neither to use filtering/sorting nor search functionality. Prototype website 2 is

designed with Infinite scrolling technique and 'Loadmore' button at the end of the page. Glimpse of 'Infinite scroll Load more' with their webpages can be seen below:

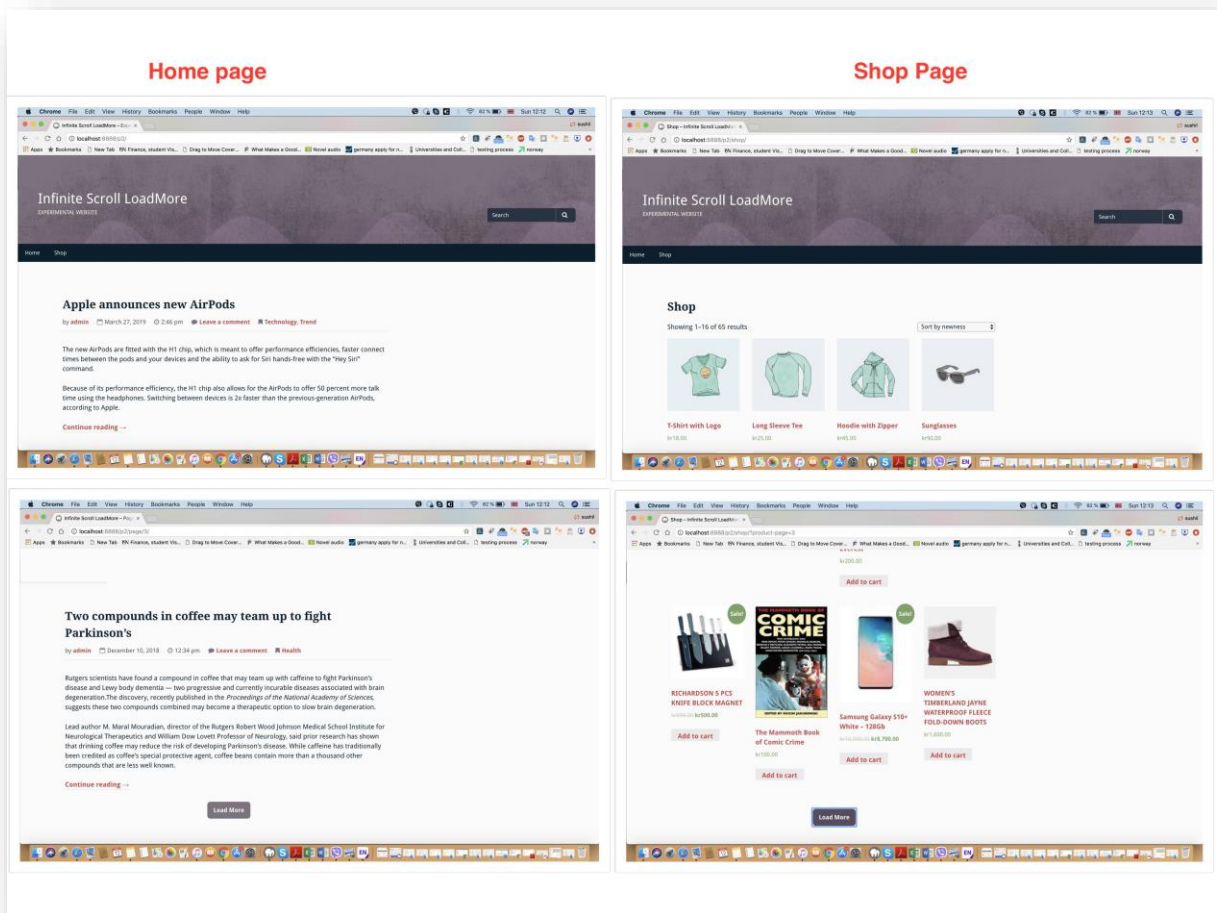


Figure 4.5-1 : Prototype 3 'Infinite Scrolling Load More website'

4.6 Prototype Website 4

Fourth prototype designed in this research experiment was infinite scrolling with pagination button. With the experiment purpose, every prototype has same content, design and layout but scrolling technique is different. Prototype website 4 was 'Infinite scroll pagination' designed with home and Shop page. Home page has blogs contents, news feed and tasks related to serendipitous discovery and goal-driven finding activities information which can be explored during experiment. Similarly, Shop page has E-commerce contents, like products, electronic gadgets and online goods. Categorized sort/ filter, and search button at the top of page, all features are disabled in this prototype website. Because tasks are

designed neither to use filtering/sorting nor search functionality. Prototype website 2 is designed with Infinite scrolling technique and 'Loadmore' button at the end of the page. Glimpse of 'Infinite scroll Load more' with their webpages can be seen below:

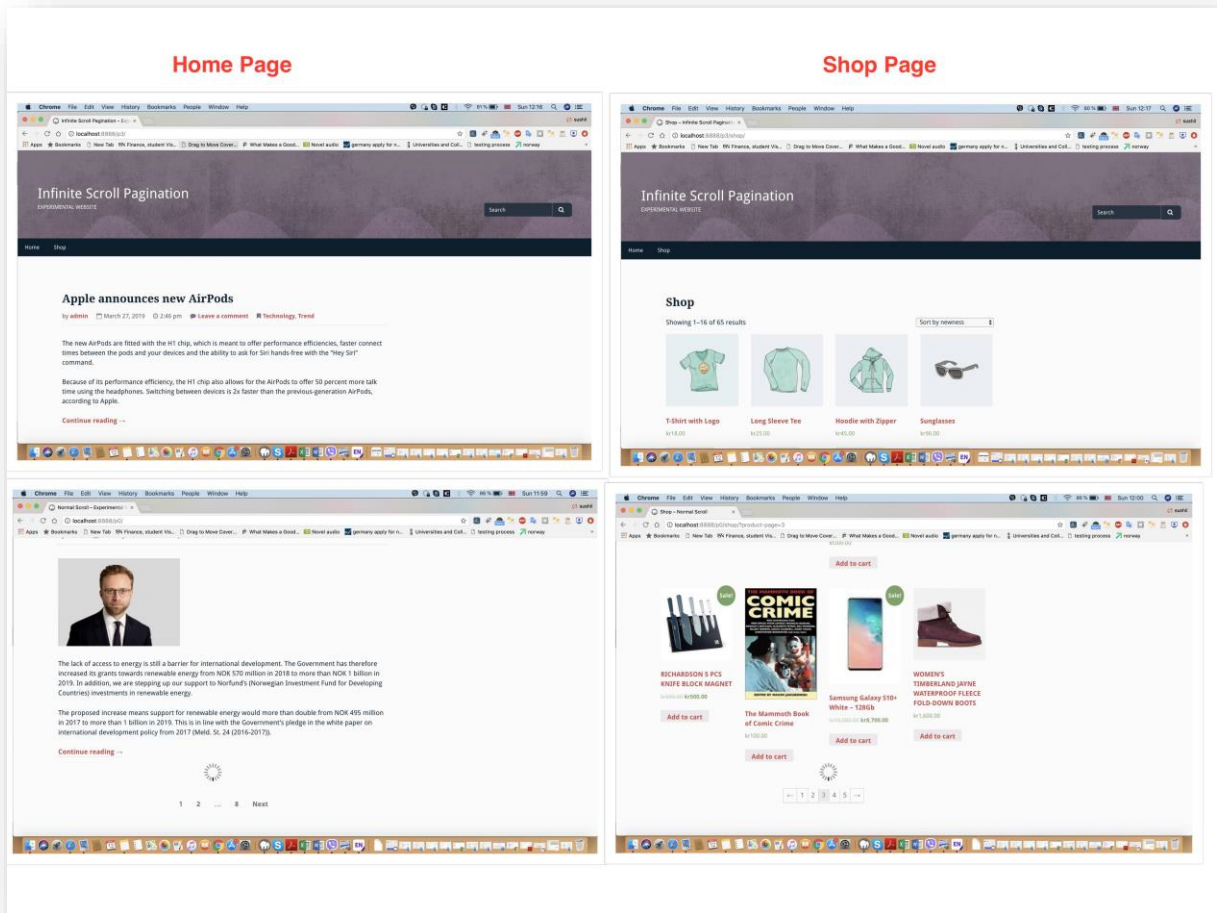


Figure 4.6-1 : Prototype 4 'Infinite Scrolling pagination website'

4.7 Prototypes Evaluation

It is important to make sure that the system or prototype used in any experiment are evaluated and every function are working properly. As mentioned earlier, all the prototype websites have been designed using seven principles of universal design (NDA, 2014) and web content accessibility guidelines (W3C®, 2008) with the aim to make scrolling techniques are more accessible and user-friendly. An Automated testing tool, as well as some manual testing, were used to evaluate the prototype websites.

According to Lazar et al. (2017), automation usability tools are often used when a large number of interfaces that need to be examined and little time is available to do human based reviews. He also added the strength of automation testing tool is that these tools can read through the code very quickly, looking for usability issues that can be collected and improved. With those benefits, automation tools were used to verify four different prototype websites having two pages with scrolling techniques. Automatic evaluation methods involve the analysis of aspect of user interfaces including layout, content, language to determine how well they conform to design guidelines (Ivory & Hearst, 2001). An Automation tool provides reports indicating the extent to which specific functionality has some flaws with respect to guidelines. The report also helps the designer to understand where user might get the problems and how those issues can be improved. Lazar et al. (2017) found that automation evaluation tools have been mostly used to verify accessibility issues in websites and evaluation provided by those tools are based on empirical evidence, accumulated experience, and accepted design practices.

A trial version of SorSite Desktop (Software, 2018) desktop automation tool was used for prototype evaluation. SorSite Desktop is a once click website testing tools that evaluate the website in the following aspects (Software, 2018).

- Accessibility: Check WCAG 2.0 and Section 508 guidelines
- Usability: check against usability.gov guidelines
- Web standards: validate HTML and CSS
- Broken links: identify broken links and spelling errors if any
- Compatibility: browser compatibility
- Privacy: check privacy concern

This tool has a feature to evaluate the websites by each page, or pages & links or entire sites. This tool provides a descriptive summary with categories, issue range, affected pages and what was tested. It gives clear views of every issues found on website with priority and classifies in total number of errors, accessibility, compatibility, search, standards, and usability.

With many areas of usability and accessibility that can be tested through the automation tool, however, tool did not provide the support for screen reader testing for used version. To cover this screen reader testing, manual testing has been performed by downloading NVDA screen

reader software (NVaccess) and which verified the prototype websites whether they were working properly or not.

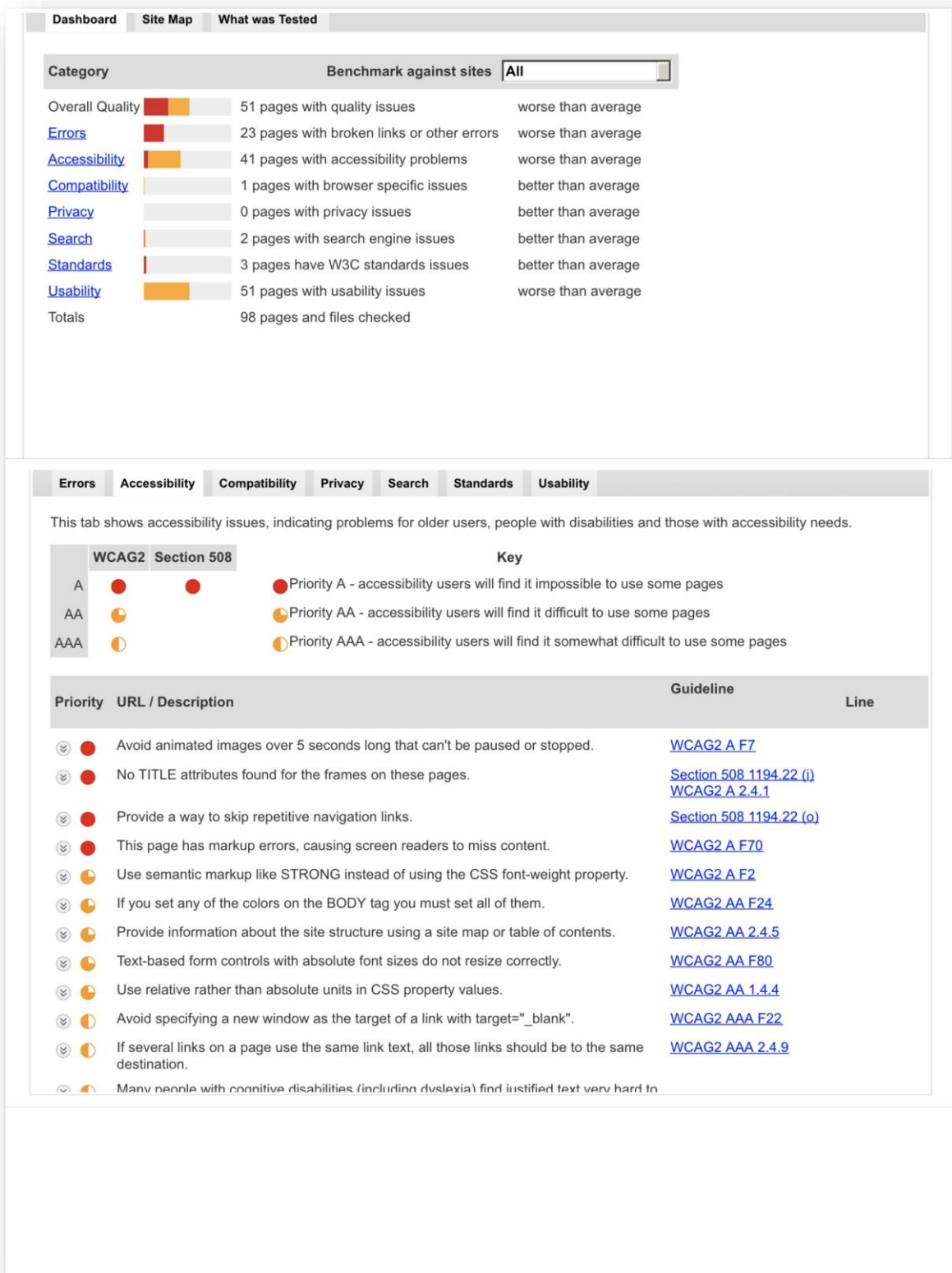


Figure 4.7-1 Report of automation tool 'sorsite' for prototypes

Figure 4.7-1 gives the Report regarding the prototype website tested by sorsite in the context of usability and accessibility. Sorsite tested every website in terms of the total number of errors in terms of quality, errors, accessibility, compatibility, standard, usability, etc. and errors were generalized by WCAG guidelines and standards and represented by conformance level, A, AA, or AAA as shown in the above report.

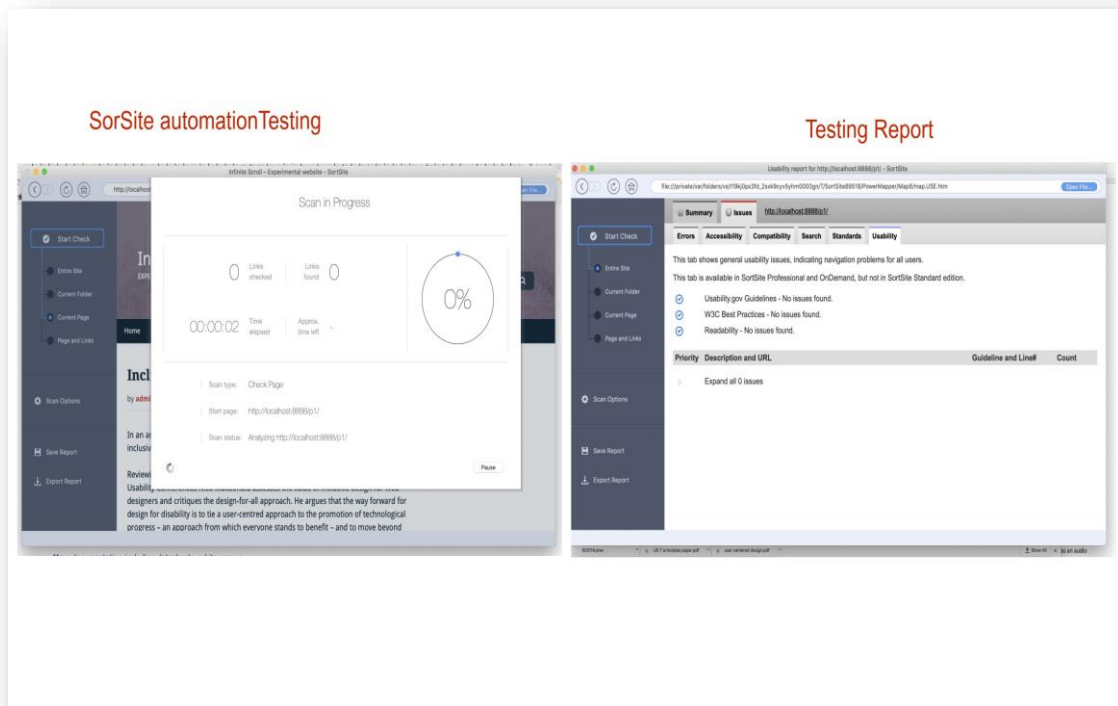


Figure 4.7-2 :Report after all fixed issues

Figure 4.7-2 gives the details that all the issues related to accessibility and usability found in the prototype websites were fixed and there are no any issues on websites while running the automated script.

5. Data Collection Procedure

Data collection is one of the most important and exciting parts of the research study. Data collection procedure takes place after when hypotheses are designed, research questions were formed, and the development and evaluation of prototype were successfully done. There are standard procedures to collect data in experimental research design. According to (Lazar et al., 2017), when all the prerequisites of experimental research are met, specific experiment sessions need to take place with the following procedure.

- In the beginning, make sure all the components of the product (prototype websites on this study) being evaluated working properly.
- Related devices or instruments are ready for the experiment.
- Welcome the participants and provide brief information about yourself.
- Give briefing about the study purpose and about the experiment details.
- Get Consent form (see [9.1.1 Consent form](#) under Appendix A).
- Get demographic details from participants using the pre-experiment questionnaire.
- Short training session about task details (experiment tasks based on specific information, which participant may not hear before) (see [4.1.1](#) and [4.1.2](#))
- Participant complete trial tasks
- Participant complete Real Experiment
- Get feedback about experiment from participants using a post-experiment questionnaire.
- Debriefing the experiment session.

Randomization was used to control the impact of the learning effect. During experiment time, participant's performance was measured using a stop-watch and screen recorder and participant opinions were collected through a post-experiment questionnaire designed using Likert-scale (Likert, 1932) from 1 to 5 with strongly agree to strongly disagree.

5.1 Tasks Design

There are four task groups were designed within this experiment. All the tasks were related to serendipitous discovery, exploration and goal-driven finding tasks. Those tasks were designed around the concept found in the study of Loranger (2014) from Nielsen Norman Group where people's activities tend to be either time-killing with serendipitous discovery or goal-driven finding or both. It is really important to know what actually and time killing activities with the mind-set of serendipitous discovery and the goal oriented finding activities are.

What is time killing activities with mind-set of serendipitous discovery?

It is wise to know what actually serendipitous discovery before designing the task relevant to this activity. Serendipitous discovery is occurring by accidentally which results in happiness or a beneficial way. In Hangal et al. (2012) study, they propose the concept of an experience-infused browser that has functionality which can serendipitously help users to recall connections to their past life experiences that have been forgotten. André et al. (2009) have performed a study on the serendipitous discovery and proposed several design areas based on their observation which help to develop an application to enhance the opportunity for making connections leading to new discoveries. With the context of the task, time-killing activities mean those activities which generally happen when people have nothing to do or bored in a specific field and want to spend the time on their interest area. For this study, time-killing activities were those tasks where participants are given specific information to find which could be interesting in a prototype website.

What is Goal-oriented Finding activities?

Goal oriented finding activities is defined as a task that focuses on reaching some specific objectives to achieve a targeted result. People use websites with the intention to find specific information regarding their area of interest and set a goal to find them as quickly as they want. There are several scientific research and experiments that have been done in goal- driven requirement analysis (Bolchini & Paolini, 2004). For this research study, goal

oriented finding tasks were those tasks where participants are given a goal information to find in a prototype website in the shortest time.

To design a task for an experiment to measure the usability of the scrolling techniques, a study from Nielsen Norman group (Jacob Nielsen & Norman, 2014) and (Pinelle & Gutwin, 2001) were used. There were four tasks in each task group which was categorized with the type of task, either serendipitous or goal-driven. All the prototype websites have two pages and tasks were designed to find or explore content on those pages. Although the tasks seem to differ, they are actually approximately equivalent to each other because the information to be found was placed at positions that did not require extra scrolling or more effort. Below are four tasks groups, A, B, C and D designed for real experiment and another four trial tasks were designed to give participants before to start of real experiment.

Table 5.1-1 Task Group A

Task Group A

No	Task Type	Task Details
1	Serendipitous	Go to Home page, discover sports news that you find really interesting or informative.
2	Serendipitous	Go to shop page, explore an electronics product which is latest or fascinating
3	Goal-Driven	Go to Home page, find music news with title “10 long-awaited albums that will be the soundtrack of 2019”.
4	Goal-Driven	Go to shop page, Find a book with name “The climb: Tragic ambitions on Everest” and price “200kr”.

Table 5.1-2 Task group B

Task Group B

No	Task Type	Task Details
1	Serendipitous	Go to Home page, discover cars related news that you find really interesting or informative
2	Serendipitous	Go to shop page, explore shoes product which is latest or fascinating in Shop page
3	Goal-Driven	Go to Home page, find a health news with title “Two compounds in coffee may team up to fight Parkinson’s”
4	Goal-Driven	Go to shop page, find a kitchenware product with Title “Richardson 5pcs knife block magnet” which is on “sale”.

Table 5.1-3 Task group C

Task Group C

No	Task Type	Task Details
1	Serendipitous	Go to Home page, discover music news that you find really interesting
2	Serendipitous	Go to shop page, explore a book which is interesting or informative
3	Goal-Driven	Go to home page, find sports news with title “Women-only motorsport series launched to find potential F-1 Stars”.
4	Goal-Driven	Go to shop page, find an electronics product with Title “JBL Xtreme2’ and price “1200kr”

Table 5.1-4 Task Group D

Task Group D

No	Task Type	Task Details
1	Serendipitous	Go to Home page, discover a Health news that you find really beneficial or informative.
2	Serendipitous	Go to shop page, explore a kitchenware product which is interesting and useful in Shop page
3	Goal-Driven	Go to Home page, find cars related news with title “Porsche Taycan Electric Car Teased, to debut in September”
4	Goal-Driven	Go to shop page, Find shoes with Title “JORDAN 1 MID RETRO BASKETBALL SHOES “with price “700kr”

5.2 System and materials for experiment

For this experiment following systems and materials were used to collect the data from participants.

- MacBook Pro with Mac OS Mojave, Intel Core i5 processor, 4GB RAM and 13” screen
- HP laptop with windows 10 OS, 4GB RAM, Intel Core i3 processor and 17” screen
- A stopwatch
- Chrome Web Browser (Firefox/Safari depends on the participant’s choice)
- Screen recorder (Chrome browser extension)
- Consent Form
- Pre-Experiment Questionnaire

- Tasks document for experiment
- Post Experiment Questionnaire

5.3 Participants

A total of 16 participants were included in this experiment. Those participants are the university students who have been pursuing their bachelor or master's degree and some are skill worker (software developer, designer, and quality assurance). To make the experiment more efficient, a choice of places was given, either at a university project room or participant's own place where they felt comfortable to perform the tasks. The experiment date and time were informed to participants in advance by means of social media, text message, phone call. Only experimenter and participant were allowed in a quiet and private room to conduct an experiment.

5.4 Ethical Consideration

To preserve the ethical aspects, a consent form with the following consideration was informed in this research study. Below are ethical consideration done in this study referenced from (Creswell & Creswell, 2017) (Nestor & Schutt, 2018). Please see [Appendix A- Consent form](#) for the structure of the consent form.

- Participant's personal details like name, address, phone number did not use in this study, rather a field 'Participant ID' (only numeric number) was used to record the data.
- Participants have right to refuse to participate in an experiment without any explanation.
- Participants have right to know about the purpose of the research study, use of data, and goal of the study.
- Participants have right to ask any question before, during and end of experiment and can contact the concerned person in the future.
- Participants were ensured the collected information will be anonymous.
- Participants were known not to share details of the study to anyone until the research is completely done.

5.5 Pilot Study

Before the start of the real experiment with the selected participants, pilot testing was conducted within two participants who were pursuing a master degree at the University of Oslo. The goal of the pilot study was to investigate the possible biases before conducting the real experiment to collect the data. Within setup experimental design, they were given tasks to perform in an experiential website.

After completion of the experiment, following results were drawn and possible changes were done in a real experiment.

- Participants had taken longer time than expected, the reason was they had difficulty to use scrolling techniques at the beginning. To overcome this issue, training was added before the start of a real experiment.
- Participants learned from task experience and performed better in the last two tasks. To minimize this issue, randomization (Campbell & Stanley, 2015) was used in the real experiment, due to which experiment conditions and tasks were randomly assigned to participants.

5.6 Experiment Procedure

The experiment procedure was divided in four segments. When participants agreed to participate in an experiment, they were greeted and brief information about experimenter was given. After that, experiment was conducted with four segments; pre-experiment, training, real experiment and post-experiment.

5.6.1 Pre-Experiment

After participants got seated, they were given a consent form and told to read carefully before to get them signed. The consent form had details about research study information, purpose of study, all experiment procedures, confidentiality information which ensured there would be no risk on participation. By checking all the list of checkbox information on the consent form participant were given a pre-experiment questionnaire form (please see [appendix B-pre experiment questionnaire](#)). The questionnaire form helped to gather the demographic

information about the participants and also information regarding their experience on computer use, website uses, different scrolling technique uses etc. will be taken for further analysis. To design a demographic information form, following scientific paper from authors (B. Fogg et al., 2001; B. J. Fogg et al., 2003; Fraenkel et al., 2011; Grudin & Pruitt, 2002) were studied.

5.6.2 Training

After the pilot study, it was found that participant had some confusion on using different scrolling techniques used in prototype websites. To lower down the potential bias and to make experiment more effective, a short training session was added about the different scrolling techniques used in prototype websites. Training session was around 3-7 minutes, where basic functionality of scrolling techniques used in website with examples was given.

After a training session, trial tasks were given to each participant that gives an equal opportunity to all participant to perform each of the tasks smoothly.

5.6.3 Real Experiment

Real experiment was an important part of the study. When each participant completed the pre-experiment requirements and training session with trail tasks, they were considered eligible to perform the real experiment with real tasks in developed prototype websites. A screen recorder was started and the stopwatch was made ready before participants started the real task. Real experiment was conducted in the following sequence;

- Total 16 participants were included.
- There were 4 prototype websites with 4 different scrolling techniques.
- There were 4 real tasks groups; A, B, C, and D to perform by each participant.
- Randomization was used in the experiment to remove potential bias (please see [appendix B-Randomization](#)).
- There were three dependent variables being measured during the experiment.

If a participant had any questions regarding issues while performing tasks in between experiment, the experimenter gave some hints to complete the tasks. Those hints were same

for every participant and visible to everyone so that there was no potential bias in an experiment.

5.6.4 Post-Experiment

When participants completed the assigned tasks on websites with scrolling techniques, they were given a post-experiment questionnaire to fill up their preferences/opinions about four scrolling techniques, task design, and website design. The Questionnaire was like most user feeling based where participants were asked to give a rating on simple and easy to use, pleasant to use, responsive to use, felt confident to use and recommended to use on different scrolling techniques (please see [appendix B-post experiment questionnaire](#)). Those feedbacks were used to evaluate the usability factor, user satisfaction. To design a questionnaire related to the usability of scrolling techniques, tasks and experiment, following scientific paper from authors (Brooke, 1996; Laubheimer, 2018; J. R. Lewis & Sauro, 2009) were studied.

At the end of the experiment, participants were given a big thank you with a smile for their participation.

5.7 Quantitative data analysis

With the completion of experiments, quantitative data were collected from participant's performances; total task completion time in second, total number of errors (please see section [3.3.2](#) about error type) and subjective opinions Likert scale rating from 1 to 5 (1-strongly disagree to 5-strongly agree). It is really important to choose the appropriate statistical test to analyze those qualitative data and report them wisely to answer the research questions of the study (Creswell, 2002).

There were four scrolling techniques need to be compared based on serendipitous discovery and goal-driven finding tasks. To compare those, it is wise to use a statistical significant test to evaluate the variances that can be explained by the independent variable (Lazar et al., 2017). Result of significant test provides evidence of whether to reject or accept the null hypothesis.

There are various significant tests that are available to use to compare the mean of multiple experimental conditions, mostly used tests are t-pair test and ANOVA test (Lazar et al.,

2017). One way repeated measure ANOVA test was chosen to analyze as study has one independent variable with multiple experimental conditions and within-subject design experiment (Mayers, 2013).

5.7.1 One-Way Repeated Measure ANOVA

One-way repeated Measure ANOVA is a parametric statistics test used to measure the significant difference between different conditions. One independent variable was repeatedly measured for task type serendipitous discovery and goal-driven and analyzed individually using this test. The reason to analyze individually was to measure the efficiency of each experiment condition (scrolling technique) for each task type. The significant value (P value) gives the probability value that the result could have occurred by chance, if null hypothesis were true (Lazar et al., 2017). The significant value (p) should be less than 0.05 to be significant. However, if P value is greater than 0.05, it will accept the null hypothesis, that there is no difference between the conditions.

Following steps were done to report the analysis result using one way repeated measure ANOVA test;

- Test of normal distribution- Normality test from SPSS (Kolmogorov-Smirnov/Shapiro-Wilk test) was conducted to check whether the data were normally distributed on each condition.
- Descriptive mean-SD analysis- Mean and standard deviation analysis
- Test of Sphericity (Mauchly's sphericity test)- Mauchly's test is the part of one way repeated measure ANOVA, is used to check the sphericity of within-group variance.
- Test of within effect- most important test as it gives the actual result of ANOVA.
- Analysis result: Summed up all the tests and present the actual result of the ANOVA test including Null hypothesis acceptance or rejection.

6. Data Analysis and Result

With the successful completion of an experiment, data were collected from all the 16 participants. At the beginning, all the raw data were managed in the excel sheet and then analysed using the statistical tool, i.e. IBM SPSS statistics (SPSS, 2019).

In this study, a one-way repeated measure ANOVA test was used to analyse the data collected from participants performance and their opinion. According to the Mayers (2013), one way repeated measure ANOVA is used to explore the differences in mean value from a single parametric dependent variable, over three or more within-group conditions from an independent variable.

Firstly, participant's general information was depicted at a high level bar chart using excel workbook, and participant performance and opinions of participants were analysed in detail using the SPSS tool (SPSS, 2019).

6.1 Participants Demographic Information

Total 16 participants were included in this research study. Among them 75% were Male and 25% were female, 69% of participants were age group 26-35 years and rest of other 18-25,35-40 and 40 above. 88% of participants were graduate and 6% each from high school and doctorate. Most of the participants were student (75%) and others were developer, designer and tester.

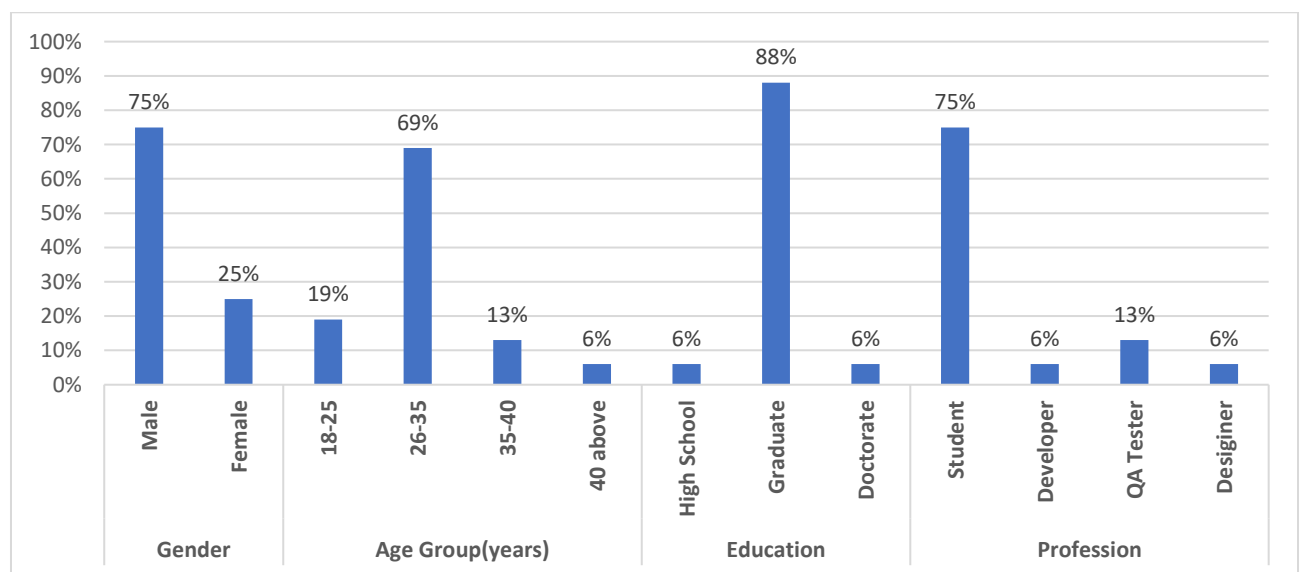


Figure 6.1-1 :Percentage of total participants in terms of gender, age, education and profession

It was found that 87% of participants have more than 5 years of computer use experience and they use internet for more than 5 years in daily life. Most of the participant’s internet browser preference was Google chrome with 62%, 25% participants preferred to use Mozilla Firefox and 13% of participants told Safari is appropriate browser to surf the internet.

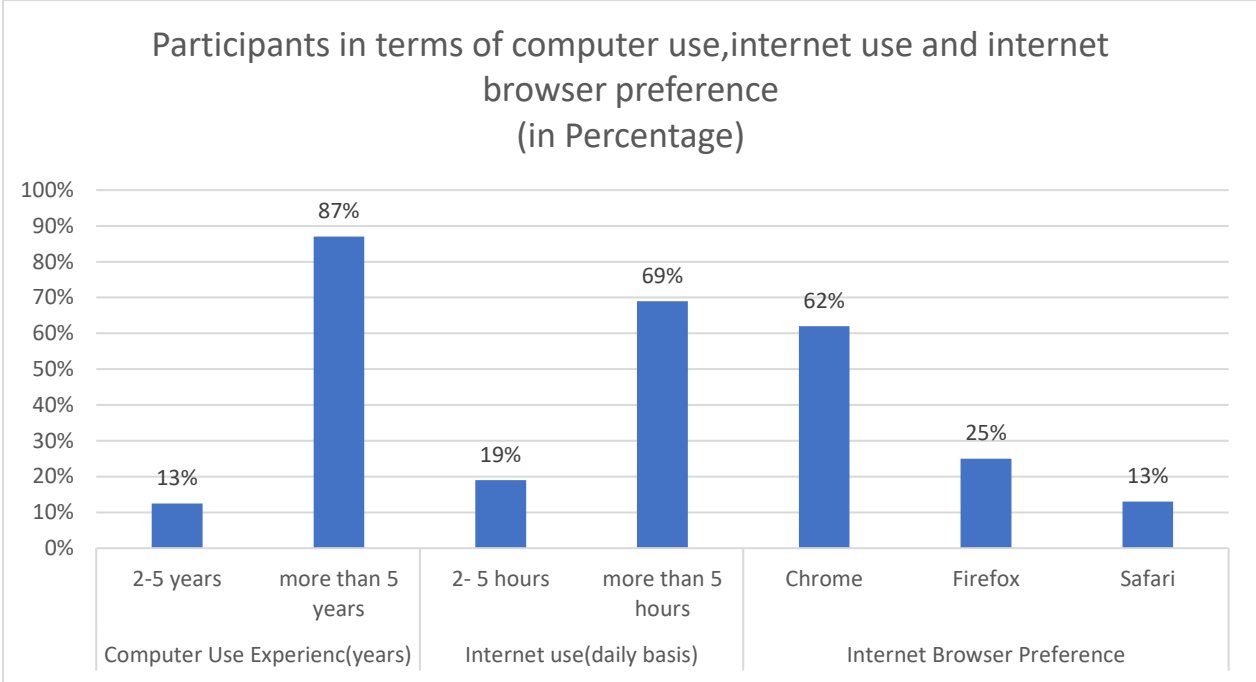


Figure 6.1-2 : Participants in terms of computer use, internet use and internet browser preference

Most of the participants have really good experience in visiting websites. It was found that they used websites for different purposes like academic, entertainment, shopping, profession related and communication. There is a slight difference in participant’s preference to use websites; 60% were uses laptops and 40% used smartphone devices to do internet things. Most of participant has used scrolling in websites, they do know about normal scrolling, infinite scrolling, infinite scrolling with ‘load more’ button and infinite scrolling with ‘pagination’ and used frequently while searching or finding contents in websites.

All the participants have known to universal design and they think it is really important to design all web content more user-friendly and accessible. None of the participants have any impairments and need assistive technology to perform the given tasks.

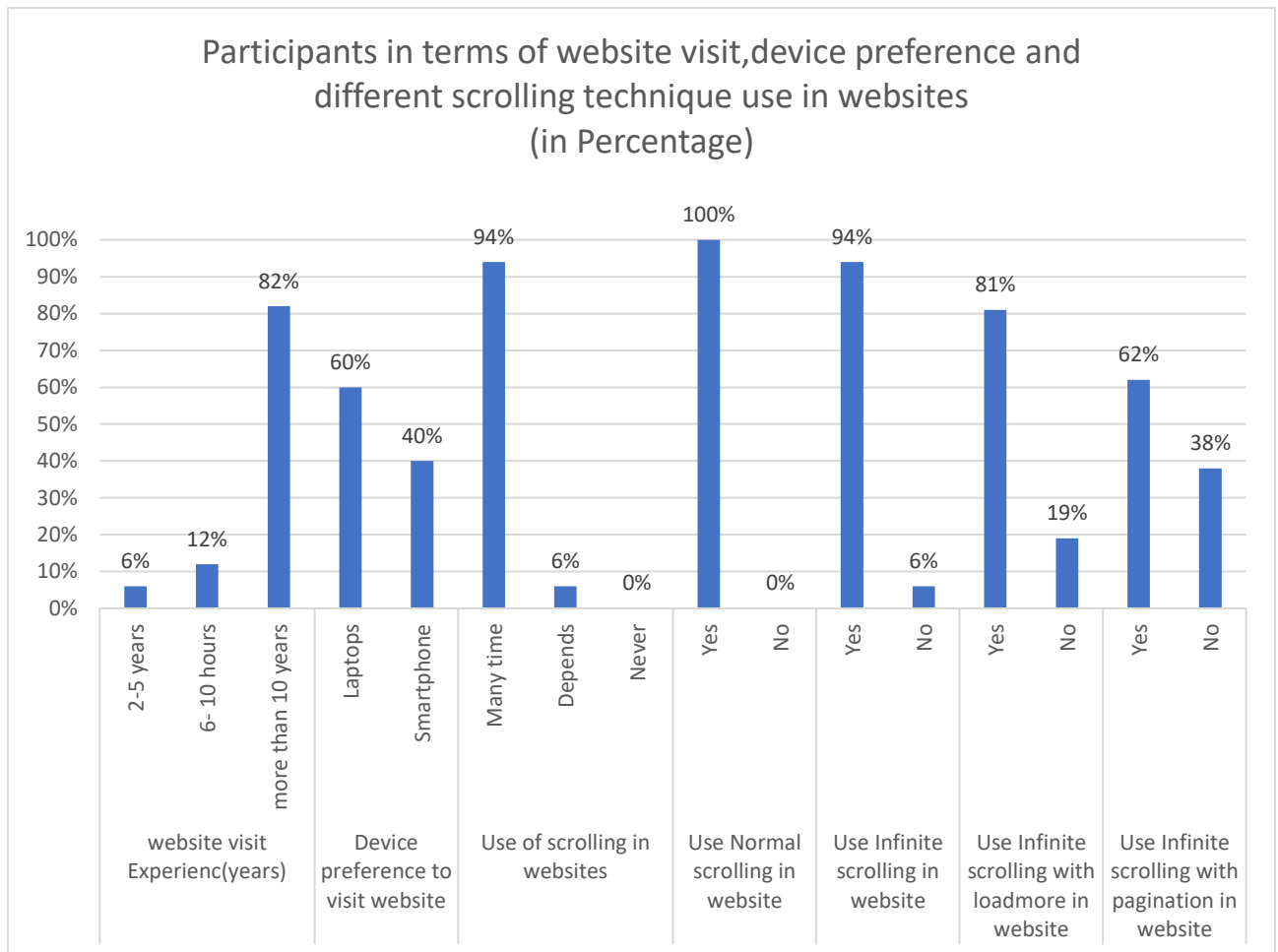


Figure 6.1-3 : Participants in terms of website visit, device preference and different scrolling technique use in websites

6.2 Subjective performance on experimental conditions

This section includes the analysis of participant's performance on four different experimental prototype websites. Participants performance in this study was total task completion time and total number of errors. One-way repeated measure ANOVA test was conducted using the SPSS tool (SPSS, 2019) to analyze the efficiency and accuracy of given task which helps to evaluate the proposed scrolling technique in this study. There were two kinds of tasks in this research; time-killing activities with serendipitous discovery and goal-driven finding, so the analyses were done based on each type of task individually. Assumptions were verified before using one-way repeated measure ANOVA test to analyze the data (please see [5.7.1](#) section for pre-requisite ANOVA).

6.2.1 Total task completion time

Total task completion time analysis was done based on two different tasks, total completion time for time-killing activities with serendipitous activities task and goal-driven finding tasks.

6.2.1.1 Time-Killing activities with serendipitous discovery task

Average time taken to complete the serendipitous discovery tasks (in seconds)

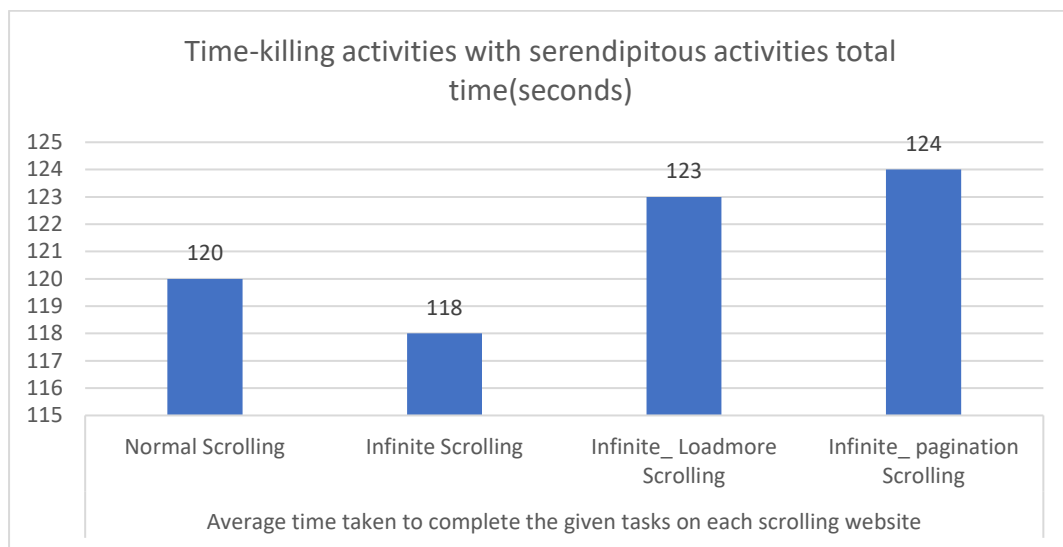


Figure 6.2-1: Average time taken to complete the given tasks (serendipitous discovery) on each scrolling website

Figure 6.2-1 depicts the participants took less time (118 seconds) in website with Infinite scrolling technique to complete the given time-killing activities with serendipitous discovery tasks, whereas they took 120 seconds for normal scrolling website, 123 seconds for infinite load more scrolling website and 124 seconds for infinite pagination scrolling website.

Test for Normal distribution

Table 6.2-1 : Normality test of total task completion time for serendipitous discovery task

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Normal scrolling	0.124	16	.200*	0.962	16	0.705
Infinite scrolling	0.147	16	.200*	0.958	16	0.629

Infinite 'Load more' scrolling	0.192	16	0.117	0.95	16	0.059
Infinite Pagination scrolling	0.181	16	0.132	0.952	16	0.072

Normality test from SPSS (Kolmogorov-Smirnov/Shapiro-Wilk test) was conducted to check whether the data were normally distributed on each condition. It was found that all the condition was normally distributed ($P > 0.05$), i.e., $p = 0.705$ on prototype with Normal scrolling, $p = 0.629$ on prototype with Infinite Scrolling, $p = 0.059$ on infinite scrolling with 'load more' and $p = 0.072$ prototype with infinite scrolling with pagination p-value 0.072 (please see table 6.2-1).

Descriptive Mean-SD details

Table 6.2-2 Mean and standard deviation analysis for total task completion for serendipitous discovery task

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal Scrolling	119.63	5.123	16
Infinite scrolling	118.38	6.781	16
Infinite 'Loadmore' scrolling	123.25	8.598	16
Infinite Pagination scrolling	123.88	20.113	16

Estimated Marginal Means of MEASURE_1

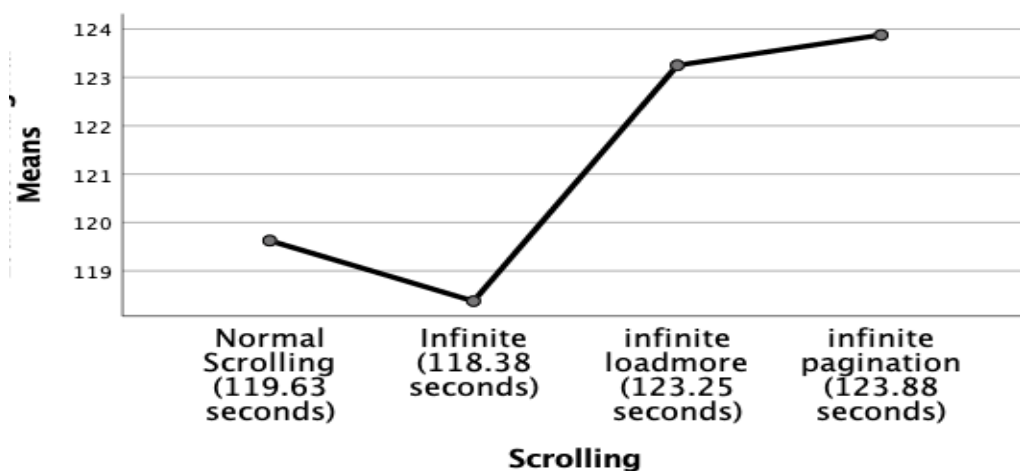


Figure 6.2-2 : Mean plot graph for total completion time for serendipitous task

From Descriptive Mean-SD analysis (Table 6.2-2) and mean-plot graph (figure 6.2-2), the total time taken by participants while completing time killing activities with serendipitous discovery tasks on website were less in Infinite scrolling (mean = 118.38; SD = 6.781), followed by normal scrolling (mean = 119.63; SD = 5.123), Infinite 'load more' scrolling (mean = 123.25; SD = 8.598) and Infinite pagination scrolling (mean = 123.88; SD = 20.113).

Mauchly's test for Sphericity of within group

Mauchly's test is the part of one way repeated measure ANOVA, is used to check the sphericity of within group variance. If sig. value(p) greater than 0.05, then it can be said that sphericity can be assumed and allow to select 'sphericity assumed' line of data when examine main ANOVA result.

Table 6.2-3 : Mauchly's sphericity test for total time (serendipitous discovery task)

Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Serendipitous time	0.224	9.834	5	.0801	0.527	0.579	0.333

Table 6.2-3 shows that sphericity has been assumed with value $\chi^2(5) = 9.834, p = .0801$.

Test of Within-subject Effect

This is the most important test, as it gives the actual result of ANOVA. In this test sphericity was assumed, so only the block of 'sphericity assumed' data are used to analyze the result. The significant value (P value) gives the probability value that the result could have occurred by chance if null hypothesis were true. The significant value (p) should be less than 0.05 to be significant. However, if P value is greater than 0.05, it will accept the null hypothesis, that there is no difference between the conditions.

Table 6.2-4 : within subject report total time taken for serendipitous task

Tests of Within-Subjects Effects	
Measure: MEASURE_1	

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Serendipitous time	Sphericity Assumed	348.687	3	116.229	0.901	0.448	0.057
	Greenhouse e-Geisser	348.687	1.582	220.349	0.901	0.398	0.057
	Huynh-Feldt	348.687	1.738	200.633	0.901	0.405	0.057
	Lower-bound	348.687	1	348.687	0.901	0.358	0.057
Error (Serendipitous time)	Sphericity Assumed	5803.813	45	128.974			
	Greenhouse e-Geisser	5803.813	23.736	244.51			
	Huynh-Feldt	5803.813	26.069	222.632			
	Lower-bound	5803.813	15	386.921			

Table 6.2-4 shows that the significant value(P) is greater than 0.05, which means there was no significant difference in 'total time taken to complete the time-killing activities with serendipitous discovery tasks' completed by the participants. As $P > 0.05$ stands, null hypothesis(H_0) cannot be rejected in this case, with statistics value ($F(3, 45) = 0.901, p = 0.488, \eta^2 = 0.057$)

Analysis Result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of total task completion time for 'time-killing activities with serendipitous discovery' tasks on the website with all four scrolling techniques, ($F(3, 45) = 0.901, p = 0.488, \eta^2 = 0.057$). However, according to the mean score, it has been seen that participant took less time in the Infinite scrolling website (118.38 seconds) as compared to Normal scrolling (119.63 seconds), Infinite scrolling with load more (123.25 seconds) and Infinite scrolling with pagination (123.88 seconds).

6.2.1.2 Goal-Driven finding tasks

Average time taken to complete the goal-driven finding tasks (in seconds)

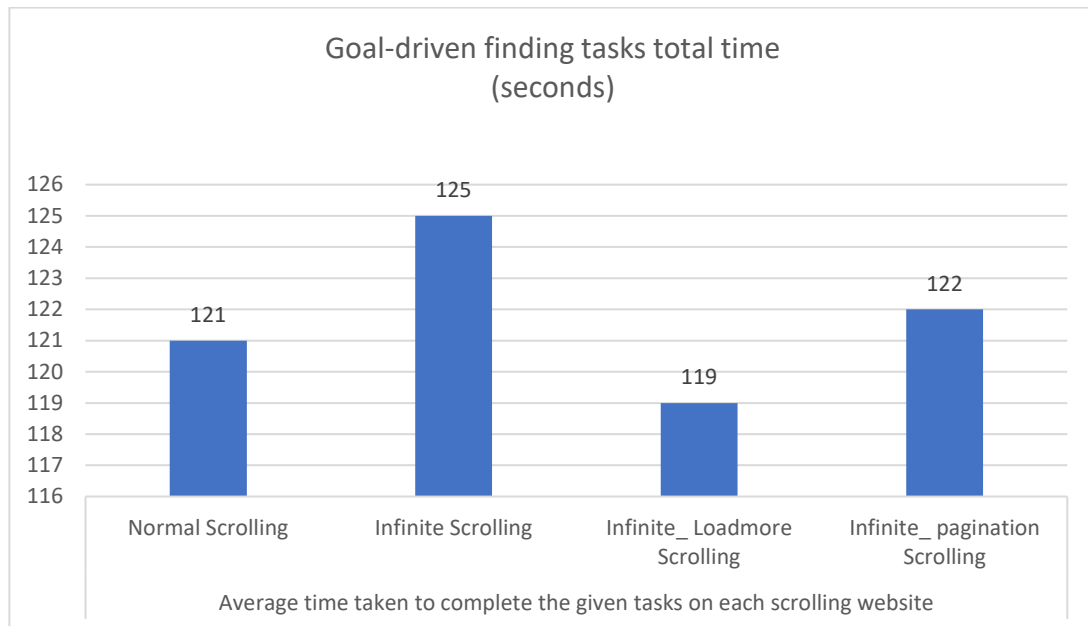


Figure 6.2-3 : Average time taken to complete the goal-driven finding tasks on each scrolling website

Figure 6.2-3 shows that the participants took less time (119 seconds) in website with Infinite load more scrolling technique to complete the given goal-driven finding tasks.

Test for Normal distribution

Normality test from SPSS (Kolmogorov-Smirnov/Shapiro-Wilk test) was conducted to check whether the data were normally distributed on each condition. It was found that all the condition was normally distributed ($P > 0.05$), i.e., $p = 0.387$ on a prototype with Normal scrolling, $p = 0.871$ on prototype with Infinite Scrolling, $p = 0.384$ on infinite scrolling with 'load more' and $p = 0.062$ prototype with infinite scrolling with pagination (please see statistics table from [Appendix C](#))

Descriptive Mean-SD details

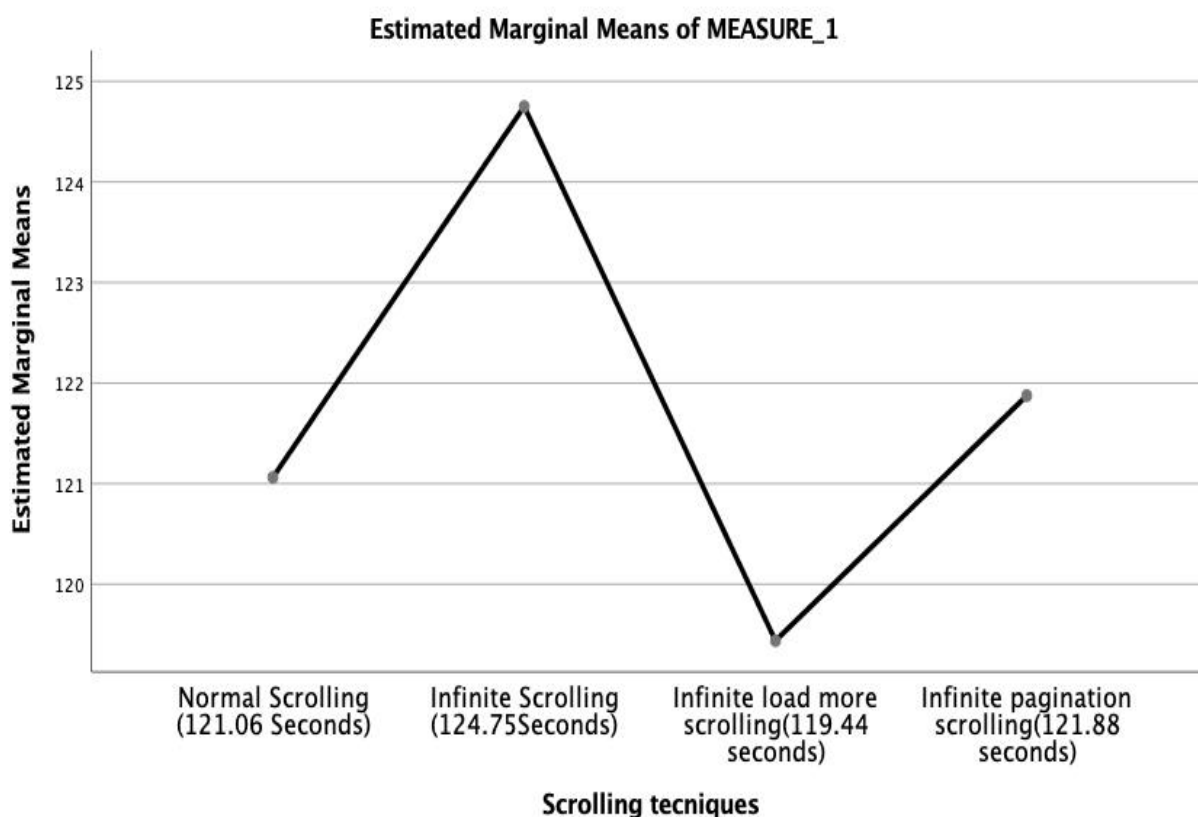


Figure 6.2-4 : Mean plot graph of total completion time for Goal-driven task

From Descriptive Mean-SD analysis (please see [appendix C](#)) and mean-plot graph (figure 6.2-4) it can be seen that, total time taken by participants while completing goal-driven finding tasks on website were less in Infinite 'load more' scrolling (mean = 119.44; SD = 6.532), followed by normal scrolling (mean = 121.06; SD = 9.781), Infinite pagination scrolling (mean = 121.88; SD = 20.35) and Infinite scrolling (mean = 124.75; SD = 12.102).

Mauchly's test for Sphericity of within group

After Applying ANOVA test, it was found that sphericity has been assumed with value $\chi^2(5) = 8.935$, $p = 0.117$. (please see statistics table from [Appendix C](#))

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.2-5 : within subject report for total time taken while completing goal-driven finding task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Goal driven time	Sphericity Assumed	237.313	3	79.104	0.445	0.722	0.029
	Greenhouse-Geisser	237.313	1.898	125.025	0.445	0.635	0.029
	Huynh-Feldt	237.313	2.165	109.596	0.445	0.66	0.029
	Lower-bound	237.313	1	237.313	0.445	0.515	0.029
Error (Goal driven time)	Sphericity Assumed	7999.688	45	177.771			
	Greenhouse-Geisser	7999.688	28.472	280.969			
	Huynh-Feldt	7999.688	32.48	246.296			
	Lower-bound	7999.688	15	533.313			

Table 6.2-5 shows that the significant value(P) is greater than 0.05, which means there was no significant difference in ‘total time taken to complete the goal-driven finding tasks’ completed by the participants. As $P > 0.05$ stands, null hypothesis(H_0) cannot be rejected in this case, with statistics value ($F(3, 45) = 0.445, p = 0.722, \eta^2 = 0.029$).

Analysis Result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of total completion time for ‘Goal-Driven finding’ tasks on the website with all four scrolling techniques, ($F(3, 45) = 0.445, p = 0.722, \eta^2 = 0.029$). However, according to the mean score, it has been seen that participant took less time in the Infinite scrolling with load more website (119.44 seconds) as compared to Normal scrolling (121.06seconds), Infinite scrolling with pagination (121.88 seconds) and Infinite scrolling (124.75 seconds).

6.2.2 Total Number of errors

Total number of error analysis was done based on two different tasks, total number of error done by participants for time-killing activities with serendipitous activities task and goal-driven finding tasks.

6.2.2.1 Time-Killing activities with serendipitous discovery task

Average number of errors done while completing the serendipitous tasks

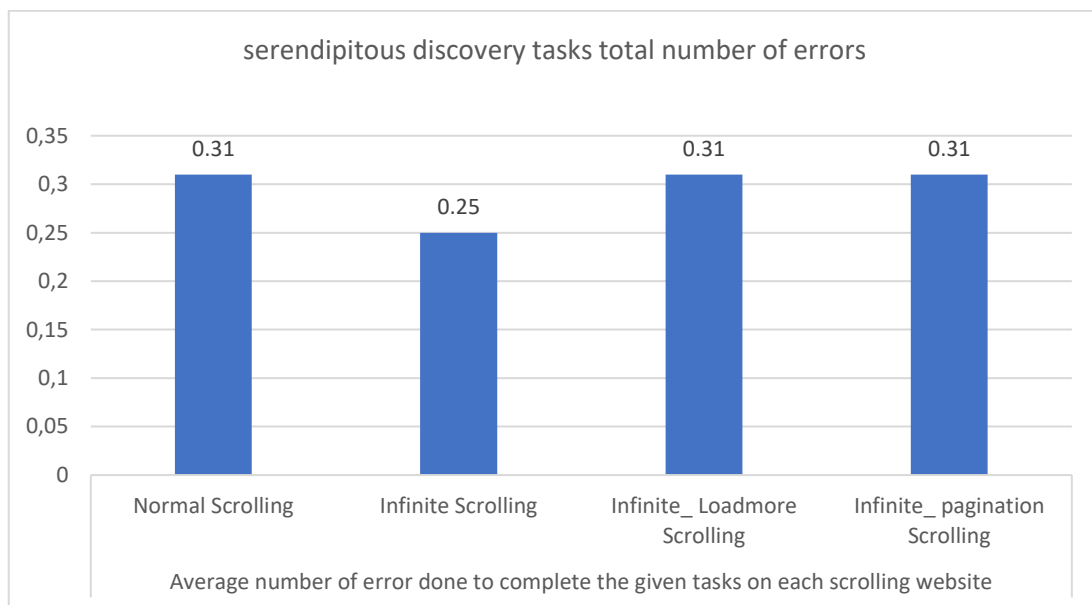


Figure 6.2-5 : Average number of error done by participant to complete the serendipitous discovery task

Figure 6.2-5 depicts the participants have done less number of errors in infinite scrolling website (0.25) to complete the time killing activities with serendipitous discovery tasks.

Test for Normal distribution

Normality test from SPSS (Kolmogorov-Smirnov/Shapiro-Wilk test) was conducted to check whether the data were normally distributed on each condition. It was found that all the condition was normally distributed ($P > 0.05$), i.e., $p = 0.089$ on prototype with Normal scrolling, $p = 0.073$ on prototype with Infinite Scrolling, $p = 0.089$ on infinite scrolling with 'load more' and $p = 0.083$ prototype with infinite scrolling with pagination (please see statistics table from [Appendix C-statistics table](#)).

Descriptive Mean-SD details

From Descriptive Mean-SD analysis (please see [Appendix C- statistics table](#)) and mean-plot graph (figure 6.2-6) it can be seen that, total number of error done by participants while completing time-killing activities with serendipitous discovery tasks on website were less in Infinite scrolling (mean = 0.25 ; SD = 0.447), as compared to normal scrolling (mean = 0.31; SD = 0.602), Infinite 'load more' scrolling (mean = 0.31; SD = 0.602) and Infinite pagination scrolling (mean = 0.31; SD = 0.479).

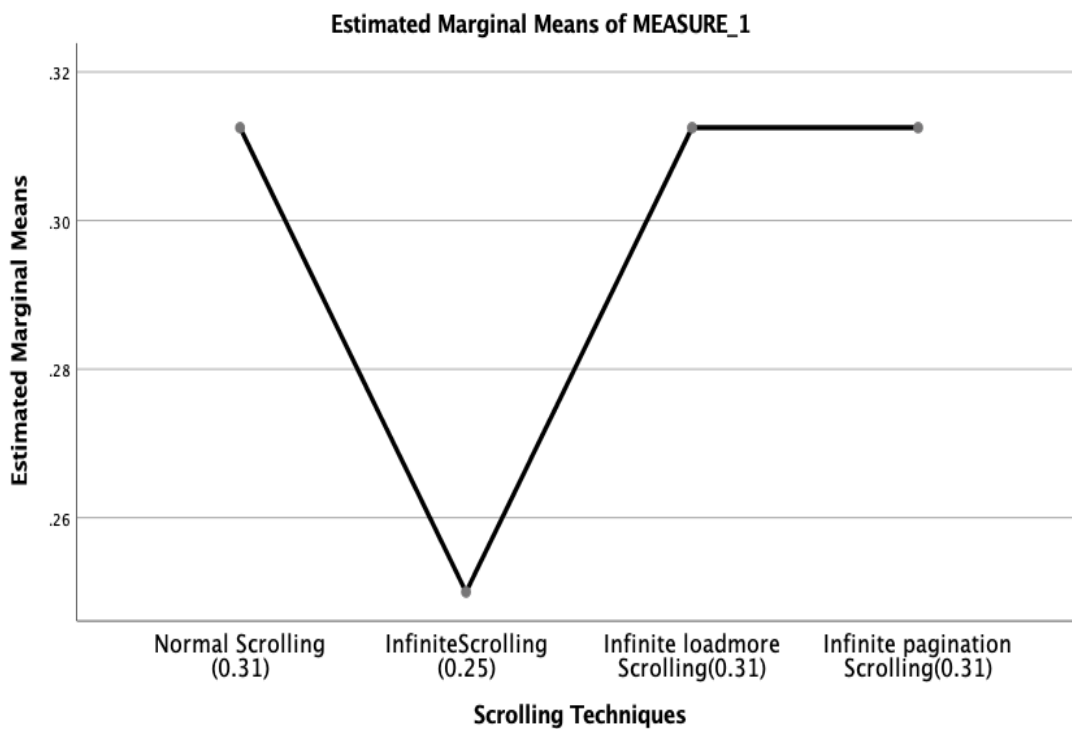


Figure 6.2-6 :Mean-graph plot for total error done while completing serendipitous tasks

Test for Sphericity of within group

After Applying One way repeated measure ANOVA test, it was found that sphericity has been assumed with value $\chi^2 (5) = 1.881, p = 0.866$. (please see statistics table from [Appendix-Statistics Table](#))

Test of Within-subject Effect

One way repeated measure ANOVA's main result with following details.

Table 6.2-6 : within subject report for total number of error done while completing serendipitous discovery task

Measure: MEASURE_1		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total error serendipitous	Sphericity Assumed	0.047	3	0.016	0.043	0.988	0.003
	Greenhouse-Geisser	0.047	2.773	0.017	0.043	0.984	0.003
	Huynh-Feldt	0.047	3	0.016	0.043	0.988	0.003
	Lower-bound	0.047	1	0.047	0.043	0.838	0.003
Error (Total error serendipitous)	Sphericity Assumed	16.203	45	0.36			
	Greenhouse-Geisser	16.203	41.6	0.389			
	Huynh-Feldt	16.203	45	0.36			
	Lower-bound	16.203	15	1.08			

Table 6.2-6 shows that the significant value(P) is greater than 0.05, that means there was no significant difference in ‘total number of error done to complete the time-killing activities with serendipitous discovery tasks’ completed by the participants. As $P > 0.05$ stands, null hypothesis(H_0) cannot be rejected in this case, with statistics value ($F(3, 45) = 0.043, p = 0.988, \eta p^2 = 0.003$).

Analysis Result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of total number of error done for ‘time-killing activities with serendipitous discovery’ task on website with all four scrolling techniques, ($F(3, 45) = 0.043, p = 0.988, \eta p^2 = 0.003$). However, according to the mean score, it has been seen that participant have done less errors in the Infinite scrolling website (0.25) as compared to Normal scrolling (0.31), Infinite scrolling with load more (0.31) and Infinite scrolling with pagination (0.31).

6.2.2.2 Goal-Driven finding tasks

Average number of errors done while completing the goal-driven finding tasks

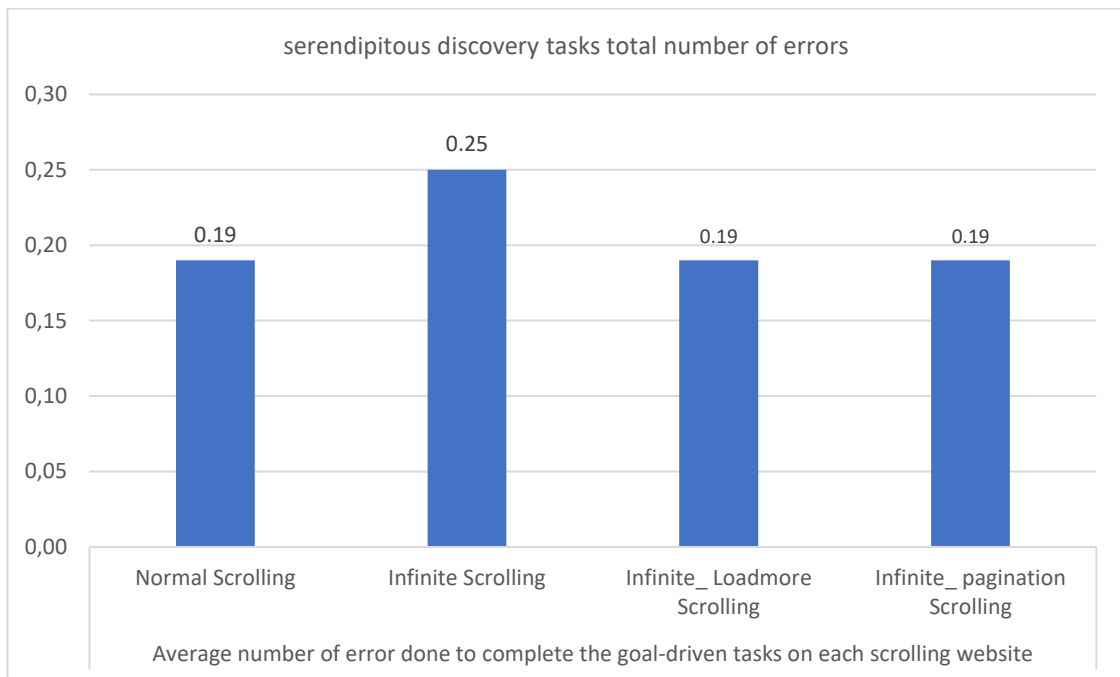


Figure 6.2-7: Average number of error done while completing goal-driven finding tasks

Figure 6.2-7 depicts the participants have done less number of errors in three different scrolling techniques; Normal (0.19), infinite load more (0.19) and infinite pagination (0.19) as compared to infinite scrolling website (0.25) while completing goal-driven finding tasks.

Test for Normal distribution

Normality test from SPSS (Kolmogorov-Smirnov/Shapiro-Wilk test) was conducted to check whether the data were normally distributed on each condition. It was found that all the condition was normally distributed ($P > 0.05$), i.e., $p = 0.677$ on prototype with Normal scrolling, $p = 0.730$ on prototype with Infinite Scrolling, $p = 0.677$ on infinite scrolling with 'load more' and $p = 0.677$ prototype with infinite scrolling with pagination (please see statistics table from [Appendix C- statistics tables](#))

Descriptive Mean-SD details

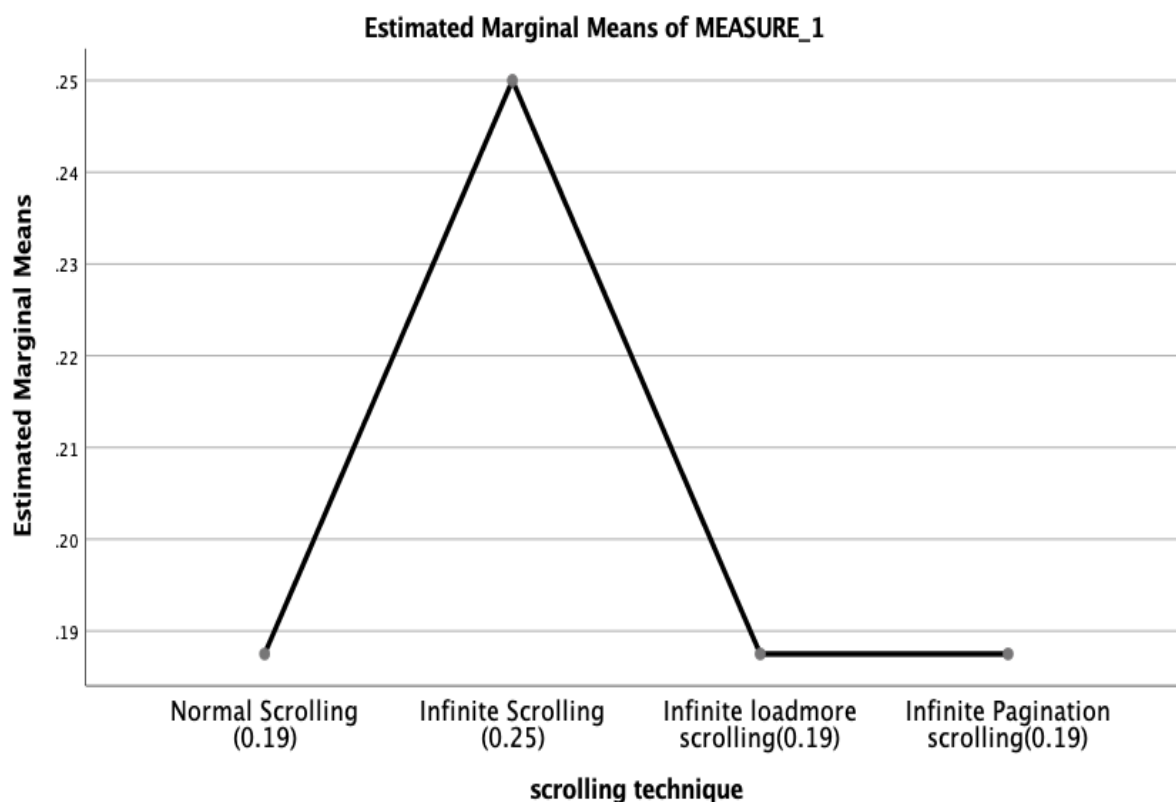


Figure 6.2-8: Mean-graph plot for total error done while completing goal-driven tasks

From Descriptive Mean-SD analysis (please see [Appendix C- statistics table](#)) and mean-plot graph (figure 6.2-8) it can be seen that, total number of error done by participants while completing goal-driven tasks on website were less in three different scrolling techniques; Normal scrolling (mean = 0.19 ; SD = 0.403), Infinite 'load more' scrolling (mean = 0.19; SD = 0.403), Infinite pagination scrolling (mean = 0.19; SD = 0.403) as compared to infinite scrolling (mean = 0.25; SD = 0.447).

Mauchly's test for Sphericity of within group

After Applying ANOVA test, it was found that sphericity has been assumed with value $\chi^2 (5) = 0.753$, $p = 0.980$. (please see statistics table from [Appendix C- statistics tables](#)).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.2-7: within subject report for total number of error while completing goal-driven task

Tests of Within-Subjects Effects							
Measure: MEASURE_1		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total error goal driven	Sphericity Assumed	0.047	3	0.016	0.076	0.972	0.005
	Greenhouse-Geisser	0.047	2.895	0.016	0.076	0.969	0.005
	Huynh-Feldt	0.047	3	0.016	0.076	0.972	0.005
	Lower-bound	0.047	1	0.047	0.076	0.786	0.005
Error (Total error goal driven)	Sphericity Assumed	9.203	45	0.205			
	Greenhouse-Geisser	9.203	43.42	0.212			
	Huynh-Feldt	9.203	45	0.205			
	Lower-bound	9.203	15	0.614			

Table 6.2-7 shows that the significant value(P) is greater than 0.05, that means there was no significant difference in ‘total number of error done to complete the goal-driven finding tasks’ completed by the participants. As $P > 0.05$ stands, null hypothesis(H0) cannot be rejected in this case, with statistics value ($F(3, 45) = 0.076, p = 0.972, \eta^2 = 0.005$).

Analysis result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of total number of error done for ‘goal-driven finding’ task on website with all four scrolling techniques, ($F(3, 45) = 0.076, p = 0.972, \eta^2 = 0.005$). However, according to the mean score, it has been seen that participant have done less number of errors in three different scrolling technique websites; Normal scrolling (0.19), Infinite scrolling with load more (0.19), and Infinite scrolling with pagination (0.19) as compared to Infinite scrolling (0.25).

6.3 Subjective opinion on experimental conditions

This section includes the analysis of participant's opinions on four different experimental prototype websites. Participants opinion data were collected from sets of questions based on the participant's feeling towards designed four scrolling techniques (experimental conditions). Participants have given their opinion on a Likert type scale (1-5 score) on five questions of two task types; i.e. time-killing activities with serendipitous discovery and goal-driven finding activities and also for task and prototype website design. Mayers (2013) explains self-rated scores (Likert type scale) from within-subject analyses are more acceptable in repeated measure ANOVA, because the outcomes are based on how scores change in different conditions within each participant and have no effect on output of other participants. Due to which, One-way repeated measure ANOVA test were conducted using the SPSS tool (SPSS, 2019) to analyze participant's opinion.

6.3.1 Time-Killing activities with serendipitous discovery task

Questions regarding user's feeling on scrolling techniques were given to each participant to give their own opinion from strongly disagree to strongly agree.

Question-1: Simple and easy to use scrolling technique while performing serendipitous tasks

Before start to use one way repeated measure ANOVA for analysis, normality test has been done. It was found that data were normally distributed. sphericity has been assumed with value $\chi^2(5) = 6.058$, $p = 0.3006$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it can be seen that on average, infinite 'load more' scrolling website (mean = 3.88; SD = 0.957) was more simple and easy to use as compared to normal scrolling (mean = 3.63 SD = 0.885), infinite scrolling (mean = 3.44; SD = 1.263) and infinite pagination scrolling (mean = 3.44; SD = 1.153).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-1 : within subject report for participant's opinion on simple and easy to use scrolling for serendipitous discovery task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Serendipitous opinion 1	Sphericity Assumed	2.063	3	.688	.681	.568	.043
	Greenhouse-Geisser	2.063	2.360	.874	.681	.536	.043
	Huynh-Feldt	2.063	2.829	.729	.681	.560	.043
	Lower-bound	2.063	1.000	2.063	.681	.422	.043
Error (Serendipitous opinion 1)	Sphericity Assumed	45.438	45	1.010			
	Greenhouse-Geisser	45.438	35.395	1.284			
	Huynh-Feldt	45.438	42.429	1.071			
	Lower-bound	45.438	15.000	3.029			

Table 6.3-1 shows that the significant value(P) is greater than 0.05, that means there was no significant difference in opinion ‘simple and easy to use scrolling technique’ for four scrolling techniques given by participant statistics value ($F(3, 45) = 0.681, p = 0.568, \eta^2 = 0.43$).

Analysis result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of user opinion ‘simple and easy to use scrolling technique’ for serendipitous discovery task on website with all four scrolling techniques, ($F(3, 45) = 0.681, p = 0.568, \eta^2 = 0.43$). However, according to the mean score, it has been seen that infinite ‘load more’ scrolling website (mean = 3.88) was more simple and easy to use as compared to normal scrolling (mean = 3.63 SD), infinite scrolling (mean = 3.44) and infinite pagination scrolling (mean = 3.44).

Question-2: I found scrolling technique was very responsive while performing serendipitous tasks.

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 7.804$, $p = 0.168$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, normal scrolling website (mean = 3.94 SD = 0.443) was more responsive as compared to Infinite scrolling (mean = 3.87; SD = 0.619), Infinite 'load more' scrolling (mean = 3.56; SD = 0.892) and infinite pagination scrolling (mean = 3.56; SD = 1.031).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-2: within subject report for participant's opinion on responsiveness of scrolling for serendipitous task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Serendipitous opinion 2	Sphericity Assumed	1.922	3	.641	1.018	.394	.064
	Greenhouse-Geisser	1.922	2.238	.859	1.018	.380	.064
	Huynh-Feldt	1.922	2.649	.726	1.018	.388	.064
	Lower-bound	1.922	1.000	1.922	1.018	.329	.064
Error (Serendipitous opinion 2)	Sphericity Assumed	28.328	45	.630			
	Greenhouse-Geisser	28.328	33.567	.844			
	Huynh-Feldt	28.328	39.732	.713			
	Lower-bound	28.328	15.000	1.889			

Table 6.3-2 shows that the significant value(P) is greater than 0.05, that means there was no significant difference in opinion 'very responsive to use scrolling technique' for four scrolling techniques given by participant with statistics value (F (3, 45) =1.018, p = 0.394, η^2 =0.64).

Analysis result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of user opinion 'very responsive scrolling technique' for serendipitous discovery task on website with all four scrolling techniques, (F (3, 45) =1.018, p = 0.394, η^2 =0.64). However, according to the mean score, it has been seen that normal scrolling website (mean = 3.94) was more responsive, as compared to infinite scrolling (mean = 3.87), infinite 'load more' scrolling (mean = 3.56) and infinite pagination scrolling (mean = 3.56).

Question-3: I found scrolling technique was pleasant to use while performing serendipitous tasks

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value χ^2 (5) = 9.251, p = 0.100 (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, infinite scrolling website (mean = 3.94; SD = 0.772) and infinite 'load more' scrolling (mean = 3.94; SD = 0.680) were more pleasant to use as compared to infinite pagination scrolling (mean = 3.75; SD = 0.683) and normal scrolling (mean = 3.69; SD = 0.793)

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-3: within subject report for participant's opinion on pleasant to use scrolling for serendipitous task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Serendipitous opinion 3	Sphericity Assumed	.797	3	.266	.452	.717	.029
	Greenhouse-Geisser	.797	2.017	.395	.452	.642	.029
	Huynh-Feldt	.797	2.332	.342	.452	.670	.029
	Lower-bound	.797	1.000	.797	.452	.512	.029
Error (Serendipitous opinion 3)	Sphericity Assumed	26.453	45	.588			
	Greenhouse-Geisser	26.453	30.259	.874			
	Huynh-Feldt	26.453	34.980	.756			
	Lower-bound	26.453	15.000	1.764			

Table 6.3-3 shows that the significant value(P) is greater than 0.05, that means there was no significant difference in opinion ‘Pleasant to use scrolling technique’ for four scrolling techniques given by participant with statistics value (F (3, 45) =0.452, p = 0.717, η^2 =0.29).

Analysis result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of user opinion ‘pleasant to use scrolling technique’ for serendipitous discovery task on website with all four scrolling techniques, (F (3, 45) =0.452, p = 0.717, η^2 =0.29). However, according to the mean score, it has been seen that infinite scrolling website (mean = 3.94) and infinite ‘load more’ scrolling (mean = 3.94) were more pleasant to use as compared to infinite pagination scrolling (mean = 3.75) and normal scrolling (mean = 3.69).

Question-4: I felt very confident to use scrolling technique to complete the serendipitous tasks.

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 4.142$, $p = 0.530$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, infinite scrolling website (mean = 4.06; SD = 0.680) was more confident to use as compared to infinite ‘load more’ scrolling (mean = 4.00; SD = 0.516), normal scrolling (mean = 3.63; SD = 0.719) and infinite pagination scrolling (mean = 3.62; SD = 0.719).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-4: within subject report for participant's opinion on confident to use scrolling for serendipitous tasks

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Serendipitous opinion 4	Sphericity Assumed	2.672	3	.891	2.047	.121	.120
	Greenhouse-Geisser	2.672	2.562	1.043	2.047	.132	.120
	Huynh-Feldt	2.672	3.000	.891	2.047	.121	.120
	Lower-bound	2.672	1.000	2.672	2.047	.173	.120
Error (Serendipitous opinion 4)	Sphericity Assumed	19.578	45	.435			
	Greenhouse-Geisser	19.578	38.429	.509			
	Huynh-Feldt	19.578	45.000	.435			

	Lower-bound	19.578	15.000	1.305			
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Table 6.3-4 shows that the significant value(P) is greater than 0.05, that means there was no significant difference in opinion 'confident to use scrolling technique' for four scrolling techniques given by participant with statistics value (F (3, 45) =2.047, p = 0.121, η^2 =0.120).

Analysis result

The result of one way repeated measure ANOVA indicated that there was no significant difference in terms of user opinion 'confident to use scrolling technique' for serendipitous discovery task on website with all four scrolling techniques, (F (3, 45) =2.047, p = 0.121, η^2 =0.120). However, according to the mean score, it has been seen that infinite scrolling website (mean = 4.06) was more confident to use as compared to infinite 'load more' scrolling (mean =4.00), normal scrolling (mean = 3.63) and infinite pagination scrolling (mean = 3.62).

Question-5: With completion of serendipitous tasks using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value χ^2 (5) = 10.058, p = 0.74) (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, infinite scrolling website (mean = 4.44; SD = 0.512) was more recommended to use as compared to Infinite 'load more' scrolling (mean =3.94; SD = 0.443), normal scrolling (mean = 3.62; SD = 0.500) and infinite pagination scrolling (mean = 3.50; SD = 0.966).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-5: within subject report for participant's opinion on recommendation to use scrolling for serendipitous tasks

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Serendipitous opinion 5	Sphericity Assumed	8.375	3	2.792	7.336	.000	.328
	Greenhouse-Geisser	8.375	1.787	4.687	7.336	.004	.328
	Huynh-Feldt	8.375	2.012	4.162	7.336	.002	.328
	Lower-bound	8.375	1.000	8.375	7.336	.016	.328
Error (Serendipitous opinion 5)	Sphericity Assumed	17.125	45	.381			
	Greenhouse-Geisser	17.125	26.800	.639			
	Huynh-Feldt	17.125	30.182	.567			
	Lower-bound	17.125	15.000	1.142			

Table 6.3-5 shows that the significant value(P) is less than 0.05, that means there was significant difference in opinion 'recommendation to use scrolling technique' for four scrolling techniques given by participant with statistics value ($F(3, 45) = 7.336, p = 0.000, \eta^2 = 0.328$).

Post Hoc test with Bonferroni correction

Pairwise comparison with Bonferroni correction test was done to evaluate exactly which pairs of scrolling technique websites were significantly different from each other.

Statistically, it was found that pair of normal scrolling and Infinite scrolling were more significant($p=0.001$) followed by infinite scrolling and infinite pagination scrolling($P=0.003$), and infinite scrolling and infinite loadmore scrolling($P=0.039$). (please see statistics table from [Appendix C-Statistic tables](#))

Analysis result

The result of one way repeated measure ANOVA indicated that there was significant difference in terms of user opinion 'recommendation to use scrolling technique' for

serendipitous discovery task on website with all four scrolling techniques, ($F(3, 45) = 7.336$, $p = 0.000$, $\eta^2 = 0.328$). Bonferroni post hoc test showed that participants significantly recommended Infinite scrolling website (mean = 4.44) more appropriate to use in websites as compared to normal scrolling (mean = 3.62; $P = 0.001$), infinite pagination scrolling (mean = 3.50; $P = 0.003$) and Infinite 'load more' scrolling (mean = 3.94; $P = 0.39$).

6.3.2 Goal-Driven finding tasks

Questions regarding user's feeling on scrolling techniques were given to each participant to give their own opinion from strongly disagree to strongly agree.

Question-1: Simple and easy to use scrolling technique while performing goal-driven tasks

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 6.514$, $p = 0.259$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, normal scrolling website (mean = 4.19; SD = 0.655) was more simple and easy to use as compared to infinite 'load more' scrolling (mean = 4.06; SD = 0.574), infinite pagination scrolling (mean = 3.56; SD = 0.892) and infinite scrolling (mean = 3.44; SD = 0.512).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-6: within subject report for participant's opinion on simple and easy to use scrolling for goal driven finding task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Goal-driven opinion 1	Sphericity Assumed	6.500	3	2.167	5.909	.002	.283

	Greenhouse-Geisser	6.500	2.342	2.775	5.909	.004	.283
	Huynh-Feldt	6.500	2.802	2.320	5.909	.002	.283
	Lower-bound	6.500	1.000	6.500	5.909	.028	.283
Error (Goal-driven opinion 1)	Sphericity Assumed	16.500	45	.367			
	Greenhouse-Geisser	16.500	35.129	.470			
	Huynh-Feldt	16.500	42.034	.393			
	Lower-bound	16.500	15.000	1.100			

Table 6.3-6 shows that the significant value(P) is less than 0.05, that means there was significant difference in opinion ‘simple and easy to use scrolling technique’ for four scrolling techniques given by participant with statistics value (F (3, 45) =5.909, p = 0.002, η^2 =0.283).

Post Hoc test with Bonferroni correction

Pairwise comparison with Bonferroni correction test was done to evaluate exactly which pairs of scrolling technique websites were significantly different from each other.

Statistically, there was only one significant difference between the pair, i.e. normal scrolling and Infinite scrolling (p=0.009). (please see statistics table from [Appendix C- statistics tables](#))

Analysis result

The result of one way repeated measure ANOVA indicated that there was significant difference in terms of user opinion ‘simple and easy to use scrolling technique’ for goal-driven task on website with all four scrolling techniques, (F (3, 45) =5.909, p = 0.002, η^2 =0.283). Bonferroni post hoc test showed that normal scrolling website (mean = 4.19) significantly more simple and easy to use as compared to infinite scrolling (mean = 3.44; P=0.009). However, neither condition with infinite scrolling load more(mean=4.06) and infinite pagination scrolling(mean=3.56) found significantly differed.

Question-2: I found scrolling technique was very responsive while performing goal-driven tasks.

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 4.216$, $p = 0.519$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, normal scrolling website (mean = 4.13; SD = 0.500) was very responsive as compared to infinite 'load more' scrolling (mean = 3.75; SD = 0.577), infinite pagination scrolling (mean = 3.69; SD = 0.479) and infinite scrolling (mean = 3.13; SD = 0.619).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-7: within subject report for participant's opinion on very responsive scrolling for goal driven task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Goal-driven opinion 2	Sphericity Assumed	8.172	3	2.724	8.408	.000	.359
	Greenhouse-Geisser	8.172	2.513	3.252	8.408	.000	.359
	Huynh-Feldt	8.172	3.000	2.724	8.408	.000	.359
	Lower-bound	8.172	1.000	8.172	8.408	.011	.359
Error (Goal-driven opinion 2)	Sphericity Assumed	14.578	45	.324			
	Greenhouse-Geisser	14.578	37.688	.387			
	Huynh-Feldt	14.578	45.000	.324			
	Lower-bound	14.578	15.000	.972			

Table 6.3-7 shows that the significant value(P) is less than 0.05, that means there was significant difference in opinion 'very responsive to use scrolling technique' for four scrolling techniques given by participant with statistics value ($F(3, 45) = 8.408, p = 0.000, \eta^2 = 0.359$).

Post Hoc test with Bonferroni correction

Pairwise comparison with Bonferroni correction test was done to evaluate exactly which pairs of scrolling technique websites were significantly different from each other.

Statistically, there was only one significant difference between the pair, i.e. normal scrolling and infinite scrolling ($p=0.000$). (please see statistics table from [Appendix C- statistics tables](#))

Analysis result

The result of one way repeated measure ANOVA indicated that there was significant difference in terms of user opinion 'very responsive scrolling technique' for goal-driven task on website with all four scrolling techniques, ($F(3, 45) = 8.408, p = 0.000, \eta^2 = 0.359$).

Bonferroni post hoc test showed that normal scrolling website (mean = 4.13) significantly very responsive as compared to infinite scrolling (mean = 3.13; $P=0.000$). However, neither condition with infinite scrolling load more(mean=3.75) and infinite pagination scrolling(mean=3.69) found significantly differed.

Question-3: I found scrolling technique was pleasant to use while performing goal-driven tasks

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 6.516, p = 0.259$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, infinite 'load more' scrolling (mean = 4.06; SD = 0.574) was more pleasant to use as compared to, infinite pagination scrolling (mean = 3.88; SD = 0.619), Normal scrolling website (mean = 3.56; SD = 0.892) and infinite scrolling (mean = 3.38; SD = 0.500).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-8: within subject report for participant's opinion on pleasant to use scrolling for goal driven task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Goal-driven opinion 3	Sphericity Assumed	4.563	3	1.521	4.041	.013	.212
	Greenhouse-Geisser	4.563	1.644	2.775	4.041	.037	.212
	Huynh-Feldt	4.563	1.820	2.507	4.041	.032	.212
	Lower-bound	4.563	1.000	4.563	4.041	.063	.212
Error (Goal-driven opinion 3)	Sphericity Assumed	16.938	45	.376			
	Greenhouse-Geisser	16.938	24.660	.687			
	Huynh-Feldt	16.938	27.295	.621			
	Lower-bound	16.938	15.000	1.129			

Table 6.3-8 shows that the significant value(P) is less than 0.05, which means there was significant difference in opinion 'pleasant to use scrolling technique' for four scrolling techniques given by participant with statistics value (F (3, 45) =4.041, p = 0.013, η^2 =0.212).

Post Hoc test with Bonferroni correction

Pairwise comparison with Bonferroni correction test was done to evaluate exactly which pairs of scrolling technique websites were significantly different from each other.

Statistically, two pairs were significantly differed, i.e. Infinite scrolling and infinite load more scrolling (p=0.000); and Infinite scrolling and infinite pagination scrolling (p=0.009). (please see statistics table from [Appendix C- statistics tables](#))

Analysis result

The result of one-way repeated measure ANOVA indicated that there was significant difference in terms of user opinion 'Pleasant to use scrolling technique' for goal-driven task on website with all four scrolling techniques, ($F(3, 45) = 4.041, p = 0.013, \eta^2 = 0.212$).

Bonferroni post hoc test showed that infinite loadmore scrolling website (mean = 4.06) significantly pleasant to use as compared to infinite scrolling (mean = 3.38; $P = 0.000$), infinite pagination scrolling (mean = 3.69, $P = 0.009$) and normal scrolling (mean = 3.56)

Question-4: I felt very confident to use scrolling technique to complete the goal-driven tasks.

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 2.867, p = 0.721$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, infinite pagination scrolling (mean = 4.31; SD = 0.602) was more confident to use as compared to normal scrolling website (mean = 4.13; SD = 0.619), infinite 'load more' scrolling (mean = 3.69; SD = 0.946), and infinite scrolling (mean = 3.38; SD = 0.806).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-9: within subject report for participant's opinion on confident to use scrolling for goal driven task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Goal-driven opinion 3	Sphericity Assumed	8.625	3	2.875	5.000	.004	.250

	Greenhouse-Geisser	8.625	2.645	3.261	5.000	.007	.250
	Huynh-Feldt	8.625	3.000	2.875	5.000	.004	.250
	Lower-bound	8.625	1.000	8.625	5.000	.041	.250
Error (Goal-driven opinion 3)	Sphericity Assumed	25.875	45	.575			
	Greenhouse-Geisser	25.875	39.673	.652			
	Huynh-Feldt	25.875	45.000	.575			
	Lower-bound	25.875	15.000	1.725			

Table 3.6-9 shows that the significant value(P) is less than 0.05, that means there was significant difference in opinion 'confident to use scrolling technique' for four scrolling techniques given by participant with statistics value ($F(3, 45) = 5.000, p = 0.004, \eta^2 = 0.250$).

Post Hoc test with Bonferroni correction

Pairwise comparison with Bonferroni correction test was done to evaluate exactly which pairs of scrolling technique websites were significantly different from each other.

Statistically, there was only one significant difference between the pair, i.e. Infinite pagination scrolling and Infinite scrolling ($p=0.011$). (please see statistics table from

[Appendix C- statistics tables](#))

Analysis result

The result of one way repeated measure ANOVA indicated that there was significant difference in terms of user opinion 'confident to use scrolling technique' for goal-driven task on website with all four scrolling techniques, ($F(3, 45) = 5.000, p = 0.004, \eta^2 = 0.250$).

Bonferroni post hoc test showed that infinite pagination scrolling (mean = 4.31) significantly confident to use as compared to infinite scrolling (mean = 3.38; $P=0.011$). However, neither condition with infinite scrolling load more(mean=3.69) and normal scrolling(mean=4.13) found significantly differed.

Question-5: With completion of goal-driven tasks using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

Normality test has been done to verify normal distribution of recorded data. It was found that data were normally distributed. Sphericity has been assumed with value $\chi^2(5) = 2.834$, $p = 0.726$ (please see statistics table from [Appendix C- statistics tables](#)).

Descriptive Mean-SD details

From descriptive mean-standard deviation table (please see statistics table from [Appendix C- statistics tables](#)) it has been seen that on average, Infinite loadmore scrolling website (mean = 4.25; SD = 0.775) was more recommended to use as compared to normal scrolling (mean = 4.19; SD = 0.574), infinite pagination scrolling (mean = 3.88; SD = 0.719) and infinite scrolling (mean = 3.06; SD = 0.574).

Test of Within-subject Effect

ANOVA test presents following results for within subject effect.

Table 6.3-10: within subject report for participant's opinion on recommendation to use scrolling for goal driven task

Tests of Within-Subjects Effects							
Measure: MEASURE_1							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Goal-driven opinion 1	Sphericity Assumed	14.312	3	4.771	9.899	.000	.398
	Greenhouse-Geisser	14.312	2.645	5.412	9.899	.000	.398
	Huynh-Feldt	14.312	3.000	4.771	9.899	.000	.398
	Lower-bound	14.312	1.000	14.312	9.899	.007	.398
Error (Goal-driven opinion 1)	Sphericity Assumed	21.688	45	.482			
	Greenhouse-Geisser	21.688	39.670	.547			
	Huynh-Feldt	21.688	45.000	.482			
	Lower-bound	21.688	15.000	1.446			

Table 6.3-10 shows that the significant value(P) is less than 0.05, that means there was significant difference in opinion 'simple and easy to use scrolling technique' for four scrolling techniques given by participant with statistics value (F (3, 45) =9.899, p = 0.000, η^2 =0.398).

Post Hoc test with Bonferroni correction

Pairwise comparison with Bonferroni correction test was done to evaluate exactly which pairs of scrolling technique websites were significantly different from each other.

Statistically, it was found that pair of infinite scrolling and infinite load more scrolling(P=0.000001) was more significant followed by normal scrolling and Infinite scrolling (p=0.000345) and infinite scrolling and infinite pagination scrolling(P=0.017). (please see statistics table from [Appendix C-Statistic tables](#))

Analysis result

The result of one way repeated measure ANOVA indicated that there was significant difference in terms of user opinion 'recommendation to use scrolling technique' for goal-driven task on website with all four scrolling techniques, (F (3, 45) =9.899, p = 0.000, η^2 =0.398). Bonferroni post hoc test showed that participants significantly recommended Infinite load more scrolling website (mean = 4.25) was more recommended to use as compared to normal scrolling (mean =4.19), infinite pagination scrolling (mean = 3.88) and infinite scrolling (mean = 3.06).

6.4 Subjective opinion on prototype and task design

To know the participant's opinion and how they felt about the task design and prototype(websites), they were asked to give the score from 1-strongly disagree to 5-strongly agree on post questionnaire. There were five questions regarding tasks clarity, tasks understandability, prototype functionality, satisfaction etc. A bar graph shown below are participant's opinion in average percentage value interpreted from strongly agree (100%), agree only (75%), undecided (50%), disagree only (25%) and strongly disagree (0%).

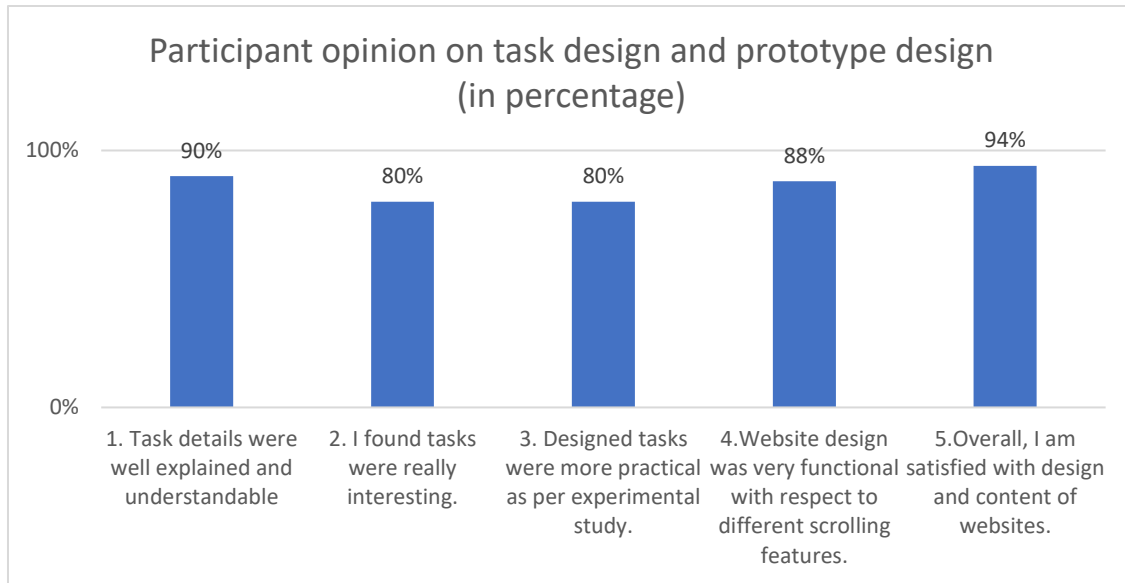


Figure 6.4-1 : Participants opinion on task design and prototype design

From figure 6.4-1 depicts that participants have rated between 'agree' to 'Strongly agree' all the five questions in terms of task and prototype design. It indicates that participants found tasks were well explained and understandable as well as interesting and more practical to study. Participants rated agree on website were very functional with scrolling techniques used in websites and satisfied with overall design and content of prototype.

7. Discussion

This section includes the discussion of the summary of analysis result, compare finding results whether they support previous study or not and limitations of the study.

7.1 Summary of analysis result

The data collected during the experiment was analyzed statistically to look over the behavior of scrolling techniques used in this study. The experiment conditions i.e. four scrolling techniques websites were compared while measuring the dependent variables: total task completion time, total number of errors and user satisfaction. These dependent variables were compared to investigate whether there was significant difference between the participant's performance and user satisfaction on four different experiment conditions of websites. Analysis result are discussed further in this section to generalize the finding and answer the proposed research questions of this study.

From participant's performance

Participant performed time-killing activities with serendipitous discovery tasks and goal-driven finding tasks in an experiment. Analysis result from participant's performance in terms of total task completion time and total number of errors addressed the four hypotheses of this study as follow:

- Null hypothesis (h_0) is accepted for hypothesis 1, states that there will be no significant difference in terms of total task completion time for 'time-killing activities with serendipitous discovery' tasks on website with all four scrolling techniques.
- For Hypothesis 2, predicted null hypothesis (h_0) is accepted as there was statistically no significant difference in total number of errors by participants while completing 'time-killing activities with serendipitous discovery' tasks on website with all four scrolling techniques.
- Similarly, null hypothesis(h_0) is accepted for hypothesis 4, statistically there was no significant difference in total task completion time of participants while completing 'goal-driven finding' tasks on website with all four scrolling techniques.

- Statistically there was no significant difference found on participants performance in terms of total number of errors while completing 'goal-driven finding' tasks on website with all four scrolling techniques which accepts null hypothesis(h_0) for Hypothesis 5.

Overall analysis result from participants performance in terms of total task completion time and total number of errors done for two tasks type shows that there was no significant difference on scrolling techniques used in websites. However, looking to the mean score it has been seen that participant took less time for task completion and produced less number of errors in infinite scrolling technique websites while completing time-killing activities with serendipitous discovery task and participant did well in infinite load more scrolling technique websites while completing goal-driven finding tasks. With above findings, study would suggest that scrolling techniques used in website for serendipitous discovery and goal-driven finding tasks does not have much impact in making of website in the context of universal design.

From participant's opinion about scrolling techniques

Participant's opinion was based on post-experiment questionnaire used to measure usability factor user satisfaction. Like participants performance, opinion was measured on time killing activities with serendipitous discovery tasks and goal-driven finding tasks. Both hypothesis 3 and hypothesis 6 rejects null hypothesis(h_0), states that statistically there was significant difference in user satisfaction.

Analysis of subjective opinion on time-killing activities with serendipitous discovery tasks and goal-driven finding tasks found mixed result.

For serendipitous discovery task,

- Opinion concerning 'simple and easy to use' has no significant difference over four scrolling technique however, infinite load more scrolling technique have better mean score.
- Opinion concerning 'very responsive to use' has no significant difference on four scrolling technique but, normal scrolling technique have better mean score.
- Similarly, opinion regarding 'pleasant to use' has no significant difference on four scrolling technique however, infinite scrolling technique have better mean score.
- Opinion regarding 'confident to use' has no significant difference on four scrolling technique but, infinite scrolling technique have better mean score.

- Likewise, participant's opinion regarding 'recommendation to use in website' has significant different on four scrolling technique and infinite scrolling technique have better significant value than other three scrolling technique.

For goal-driven finding tasks,

- Opinion concerning 'simple and easy to use' has significant different on four scrolling technique and normal scrolling technique have better significant value.
- Opinion concerning 'very responsive to use' has significant different on four scrolling technique but, normal scrolling technique have better significant score.
- Similarly, opinion regarding 'pleasant to use' has significant different on four scrolling technique however, infinite load more scrolling technique have better significant score.
- Opinion regarding 'confident to use' has significant different on four scrolling technique and infinite pagination scrolling technique have better significant score.
- Likewise, participant's opinion regarding 'recommendation to use in website' has significant different on four scrolling technique and infinite load more scrolling technique have better significant value than other three scrolling technique.

Mixed results were found on the participant's opinion/preference, the study somehow would suggest that Infinite scrolling technique would be recommended option for time-killing activities with serendipitous discovery tasks and either Infinite load more scrolling technique or normal scrolling technique would be recommended option for goal-driven finding tasks in the prospective of user satisfaction. However, there was no exact result or valid evidence to support that participant prefer to use particular scrolling techniques in website in the context of universal design.

Participant's opinion on task and prototype design

Participants were asked some questions regarding task and prototype design to know how they think or feel while performing the tasks in an experiment. Total 5 questions were asked and told to rate their opinion from strongly agree to strongly disagree (from 1- 5 Likert type scale). First three questions were regarding task design and remaining two were from prototype design. Participants rated in between 'agree' to 'Strongly agree' all the five questions regarding task and prototype design, it indicates that participants found tasks

were well explained and understandable as well as interesting and more practical to study. Participants rated agree on website were very functional with scrolling techniques used in websites and satisfied with overall design and content of prototype.

7.2 Comparison to Previous Studies

While reviewing the literature, it was found that there are lots of improvement that had been made in scrolling techniques used in websites. It has been said that scrolling was used in websites for comprehensive reading but recently it had made resurgence as one of the most popular techniques used in websites because of touch based devices and high-speed internet. Hinckley et al. (2002) conducted an experiment to evaluate a scrolling interaction technique essential for designer, likewise Frederick et al. (2015) performed a study on evaluation of parallax scrolling technique. They concluded that scrolling technique is effective when used in hedonic and fun context and recommend designer to think about the motor-impairments users that could make significant effect on the usability of scrolling technique.

Studies related to pagination in literature study outlined some benefits and drawbacks of pagination used in websites. However, it has been said that view more content technique and scrolling along with pagination could be an important enhancement in the scrolling techniques used in websites.

Loranger (2014) from Norman group said infinite scrolling is advantageous for the content that streams constantly in flat structure and has similar chances of being interesting to users, but not recommended for goal-oriented finding tasks in websites. As infinite scrolling technique is newly designed scrolling technique and there is not so much investigation has been done in past years. Since infinite scrolling technique suited to websites with large sets of data, there are some advantages and drawbacks were drawn in literature section (please see chapter 2-literature section).

For further justification, Oluwadoyin (2017) said that infinite scroll may hurt the usability of website if it is goal oriented website and user perform specific tasks and expect to find specific result. Furthermore, he recommends choosing hybrid approach to infinite scrolling that gives flexibility to get back the control and helps to maintain a consistent data on server. Similarly, Karlsson and Larsson (2016) conducted a quantitative study on how user's behavior differs between websites with pagination and scrolling, they said that infinite scrolling can be a

valuable on goal-oriented site but should apply with cautious while using in websites and recommend implementing back-button functionality to retrieve the user's positions when return to the feed of infinite scrolling websites.

An engineer from popular e-commerce website etsy conducted a study why basically infinite scrolling failed in every major way in their website. McKinley (2013) did not find exact reason even though there were no any technical issues and conclude that most annoying issue no footer available in infinite scrolling. Similarly, in Holst (2016) study different variation of load-more scrolling approaches was suggested while comparing infinite scrolling, load more scrolling and pagination in the context of loading product in websites.

With different findings and recommendations from researchers in previous studies, it can be seen that there is a still a room for enhancement in infinite scrolling technique which still has issues to use in websites in the context of universal design. The analysis result of this study also showed mixed results which indicate that normal scrolling, the enhancement version of infinite scrolling could be an appropriate option to use in a website for time-killing activities with serendipitous discovery and goal-driven finding tasks. To some extent, with finding from the analysis it can be agreed with previous study that infinite scrolling technique itself could not be good options to use in website rather if it necessary to use infinite scrolling techniques in websites, then it shall be used with hybrid technique or with caution. With the above consideration, the study somehow provides an important clue to web developer and designer how to design a website with appropriate scrolling techniques that supports both time-killing activities and goal-driven finding tasks in the context of universal design.

7.3 Limitation of the study

However, there were still some limitations to this study that might have led to a better quantitative result from user experiment. The prototypes with four scrolling techniques were developed using WCAG 2.0 guidelines and Universal design principles tried to cover as many issues in the context of universal design and research gap, but still, there are some areas that need to improve in this study which could be base for the future study.

The experiment in this study was conducted using university student as a real participant, it may have been interesting and the result could be more significant if a participant with different disabilities and elderly were included. Accessibility testing of the designed prototypes were verified with Sorsite tool (automation tool that supports guidelines of

WCAG2.0 and accessibility testing checklists), which could be more better if disabled participant were included in the experiment.

Real experiment was conducted only on computer/laptop devices. The convention is that scrolling techniques could be better and more used in mobile devices, if mobile devices were included in the experiment, more accurate result could have been expected.

Participant's task observation and the time recording were done simultaneously which could be improved because there might be lack of focus in each of the task performed by participants, however, screen recording video helped to review observation of the experiment completed by participants. It could be better to add a few more questions in post questionnaire regarding user's real feeling which helps to improve the usability of scrolling techniques used in the study.

Participants were given some training and trial task before the real experiment, from which they learned how to use designed scrolling techniques in the prototype websites. Serendipitous discovery tasks and goal-driven finding tasks were listed in an order from which some participant did well in last two experiments, so it would be better to collect participant's total task completion time if the task inside tasks group (A, B, etc.) was more random order, however, randomization was used in the experiment. In this case, the total task time could be more accurate evaluating the efficiency of the scrolling technique. The last but not least, the participants recruited for the experiment in this study was too low, which could be a reason not to get more significant result in terms of participant's performance.

8. Conclusion

The study investigated the usability and accessibility issues found in different scrolling techniques and tried to explore why infinite scrolling is not appropriate for every website. Overall study and experiment were done on the periphery of the concept found in the study of Loranger (2014) where user's activities are like time-killing activities with serendipitous discovery and goal-driven findings. First of all, the problems related to infinite scrolling were studied using different literature, those issues were generalized and four different prototypes were designed on the basis of scrolling techniques and their improvements. Four prototype websites were developed using all the WCAG2.0 guidelines and UD principles were; normal scrolling website, infinite scrolling website, infinite load more scrolling website and infinite pagination website, all of them had the same layout and same content related to serendipitous discovery and goal-driven findings activities.

On the second phase, experiments were conducted to evaluate the scrolling technique on the basis of participants performance and opinion (preference to use). The statistical tool was used to analyse the participant's data to find a significant result between the four scrolling techniques. Overall, the analysed results showed that statistically there was no significant difference in performance between the scrolling techniques used in the website in the context of participant activities; time-killing activities with serendipitous discovery and goal-driven finding activities. However, there was a significantly different result in terms of participants opinion/preference on different scrolling techniques, and it was found mixed results. The measurement factors used in an experiment were; easy to use, very responsive to use, confident to use, pleasant to use and recommendation to use. The results obtained from the experiment was participants preferred either infinite scrolling or normal scrolling or infinite load more scrolling techniques for time-killing with serendipitous discovery activities while in case of goal-driven finding they preferred to use either normal scrolling or infinite load more scrolling technique. However, no one preferred to use infinite scrolling techniques for goal-driven finding activities.

Therefore, throughout the analysis of results and previous literature, it was found that there is no valid evidence to answer the first research question, which among four scrolling technique would better to use in a website in the context of universal design. From analysis result, it is not so clear to say either normal scrolling, or infinite load more scrolling or

infinite scrolling or infinite pagination scrolling would be appropriate options to use in website in the context of universal design. However, this study would suggest further investigation by taking care of limitation of study outlined in the discussion session would help to get an answer in future. Similarly, with the help of the drawbacks of infinite scrolling techniques analysed in the literature study and mixed result from analysis result, it can be concluded that infinite scrolling technique could not be justifiable in the context of usability, a hybrid technique or improved version of infinite scrolling technique would be helpful to enhance the usability of scrolling when used in websites.

8.1 Future Research

Following recommendation could be a key factor for the researcher to do further investigation on the evaluation of scrolling techniques

- While evaluating any system in the context of universal design, it is important to include the participants regardless of their disabilities. For this study, due to a time limit, and challenges to find disabled participants with kind of impairments and elderly, only abilities participants were included. The study recommends including all the disabled and elderly participant with assistive technology to get a more accurate result in terms of usability and accessibility.
- Participant recruited for the study was too low (16 participants), which might be the reason not to get more accurate result on participant's performance, so it is highly recommended to include as much as participant (more than 50), which could bring more accurate result.
- As experiments were only done in computer devices, but it is recommended to use experiments on mobile devices to get a better result.
- A more accurate result can be expected if post-experiment questions designed with more real user's feeling.
- Adding language preference in prototype design can help to include more diverse participants for an experiment.

8.2 Journey throughout the research study

While reflecting on the experience of doing this research study, I truly enjoyed every moment I spent on this project. As being a computer science student, I always have a passion to learn something new that I can explore and enhance my knowledge in a particular field. I love to play with programming code to develop system and being a student of universal design of ICT always motivates me to study and design product more accessible and user-friendly by using guidelines and accessibility checklist. Well, at the beginning I really don't have much more idea about how to choose an appropriate topic for further investigation. However, a thorough study of a different scientific paper, I was able to find something interesting about scrolling techniques where still some room for improvement has been found in the context of universal design. Different scrolling techniques are used in a website these days and one of the most fascinating and newly designed infinite scrolling was the main topic of my thesis study. Though it was a really challenging job to conduct research on technology which was rarely known by people and less research was done in the past to make infinite scrolling more usable. In the beginning, I have started to find different paper related to scrolling techniques and try to outline the issues related to infinite scrolling technique. Fortunately, I found an important article related to infinite scrolling technique from Nielsen Normal group which was really helpful for my further investigation. And finally designed prototype websites based on previous research study, performed an experiment with the participant to collect data, analyzed them to present the result of the study. However, the mixed result was found in the study which could suggest improved version of infinite scrolling or infinite scrolling with caution only be appropriate to use on the website in the context of universal design. Not only the development and evaluation of the study, the writing was the most challenging part, but it was fun to interpret the finding of the study. I felt very lucky and grateful to my supervisor who has given his valuable time to supervise me, his continuous support, back to back meetings, feedback and suggestion were one of the important part to complete this study.

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10. Appendices

10.1 Appendix A

10.1.1 Consent Form

Oslo Metropolitan University
Department of Computer Science
Faculty of Technology, Art and Design



Title of Research Experiment: Evaluation of Scrolling techniques on Websites in the context of Universal Design.

Researcher Name: Sushil Sharma

Department: Computer Science

Contact: s310225@stud.oslomet.no

Supervisor Name: Dr. Pietro Murano

Department: Computer Science

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General Information:

You are invited to participate in master Research experiment to perform four different tasks on four different prototype websites. Each of the websites will have same content types but different in scrolling techniques. The aim of this experiment is to identify which technique is better to use in webpages to make scrolling much more accessible and user friendly.

Experiment Procedures

If you agree to be a participant, then you will be asked to do the following:

Pre-Experiment:

You are requested to fill up a questionnaire about your demographic information that is needed to participate in research study. You will not be asked to fill personal information like your name, Number and address etc.

Real Experiment:

After that you will be invited to test/perform four different tasks on four different prototype websites having same content structure. A briefing about the experiment content and information about the scrolling technique will be given at very start of experiment.

Post-Experiment:

Here you will be requested to complete post-experiment questionnaires based on your experimental experience. A set of questions will be asked based on yours' opinion about system usability, learning capability, accessibility and satisfaction based on your task completion. The total session time of experiment will be approximately 20-30minutes.

Confirmation and consent (Please Tick below)

- I confirm that I have read and understand the information for the research study and have rights to ask question regarding experiment at any time.
- I understand that my participation in this research is voluntary, I am free to refuse to participate and I am free to withdraw from the research at any time. My refusal to participate or withdrawal of consent will not affect to anything or anyone and data will be completely destroyed.
- I confirm that I do not have any health problems while using computer system and internet.
- I agree not to share details of the study to anyone until the research completely done.
- By checking these all boxes, I am indicating my consent to participate in the research. I understand that the data collected from my participation will be anonymous and used for a Master thesis and possibly other published studies.

10.2 Appendix B

10.2.1 Pre-Experiment Questionnaire

Participant ID: ____

Date ____/____/____

Pre-Experiment Questionnaire

Demographic Information

This is the beginning of the experiment where you will be asked some questions regarding your general information, computer use experience, use of internet, understanding about websites and scrolling techniques. Your responses will keep confidential and will be used for research purpose and other published study.

Please check the answer that suits you

1. **Your Gender:** Male Female Other_____

2. **Age group(years):** Below 18 18-25 26-35 35-45
 More than 45

3. **Education:** Basic School High School Graduate
 Doctorate

4. **Profession:** Student Professor Designer
 Other_____

5. **Computer Use Experience:** Less than 1 year 2-5 years
 more than 5 years

6. **How often do you use internet (in daily basis):** Less than an hour 2-5 hours
 More than 5 hours

7. What's your reason to use internet: Web Browsing Email
 Research study Time-killing activities

8. What's your browser Preference: Chrome Firefox
 Internet Explorer Safari
 Others _____

9. Your Experience about Websites visit: Less than a year 2-5 years
 6-10 years More than 10 years

10. Purpose of visiting Websites (multiple selection): Academic Entertainment
 shopping Profession
 Others _____

11. Device Preferences to visit websites: Laptop Desktop
 Smartphone devices
 Others _____

12. How often do you scroll pages while visiting the websites: Many times Depends
 Sometimes Never

13. Have you ever visit a website designed with infinite/endless scrolling: Yes No

14. Have you ever visit a website designed with "Load More" button at bottom:

Yes No

15. Have you ever visit a website designed with infinite scrolling and pagination at the

bottom: Yes No

16. Have you ever visit a website designed just with casual/normal scrolling and pagination

in bottom: Yes No

17. Do you know about Universal Design: Yes No

If Yes, please select below information you know:

- Design to make accessible for everyone
- Design to make more usable
- Design with focus to use efficiently and comfortably with low effort
- All of above

18. Do you have any impairment and need any Assistive technology to participate in experiment: Yes No

If Yes,

Impairment type _____

Name of Assistive Technology _____

10.2.2 Post-Experiment Questionnaire

Participant ID: ____

Date __/__/__

Post-Experiment Questionnaire

I would like to thank you for providing your valuable time on my research experiment. In this section, you will be asked to give your response based on your experience while completing the given task. In total, there will be 15 questions categorized on experiment conditions task design, and design of prototype website and you can give answer in the form of rating form.

Please make a circle on number to rate

Questions regarding task design & experience

1. Task details were well explained and understandable.

Strongly disagree Strongly agree

1 2 3 4 5

2. I found tasks were really interesting.

Strongly disagree Strongly agree

1 2 3 4 5

3. Designed tasks were more practical as per experimental study.

Strongly disagree Strongly agree

1 2 3 4 5

Questions regarding four experiment condition & experience

Task type: Time killing activities with Serendipitous discovery

4. Simple and easy to use scrolling technique while performing **serendipitous tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

5. I found scrolling technique was very responsive while performing **serendipitous tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

6. I found scrolling technique was pleasant to use while performing **serendipitous tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree

Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree

Strongly agree

1 2 3 4 5

Website with "Load More" Infinite Scrolling technique (website 3)

Strongly disagree

Strongly agree

1 2 3 4 5

Website with Infinite Scrolling "pagination" technique (website 4)

Strongly disagree

Strongly agree

1 2 3 4 5

7. I felt very confident to use scrolling technique to complete the **serendipitous tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree

Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree

Strongly agree

1 2 3 4 5

Website with "Load More" Infinite Scrolling technique (website 3)

Strongly disagree

Strongly agree

1 2 3 4 5

Website with Infinite Scrolling "pagination" technique (website 4)

Strongly disagree

Strongly agree

1 2 3 4 5

8. With completion of **serendipitous tasks** using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

Task type: Goal-driven finding tasks

9. Simple and easy to use scrolling technique while performing **goal-driven Tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

10. I found scrolling technique was very responsive while performing **goal-driven tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

11. I found scrolling technique was pleasant to use while performing **goal-driven tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

12. I felt very confident to use scrolling technique to complete the **goal-driven tasks**.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

13. With completion of **goal-driven tasks** using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

Website with Normal Scrolling technique (website 1)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling technique (website 2)

Strongly disagree Strongly agree

1 2 3 4 5

Website with “Load More” Infinite Scrolling technique (website 3)

Strongly disagree Strongly agree

1 2 3 4 5

Website with Infinite Scrolling “pagination” technique (website 4)

Strongly disagree Strongly agree

1 2 3 4 5

Question regarding website design & experience

14. Website design was very functional with respect to different scrolling features.

Strongly disagree Strongly agree

1 2 3 4 5

15. Overall, I am satisfied with design and content of websites.

Strongly disagree Strongly agree

1 2 3 4 5

10.2.3 Randomization of Participants

Participants	Experiment session 1		Experiment session 2		Experiment session 3		Experiment session 4	
	Scrolling website	Task Group	Scrolling website	Task Group	Scrolling website	Task Group	Scrolling website	Task Group
1	W1	A	W2	B	W3	C	W4	D
2	W1	B	W2	C	W3	D	W4	A
3	W1	C	W2	D	W3	A	W4	B
4	W1	D	W2	A	W3	B	W4	C
5	W2	A	W3	B	W4	C	W3	D
6	W2	B	W3	C	W4	D	W3	A
7	W2	C	W3	D	W4	A	W3	B
8	W2	D	W3	A	W4	B	W3	C
9	W3	A	W4	B	W1	C	W2	D
10	W3	B	W4	C	W1	D	W2	A
11	W3	C	W4	D	W1	A	W2	B
12	W3	D	W4	A	W1	B	W2	C
13	W4	A	W1	B	W2	C	W1	D
14	W4	B	W1	C	W2	D	W1	A
15	W4	C	W1	D	W2	A	W1	B
16	W4	D	W1	A	W2	B	W1	C

W1: Prototype website1 with “Normal Scrolling”

W2: Prototype website2 with “Infinite Scrolling”

W3: Prototype website3 with “Infinite Scrolling with Load More”

W4: Prototype website4 with “Infinite Scrolling with Pagination”

Task group (A, B, C, D): Tasks (2 serendipitous discovery tasks 2 goal-driven finding tasks)

10.2.4 Participant’s Performance Sheet

	Experiment website (W1, W2, W3, W4)	Tasks group (A, B, C, D)	Task type	Total time of completion	Number of error
1	W1	A	Serendipitous		
			Goal-driven		
	W2	B	Serendipitous		
			Goal-driven		
	W3	C	Serendipitous		
			Goal-driven		
	W4	D	Serendipitous		
			Goal-driven		
2	W2	A	Serendipitous		
			Goal-driven		
	W3	B	Serendipitous		
			Goal-driven		
	W4	C	Serendipitous		
			Goal-driven		
	W1	D	Serendipitous		
			Goal-driven		
3	W3	A	Serendipitous		
			Goal-driven		
	W4	B	Serendipitous		
			Goal-driven		
	W1	C	Serendipitous		
			Goal-driven		
	W2	D	Serendipitous		
			Goal-driven		
4	W4	A	Serendipitous		
			Goal-driven		
	W1	B	Serendipitous		
			Goal-driven		
	W2	C	Serendipitous		
			Goal-driven		
	W3	D	Serendipitous		
			Goal-driven		
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16				-	---

10.3 Appendix C

10.3.1 Participants Data

10.3.1.1 Total tasks completion time

Time Killing activities with Serendipitous discovery time(seconds)

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	124	116	130	190
2	118	108	128	128
3	118	114	130	130
4	116	118	126	116
5	124	126	126	126
6	118	122	134	104
7	122	108	132	132
8	114	118	122	122
9	116	120	100	100
10	120	134	126	126
11	108	122	118	118
12	126	118	124	114
13	122	112	111	128
14	116	114	126	126
15	124	118	123	106
16	128	126	116	116

Goal Driven finding time(Seconds)

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	120	142	118	122
2	136	129	128	108
3	114	112	124	120
4	98	146	112	114
5	116	118	128	124
6	128	112	106	126
7	112	124	120	122
8	126	125	122	112
9	122	130	112	116
10	118	110	116	100
11	118	122	122	116
12	116	116	112	118

13	119	118	118	194
14	134	124	128	124
15	124	118	124	114
16	136	150	121	120

10.3.1.2 Total Number of errors

Time-killing activities with Serendipitous discovery total no. of error(numbers)

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	0	0	1	0
2	0	1	0	1
3	0	1	0	0
4	0	0	2	0
5	1	0	0	0
6	1	0	0	1
7	0	0	1	0
8	2	0	0	0
9	0	1	0	0
10	0	0	0	1
11	1	0	0	0
12	0	0	0	1
13	0	0	0	0
14	0	0	1	0
15	0	1	0	0
16	0	0	0	1

Goal Driven finding total no. of errors(numbers)

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	0	0	1	0
2	0	0	0	1
3	0	1	0	0
4	0	0	1	0
5	1	0	0	0
6	0	1	0	0
7	0	0	0	1
8	1	0	0	0
9	0	1	0	0

10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	1	0	0	0
14	0	0	0	0
15	0	1	1	0
16	0	0	0	1

10.3.1.3 Participant opinion data on experimental conditions

Time killing activities with serendipitous discovery tasks

1.Simple and easy to use scrolling technique while performing **serendipitous tasks**

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	3	2	3	4
2	4	2	2	4
3	5	1	5	4
4	4	3	3	4
5	5	4	4	4
6	4	5	5	4
7	5	4	4	4
8	2	5	5	4
9	3	4	4	1
10	3	5	5	4
11	3	3	3	3
12	4	3	3	2
13	3	2	4	4
14	3	4	4	5
15	4	5	5	3
16	3	3	3	1

2. I found scrolling technique was very responsive while performing **serendipitous tasks**

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	4	3	4	4
2	4	4	3	2
3	4	4	4	4
4	3	4	3	1
5	4	3	1	5
6	4	4	4	4
7	4	4	4	4
8	4	5	4	3
9	5	3	3	4
10	4	4	3	4
11	4	4	4	4
12	4	3	5	3
13	4	5	3	3
14	4	4	4	3
15	3	4	4	4
16	4	4	4	5

3. I found scrolling technique was pleasant to use while performing **serendipitous tasks.**

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	3	5	3	3
2	4	4	4	3
3	2	5	3	3
4	3	4	4	4
5	3	5	4	4
6	4	4	3	3
7	4	5	3	5
8	4	4	4	4
9	3	3	4	4
10	4	4	4	4
11	5	3	4	4

12	4	4	4	3
13	5	3	5	5
14	3	4	4	4
15	4	3	5	4
16	4	3	5	3

4.I felt very confident to use scrolling technique to complete the **serendipitous tasks**.

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	4	3	4	4
2	4	3	4	3
3	4	5	5	4
4	3	4	4	4
5	2	4	4	3
6	4	4	4	2
7	3	5	4	4
8	4	5	4	4
9	3	4	4	3
10	3	4	4	5
11	4	4	3	4
12	4	3	4	3
13	5	4	4	4
14	3	5	4	4
15	4	4	3	4
16	4	4	5	3

5. With completion of **serendipitous tasks** using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	4	2	5	4
2	4	3	5	3
3	4	3	4	4
4	3	3	3	4
5	4	3	4	3
6	4	4	4	4

7	5	3	5	5
8	4	3	4	4
9	5	3	5	3
10	4	4	3	5
11	4	4	5	3
12	5	3	5	4
13	4	3	4	4
14	5	3	4	5
15	3	2	5	4
16	5	3	3	3

Goal-driven finding tasks

1.Simple and easy to use scrolling technique while performing goal-driven tasks

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	4	3	4	4
2	4	4	4	5
3	4	3	5	3
4	4	4	4	4
5	5	3	5	3
6	5	3	4	3
7	4	3	4	3
8	4	4	4	4
9	4	4	4	4
10	3	3	4	4
11	4	4	3	4
12	5	4	4	4
13	4	3	4	4
14	5	4	4	3
15	5	3	5	4
16	3	3	3	1

2. I found scrolling technique was very responsive while performing **goal-driven tasks**

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	3	3	3	4
2	4	3	5	4
3	4	2	4	4
4	4	2	4	4
5	4	3	4	3
6	4	3	4	4
7	4	4	4	4
8	4	3	3	3
9	5	3	3	4
10	4	3	4	4
11	4	4	3	3
12	4	3	4	4
13	5	3	4	3
14	4	3	4	4
15	4	4	3	4
16	5	4	4	3

3. I found scrolling technique was pleasant to use while performing **goal-driven tasks**.

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	3	3	4	3
2	3	4	4	4
3	3	3	3	4
4	2	3	4	4
5	3	4	4	5
6	4	3	4	3
7	4	3	4	4
8	4	3	4	4
9	4	4	5	5
10	2	4	4	4
11	4	3	3	3
12	3	3	4	4

13	4	4	5	4
14	5	3	4	3
15	4	4	5	4
16	5	3	4	4

4.I felt very confident to use scrolling technique to complete the **goal driven tasks**.

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	5	4	5	4
2	4	3	3	4
3	4	4	5	5
4	4	3	4	4
5	4	4	3	4
6	4	3	4	5
7	4	3	3	5
8	5	3	2	4
9	5	4	4	4
10	4	2	4	3
11	4	3	3	4
12	3	5	2	4
13	5	2	4	5
14	4	4	4	4
15	3	3	5	5
16	4	4	4	5

5. With completion of **goal driven tasks** using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

ID	Normal Scrolling	Infinite Scrolling	Infinite load more Scrolling	Infinite Pagination Scrolling
1	5	2	4	4
2	4	3	4	3
3	4	3	4	4
4	3	3	4	4
5	4	3	4	4
6	4	4	4	4

7	5	3	4	5
8	4	2	4	4
9	4	3	5	4
10	3	3	4	5
11	5	2	4	4
12	4	3	5	4
13	4	3	4	4
14	4	3	5	5
15	5	2	4	4
16	4	3	4	5

10.3.1.4 Subjective opinion on prototype and task design.

1. Task details were well explained and understandable.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Response	4	4	5	4	5	4	5	5	4	5	5	4	4	5	5	4

2. I found tasks were really interesting.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Response	4	4	3	4	4	4	4	4	5	4	4	5	4	4	3	4

3. Designed tasks were more practical as per experimental study.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Response	4	5	4	3	4	4	4	3	4	4	5	4	4	3	4	5

4. Website design was very functional with respect to different scrolling features.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Response	4	4	4	4	5	4	5	5	5	5	5	4	4	5	4	4

5. Overall, I am satisfied with design and content of websites.

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Response	5	4	5	5	5	5	5	5	4	5	4	5	5	4	5	4

10.3.2 Statistics Tables

10.3.2.1 Total completion time-Goal Driven table

Normality test

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Normal scrolling	0.115	16	.200*	0.943	16	0.387
Infinite scrollin	0.179	16	0.118	0.896	16	0.871
Infinite 'Loadmore' scrolling	0.123	16	.200*	0.943	16	0.384
Infinite Pagination scrolling	0.157	16	0.093	0.818	16	0.062

Mauchly's test of sphericity

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Goal_driven_time	0.362	8.935	5	0.117	0.633	0.722	0.333

Descriptive Mean-SD details

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	121.06	9.781	16
Infinite scrolling	124.75	12.102	16
Infinite 'Load more' scrolling	119.44	6.532	16
Infinite Pagination scrolling	121.88	20.35	16

10.3.2.2 Total number of error- Time killing activities with serendipitous discovery

Normality test data

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	f	Sig.	Statistic	df	Sig.
Normal scrolling	0.448	6	0.121	0.887	16	0.089
Infinite Scrolling	0.462	6	0.132	0.846	16	0.073
Infinite load more scrolling	0.448	6	0.121	0.887	16	0.089
Infinite pagination scrolling	0.431	6	0.102	0.891	16	0.083

Mauchly's Sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error serendipitous	0.872	1.881	5	0.866	0.924	1	0.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	0.31	0.602	16
Infinite scrolling	0.25	0.447	16
Infinite 'Load more' scrolling	0.31	0.602	16
Infinite Pagination scrolling	0.31	0.479	16

10.3.2.3 Total number of error- Goal-driven finding tasks

Normality test

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Normal Scrolling	.492	16	.153	.484	16	.677
Infinite scrolling	.462	16	.132	.546	16	.730
Infinite scrolling load more	.492	16	.153	.484	16	.677
Infinite scrolling pagination	.492	16	.153	.484	16	.677

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	0.947	.753	5	0.980	.965	1.000	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	0.19	0.403	16
Infinite scrolling	0.25	0.447	16
Infinite 'Load more' scrolling	0.19	0.403	16
Infinite Pagination scrolling	0.19	0.403	16

10.3.2.4 Participant's opinion- time killing activities with Serendipitous discovery task

Question-1: Simple and easy to use scrolling technique while performing serendipitous tasks

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	0.643	6.058	5	0.3006	.787	.943	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	3.63	.885	16
Infinite scrolling	3.44	1.263	16
Infinite 'Load more' scrolling	3.88	.957	16
Infinite Pagination scrolling	3.44	1.153	16

Question-2: I found scrolling technique was very responsive while performing serendipitous tasks.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.566	7.804	5	.168	.746	.883	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	3.94	.443	16
Infinite scrolling	3.87	.619	16
Infinite 'Load more' scrolling	3.56	.892	16
Infinite Pagination scrolling	3.56	1.031	16

Question-3: Question-3: I found scrolling technique was pleasant to use while performing serendipitous tasks

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.510	9.251	5	.100	.672	.777	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	3.69	.793	16
Infinite scrolling	3.94	.772	16
Infinite 'Load more' scrolling	3.94	.680	16
Infinite Pagination scrolling	3.75	.683	16

Question-4: I felt very confident to use scrolling technique to complete the serendipitous tasks.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.739	4.142	5	0.530	.854	1.000	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	3.63	.719	16
Infinite scrolling	4.06	.680	16
Infinite 'Load more' scrolling	4.00	.516	16
Infinite Pagination scrolling	3.62	.719	16

Question-5: With completion of serendipitous tasks using scrolling techniques, I recommend, it would be an appropriate scrolling technique to use in website.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.342	10.058	5	0.074	.596	.671	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	3.62	.500	16
Infinite scrolling	4.44	.512	16
Infinite 'Load more' scrolling	3.94	.443	16
Infinite Pagination scrolling	3.50	.966	16

Post Hoc test with Bonferroni correction

Pairwise Comparisons						
Measure: MEASURE_1						
(I) goal-driven opinion 1	(J) goal-driven opinion 1	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-.813*	0.164	0.001	-1.31	-0.315
	3	-0.313	0.176	0.577	-0.847	0.222
	4	0.125	0.315	1.000	-0.83	1.08
2	1	.813*	0.164	0.001	0.315	1.31
	3	.500*	0.158	0.039	0.02	0.98
	4	.938*	0.213	0.003	0.289	1.586
3	1	0.313	0.176	0.577	-0.222	0.847
	2	-.500*	0.158	0.039	-0.98	-0.02
	4	0.438	0.241	0.537	-0.294	1.169
4	1	-0.125	0.315	1.000	-1.08	0.83
	2	-.938*	0.213	0.003	-1.586	-0.289
	3	-0.438	0.241	0.537	-1.169	0.294

10.3.2.5 Participant's opinion-Goal-driven finding task

Question-1: Simple and easy to use scrolling technique while performing goal-driven tasks

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.622	6.514	5	0.259	.781	.934	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	4.19	.655	16
Infinite scrolling	3.44	.512	16
Infinite 'Load more' scrolling	4.06	.574	16
Infinite Pagination scrolling	3.56	.892	16

Post Hoc test with Bonferroni correction

Pairwise Comparisons						
Measure: MEASURE_1						
(I) goal-driven opinion 2	(J) goal-driven opinion 2	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	.750*	.194	.009	.162	1.338
	3	.125	.155	1.000	-.345	.595
	4	.625	.256	.166	-.153	1.403
2	1	-.750*	.194	.009	-1.338	-.162
	3	-.625	.221	.077	-1.297	.047
	4	-.125	.202	1.000	-.737	.487
3	1	-.125	.155	1.000	-.595	.345
	2	.625	.221	.077	-.047	1.297
	4	.500	.242	.337	-.233	1.233
4	1	-.625	.256	.166	-1.403	.153
	2	.125	.202	1.000	-.487	.737
	3	-.500	.242	.337	-1.233	.233

Question-2: I found scrolling technique was very responsive while performing goal-driven

tasks.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.735	4.216	5	.519	.838	1.000	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	4.13	.500	16
Infinite scrolling	3.13	.619	16
Infinite 'Load more' scrolling	3.75	.577	16
Infinite Pagination scrolling	3.69	.479	16

Post Hoc test with Bonferroni correction

Pairwise Comparisons						
Measure: MEASURE_1						
(I) serendipitous opinion 5	(J) serendipitous opinion 5	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	1.000 [*]	.183	.000	.446	1.554
	3	.375	.180	.326	-.171	.921
	4	.438	.203	.290	-.180	1.055
2	1	-1.000 [*]	.183	.000	-1.554	-.446
	3	-.625	.239	.118	-1.352	.102
	4	-.563	.223	.141	-1.240	.115
3	1	-.375	.180	.326	-.921	.171
	2	.625	.239	.118	-.102	1.352
	4	.063	.170	1.000	-.454	.579
4	1	-.438	.203	.290	-1.055	.180
	2	.563	.223	.141	-.115	1.240
	3	-.063	.170	1.000	-.579	.454

Question-3: I found scrolling technique was pleasant to use while performing goal-driven

tasks.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.261	6.516	5	.259	.548	.607	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	3.56	.892	16
Infinite scrolling	3.38	.500	16
Infinite 'Load more' scrolling	4.06	.574	16
Infinite Pagination scrolling	3.88	.619	16

Post Hoc test with Bonferroni correction

Pairwise Comparisons							
Measure: MEASURE_1							
(I) serendipitous opinion 5	(J) serendipitous opinion 5	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b		
					Lower Bound	Upper Bound	
1	2	.188	.277	1.000	-.654	1.029	
	3	-.500	.242	.337	-1.233	.233	
	4	-.313	.299	1.000	-1.220	.595	
2	1	-.188	.277	1.000	-1.029	.654	
	3	-.688*	.120	.000	-1.051	-.324	
	4	-.500*	.129	.009	-.892	-.108	
3	1	.500	.242	.337	-.233	1.233	
	2	.688*	.120	.000	.324	1.051	
	4	.188	.164	1.000	-.310	.685	
4	1	.313	.299	1.000	-.595	1.220	
	2	.500*	.129	.009	.108	.892	
	3	-.188	.164	1.000	-.685	.310	

Question-4: I felt very confident to use scrolling technique to complete the goal-driven

tasks.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.811	2.867	5	.721	.882	1.000	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	4.13	.619	16
Infinite scrolling	3.38	.806	16
Infinite 'Load more' scrolling	3.69	.946	16
Infinite Pagination scrolling	4.31	.602	16

Post Hoc test with Bonferroni correction

Pairwise Comparisons						
Measure: MEASURE_1						
(I) serendipitous opinion 5	(J) serendipitous opinion 5	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	.750	.281	.106	-.104	1.604
	3	.438	.273	.782	-.393	1.268
	4	-.188	.228	1.000	-.879	.504
2	1	-.750	.281	.106	-1.604	.104
	3	-.313	.326	1.000	-1.301	.676
	4	-.938*	.249	.011	-1.695	-.180
3	1	-.438	.273	.782	-1.268	.393
	2	.313	.326	1.000	-.676	1.301
	4	-.625	.239	.118	-1.352	.102
4	1	.188	.228	1.000	-.504	.879
	2	.938*	.249	.011	.180	1.695
	3	.625	.239	.118	-.102	1.352

Question-5: With completion of goal-driven tasks using scrolling techniques, I recommend,

it would be an appropriate scrolling technique to use in website.

Mauchly's sphericity test

Mauchly's Test of Sphericity ^a							
Measure: MEASURE_1							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Total error goal driven	.813	2.834	5	.726	.882	1.000	.333

Descriptive Mean-SD data

Descriptive Statistics			
	Mean	Std. Deviation	N
Normal scrolling	4.19	.655	16
Infinite scrolling	3.06	.574	16
Infinite 'Load more' scrolling	4.25	.775	16
Infinite Pagination scrolling	3.88	.719	16

Post Hoc test with Bonferroni correction

Pairwise Comparisons							
Measure: MEASURE_1							
(I) serendipitous opinion 5	(J) serendipitous opinion 5	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b		
					Lower Bound	Upper Bound	
1	2	1.125*	.202	.000	.513	1.737	
	3	-.063	.232	1.000	-.767	.642	
	4	.313	.237	1.000	-.406	1.031	
2	1	-1.125*	.202	.000	-1.737	-.513	
	3	-1.188*	.277	.000	-2.029	-.346	
	4	-.813*	.228	.017	-1.504	-.121	
3	1	.063	.232	1.000	-.642	.767	
	2	1.188*	.277	.004	.346	2.029	
	4	.375	.287	1.000	-.496	1.246	
4	1	-.313	.237	1.000	-1.031	.406	
	2	.813*	.228	.017	.121	1.504	
	3	-.375	.287	1.000	-1.246	.496	